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Preface

We are pleased to welcome you to the second annual Australasian Road Safety Conference, an amalgamation of the Road Safety Research, Policing and Education Conference and the Australasian College of Road Safety Conference. The conference provides the unique opportunity for those involved in all aspects of road safety, including researchers, practitioners, policymakers, police, and educators, to meet, present, and discuss their work.

These proceedings describe research, educational and policing program implementation and policy and management strategies related to all aspects of road safety and especially related to the conference themes of ‘Agility, Innovation and Impact. Some of the popular topic areas for this year include young and ageing drivers, human factors related to distraction, inattention, and fatigue, policing, vehicle safety technology, and road design. The authors of accepted papers and extended abstracts represent international and local institutions from all aspects of their respective communities including research centres, private companies, government agencies, and community groups. This great set of papers is a wonderful indication of the work being done in Australia and abroad as part of the United Nations Decade of Action for Road Safety.

The Conference Organising Committee allowed three manuscript types for the Conference: full peer-reviewed papers, extended abstracts, and symposium papers. Each manuscript type was initially submitted as an extended abstract (approx. 1 to 3 pages) to expedite the review process. Each extended abstract was assigned to a conference editor with senior peer status in the respective field of road safety who allocated at least two reviewers to review the submission. Extended abstracts were reviewed for applicable content with respect to the conference theme and aims including, but not limited to, the following: novel information or data, clarity, relevance to practice or policy, scientific merit, and interest to audience.

Using a similar format to the previous successful conference in 2015, the Conference Organising Committee called for submissions in the form of Extended Abstracts. Groups of papers around similar themes were assigned to Conference Editors who organised the review process. Each Extended Abstract was reviewed by two independent reviewers on select criteria: content consistent with the conference theme, novelty of information or data, clarity, relevance to practice or policy, scientific merit, and interest to audience. A total of 138 manuscripts were accepted as extended abstracts and are presented here. For a further 31 accepted papers, the authors elected to provide full papers which were reviewed a second time and these are also included in these proceedings. Finally, a total of 11 symposium outlines were accepted which are also included.

Putting together such a high-quality program requires a contribution from many people. The proceedings editors would like to thank the conference editors for taking the time to handle submissions, allocate appropriate reviewers, and provide useful and constructive feedback to authors. Likewise, we are most grateful for those peers in the road safety field that helped to review over 225 submissions. The calibre of the conference proceedings would not be so high without your assistance and we thank you all for giving up your valuable time. The proceedings editors would also like to warmly thank all the keynote speakers and presenters, the respective Conference Organising and Scientific Committees, the conference sponsors, and session chairs. The valuable input and enthusiasm from each person and group has helped to ensure the 2016 Australasian Road Safety Conference meets the needs of the diverse range of participants and contributes to the overall success of the event. Most importantly, we hope that the work described in these proceedings will contribute to the reduction in road trauma both in Australia and internationally.

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2016

Higher Education Research

Data Collection

Specifications for the collection of 2015 data

April 2016

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1.1 Purpose

The Australian Government's provision of research block grant (RBG) funding to eligible higher education providers[1] (HEP) is enabled by the *Higher Education Support Act 2003* (HESA), which provides for "grants to support research by, and the research capability of, higher education providers" and "grants to support the training of research students".

The purpose of the 2016 Higher Education Research Data Collection (HERDC) Specifications is to provide guidance to HEPs and auditors on the requirements for providing 2015 research income data.

1.2 Use of data

The department uses the HERDC data in conjunction with data from the Higher Education Student Data Collection to determine HEPs' annual RBG amounts.

Information about the RBG, including program guidelines, conditions of grants and processes for calculating grants can be found on the department's website:

www.education.gov.au/research-block-grants

It is a condition of the grants that the materials required in section 1.4 of these Specifications be provided to the department by 30 June 2016.

Submitted HERDC data may be used to inform other analyses conducted by the department and provided to other government agencies.

HERDC data is published on the department's website at:

www.education.gov.au/higher-education-research-data-collection

1.3 Use of funding

The department's allocation of RBG to HEPs is independent of funding for individual research projects. HEPs have the autonomy to decide what projects, personnel, equipment and infrastructure that block grants should support across their research and research training activities.

The department does not intend that HEPs use the HERDC as the basis for their internal systems for allocating their research and research training funding. HEPs should develop their own internal allocation mechanisms.

[1] Eligible higher education providers are those institutions identified as Table A and Table B providers in sections 16-15 and 16-20 of the *Higher Education Support Act 2003*.

1.4 Information to be submitted

HEPs must provide research income returns data to the department along with a Vice-Chancellors Certification Statement and Audit Report.

Research Income Return

HEPs must provide research income received for the reference year. Data must be grouped into four categories:

- Category 1: Australian competitive grants
- Category 2: Other public sector research income
- Category 3: Industry and other research income
- Category 4: Cooperative Research Centre (CRC) research income

Vice-Chancellor certification statements

Vice-Chancellors (or equivalent) must certify that their HEPs Research Income Return is correct and has been compiled in accordance with this specification document.

Each HEP must supply one certification statement to the department. The format for this statement is provided with the submissions Smart Form detailed on the department's website (**section 1.7**).

Audit of research income

Each HEP must arrange for an audit of the category 1, 2, 3 and 4 research income in their respective Research Income Return and provide the department with a Special Purpose Audit Report under the Auditing and Assurance Standard Board's Auditing Standard ASA800, which clearly certifies that the research income recorded is correct.

In addition to ensuring that the research income reported by a HEP under its research income return is correct, the department's expectation is that the audit also ensures that research income:

- is attributed to activities that comply with the definition of research,
- is attributed to the correct category of research income, as per **Parts A and B**; and
- is identified by transparent and explicit transactions.

The audit should be conducted by an independent, external, qualified auditor (for example, a state auditor-general officer or certified public accountant). It may be conducted as part of an annual audit. For the audit of their HERDC returns, HEPs may prefer to use the same auditors that undertake the audit of their financial statements.

1.5 Submission due date

Material must be submitted according to the table below.

Material Required in the Return	Format of the Return	Due Date
Research Income Return	Electronic Submission	30 June 2016
Vice-Chancellor's Certification Statement		
Audit Report		

The instructions for electronic submission of the Research Income Return, Vice-Chancellor's Certification Statement and Audit Certificate (scanned version of the signed hard copy) are set out on the department's website (**section 1.7**). Submissions must be sent to: RBGrants@education.gov.au

In the event that it is not possible to lodge this return by electronic submission, hard copy submissions can be sent to:

HERDC Officer
Higher Education Research Data Collection (HERDC)
Research Funding and Policy Branch
Research and Economic Group
Department of Education and Training
GPO Box 9880
Canberra ACT 2601

1.6 Verification material

HEPs must maintain verification material to demonstrate that research income (e.g. funding agreements, memorandums of understanding, letters of agreement, contracts, proof of acceptance of a tender or approval of an application for funding) meet the criteria against the categories being reported.

For the purposes of the HERDC, HEPs must retain verification material for a minimum of three years to facilitate any audit of research income data that may be conducted by, or on behalf of the department.

HEPs are advised to ensure that their relevant funding agreements and contracts are up to date, reflect the nature of the research activity being undertaken and the roles of the parties. Arrangements supported by email only (without supporting attachments) do not constitute appropriate verification material.

1.7 Related documents

This document should be read in conjunction with the following resources:

- *Instructions for electronic submission of HERDC returns.*

These resources are available on the department's website: https://www.education.gov.au/higher-education-research-data-collection.

1.8 Freedom of Information Act 1982

All documents sent to the department with regard to the HERDC are subject to the Freedom of Information Act 1982 (FOI Act). Unless a document falls under an exemption provision, it may be made available to the applicant, if requested, under the FOI Act. All freedom of information requests are to be referred to:

The FOI Coordinator
Schools, Youth, Child Care and Corporate Legal Branch
Location Code: C50MA10 - LEGAL
GPO Box 9880
Canberra ACT 2601

Decisions regarding requests for access to documents will be made by the department's authorised freedom of information decision-maker in accordance with the requirements of the FOI Act.

1.9 Contact Details

Queries concerning the HERDC and this document should be directed to: RBGrants@education.gov.au.

2. Key differences between the 2016 and 2015 HERDC Specifications

2016 HERDC Specifications (for 2015 data)

The Government announced new research block grant arrangements for universities through the National Innovation and Science Agenda on 7 December 2015. The new arrangements will replace the existing six research block grants with two streamlined programmes:

- Research Support Programme (RSP) replaces the Research Infrastructure Block Grants, Joint Research Engagement and the Sustainable Research Excellence.

- Research Training Programme (RTP) replaces the Australian Postgraduate Awards, International Postgraduate Research Scholarships and the Research Training Scheme.

Additional funding of $127 million over the forward estimates will reward industry engagement and assist transition to the new funding arrangements.

The new arrangements will commence on 1 January 2017 and will only use research income data from the HERDC. As a result, the collection of research publications data has been removed from the 2016 HERDC Specifications.

The Government will consult with universities and other stakeholders on new guidelines in 2016.

Section 1.5: The mandatory requirement to submit part of a HEP's HERDC return in hard copy has been removed although a hard copy option has been retained in the event that an electronic copy cannot be lodged.

Section 4.1: In response to feedback from HEPs during the draft 2016 HERDC Specification consultation, the department has removed the requirement that research income must be reported in the HERDC Research Income Return on the same basis as a HEP's audited financial statements. HEPs can continue to report research income as they historically have, however, HEPs must notify the department if they intend to change the basis for reporting HERDC research income (i.e. change from accrual to cash reporting or vice versa) prior to submitting the HERDC Research Income Return.

Section 4.5.1: In 2015, the department sought feedback from HEPs regarding the treatment of partner income received in addition to schemes listed on the Australian Competitive Grants Register (ACGR). The consultation paper presented two options:

- Option A proposed that partner contributions to grants awarded by schemes listed on the ACGR could be reported under Category 1 if those arrangements were identified in the original application.

- Option B proposed that partner contributions to grants awarded by schemes listed on the ACGR should be reported in the relevant category.

Feedback was received from 26 HEPs and one peak body. Six respondents preferred option A and 21 preferred option B. Option B ensures that only funds received from funding bodies responsible for administering schemes listed on the ACGR could be reported in Category 1. This supports a 'first principles' view of the purpose of HERDC and its relationship to research block grant funding. This option assists to better align the performance based research block grant funding with the policy intent of the various schemes.

Section 4.5.1 has been amended accordingly, with the revised wording also informed by the sector's feedback.

The 2016 HERDC Specifications have also been re-formatted slightly to improve readability. The appendices have also been removed from the document and placed on the department's website[2].

2016 Smart Form

As indicated in the 2015 HERDC Specifications, the department will require HEPs to separately report any third party affiliate research income reported in accordance with section 4.3 of the 2016 HERDC Specifications. This income must be reported separately even if it is recognised as university income within the university's finance systems, and the affiliate is recognised as a school or faculty of the university. This is intended to improve transparency of affiliate research income reported through the HERDC and support further analysis of the current arrangements later in 2016. To offset this format change, HEPs will no longer have to separately report income from controlled entities. Controlled entity income should be reported as 'University' income in the 2016 Smart Form.

Only income reported in accordance with the third party affiliate provision of section 4.3 of this specification should be reported in the 'affiliate' column. The sum of 'university' and 'affiliate' income as described in the two columns in the 2016 Smart Form will equate to the HEPs total research income.

As noted in the 2015 HERDC Specifications, the department will revisit whether unpaid/honorary (e.g. adjunct) appointments should be recognised as bona fide employment arrangements for the purpose of reporting affiliate research income in the 2017 HERDC Specifications. Third party affiliate research income, reported separately in 2015, will inform the consultation.

[2] www.education.gov.au/higher-education-research-data-collection

3. Definition of Research

Research is defined as the creation of new knowledge and/or the use of existing knowledge in a new and creative way so as to generate new concepts, methodologies and understandings. This could include synthesis and analysis of previous research to the extent that it leads to new and creative outcomes.

This definition of research is consistent with a broad notion of research and experimental development (R&D) as comprising of creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of humanity, culture and society, and the use of this stock of knowledge to devise new applications.[3]

This definition of research encompasses pure and strategic basic research, applied research and experimental development. Applied research is original investigation undertaken to acquire new knowledge but directed towards a specific, practical aim or objective (including a client-driven purpose).

Activities that support the conduct of research and therefore meet the definition of research include:

- professional, technical, administrative or clerical support staff directly engaged in activities essential to the conduct of research
- management of staff who are either directly engaged in the conduct of research or are providing professional, technical, administrative or clerical support or assistance to those staff
- the activities and training of HDR[4] students enrolled at the HEP
- the development of HDR training and courses
- the supervision of students enrolled at the HEP and undertaking HDR training and courses
- research and experimental development into applications software, new programming languages and new operating systems (such R&D would normally meet the definition of research)

Activities that do not support the conduct of research must be excluded, such as:

- scientific and technical information services
- general purpose or routine data collection
- standardisation and routine testing
- feasibility studies (except into research and experimental development projects)
- specialised routine medical care
- literature reviews that are predominantly a summary of the current knowledge and findings of a particular research field or topic and do not include any critical assessment or report any new findings or original experimental work
- commercial, legal and administrative aspects of patenting, copyright or licensing activities
- routine computer programming, systems work or software maintenance.

[3] OECD (2002), *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*, OECD: Paris.

[4] Higher degree by research (HDR) training is training undertaken by students to achieve a Research Doctorate (including a Professional Doctorate) or Research Masters. A Research Doctorate is a Level 10 qualification (as described in the Australian Qualifications Framework) where a minimum of two years of the program of learning, and typically two-thirds of the qualification is research, and a Research Masters is a Level 9 qualification (as described in the Australian Qualifications Framework) where a minimum of two-thirds of the program of learning is for research, research training and independent study.

Part A

Part A provides the information necessary for HEPs to determine what can and cannot be included under Categories 1-3 of the HERDC Return.

For information on Category 4 (CRC research income) refer to Part B of this specification document.

4. Categories 1 – 3 Research Income

HEPs must provide information on all research income received in the reference year that falls into the following three categories:

- Category 1: Australian competitive grants
- Category 2: Other public sector research income
- Category 3: Industry and other research income

4.1 General requirements

Category 1-3 research income can only be included in a HEP's return if it meets all of the following principles:

- **It must be for activities consistent with the definition of research**
  (See the definition of research in **section 3**).

- **It must be net receipted income, received in the reference year and recognised in a HEPs financial system as being related to the reference year**
  Net receipted income is the amount of research income a HEP (or its subsidiary) retains in its accounting system after shared research income has been divided and/or third party income has been expended and/or distributed.
  The reference year for Category 1, 2 and 3 research income is the 2015 calendar year and for Category 4 research income, the reference year is the 2014-15 financial year.

- **It must be consistent with a HEPs audited financial statements**
  Research income must be reported in accordance with the *Financial Statement Guidelines for Australian Higher Education Providers* for the 2015 Reporting Period. It must be verified by and consistent with the HEP's audited financial statements unless exempt as income received from a CRC.

  HEPs must notify the department if they intend to change the basis for reporting HERDC research income (i.e. change from accrual to cash reporting or vice versa) prior to submitting the HERDC Research Income Return (**section 1.5**).

- **It must only be counted once**
  HEPs should apply the principle that no income is to be double counted, or included in the income returns for multiple years.

- **It must include any variations to research income previously reported**
  HEPs may count research income for 2014 (Categories 1, 2 and 3) or 2013-14 (Category 4) only where the HEP has made a genuine omission of that income from its previous year's HERDC return and the HEP can verify to its auditor's satisfaction that the income has not been reported in the previous year's return. A HEP must reduce the research income reported for a particular category where research income received in an earlier year has been refunded.

4.2 Inclusions and Exclusions

The sections below provide guidance in respect of the net receipted research income that can be included and excluded from a HEP's research income return. These lists are not exhaustive and it is the department's expectation that HEPs work with their auditors in determining which research income can be reported. Additional guidance on income involving other parties is at section 4.3.

4.2.1. Net receipted income which can be included in the Research Income Return – Return 1

- stipends and scholarships for HDR students enrolled at the HEP, unless explicitly excluded below
- competitive, peer reviewed HDR student stipends and scholarships from non-Australian industry or non-Australian Government agencies
- income derived from the investment of donations, bequests and foundations
- income derived from the provision of research services (exclusive of GST)
- travel grants where funds are provided specifically for the purpose of travel and used to enable access to a program of research. Researchers using the funds are expected to be active participants in the research program, rather than observers or visitors
- funds provided for the conduct of clinical trials provided the purpose of the trial meets the definition of research
- research infrastructure grants (unless explicitly excluded below - this includes grants for specific and specialised equipment used for the conduct of research)
- income from overseas HEPs provided specifically for the conduct of research
- income used to manage staff directly engaged in the conduct of research or providing professional, technical or clerical support or assistance to those staff[5]
- income received in support of:

— professional, technical, administrative or clerical support staff directly engaged in activities essential to the conduct of research[6]
— the activities and training of HDR students enrolled at the HEP. This includes funds providing the cost of a student's HDR fee-paying place, but excludes Commonwealth supported places or places funded through the RTS. Funds include tuition fees that fee paying students (non-Commonwealth supported) pay to their HEP for a HDR program or HDR-related course of study
— the development of HDR training and courses
— the supervision of students enrolled at the HEP and undertaking HDR training and courses
— research and experimental development into applications software, new programming languages and new operating systems (such R&D would normally meet the definition of research)

- where a HEP receives a general or untied grant from an Australian government (whether Commonwealth, state, territory or local) for the purposes of conducting research, the HEP may report the proportion of that grant that can be clearly and transparently attributed as to be expended on the direct costs of conducting research. HEPs must **exclude** indirect costs of conducting research to be expended from the grant.
- where a HEP receives income for the purposes of conducting research but also for activities that do not comply with the definition of research, the HEP may report the proportion of that grant that can be clearly and transparently attributed as to be expended on the direct costs of conducting research. HEPs must **exclude** indirect costs of conducting research to be expended from the grant.

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[5] See also Section 4.3, Income involving other parties; this includes where a HEP has made payments to a third party for goods and services in support of the conduct of research under the control of the HEP.
[6] See note above.

4.2.2. Research income which is excluded in the Research Income Return – Return 1

- any income above the amount of net receipted income
- any research income received by the HEP from its subsidiaries[7]
- any research income received by the HEP from any other Australian HEP or its subsidiaries except in respect of shared research income (in accordance with **section 4.3 of Part A**) or transfers (in accordance with **section 4.4 of Part A**)
- any income received by a HEP or its subsidiaries for the rental and use of its facilities and accommodation, even if this is related to the conduct of research
- any third party income except for those instances specified in **section 4.3 of Part A**
- any scholarships or grants that are provided by the HEP for its own students
- income received in respect of fees that have been charged by a HEP to a domestic HDR student who has exhausted his/her RTS funding entitlement and has continued his/her enrolment
- income received in respect of Commonwealth contributions paid by the Australian Government directly to HEPs for Commonwealth supported places
- income received by honours students, or by HEPs on behalf of honours students, for the research component of their honours degrees, including externally funded scholarships or stipends
- in-kind contributions
- capital grants[8]
- income received from a general or untied grant from an Australian government (whether Commonwealth, state, territory or local) that cannot be attributed as to be expended on the direct costs of conducting research, even if the income was provided for research purposes. HEPs **must exclude** indirect costs of conducting research that are to be expended from the grant
- income received from government grants that are for other purposes which have been specified by the funding source or sponsor (such as teaching), even if a proportion of income is to be expended on the conduct of research at the HEP's discretion
- income received by HEPs from the sale of assets, even if that income is to be expended on the conduct of research at the HEP's discretion
- funds provided specifically for the purpose of hosting, organising or travel to and attending a conference, workshop or meeting unless funds are specifically for enabling access to a program of research
- funds provided specifically for the purpose of producing research publications (that is, for publishing research rather than conducting it)
- consultancy fees for projects that do not meet the definition of research
- interest income accruing to research grants and contract research grants
- research income received by independent operations which do not meet the definition of a subsidiary
- income provided for preparation for teaching
- funds used for:

— scientific and technical information services
— general purpose or routine data collection
— standardisation and routine testing
— feasibility studies (except into research and experimental development projects)

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[7] A subsidiary is an entity, including an unincorporated entity such as a partnership that is controlled by another entity (known as the parent).

[8] Capital grants are those grants provided to a HEP to purchase an asset of a durable nature, even if the asset is for the purpose of conducting research. Capital grants include grants for the construction and/or upgrade or refurbishment of buildings, centres or facilities, as well as purchase of properties or land. Capital grants are distinct from grants for research infrastructure. Grants for research infrastructure are considered to include grants for specific and specialised equipment which are used in the conduct of research.

- specialised routine medical care
- literature reviews that are predominantly a summary of the current knowledge and findings of a particular research field or topic and do not include any critical assessment or report any new findings or original experimental work
- commercial, legal and administrative aspects of patenting, copyright or licensing activities
- routine computer programming, systems work or software maintenance

- Grants or funding from the following Commonwealth programs:

- Australian Research Council (ARC) Linkage-Infrastructure, Equipment and Facilities (LIEF)
- Independent Research Institutes Infrastructure Support Scheme (IRIISS) grants
- ARC’s Research Networks scheme
- Commonwealth Grant Scheme (CGS)
- National Computational Infrastructure

- Grants from the following Department of Education and Training programs:

- National Collaborative Research Infrastructure Strategy (NCRIS)
- Collaborative Research Infrastructure Scheme (CRIS)
- the Education Investment Fund (EIF)
- Research Training Scheme (RTS)
- Joint Research Engagement (JRE)
- Sustainable Research Excellence (SRE)
- Research Infrastructure Block Grants (RIBG)
- Australian Postgraduate Awards (APA)
- International Postgraduate Research Scholarships (IPRS)
- Collaborative Research Networks (CRN)

4.3 Income involving other parties

Third party income

Net receipted income is intended to identify only the income that a HEP (or its subsidiary) receives for its own research activities.

Research income administered by a HEP on behalf of a third party research organisation where the third party conducts the research independently of the HEP, must be excluded.

Exceptions to this rule are:

- where the third party is a subsidiary of the HEP
- where the third party is an affiliate of the HEP
- where a HEP has made payments to a third party for goods and services in support of the conduct of research under the control of the HEP

Where HEPs have entered into formal employment arrangements with researchers in affiliated or partner organisations (external to the HEP), income that can be reported must be net receipted income and commensurable with the employment arrangements.

However, HEPs can report the total amount of income for a research project - even if the researcher(s) conducting the research project is partially employed by the HEP (i.e. the HEP pays a proportion of salary direct to the researcher or there is a formal legal relationship or agreement which covers employment) - as long as the HEP is the grant recipient and where that total amount of income is net receipted income (i.e. received, retained in the HEP’s accounting system and verified in the HEP’s audited financial statements).

Employment arrangements must be bona fide. HEPs must exclude that research income which is subject to cost reimbursement arrangements with affiliates or partner organisations (i.e. to reimburse research costs, including researcher salaries) which are not explicitly covered within a formal legal relationship between the HEP and the external organisation.

Any third party affiliate income reported in accordance with section 4.3 and included in a HEP's Research Income Return must be reported separately from other university income in the 2016 Smart Form. HEPs should report all eligible income in the 'university' column of the form except any income reported in accordance with section 4.3 of this specification.

Shared income

A grant is considered shared research income if a component of the grant is passed from the primary recipient to another party, where that party is named in the contract/agreement for the grant or tender/application for funding. A party may be a HEP, the staff of a HEP, or another research performing organisation.

HEPs can only report the income received or retained following the distribution of shared research income.

Example

Where a shared research income grant exists, if HEP A receives a grant of $50,000 of which $20,000 is transferred to HEP B, HEP A should report $30,000 and HEP B $20,000.

4.4 Transfers

Where staff transfer into, exit from, or move between HEPs and carry research grant funding with them, this must be reflected in adjustments to the affected HEPs' income returns.

4.5 Research income categories

HEPs must enter all research income into Research Income Return - Return 1 according to the following four categories:

- Category 1: Australian competitive grants
- Category 2: Other public sector research income
- Category 3: Industry and other research income
- Category 4: CRC research income (**Part B)**

There is no separate category for income received through shared research arrangements. Shared research income should be assigned to the appropriate reporting category (according to the original source of the income).

HEPs are to manage the categorisation of research income correctly. It is suggested that HEPs nominate the appropriate HERDC income category (or categories) at the time that funding agreements, grants or contracts are executed. HEP faculties or departments should be provided with this information to help ensure that all income is coded to the correct HERDC income category for the duration of the funding.

Where HEPs have received funding from multiple sources for a research project, then funding must be apportioned to the correct category based on each funding source.

4.5.1. Category 1: Australian competitive grants

Category 1 consists only of net receipted income received from funding bodies for those research schemes and programs registered on the 2016 Australian Competitive Grants Register (ACGR).

The ACGR is available through the department's website at: www.education.gov.au/australian-competitive-grants-register.

Partner organisation contributions to grants awarded by schemes listed on the ACGR should not be reported in Category 1 regardless of whether the partner contributions were identified in an Australian Competitive Grant application or not. This income should instead be reported under the HERDC category relevant to the source of the funding.

Australian Competitive Grant applications are competitive funding applications that result in grants (income) from schemes listed on the ACGR.

4.5.2. Category 2: Other public sector research income

Category 2- Other public sector research income includes:

Australian government (– Non Category 1):

This relates to any other income for the purposes of conducting research received from the Australian Government; whether through programs, grants or contracts, that are not eligible for inclusion as Category 1 research income.

State or Territory government:

This is income received from state or territory government departments or agencies for the conduct of research; whether through programs, grants or contracts.

Local government:

This is income received from local government departments or agencies for the conduct of research; whether through programs, grants or contracts.

Income as set out below can be reported in Category 2.

Government business enterprises:

This is income for the conduct of research received from enterprises that are wholly or partly owned or funded by Commonwealth, state or territory, or local governments; have a board; and operate on a profit or cost-recovery basis.

Cooperative Research Centres:

This is research income from CRCs, where the reporting HEP has not been defined within the Commonwealth Agreement as “The Researcher” or a “Participant” (i.e. was not a signatory to the Commonwealth Agreement, a CRC Participants Agreement, or a Company Constitution during the reporting period).

Reporting of eligible general or untied income from government grants

HEPs are to report any eligible proportion of general or untied income received from government grants for the purposes of conducting research according to the source of that grant (i.e. whether Australian government - Non Category 1, State or Territory government, or Local government). HEPs must exclude indirect costs of conducting research to be expended from the grant.

4.5.3. Category 3: Industry and other research income

Category 3: Industry and other research income must be categorised in the following subcategories:

Australian
Contracts:

- contract research income provided by industry or other non-government agencies

Grants:

- grants for the conduct of research other than government provided grants (which should be reported in either Category 1 or Category 2).
- income received from syndicated research and development arrangements

Donations, bequests and foundations:

- donations and bequests for the conduct of research that have been received from Australian business, Australian non-profit organisations and Australian individuals

HDR fees for domestic students:

- funds received for providing the cost of a domestic student's HDR fee-paying place (but excluding Commonwealth supported places or places funded through the RTS). This includes tuition fees[9] that domestic fee paying students (non-Commonwealth supported) pay to their HEP for a HDR program or HDR-related course of study.

Many research income arrangements involve grants covered by a contract. In categorising funds as either contract research income or grant income, HEPs should regard:

- funding for research where the project was developed primarily by the funding agency, or jointly by the funding agency and the investigator(s) as contract research income
- funding for research where the project was developed primarily by the investigator(s) as grant income.

International A: Competitive, Peer-reviewed research grant income

- Competitive grants, peer reviewed grants for research from non-Australian industry or non-Australian Government agencies including non-Australian industry collaborative research grants.
- Grants that can be included are those where:
  a) funds are provided on a competitive basis and are clearly for the conduct of research only; and
  b) there is a well-defined mechanism for competition and selection by a well-qualified panel.
- Grants that are not eligible are those that provide:
  a) grants in kind such as the use of facilities, equipment etc. or subsidised travel or accommodation; and
  b) funding wholly or mainly for infrastructure purposes.

International B: Other income

- contract research provided by non-Australian industry or non-Australian Government agencies including non-Australian industry collaborative research grants
- non-competitive grants for research from non-Australian industry or non-Australian Government agencies including non-Australian industry collaborative research grants

[9] Exclude fees that HEPs may charge domestic HDR students who exhaust their RTS funding entitlement and continue their enrolment as listed under section 4.2.2. Also exclude Commonwealth contributions paid by the Australian Government directly to HEPs for Commonwealth supported places.

- donations and bequests for conduct of research that have been received from non-Australian business, non-Australian not-for-profit organisations and non-Australian citizens

International C: HDR fees for international students

Category 3 includes:

- funds received for providing the cost of an international student's HDR fee-paying place (but excluding Commonwealth supported places). This includes tuition fees[10] that international fee paying students (non-Commonwealth supported) pay to their HEP for a HDR program or HDR-related course of study.

For donations and bequests (Australian and international):

Where all, or a proportion, of a donation or bequest is invested then only the income earned from that investment which is available for expenditure on research in the reference year should be included.

[10] As listed under **section 4.2.2**, funds also exclude Commonwealth contributions paid by the Australian Government directly to HEPs for Commonwealth supported places.

Part B

Part B provides the information necessary for HEPs to determine what can and cannot be included under Category 4 of the Research Income Return.

For information on Categories 1-3 of the research income return, refer to Part A of this specification document.

5. Category 4: CRC Research income

5.1 General requirements

Under Category 4: CRC research income, HEPs must report the research income received for the 2014-15 financial year from a CRC in which they were defined within the Commonwealth Agreement as a “Participant”, and are a signatory to the CRC‘s Commonwealth Agreement or Participant‘s Agreement.

Income received from CRCs in which the reporting HEP is not a Participant must be reported under Category 2: Other public sector research income (as per **section 4.5.2 of Part A**).

Category 4 comprises the following subcategories:

- research income derived from Australian Government grants to CRCs
- research income derived from non-HEP members of CRCs
- research income derived from external parties contributing to CRCs.

HEPs must consolidate the research income from all CRCs in which they were a Participant and enter this into Research Income Return - Return 1, categorised according to the appropriate subcategories. This data does not need to be split between HEPs and their subsidiaries.

Section 5.5 of Part B provides guidance for HEPs that are unable to easily categorise research income into the subcategories using CRCs accounting systems.

5.2 Arrangements applying to the collection and certification of CRC research income

HEPs must determine the eligible research income that they can report under Category 4: CRC research income for the financial year 2014-15. HEPs must also verify research income data with the respective CRCs in which they are a Participant.

HEPs must certify that Category 4: CRC research income data is correct, as reported in the Research Income Return - Return 1, through provision of the Vice-Chancellor’s Certification Statement and the Audit Certificate.

5.3 Eligible research income

To be counted in Category 4, all research income must:

- be received by a HEP and its subsidiaries for the financial year 2014-15
- be classified into subcategories (see **section 5.1 of Part B**)
- comply with the definition of research
- be provided to a HEP account, for the HEP to spend (net receipted income).

Types of research income eligible to be counted include:

- funds for non-capital aspects of facilities such as laboratories, libraries, computing centres, animal houses, herbaria, and experimental farms
- funds for equipment purchase, installation, maintenance, hire and lease

- funds for salaries of research staff and research support staff
- funds providing a stipend to a student and/or the cost of a student’s higher degree by research fee-paying place, unless the places are Commonwealth supported places or funded through the Research Training Scheme, Australian Postgraduate Awards, or International Postgraduate Research Scholarships
- payments for contracted projects which meet the definition of research
- funds provided specifically for the purpose of travel to enable access to a program of research. Researchers using the funds are expected to be active participants in the research program, rather than observers or visitors.

5.4 Research income not eligible to be included

Research income that may not be eligible to be counted include:

- funds provided to the personal accounts of HEP staff, or funds used by the CRC to purchase goods or services for use by the HEP
- funds provided specifically for travel to conferences, workshops and/or meetings
- in-kind contributions
- cash contributions made to a HEP on condition that the HEP use these contributions to purchase goods or services from a CRC or other funding provider. Such arrangements are regarded as in-kind contributions
- capital grants[11]
- funds provided to HEPs for them to manage on behalf of other parties, which are not to be used for research purposes by the HEP
- omissions from previous Research Income Return - Return 1
- payments to HEPs which are not earmarked for research, even if they may be spent on research at the HEPs’ discretion
- funds provided specifically for the purpose of hosting, organising or attending a conference or workshop
- funds provided specifically for the purpose of producing research publications (that is, for publishing research rather than conducting it)
- funds provided to a HEP which is not a participant in the CRC. These funds may be counted under Category 2: Other public sector research income, provided they are for the purposes of research (as defined at **section 3**) and subject to meeting other relevant requirements in **section 4 of Part A**
- GST amounts.

5.5 Breakdown by source category

If a CRC’s accounting systems do not readily enable it to distinguish between the funds provided to HEPs which are sourced from government grants, and funds provided to HEPs which are sourced from non-HEP participants, the CRC may split the funds between these two components in the same proportion as the cash funding it receives from these sources. If the receipt of funds from external parties can also not be tracked separately, the principle described above again applies. Income sourced from Australian HEPs or subsidiaries of Australian HEPs is not eligible to be counted (consistent with **section 4 of Part A**).

[11] Ibid, p.9.

Example

In the 2014-15 financial year a CRC receives cash funding into single account from:

Australian HEP sources:	$5 million (25%)
Government grant:	$3 million (15%)
non-HEP participants:	$7 million (35%)
external parties:	$5 million (25%)

If the CRC allocates $800,000 of the funds (which it is not readily able to attribute to particular sources) to HEP X for research purposes, in its Certified Statement for HEP X, the CRC may attribute:

- $120,000 (15% of the $800,000) to the 'Allocation of funds from Commonwealth grant' component;
- $280,000 (35% of the $800,000) to the 'Allocation of funds from non-HEP participants' component; and
- $200,000 (25% of the $800,000) to the 'Allocation of funds from external parties' component.

The 25% share of the $800,000 sourced from Australian HEPs is not able to be counted.

5.6 Special cases

5.6.1. Refunds

Where, in the reference year covered by the Research Income Return - Return 1, a HEP refunds any monies received, either in the current year or an earlier year, income reported in the reference year must be reduced by the amount of the refund.

5.6.2. CRCs which are no longer operational

Where a CRC is no longer operational, and it is not possible to verify the research income data with the CRC in which the HEP was the Researcher or a Participant, the amount reported and attributable to that CRC may be reported on the basis of the HEP's financial records alone (i.e. the HEP does not need to comply with paragraph 1 of **section 5.2 of Part B**).

The HEP must ensure that the amounts reported are accurate. **Section 5.5** may be of assistance in determining the breakdown of funds.

6. Glossary

ACGR	Australian Competitive Grants Register
ARC	Australian Research Council
CRC	Cooperative Research Centre
The department	Department of Education and Training
EIF	Education Investment Fund
ERA	Excellence in Research for Australia
FOI Act	*Freedom of Information Act 1982*
GST	Goods and Services Tax
HEP	Higher Education Provider
HERDC	Higher Education Research Data Collection
HESA	*Higher Education Support Act 2003*
HDR	Higher Degree by Research
IRIISS	Independent Research Institutes Infrastructure Support Scheme
LIEF	Linkage—Infrastructure, Equipment and Facilities
NCRIS	National Collaborative Research Infrastructure Strategy
OECD	Organisation for Economic Cooperation and Development
R&D	Research and Experimental Development
RBG	Research Block Grants
RSP	Research Support Programme
RTP	Research Training Programme

Monday 5 September 2016

1.00pm	**Registration Opens** Registration Desk, Ground Floor
1.30pm - 5.30pm	***Pre-Conference Meetings*** 1. Early Career Professionals Event 2:30-5:30pm - **Open to all Road Safety Professionals within their first 8 years of professional work** 2. Senior Policing/Enforcement Meeting 3. Road Safety Education Reference Group Australasia Meeting 4. Heads of Road Safety Research Meeting
5.30pm - 6.30pm	**Pre-Conference Networking Function - FOR ALL CONFERENCE DELEGATES - In the Exhibition Hall of the NCC**

Tuesday 6 September 2016

8.00am	**Registration Opens** Registration Desk, Ground Floor
9.30am	**Arrival Tea and Coffee** Conference Exhibition

Concurrent Sessions 1 (10.00am – 12noon)

Bradman	Sutherland	Swan	Nichols	Royal	Menzies	Torrens
Symposium One	**Road Safety Across Cultures**	**Workshop One**	**Workshop Two**	**Road Safety for the Ageing Population**	**Crash Testing /ANCAP**	**Motorcycle Clothing**
The Real Cost of Serious Injury Dr Ailene Fitzgerald, Rebekah Ogilvie, PA.R.T.Y. Program at Canberra Hospital Warwick Teague, Quad bike injuries in the young Dr Valerie Malka, Distracted young driver Dr John Crozier, Australian Trauma Registry - Serious injuries, rehabilitation and costs	**The correlation between Governance Quality and Road Fatalities** Tana Tan, Transport And Road Safety (TARS) Research Centre, UNSW	**Educators Workshop (Note: 9:00am start)** **A resilience approach to road safety education** A/Prof Teresa Senserrick University of New South Wales **Early childhood road safety education, Early Learning Association Australia** **Road safety activities in focus**, SDRA, WA **What does good practive in road safety education look like in primary schools?** SDRA, WA **What does good practive in road safety education look like in secondary schools?** Anne Harris, Harris Cook Pty Ltd, VIC **Road safety education and students with special educational needs**, RACV	**Policing Workshop** **Mandatory In-Vehicle Recording of Crash Data to Reduce Road Closure Times and Target Preventative Road Safety** Senior Crash Analyst, Sgt David Stoker, Forensic Crash Unit, Queensland Police Services **Is Seniors' Road Safety a No-Go Topic?** Senior Sgt Mick Timms, NSW Police **Police Pursuits in Victoria; Community Expectations v. Risk** Assistant Commissioner Doug Fryer, Victoria Police	**Naturalistic driving study analysing the effect of rainfall on driving behaviour for older drivers** Shanuka Samaranayake, The George Institute for Global Health	**Future vehicle safety in Australia and the role of the Australasian New Car Assessment Program** Michael Paine, ANCAP	**UNECE Regulation 22.05 Motorcycle Helmets in Australia** Tom Gibson, Human Impact Engineering
	Magnitude and risk factors of Road Traffic Injury Disabilities: Evidence from Bangladesh Health and Injury Survey Kamran Baset, Centre for Injury Prevention and Research, Bangladesh			**Rapid Deceleration and Crash Events in an RCT Evaluating a Safe Transport Program for Older Drivers** Lisa Keay, The George Institute for Global Health	**Replacement Windscreens - A serious vehicle and road safety issue** George Rechnitzer, Transport and Road Safety (TARS) Research Centre, UNSW	**Development of Ranking Equations for a Protection Level Star Rating System for Motorcycle Clothing** Christopher Hurren, Deakin University
	Road Users' Avoidance of Safety Measures: Challenge on Road Safety (An experience from Nepal) Writtu Bhatta, Swatantrata Abhiyan Nepal			**Older drivers and rapid deceleration** Anna Chevalier, Safer Roads Consulting	**Investigations of Conditions for Repeatability/Reproducibility of Vehicle Rollover Crash Tests with Devices Based on the Jordan Rollover System** Mario Mongiardini, Transport And Road Safety (TARS) Research Centre, UNSW	**Protective Clothing and Impact Protection for Motorcyclists** Bianca Albanese, Neuroscience Research Australia
	Socio-Cultural Beliefs and Road Use in a Low Income Country: a Qualitative Investigation of Superstition-Related Road Use Behaviour in Pakistan Ahsan Ul Haq Kayani Government of Pakistan			**Behind the wheel: Process evaluation of a safe-transport program for older drivers delivered in a randomised controlled trial** Kristy Coxon, Western Sydney University	**Quad Bikes - why they should NOT be ridden on public roads!** David Hicks, Transport And Road Safety (TARS) Research Centre, UNSW	**Comparative Performance of the Cambridge Abrasion Machine in Different Laboratories** Lauren Meredith, Neuroscience Research Australia
	Speeding among Jordanian Drivers Faisal Magableh, Transport and Road Safety (TARS) Research Centre, UNSW			**Mobility beyond driving - Exploring the issues for older non-drivers** Tim Davern, Royal Automobile Club of Victoria	**Development and application of a vehicle safety rating scale for public transport minibuses** Brian Fildes, Monash University Accident Research Centre	**Motorcycle protective clothing: Impact on cognitive performance and mood when worn in hot conditions** Liz de Rome, Neuroscience Research Australia

12noon	**Lunch** Conference Exhibition Hall

Concurrent Sessions 2 (1.00pm – 3.00pm)

Bradman	Sutherland	Swan	Nichols	Royal	Menzies	Torrens
Post Crash Care	**Urban Cycling Sponsor: ACT Government**	**Educating Young People**	**Targeted Policing**	**Driving with Disability**	**Optimising Workplace Safety**	**Roadside Barriers Sponsor: CSP Pacific**
Establishment of a formal trauma system in NZ to improve post-crash outcomes for trauma patients: Challenges and Achievements Ian Civil, Major Trauma National Clinical Network	**Evaluation Of The Queensland Minimum Passing Distance Rule - Overview of Results** Narelle Haworth, Centre for Accident Research and Road Safety - Queensland	**Development of a learning to drive framework for Victoria** Jan Hagston, Multifangled	**The development of an intelligence-based deployment model to enhance road policing service delivery: A case study** Nils van Lamoen, New Zealand Police	**Driving Safety in Mild Cognitive Impairment Compared with Cognitively Normal Adults Assessed with an On-Road Test and Off-Road screening tools** Kaarin Anstey, Centre for Research on Ageing, Health and Wellbeing	**'Safer Together' - Aligning Queensland's Natural Gas E&P Industry 'Safe Systems Approach' for Improved Road Safety Outcomes** David Pearce, Santos GLNG	**A study of the mass-frequency distribution of the registered light vehicle fleet in Queensland** Andrew Burbridge, Department of Transport and Main Roads
Factors Influencing Social and Health Outcomes after Land Transport Injury: Recruitment and participant characteristics, and interim results Rebecca Ivers, The George Institute for Global Health, University of Sydney	**Safer cycling: An in-depth crash study in Melbourne, Australia** Ben Beck, Monash University	**Social Voices - Evaluation of the RACV Safe Mates road safety for secondary schools pilot program** Rebekah Smith, RACV	**Toward Automated Enforcement At Active Level Crossings In Australia** Grégoire Larue, Centre for Accident Research and Road Safety - Queensland	**Motor vehicle crashes and dementia: A population-based study** Michelle Hobday, Curtin University	**Identifying the organisational determinants of work-related road traffic injury** Sharon Newnam, Monash University Accident Research Centre	**Using the Australian / New Zealand Standard to review barriers for Australian and New Zealand roads** Rod Troutbeck, Queensland University of Technology
Function, health related quality of life and cost after injury in a city of North India: Interim results Rebecca Ivers, The George Institute for Global Health, University of Sydney	**From the couch to the bike: An evaluation of a cycling skills training program for women** Marilyn Johnson, Monash University and Amy Gillet Foundation	**The True Impact Of Transport Safety Education: Aren't We Forgetting The Young People? A Rail Safety Education Perspective.** Janine Ferris, TrackSAFE Foundation	**Identifying optimal sites for static speed cameras in New Zealand - A geospatial approach** Dale Harris, Abley Transportation Consultants	**Predicting on-road performance of older drivers with cognitive impairment: Brief in-office screening of attention, visuospatial ability, and planning and foresight** Carol Snellgrove, Flinders University of South Australia	**Evidence-based approach to manage the risk of working near traffic to optimise safety, efficiency and road user journeys through worksites** Miranda Cornelissen and Patricia De Pomeroy, Roads and Maritime Services	**Better than nothing? Safety barriers in construction zones principles and practice** Peter Harris, Road Safety Audits Pty Ltd
A systems approach to monitoring trauma system performance Jason Thompson, University of Melbourne and Rod McClure, Harvard School of Public Health	**Learning to drive with bikes: Insights about how learner drivers are taught to share the road with cyclists** Jennifer Bonham, University of Adelaide	**Road Safety Education Intervention For Primary Schools in Malaysia: Any Reduction in Traffic Casualties?** Kulanthayan KC Mani, Universiti Putra Malaysia	**Community perceptions of speed enforcement tolerances in Queensland** Katherine Zacarias, Queensland Department of Transport and Main Roads	**Australian drivers with disabilities using vehicle modifications: User demographics, human factors and road safety issues** Marilyn Di Stefano, VicRoads	**A longitudinal study evaluating work driving safety interventions implemented by a number of organisations** Darren Wishart, Centre for Accident Research and Road Safety - Queensland	**Decompartmentalising road safety barrier stiffness in the context of vehicle occupant risk** Andrew Burbridge, Department of Transport and Main Roads
Application of social network analysis to the study of post-injury rehabilitation and health service utilisation Jason Thompson, University of Melbourne	**Factors in cyclist fatality crashes: outcomes from an analysis of medico-legal investigations in Victoria** Marilyn Johnson, Monash University	**Exploring young driver attitudes to drink-driving in NSW: Quantitative and qualitative research** Louise Higgins-Whitton, Transport for NSW	**Trail bike road trauma: Intelligence-led approach to reducing community harm** Daniel Hilton, Victoria Police	**Fitness-to-drive after mild traumatic brain injury: Mapping the time trajectory of recovery in the acute stages post injury** Anne Baker, Australian Catholic University	**Best practice versus 'in practice': Insights into Improving Australian Industry Road Safety Management** Amanda Warmerdam, Monash University Accident Research Centre	**A Crash Testing Evaluation of Motorcyclist Protection Systems for use on Steel W-Beam Safety Barriers** Joanne Baker, Transport for NSW

3.00pm	**Afternoon Tea** Conference Exhibition

Concurrent Sessions 3 (3.30pm – 5.00pm)

Bradman	Sutherland	Swan	Nichols	Royal	Menzies	Torrens
Crash Data	**Safe Cycling**	**Education Evaluation**	**Policing, Speed and Alcohol**	**Symposium Two**	**Symposium Three**	**Innovative Methods & Data Usage**
Modelling Crash Unobserved Heterogeneity Using Semi-Parametric Geographically Weighted Poisson Regression Richard Amoh-Gyimah, Monash University	**Estimating the safety benefits of separated cycling infrastructure: Does modelling the mechanism matter?** Jason Thompson, University of Melbourne	**Likely sustainability of a child restraint program among Aboriginal and Torres Strait Islander children in 12 communities in NSW** Martyn Ralph, The George Institute for Global Health	**Not just the booze: Polysubstances use among fatally injured drivers** Peter Palamara, Curtin University	**Road Safety's Family Feud** Marilyn Johnson, Australasian College of Road Safety (Victorian Chapter), Institute of Transport Studies, Monash University and Amy Gillett Foundation Kenn Beer Australasian College of Road Safety (Victorian Chapter), Safe System Solutions Pty Ltd	**Embracing Safety - Road Safe: Worker Safe** Michael Caltabiano, CEO Australian Asphalt Pavement Association Craig Moran, Roads and Maritime Services, NSW – Chair of the Austroadssub committee Safety at Road Work Sites Eric Denneman, Director Technology and Leadership, Australia Asphalt Pavement Association	**An examination of the effectiveness and acceptability of mobile phone blocking technology among drivers of corporate fleet vehicles** Giulio Ponte, Centre for Automotive Safety Research
Regular linkage of crash and hospital data to inform the monitoring and evaluation of countermeasures on serious injury Hassan Raisianzadeh, Transport for NSW	**Preparing New Zealanders for transport cycling: A competency model** Greer Hawley, Mackie Research & Consulting	**Substance impaired driving education - A collaborative, systems approach to educating drivers to become responsible, informed, Safe Users** Anne Dowden, REWA	**You Don't have to be Speeding to be driving too fast on country roads. NSW/ACT 'drive to conditions' awareness campaign** Melissa Weller, Yass Valley Council, Chad Gillies, The Hume LAC and Tracey Norberg, Goulburn Malwaree Council			**Telematics, A tool which is just another element in a safety management system** Jeome Carslake, ARRB Group Ltd
In-depth crash investigations in South Australia Sam Doecke, Centre for Automotive Safety Research	**The safety of child passengers of adult cyclists** Jeremy Woolley, Centre for Automotive Safety Research	**Let's CHAT about a whole school approach to road safety and health** Mick Jackson Pierce, School Drug Education and Road Aware	**MDT - Mobile Drug Testing': Using research to develop the first drug driving public education campaign in NSW** Louise Higgins-Whitton, Transport for NSW			**Enhancing road safety with in-vehicle telematics** Jasper Wijnands, University of Melbourne
Should We Treat Fatal and Injury Crashes Differently for Road Safety Treatment Selection? The Evidence says Sometimes Yes Sometimes No Soames Job, World Bank	**Cycling Safety in NSW: Attitudes and Behaviours** Claire Murdoch, NSW Centre for Road Safety	**2015 Evaluation of Keys for Life Pre-Driver Education** Deb Zines, School Drug Education and Road Aware	**Development and implementation of the NSW Mandatory Alcohol Interlock Program** Alice Ma, NSW Centre for Road Safety			**European TeleFOT Project: Benefit-Cost Analysis Sat Nav and Eco Drive Technologies** Brian Fildes, Monash University Accident Research Centre

6.30pm - 8.30pm	**CONFERENCE WELCOME RECEPTION** **ANZAC Gallery, Australian War Memorial** *Including an Address from: The Governor-General of Australia, Sir Peter Cosgrove AK MC*

Wednesday 7 September 2016

7.30am	**Registration Opens** Registration Desk, Ground Floor
8.30am - 10.30am	***Conference Opening Plenary - Sponsored By: Toll*** **Official Opening and Welcome by Conference Hosts** Mr Lauchlan McIntosh, President, Australasian College of Road Safety Professor Rebecca Ivers, Director, Injury Division, The George Institute for Global Health Mr Nick Koukoulas, Chief Executive Officer, Austroads Safety Taskforce **Welcome to Country**: Mr Warren Daly **Keynote Speakers** Dr Soames Job, Global Road Safety Lead, World Bank, Washington DC Professor Mary Lydon, Chief Scientific Advisor, ARRB **Plenary Panel: Road Safety Impacts** Dr Soames Job, Prof Mary Lydon Professor Rebecca Ivers, Director, Injury Division, The George Institute for Global Health (Session Chair) Senator Katy Gallagher, Senator for the ACT
10.30am	**Morning Tea** Conference Exhibition Hall
11.00am - 12:30pm	***Plenary Panel Session*** **Sustainability and Technology Innovation** Ms Wendy Machin, Chair, ANCAP Australasia Ltd (Session Chair) Ms Marg Prendergast, Coordinator General, CBD, Transport for NSW Professor Mark Stevenson, Urban Transport and Public Health, University of Melbourne Mr Adrian Beresford-Wylie, Chief Executive Officer, Australian Local Government Association Mr Ken Kroeger, Chief Executive Officer, Seeing Machines
12.30 - 1:30pm	**Lunch** - sponsored by Intelligent Traffic Systems - Conference Exhibition & Poster Presentation Session - sponsored by BITRE

Concurrent Sessions 4

1.30pm – 3.00pm

Bradman	Sutherland	Swan	Nichols	Royal	Menzies	Torrens
Driving Evaluation	**Safer Roads**	**Safety Technology (I) Sponsor: TCCS**	**Safer Speeds**	**Symposium Four**	**Heavy Vehicles**	**Advertising /Driver's perception**
A transport crash injury return-on-investment calculator Rod McClure, Harvard School of Public Health and Jason Thompson, University of Melbourne	**Bicycle rest stops in mountainous terrain to improve road safety for cyclists** Jess Peters, Point8 Pty Ltd	**The bumpy road towards automated vehicles: Can we smooth the path?** Ann Williamson, Transport and Road Safety (TARS) Research Centre, UNSW	**Not all Roads are Created Equal: A Framework to Align Travel Speeds with Road Function, Design, Safety and Use** Paul Durdin, Abley Transportation Consultants	**Safe System Transformation for Pedestrians** **Pedestrian safety in Australia and New Zealand – risk factors and emerging issues** Shane Turner, MWH Global	**Proposed Australian/New Zealand AS/NZS 3845.2 Standard for Truck Underrun Barriers: Design, Testing and Performance Requirements** Raphael Grzebieta, Transport and Road Safety (TARS) Research Centre, UNSW	**An accident is a crash is a collision - or is it?** Sonia Roberts, NSW Police Force
'It's exactly what we needed': A process evaluation of the DriveSafe NT Remote driver licensing program Patricia Cullen, The George Institute for Global Health	**Motorcycle Red Box Evaluation at Signalized Intersections in Bogor: Traffic Flow, Occupancy Rate and Stop Line Violation** Agah Mulyadi, Institute of Road Engineering, Ministry of Public Works and Housing of Indonesia	**Driverless vehicles: is it time to rethink where and how we spend our road safety research dollars?** Ian Webb, Roads Australia	**An Automated Process of Identifying High-Risk Roads for Speed Management Intervention** Haris Zia, Abley Transportation Consultants	**Developing a practical guide to achieve Safe System outcomes for pedestrians** Bruce Corben, CorbenCosulting; Hafez Alavi, Transport Accident Commission	**A Preventative Approach to Heavy Vehicle Road Safety - Reforming Australia's Heavy Vehicle Chain of Responsibility Laws** Anna Beesley, National Transport Commission	**Framing road risks: Why road crash messages don't put people in the driver's seat** Rebecca Pedruzzi, James Cook University
Driving Change: Process Evaluation of a Multi-Site Community Licensing Support Program Patricia Cullen, The George Institute for Global Health	**The Use of Safety Platforms at Intersections for Safe System Speeds - Preliminary Evaluation of a Trial Site in Victoria** Bill Bui, VicRoads	**An estimate of the future road safety benefits of autonomous emergency braking and vehicle-to-vehicle communication technologies** Jeffrey Dutschke, Centre for Automotive Safety Research	**Long-term speed and safety outcomes from New Zealand's Rural Intersection Active Warning System** Hamish Mackie, Mackie Research and Consulting Ltd	**Evaluating the effectiveness of pedestrian safety measures in Victoria** Amir Sobhani, ARRB Group; Hafez Alavi, Transport Accident Commission	**Heavy Vehicle Safety Chain of Responsibility Implications** Arnold McLean, McLean Technical Services	**What do people think of road safety advertising campaigns?** Paul Graham, New Zealand Transport Agency
Maximising the Impact of Evaluation in Road Safety Ben Barnes, NSW Centre for Road Safety, Transport for NSW	**Safety of raised platforms on urban roads** Blair Turner, ARRB Group Ltd	**FleetCAT - A trial of an Advisory Collision Warning System in Government Fleet Vehicles** John Wall, NSW Centre for Road Safety	**Rural Regional Roads - Reducing Motorcycle Trauma Through Speed Limits and Infrastructur** Kenn Beer, Safe System Solutions Pty Ltd	**Identifying high pedestrian serious casualty areas in Victoria - a geospatial analysis** Deepak Gupta, VicRoads; Hafez Alavi, Transport Accident Commission	**Timing of drowsiness events in heavy vehicle fleets** Mike Lenné, Seeing Machines	

3.00pm **Afternoon Tea** Conference Exhibition

Concurrent Sessions 5

3.30pm - 5.00pm

Bradman	Sutherland	Swan	Nichols	Royal	Menzies	Torrens
Symposium Five	**Road Environemnt**	**Safety Technology (II)**	**Reduced Speeds**	**Symposium Six**	**Symposium Seven**	**Driver Error / Fatigue**
Building Capacity for Road Safety and Taking Responsibility **How is the Australian Road Safety Strategy and Action Plan allocating responsibility within the five pillars and what are the coordination mechanisms?** David Bobberman, Austroads **Building capacity with road safety leadership and management training** Eric Howard, Monash Accident Research Centre **The use of the insurance market has potential to result in a massive step-change and cost-effective improvement in road-safety.** Richard Tooth, Sapere Research Group Limited **How can or should a professional organization such as ACRS contribute to building capacity and encourage coordination?** Lauchlan McIntosh, Australasian College of Road Safety	**Green Reflector Marking of Informal Truck Bays** Rod Hannifey, Truckright	**The Transport for New South Wales FleetCAT (Fleet Collision Avoidance Technology) Trial: Driver Attitudes to the Technology** James Thompson, Centre for Automotive Safety Research	**Is 40 the new 50? The case for a national reduction in the local road speed** Mark King, Centre for Accident Research and Road Safety - Queensland	**Gruen Transfer: The Road Safety Pitch** Host: Kenn Beer (Safe System Solutions) **Student teams: The students will be confirmed once teams are shortlisted** **The expert judging panel will be comprised of:** A road safety expert from the Amy Gillett Foundation; A representative from the Australian College of Road Safety (Lauchlan McIntosh tbc) A road safety expert from sponsor 3M; An advertising and media expert from award winning Advertising Agency McCann	**Engaging organisations to develop an effective policy around the use of mobile phones in vehicles** **Research evidence that supports the policy development** Mitchell Cunningham, ARRB Group Ltd Agreed principles and their successful implementation in an organization Jerome Carslake, ARRB Group Communications to influence businesses to adopt the policy Andrew Hardwick Hard Edge Media	**Driver perceptions of the system-wide factors contributing to driving while fatigued** Paul Salmon, University of the Sunshine Coast
	What works when providing safe road infrastructure? 10 treatments that need to be used more Blair Turner, ARRB Group Ltd	**The INDEMO Project - An innovation and knowledge transfer project for enhancing ambulance design** Nadine Levick, EMS Safety Foundation	**Compliance with reduced speed limits at roadworks: What can we learn from other speeding attitudes and self-reported behaviours?** Katherine Zacarias, Queensland Department of Transport and Main Roads			**Closing the gap between science and practice in the prediction of drowsiness-related driving events** Mike Lenné, Seeing Machines
	Township Entry Treatments - Queensland Pilot Program Michael Gillies, Queensland Department of Transport and Main Roads	**Heavy vehicle driver acceptance of safety applications in a trial of CITS** Vanessa Vecovski, NSW Centre for Road Safety, Transport for NSW	**Innovative Weather-Activated Variable Speed Sign Trial - A first for road safety in New Zealand** Adam Francis, NZ Transport Agency			**The Safest System: Preventing crashes by preventing errors** Julie Hatfield, Transport and Road Safety (TARS) Research Centre, UNSW
	Life-cycle cost analyses for road barriers Thomas Schroeck, Delta Bloc International	**How companies are using IVMS to improve driver safety in Australia - are they doing it right?** Stewart O'Brien, MiX Telematics Australasia	**Enhancing Public Demand for Safer Speeds on the Road: Input from Australian and New Zealand Stakeholders** Sherrie-Anne Kaye, Queensland University of Technology			

6.30pm - 11pm	**CONFERENCE GALA DINNER & AWARDS CEREMONY** **Great Hall, Parliament House** **Including presentation of the prestigious 3M-ACRS Diamond Road Safety Awards** **By the Federal Minister for Infrastructure and Transport, the Hon Darren Chester MP**

Thursday 8 September 2016

7.45am	**Registration Opens - Registration Desk, Ground Floor**
8.30am - 10.00am	***Plenary Panel Session - Sponsored By: Department of Infrastructure & Regional Development*** **Heavy Vehicles** Mr Eric Howard (Session Chair) Professor Ann Williamson, Director, Transport and Road Safety Research, University of NSW Assistant Commissioner John Hartley APM, Commander, Traffic and Highway Patrol Command Mr Sal Petroccitto, Chief Executive Officer, National Heavy Vehicle Regulator Dr Sarah Jones, Group Manager for Road Transport Compliance, Toll Group
10.00am - 10.30am	**Morning Tea - Conference Exhibition Hall**
10.30am - 11.30am	***Conference Plenary*** **Keynote Speakers** Mr David Bobbermen 2015 3M-ACRS Diamond Road Safety Award Grand Prize Winner The Honourable Mark Bailey MP, QLD Minister for Road Safety Minister Shane Rattenbury, ACT Minister for Road Safety

Concurrent Session 6

11.30am - 1.00pm

Bradman	Sutherland	Swan	Nichols	Royal	Menzies
Symposium Eight	Safe System / Community	Driver Risk and Psychology	Young Drivers	Symposium Nine	Symposium Ten - Sponsor: George Institute
Autonomous, semi-autonomous and existing vehicles. What will be the impact on road safety results and when? **Subaru is a leader in preventative safety innovations with "Eyesight®" driver assist as well being the first manufacturer in Australia to offer 5 star ANCAP rating for every cars old** Hiep Bui, Subaru Australia **The Initiative's vision is "To accelerate the safe and successful introduction of driverless vehicles onto Australian roads"** Gerard Waldron, ARRB Group Ltd and Australian Driverless Vehicle Initiative **ANCAP's role is to test and assess the relative safety of new vehicles for new car consumers. How will consumers react to and trust "automation"?** Wendy Machin, ANCAP Australasia **Seeing Machines' driver fatigue and distraction monitoring technology has evolved into a driver monitoring solution that is being implemented by the global automotive industry to help manage safety during automated driving** Mike Lenné, Human Factors at Seeing Machines	**Estimating the value of contributions to community-level action for road safety** Terri-Anne Pettet, WA Local Government Association **Who Rules the Road? Pedestrian Road Rules Assessment in Victoria** Ken Beer, Safe System Solutions Pty Ltd, Rachel Carlisle, Vic Roads **The Safe System Hierarchy of Control Framework for Local Roads** David McTiernan, ARRB Group Ltd **Working Toward Effective Integration of Road Safety into Major Transport Projects: Learnings from NSW** Ralston Fernandes, NSW Centre for Road Safety, Transport for NSW	**Differences in drivers' perception and interactions with boom-controlled rail level crossings in urban versus rural environments** Vanessa Beanland, University of the Sunshine Coast **Understanding driver distraction associated with specific behavioural interactions with in-vehicle and portable technologies** Mitchell Cunningham, ARRB Group Ltd **Anticipated Regret and Risky Driving: A Focus on Texting Behaviour** Tricia Brown, University of Canberra **Off the beaten track: Situation awareness in experienced and novice off-road drivers** Paul Salmon, University of the Sunshine Coast	**The role of supervisors in ensuring learner driver compliance with road laws: An application of Akers' Social Learning Theory** Lyndel Bates, Griffith University **Night driving and the situation awareness of learners and parents: Are they seeing the same road?** Bridie Scott-Parker, University of the Sunshine Coast **Development of a road safety program for young offenders** Sarah Chapman, Transport Accident Commission **Parental experiences of encouraging compliance with restrictions of Graduated Driver Licensing (GDL) during their children's provisional licensing phase** David Belsham, Centre for Accident Research and Road Safety - Queensland	**The MUARC TAC Enhanced Crash Investigation Study: Early findings from the case and control data** **The MUARC-TAC Enhanced Crash Investigation Study: Study Update, analysis of crash types and contributing factors** Michael Fitzharris, Monash University Accident Research Centre **Injury reduction benefits of roundabouts evaluated using real-world data and simulation software** Sujanie Peiris, Monash University Accident Research Centre **What drivers do while speeding: Examining the associations between speeding and driver distraction through the Enhanced Crash Investigation Study protocol** Amanda Stephens Monash University Accident Research Centre **Associations between sleep quality and distracted driving. Exploratory results from the Enhanced Crash Investigation Study (ECIS) control data** Amanda Stephens Monash University Accident Research Centre	**Driver licensing for Aboriginal and Torres Strait Islander People; challenges and opportunities** **Overview of the Driving Change program, a trial of an end-to-end community based driver licensing support program in NSW, the model of delivery, implementation challenges and outcomes** Rebecca Ivers, The George Institute for Global Health **Alex and Elizawill talk through their experience working with Aboriginal clients, the complex challenges, opportunities and positive outcomes** Alex Niki and Eliza Fleming: Driving Change coordinators, Wagga and Taree **Birrang delivers licensing services to Aboriginal people across NSW. This presentation will highlight the unique service delivery model and outcomes** Brett Naden, Birrang Aboriginal Corporation **DriveSafe NT Remote is a holistic Government funded program that delivers services to over 62 remote communities and outstations across the Northern Territory. Program outcomes and evaluation will be discussed and the flexible delivery model** Wayne Buckley, DriveSafe NT Remote, NT Government **TfNSW in partnership with the Australian Football League (AFL) NSW/ACT supports the Adam Goodes Talent Program. The program delivery and road safety outcomes will be presented.** Angela Webb, Centre for Road Safety, Transport for NSW

1.00pm	**Lunch** Conference Exhibition & Poster Presentation Session - sponsored by BITRE

Concurrent Session 7

2.00pm – 3.20pm

Bradman	Sutherland	Swan	Royal	Menzies
Symposium Eleven	Road Design / iRap	Distractions and Communication	Child Safety	Motorcycle Strategy
Applying Australia's approach to road safety in low and middle income countries **Regional overview in road safety and comparing Australasia's standing to other countries.** Jonathon Passmore, World Health Organisation (Western Pacific Region) **The importance of evidence-based laws and law enforcement is an important way to reduce trauma dramatically in the short term** Soames Job, World Bank **Exploring Disabilities and implications for the UN Decade of Action for Road Safety, a case study of Cambodia** Socheata Sann, Centre for Accident Research and Road Safety, QUT **Raising the star rating performance of road infrastructure with safe system interventions in LMICs** Rob McInerney, International Road Assessment Program	**Development and use of the Austroads Safe System Assessment Framework** Blair Turner, ARRB Group Ltd **Interim Evaluation of the Victorian Safer Road Infrastructure Program Stage 3 (SRIP3)** Stuart Newstead, Monash University Accident Research Centre **Brunei iRAP - Speed Management and Infrastructure Improvements** Shane Turner, MWH Global **What are stars made of? : The process of "star rating" the state controlled road network in Queensland** Michael Gillies, Queensland Department of Transport and Main Roads	**Dry Drivers and Mates Motels - Creating Social Change through Integrated Marketing Communications** Kerrie Tregenza, Queensland Department of Transport and Main Roads **Coming out of nowhere: Attention and motorcycle detection in driving** Kristen Pammer, The Australian National University **Digital Billboards and Road Safety: How can we best assess the risk?** Paul Roberts, ARRB Group Ltd **Driver stress in response to infrastructure and other road users: simulator research informing an innovative approach to improving road safety** Bridie Scott-Parker, University of the Sunshine Coast	**Qualitative Consumer Input for Enhancing Child Restraint Product Information to Prevent Misuse: Preliminary Results** Alexandra Hall, Neuroscience Research Australia **Child restraint use among Aboriginal and Torres Strait Islander children in 10 communities in NSW** Kate Hunter, The George Institute for Global Health **Getting Children Riding Again - Making Local Streets Safer for Cycling** Phil Gray, GTA Consultants	**Do motorcyclists have greater exposure to situations in which another driver fails to give way?** Trevor Allen, Monash University Accident Research Centre **NSW Motorcycle Strategy: A Model for Consultative Strategy Development and Implementation** Alice Ma, NSW Centre for Road Safety, Transport for NSW **Enhanced Maintenance Strategies for Popular Motorcycle Routes** Kenn Beer, Safe System Solutions Pty Ltd **Motorcycle Passenger Helmet Use in Cambodia - A Turning Point?** Pagna Kim, AIP Foundation

3.30pm – 4.15pm	**Conference Closing Plenary** Farewell and Thank You **Presentation of the Conference Awards for best papers/posters/presentations - $7,000 in prize money** 1. Peter Vulcan Award for Best Research Paper - $1000 prize plus certificate (Sponsor: TAC) 2. Road Safety Practitioners Award - $1,000 prize plus certificate (Sponsor: TAC) 3. Best Paper by a New Researcher Award (previously John Kirby Award) - $1,000 prize plus certificate (Sponsor: TAC) 4. Road Safety Poster Award - $500 prize plus certificate (Sponsor: TAC) 5. Conference Theme Award - $500 prize plus certificate (Sponsor: TAC) 4. Best Paper by a New Practitioner Award - $1000 plus certificate (Sponsor: TAC) 7. Best Paper with Implications for Improving Workplace Road Safety - $1000 plus certificate + Paper to be converted to an NRSPP Thought Leadership Piece & Webinar (Sponsor: NRSPP) 8. Policing Practitioner's Paper Award - $1000 plus certificate (Sponsor: ACT Policing)
4.15pm	**Conference Ends**

Quad Bikes – why they should not be ridden on public paved roads!

David Hicks[a], Raphael Grzebieta[a], Keith Simmons[a,b], George Rechnitzer[a,c] and Mario Mongiardini[a]

[a]Transport and Road Safety (TARS) Research Centre, UNSW Australia; [b]KND Consulting Pty Ltd; [c]George Rechnitzer & Associates Pty Ltd

Abstract

Quad bikes or All-Terrain Vehicles (ATVs) continue to be a significant cause of serious injuries and fatalities in many countries. Of particular concern are fatalities related to quad bike use on public paved roads. Results from the University of New South Wales (UNSW) Quad Bike Performance Project (QBPP) demonstrated that most commercial quad bikes tested demonstrated an over-steer steady-state handling characteristic. A mathematical relationship exists between a vehicles oversteer characteristic and a 'critical speed' in which the vehicle is at risk of suddenly losing control. Theoretical analyses determining a quad bikes' 'critical speed', indicate it ranges from between 26 km/h and 35 km/h. Simulations were also performed to predict whether quad bikes can safely interact with speed humps and roadside structures such as kerbs and traffic islands. Simulations indicated that quad bikes could negotiate on-road speed humps without displacing the rider off the seat. However, riding over roadside structures, such as a kerb or a pedestrian island, can displace the rider off the seat and thus potentially lead to a loss of control and/or rollover crash. As a result of these analyses it was concluded that quad bikes were unsuitable and unsafe for such public paved road use where speed limits have been set to 50 km/h or more and where there were various road features such as kerbs and traffic islands that had to be negotiated by the rider. These typical handling characteristics of quad bikes on paved road surfaces lead to an increased crash risk, which in turn lead to serious injury risk as quad bikes provide no effective protection to riders in such crashes.

Introduction

General

Quad bikes, sometimes called All-Terrain Vehicles (ATVs), are high-mobility off-road vehicles characterised by a straddle-type seat and a handlebar for throttle and steering control as well as large low pressure tyres and a locked rear axle (no rear differential) for increased traction in rocky and soft terrains.

Quad bikes have several handling characteristics that are different to other four-wheeled vehicles including cars, four-wheeled drives and even other off-road vehicles (SVIA, 2013; Weir, Zellner, 1986) but the predominant characteristic is that they have a very low stability threshold (Grzebieta et al, 2015a). Quad bikes have a relatively high centre of gravity and narrow wheel track which means they are prone to rollover whilst negotiating turns and riding on slopes (Milosavljevic et al., 2011; Grzebieta, Rechnitzer, Simmons and McIntosh, 2015b). Because of this, quad bike riding requires riders to actively change their position on the vehicle to increase the vehicle stability when turning as well as when going over irregular terrain, bumps and perturbations (Lenkeit and Broen, 2014; Honda Australia Rider Training, 2012). Such movement of the rider on the quad bike is commonly referred to as "Active Riding" and can involve a wide range of body movements, from leaning from a sitting position, sliding the pelvis across the saddle to increase the shift in body weight, or adopting a crouched or standing position.

Aspects of their design for use on low-traction off-road surfaces, such as low pressure tyres and locked rear axle, means their use on paved on-road type surfaces can be dangerous and is warned against by quad bike manufacturers (SVIA, 2013).

Similar to motorcycles, quad bikes also do not offer any crash protection (i.e., rider restraint and roll cage) making the rider vulnerable in a public road environment where they can crash into other vehicles or other vehicles can crash into them.

Fatalities

Quad-bike deaths and serious injuries related to quad-bike use on paved public roads are being observed all over the world including in the USA, Sweden and Australia. It has been observed in the USA and Sweden that public road quad bike fatalities account for a higher percentage of the overall fatalities than off-road fatalities, being 65 and 58 percent, respectively (Persson, 2013; Williams, Oesch, McCartt, Teoh, & Sims, 2014). In the USA, single-vehicle crashes accounted for up to three-quarters of on road fatalities and injuries, with vehicle rollover also often occurring (NHTSA, 2015; Williams et al., 2014; Denning, Jennisson, Harland, Ellis, Buresh, 2012; Denning, Harland, Ellis, Jennissen, 2013). Collisions with other road vehicles were also common. Similarly, single-vehicle crash events occurred in approximately 90 percent of cases in Sweden, with rollover being the most prevalent injury mechanism associated with fatalities, which accounted for 70 percent of all the cases (Persson, 2013). In a recent study of 141 Australian quad-bike related fatalities, 11 percent were noted as occurring on public roads, where collisions with other vehicles or objects were often involved (Grzebieta et al., 2014a, McIntosh, Patton, Rechnitzer and Grzebieta, 2016). These Australian crashes all occurred in a rural environment and it is unclear whether they occurred on a paved road surface.

Public Road Access

There is worldwide unanimous agreement between quad bike manufacturers and safety stakeholders that quad bikes should not be used on public paved roads (Weintraub and Best, 2014). Despite this, many countries around the world continue to allow quad bike access to public paved roadways with increasing pressure placed on regulatory authorities to permit their use in such environments (Grzebieta et al., 2014b). In the USA, quad-bike use on public paved roads is permitted in 36 out of 50 states, with varying levels of access ranging from travelling only on certain road surfaces or at certain times of day to complete access to all public roads including paved roads (Maciag, 2016). In many US states, quad-bike jurisdiction is implemented by local ordinances (Maciag, 2016). In West Virginia, where the quad bike fatality rate is eight times the national average, quad bikes are banned from public roads except for the purpose of crossing a roadway (Hall, Bixler, Helmkamp, Kraner, Kaplan, 2009). Despite this, traffic fatality rates have continued to rise suggesting that the state laws have not been effective in curbing this issue.

In the European Union (EU), agricultural quad bikes that are designed for off-road surfaces are not permitted for public road use under Regulation (EU) 168/2013 as of January 2013. Furthermore, from January 2016, quad bikes that are designed to travel on roads are required to have a "safe cornering device", such as a rear differential (European Union, 2013).

In Australia, quad bike access to roads is very restricted with some states allowing only conditional registration with limited access to public roads for the purpose of crossing from one section of a farm or workplace via a public road to another section of the road or farm place (Roads & Maritime Services, 2015; Vicroads, 2014).

Cornering Hazard

As mentioned above, the majority of quad bikes use a locked rear axle (no differential) to provide drive to the rear wheels. A fixed rear axle constrains or 'locks' both rear wheels to rotate at the same rate in order to provide added traction over rocky terrain or loose soft soils. However, this locking of the rear wheels is detrimental when the vehicle is cornering on a hard or paved surface because each rear wheel follows a different turn radius and therefore requires a different rate of rotation during a turn.

The fixed rear axle of a quad bike produces a yaw torque that resists the turning motion of the vehicle. In loose soft soils, where quad bikes are designed to be ridden, this effect is minimised because the inside rear wheel can break traction (Fowler, Fries, McCarthy, Forouhar, Larson, 1994). However, on hard high-friction surfaces, like that found on public paved roads, it is more difficult for the inside rear wheel to break traction and, as a result, the fixed rear axle resists the turning motion of the vehicle (Allen, Rosenthal, Klyde, Szostak, 1989a; Allen, Szostak, Rosenthal, Klyde, 1989b).

To help overcome this undesired effect, quad bikes use a trailing-arm type suspension system or independent A-arm type suspension fitted with a sway bar for the rear axle to provide greater roll stiffness at the rear of the vehicle (Allen et al., 1989a, 1989b). This allows the unloading (lifting) of the inside rear wheel during cornering, which reduces the yaw torque introduced by the locked rear axle and makes the quad bike easier to turn (ACC, 2002). Nevertheless, when the inside rear wheel lifts, power can still be applied to the ground through the outside rear wheel. This characteristic means that turning a quad bike requires careful throttle and steering control as well as appropriate 'active riding' to ensure that the correct level of lateral acceleration is achieved to unload the inside rear wheel but not induce rollover (Grzebieta et al, 2015b). This process involves continuous subtle adjustments to these parameters by the rider during a turn in order to keep the inside rear wheel dragging freely or hovering just above the ground. The high level of concentration required to control the quad bike when negotiating a turn may reduce the rider's ability to assess any road hazards, including oncoming traffic, pedestrians and maneuvering between parallel lanes. Such potential distraction may be one of the causes for the higher number of crashes and therefore serious injuries that have occurred in the USA in situations where quad bikes are cornering on paved and hard surface roads (Williams et al., 2014).

Four-wheeled passenger vehicles that are used on-road typically include a differential across the drive axles to allow each wheel to rotate at different rates during a turn, thus eliminating the yaw torque experienced with a fixed drive axle. Also a feature of a rear differential is that if the inside rear wheel unloads (through body roll while cornering), the differential transfers drive from the outside wheel to this inside rear wheel, causing it to "spin up" and at the same time, cutting power to the wheel that is in contact with the ground. The vehicle then slows and hence reduces the lateral acceleration, bringing the raised wheel back in contact with the ground where it regains traction. This feature of a differential provides an inherent safety characteristic that helps reduce vehicle speed and lateral acceleration below the limits of the vehicle's handling. In the EU, Regulation 168/2013 requires quad bikes to have a rear differential which provides this safer handling characteristic the vehicle needs for use on public paved road surfaces (European Union, 2013).

These different design features each contribute to a vehicle's handling characteristics. One method of assessing a vehicles handling characteristics is by measuring it's 'understeer' or 'oversteer' characteristic. This is measured by determining the relative amount of lateral slip experienced by the front and rear wheels during a turn and can be measured experimentally through the test procedures outlined in SAE J266 (SAE, 2002) and ISO 4138:2012 (ISO, 2012). When slip at the front tyres exceeds that at the rear, a vehicle is said to be in 'understeer' and the driver or rider must increase the steering input to remain on the desired path. A vehicle with more slip at the rear than the front is said to be in 'oversteer' and the driver or rider must decrease the steering input to remain on the desired path. A vehicle that has the same amount of slip at the front and the rear is said to be 'neutral steer'.

At the vehicle's limit of handling (when the traction limit of the tyres has been reached), an 'understeering' vehicle will plow out of a turn and an 'oversteering' vehicle will spin out at the rear, as seen in Figure 1. An understeer characteristic is desirable as it provides a more predictable vehicle response. Importantly, Quad bikes commonly demonstrate an 'oversteer' characteristic which means they are likely to spin out or rollover (due to their low rollover resistance) at the vehicle's limit of handling (Forouhar, 1997; Grzebieta R., Rechnitzer G., Simmons K., 2015a, Allen et al., 1989b; Chen, Tsal, Chen, and Holloway, 1989).

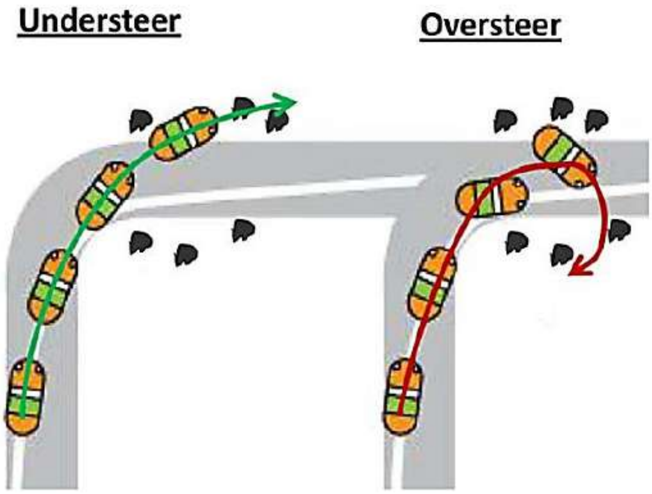


Figure 1: Understeer and oversteer path (after Pollitzer and Little, 2014)

Oversteer and Critical speed

For a vehicle with an oversteer characteristic, at speeds greater than its 'critical speed' the vehicle can become dynamically unstable if perturbed and reach the limit of it's handling and spin out or rollover.

The critical speed of an oversteering vehicle is found using the following mathematical relation (Gillespie,1992):

$$V_{crit} = 3.6\sqrt{-Lg/k}\ (km/h) \qquad \text{Equation 1}$$

where,

L = wheelbase (m)
g= 9.81 m/s²
k=understeer gradient (rad/g)

Gillespie (2015) advised the US Recreational Off-Highway Vehicle Association (ROHVA) that an *"oversteer vehicle can be driven safely as long as they are below the critical speed"*. The US Consumer Product Safety Commission (CPSC) has also expressed concerns regarding an oversteer characteristic in relation to off-road Recreational Off-highway Vehicles (ROVs and also referred to as Side-by-Side Vehicles (SSV's)) stating that *"oversteer in ROVs is an unstable condition that can lead to a rollover incident, especially given the low rollover resistance of ROVs"* (Pollitzer and Little, 2014). Testing conducted by the CPSC demonstrated sudden loss of control experienced when a vehicle reaches it's critical speed (Pollitzer and Little, 2014). In 2009, the CPSC negotiated a repair program involving the redesign of a Yamaha Rhino ROV to have increased lateral stability and the vehicle's handling characteristic changed from oversteer to understeer. The program resulted in a dramatic reduction of turn-related rollover events reported for the Yamaha Rhino

ROVs (CPSC, 2014). It is worth noting however, that Forouhar et al. (1997) performed rider tests at speeds higher than the critical speed which demonstrated no directional instability. Nevertheless, this result was attributed to the rider's ability to influence the dynamic handling characteristics of the vehicle through 'active riding' body movements as well as careful throttle, steering and brake control.

Infrastructure Hazards

Mattei et al. (2011) has shown that traversing a bump-like obstacle placed perpendicular to the direction of travel of a quad bike and in-line with both wheel tracks displaces a seated rider vertically off the seat. Similarly, the authors have shown that a bump-like obstacle placed perpendicular to the direction of travel and in-line with one wheel track of a quad bike can cause a seated rider to be displaced vertically and laterally across the seat of the quad bike (Grzebieta et al, 2015b & 2015c, Hicks, Mongiardini, Grzebieta, Rechnitzer, Simmons, 2015). This lateral displacement can cause the rider to unintentionally steer the quad bike and increase the yaw motion of the vehicle. In the Author's opinion this has led to quad bike roll overs.

Quad bikes are designed to traverse obstacles with the rider assuming an 'active riding' standing position (Honda Australia Rider Training, 2012). In an on-road environment, the Authors believe that quad bike users are less likely to use 'active riding' techniques. For example, the rider's attention could be distracted in a road environment because of other issues such as avoiding crashing into other vehicles or people. Also the psychological perception of a paved road being an easier riding environment than off-road could relax the rider into a non-active posture. Bump-like obstacles are commonly found in the form of speed humps, kerbs and traffic islands on public paved roads. Figure 2 shows two traffic islands which could be ridden over in an errant driving scenario.

Barrier Kerb Profile **Semi-mountable Kerb Profile**

Figure 2: Examples of traffic islands

Objective

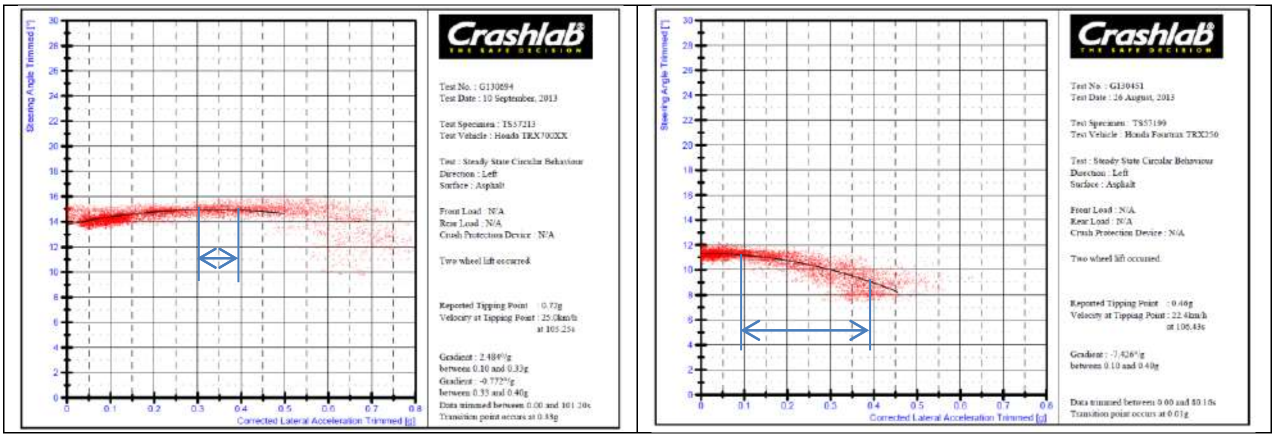
This paper aims to investigate the dynamic handling characteristics of a quad bike and whether these attributes affect their on-road performance and the increased crash risk that these handling characteristics may pose for on-road use of quad bikes. Using the oversteer gradient obtained for the series of quad bikes tested during the dynamic handling phase of the QBPP, the 'critical speed' for these vehicles was determined and considered in light of current road speed limits. In addition, computer simulations were also performed to observe whether a quad bike can safely manoeuvre over speed humps and roadside features including kerbs and traffic islands. This is now presented in the following sections.

Method

Cornering Hazard

The critical speed for the nine commercially available adult-sized quad bikes was calculated using Equation 1. The oversteer gradient published in the steady-state circle test results from the QBPP were used to determine the critical speed of the quad bikes tested (Grzebieta et al., 2015a). The circle tests were performed on an asphalt surface that had an average coefficient of friction of 0.76 determined from skid tests (Grzebieta et al, 2015b).

The oversteer gradient (steering angle/lateral acceleration) between the transition point from understeer to oversteer and 0.4g lateral acceleration was used for these calculations (left side of Figure 3). However, if the transition point occurred at less than or equal to 0.1 g, then the oversteer gradient between 0.1 g and 0.4 g was used (right side of Figure 3).



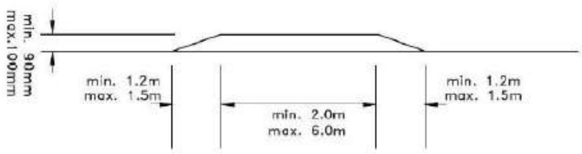
Transition point at 0.1 g **Transition point at 0.33 g**

Figure 3: Lateral acceleration versus steering angle measured for two different vehicles during the QBPP (Grzebieta et al, 2015b)

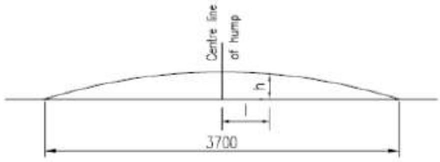
Infrastructure Hazards

Simulations were performed to determine whether on-road features such as speed humps, kerbs and traffic islands present a hazard to quad bike riders and can potentially cause them to lose control of their vehicle. The simulations were performed using a Finite Element (FE) model of a quad bike and seated rider to observe the kinematics of riding over speed humps and roadside kerb structures. The FE quad bike model was previously verified and validated for moving over bump obstacles (Hicks et al., 2015; Mongiardini, Hicks, Grzebieta, Rechnitzer, 2015). A seated 95th percentile HIII Anthropometric Test Device (ATD), commonly referred to as a crash test dummy, was used for this analysis.

Scenarios were simulated with the rider seated on the quad bike while traversing two different speed hump profiles that are used for local area traffic management (LATM) on suburban public paved roads across Australia (Austroads, 2015). These speed humps included a ‘Watt’s Profile’ speed hump simulated at two different heights equal to 75 and 100 mm as well as a ‘Flat-top’ type speed hump (Figure 4). The Flat-top speed hump was simulated with the minimum recommended longitudinal dimensions (i.e.,1.2 m and 2.0 m) and the maximum height of 100 mm to provide the most severe perturbation.



Flat Top Profile (Austroads, 2015)



Watts Profile (Moreland City Council)

Figure 4: Speed Hump Types

Simulations were performed at the range of speeds for each type of speed hump at which it was designed to be traversed (Austroads, 2015). The matrix of speed hump simulations performed is shown in Table 1. Each speed bump was positioned perpendicular to the direction of travel and in-line with both wheel tracks of the vehicle. In addition to this, the 100mm tall 'Watts Profile' speed hump was simulated placed in-line with only one wheel track of the vehicle to represent a speed hump that can be avoided with one wheel track.

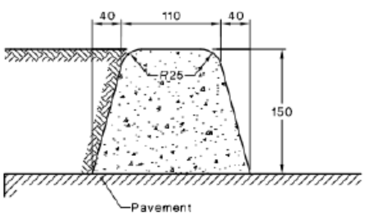
A series of simulations were also performed to investigate the effect of impacting a traffic island. Two different types of Austroads standard kerb profiles were simulated including the 'Barrier Kerb' type and the 'Semi-mountable' kerb profiles (Figure 5) (Austroads, 2015; Standards Australia, 2000). The kerb profiles were simulated placed perpendicular to the direction of travel and in-line with one wheel track as well as in-line with both wheel tracks. The simulations were performed at 30 km/h and 40 km/h to represent scenarios where a rider had only time to slow down before impacting the kerb without swerving (Table 2). The kerb profiles were simulated with a longitudinal length of 400 mm to represent a traffic island (Figure 2). In addition, the barrier kerb was simulated with an infinite longitudinal length to represent the scenario of hitting a kerb placed along the road edge.

Table 1: Speed Hump Simulations

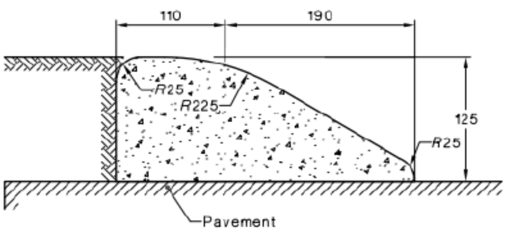
Speed Hump Type	Wheel Track(s)	Speed (km/h)			
		20	25	30	35
Flat Top (100mm)	Both	Yes	Yes	Yes	No
Watts 1 (100mm)	Both	No	Yes	Yes	No
Watts 2 (75mm)	Both	No	No	Yes	Yes
Watts 1 (100mm)	Single	No	Yes	Yes	No

Table 2: Kerb Simulations

Kerb Type	Wheel Track(s)	Speed (km/h)	
		30	40
Barrier	Both	Yes	Yes
	Single	Yes	Yes
Semi-mountable	Both	Yes	Yes
	Single	Yes	Yes
Infinite Barrier	Both	Yes	Yes



Barrier Kerb



Semi-mountable Kerb

Figure 5: AS 2876 Kerb Profiles (Standards Australia, 2000)

Results

Cornering Hazard

The critical speeds calculated for the quad bikes tested in the QBPP (Grzebieta et al, 2015c) are shown in Table 3. The results range from 26 km/h to 34 km/h with an average of around 30 km/h. According to Gillespie (1992) these are the speeds at which an oversteer vehicle is no longer directionally stable and the vehicle will be difficult to control and possibly spin out or rollover if the rider is not able to counteract the effect. These critical speeds are below the default speed limit of 50 km/h on public paved roads.

Table 3: Calculated Critical Speeds

Quad Bike Model	Critical Speed (km/h)
Honda TRX500	34
Yamaha YFM450	32
CF Moto CF500	32
Polaris Sportsman 450	32
Yamaha YFM250 Raptor	31
Suzuki Kingquad 400ASI	29
Kawasaki KVF300	28
Kymco MXU300	27
Honda TRX250	26

Infrastructure Hazards

The **'Flat-top' speed hump and both 'Watts profile' speeds humps**, when traversed with both wheel tracks by a seated rider did not displace the rider off the seat of the quad bike. Similarly, the taller (100mm high) 'Watts profile' speed hump traversed with one wheel track did not displace the rider off the seat of the quad bike. These results are shown in Table 4. It demonstrates that speed humps that conform to the design profiles used here can safely be maneuvered over by a seated rider at speeds 35 km/h or less.

In contrast, in all simulations of the seated quad bike rider traversing a **kerb and traffic island** the rider was displaced vertically off the seat and in the single wheel track scenarios laterally as well. The rider was displaced higher off the quad bike during the simulations of the quad bike traversing the traffic island as opposed to the roadside kerb. This was attributed to the increased pitching motion of the vehicle when it moved over the traffic island and meant the ATD was separated from the quad bike for a longer period of time. At 40 km/h, impacting the barrier kerb profile traffic island with a single wheel track resulted in the quad bike rolling over.

Table 4: Rider separation for speed humps

Speed Hump Type	Wheel Tracks (s)	Speed (km/h)			
		20	25	30	35
Flat Top (100mm)	Both	No	No	No	-
Watts 1 (100mm)	Both	-	No	No	-
Watts 2 (75mm)	Both	-	-	No	No
Watts 1 (100mm)	Single	-	No	No	-

Table 5 Rider Separation for Kerbs

Kerb Type	Wheel Track(s)	Speed (km/h)	
		30	40
Barrier	Both	Yes	Yes
	Single	Yes	Yes (Rollover)
Semi-mountable	Both	Yes	Yes
	Single	Yes	Yes
Infinite Barrier	Both	Yes	Yes

Discussion

Vehicles that have an oversteer characteristic can become uncontrollable and spinout if perturbed during use at or above its critical speed (Pollitzer and Little, 2014; Grzebieta et al., 2015b). For quad bikes with low lateral stability and higher friction tyres on paved roads, the vehicle may instead rollover suddenly. The CPSC recognised the importance of understeer in their proposed standard for ROVs noting that oversteer *"can contribute to ROV rollover on level ground, and especially on pavement"* (Pollitzer and Little, 2014). An understeer characteristic does not prevent rollover from occurring. However, it provides a more predictable vehicle response prior to rollover occurring as well as larger tolerance for the rider to take any corrective action.

Unfortunately, there is not enough detail known about the crash mechanisms of on-road quad bike crashes to determine whether being operated at higher than the vehicles critical speed has contributed to the crash scenario. It is however possible that loss of control due to 'critical speed' may have contributed to some of the single vehicle crashes that have occurred, especially in the case of the 42 percent of single vehicle fatalities in the USA that involved speeds that were too fast for the conditions or exceeding the speed limit (Williams et al., 2014).

The critical speed calculations presented in this study provide an understanding of when an oversteering quad bike could become unstable (Gillespie, 1992). These speeds of commonly used quad bikes are lower than the speed limits and traffic flow speeds of local and main roads across Australia. Thus, if regulators permitted the use of quad bikes on public paved roads, these vehicles would likely operate at speeds higher than their 'critical speed' which, as vehicle handling theory indicates, may become directionally unstable and result in loss of control and rollover crashes. Testing should also be conducted to confirm the potential and circumstances for loss of control due to exceeding the calculated critical speeds.

Rider testing suggests that if the rider remains vigilant and uses appropriate 'active riding' techniques, the quad bike can be safely ridden at speeds higher than the critical speed (Forouhar, 1997). This is the same as a racing car driver being able to control a race car that has an oversteer characteristic. Close attention to vehicle parameters and early intervention (using steering and throttle) at the slightest variation in detected yaw rates or lateral acceleration allows the driver to keep the vehicle under control. However, the public road environment presents a number of hazards that would require the rider's full attention, such as other road users. These distractions would considerably limit the rider's ability to assess and adopt appropriate 'active riding' techniques and to monitor feedback from the vehicle. In addition, the on-road environment being characterised by flat, smooth surfaces may influence riders to believe that active riding techniques are not required and may also encourage higher travel speeds. Without appropriate warning and training, quad bike riders would be unaware of the risks associated with operating at speeds higher than the vehicle's critical speed.

One noteworthy exception in regards to the quad bikes tested in the QBPP was the Honda TRX700, which demonstrated understeer up to its limit of lateral acceleration and therefore does not have a critical speed (Grzebieta et al., 2015b) per say. This characteristic was attributed to the larger relative roll stiffness between the front and rear axles. The vehicle, however, has a locked rear axle which contributed to it rolling when it reached the limit of its lateral acceleration during the circle testing. The Honda TRX700 demonstrates that an understeer characteristic can be achieved, even within the current design of quad bikes with locked differentials.

Results suggest that well designed speed humps on public paved roads may not necessarily present a risk to quad bike riders if traversed at a safe speed, i.e. below the vehicle's critical velocity, although previous research suggests that bump-like obstacles similar to speed bumps can be hazardous for seated riders (Mattei et al., 2011; Hicks et al, 2015; Huston and Xia, 1989). To ensure safety when traversing speed humps, e.g. on private and farm roads, riders should use active riding from a standing position (Honda Australia Rider Training, 2012).

The simulations indicated that roadside structures such as traffic islands and kerbs can displace a seated rider from the quad bike. Of particular concern is clipping a roadside feature with one wheel as this can induce a rollover mechanism. Even travelling at speeds close to the 50 km/h default urban speed limit of suburban roads and some main roads would still be a particularly high risk activity.

The evidence and discussion provided in this paper are also applicable to the use of quad bikes in the off-road environment and on farms. Many quad bike serious injuries and fatalities occur whilst riding on hard off-road surfaces including unsealed roadways, clay soils and grass covered paddocks where the co-efficient of friction is similar to that of a sealed paved road surface (Grzebieta et al., 2014b, Renfroe, 1996; Wright, Carpenter, Johnson, Nelson, 1991).

Although not discussed in detail in this paper, the lack of rider restraint and rollover protection means that quad bike users are vulnerable road users similar to motorcycle and bicycle riders. The high number of quad bike collisions with other road users seen in the USA, Sweden and Australia highlights the vulnerability of quad bike users in public road environment (Denning et al., 2012; Denning et al., 2013; Grzebieta et al., 2014b).

Conclusions

Quad bike manufacturers warn against riding on paved surfaces such as on public roads. Despite this, there is increasing pressure on governments and regulatory authorities worldwide to permit their use on such roads, though mainly in the USA and more recently in Europe. This study highlights and discusses the dynamic handling characteristics of quad bikes that indicate these vehicles have an increased crash risk when used on paved surfaces and are therefore unsuitable for use on public paved roads, particularly when considering their lack of crashworthiness.

In Australia, a quad bike's critical speed would be likely exceeded if operated in a public road environment. This feature when combined with its underlying oversteer characteristic and low stability, indicate a significantly elevated risk potential for quad bikes to lose control and rollover as a result of interaction with public paved roads. Moreover, simulation analyses of a quad bike interacting with roadside kerbs and traffic islands further indicate that a rider traveling over such road features could be displaced off their seat and lose control of their vehicle and in some situations even rollover.

Acknowledgements

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Replacement Windscreens – a serious vehicle and road safety issue

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Abstract

In modern vehicle design the car's windscreen is integral to a vehicle's safety and crashworthiness design. Australian Standard AS4739 (Standards Australia, 2002) for windscreen replacement stipulates the vehicle must be returned to the Original Equipment Manufacturer (OEM) standard but does not specify adhesive characteristics.

The quality of replacement windscreen installations and compliance to AS4739 is dependent on both the correct adhesive being used and that correct practice is being used by installers. However, from the experience of personnel involved in the replacement windscreen industry such as the Australian Autoglass Industry Alliance (AAIA), neither of these factors is assured as a matter of course. This Extended Abstract discusses issues associated with the after-market adhesives.

For the approximately one million windscreens being replaced in Australia each year it is a matter of good luck that a replacement windscreen is bonded with an after-market adhesive that meets the OEM specification.

This paper presents the issues regarding this situation and improvements required in the windscreen replacement industry to ensure vehicle safety is maintained.

Background – the Windscreen Replacement Industry

The windscreen replacement industry in Australia consists of more than 500 businesses that operate as large repair networks, independent businesses or sole traders. These businesses fit an estimated one million replacement windscreens per annum.

Australian Standard AS4739 (Standards Australia, 2002) for windscreen replacement stipulates the vehicle must be returned to the OEM standard, but it does not specify the adhesive characteristics.

Windscreen Replacement Industry associations such as the Australian Autoglass Industry Alliance (AAIA) and others (Rechnitzer, 2015, Call Kurtis Investigate, 2013) have raised major concerns with windscreens being improperly fitted and incorrect adhesives being used. Indeed, Murray (1994) highlighted this more than two decades ago in United States (US) Federal Motor Vehicle Safety Standard (FMVSS) 216 roof crush tests he carried out at Monash University for VicRoads (Murray, 1991, 1994). Both co-authors Rechnitzer and Grzebieta were involved in the FMVSS 216 tests at Monash University in 1991. In these tests, the Ford Falcon tested failed the US roof strength FMVSS 216 criterion because the windscreen was incorrectly bonded, and on retest with the correct windscreen adhesive being used, passed the US test. It should be noted that Australia then and now does not have an Australian Design Rule that requires minimum roof strength for passenger sedan vehicles.

Replacement of windscreens can be a 'safety lottery' for Australian car occupants where in the event of an collision or rollover crash, their windscreen may perform as the vehicle manufacturer intended or it may have been poorly installed and separate from the vehicle altogether.

‘Safety lottery’ is emotive language, but it is the AAIAs contention after surveying members and non-members that there would be no windscreen repairer in Australia that would be able to locate the OEM adhesive specification for a range of common vehicles sold in Australia such as Toyota, Holden, Mazda, Mercedes, Ford. AS4739-2002 Direct Glazed Automobile Glass Replacement – Light Vehicles standard requires among other things that the adhesive sealant system ‘shall’ be equivalent to the vehicle manufacturer’s specifications. Yet there is no published document that outlines what these specifications are. In the absence of this information, repairers have come to rely on the general marketing claims of adhesive suppliers.

Relevance of the various vehicle tests for validating Windscreen adhesive performance

The Euro-NCAP 64 km/h frontal impact test is a consumer crash test that rates the injury severity risk to vehicle occupants and thus the crashworthiness of new vehicles. The testing has no relevance to windscreen retention but many aftermarket adhesive manufacturers market their product as meeting Euro-NCAP requirements.

On the other hand in the US FMVSS 212 Windshield Mounting, relates to windscreen retention in a collision, with the purpose of “*preventing the ejection of occupants from the vehicle*” (NHTSA, 2007). It involves a crash test into a fixed barrier at 48km/h, and requires that for vehicles fitted with passive restraints the windshield mounting of the vehicle shall retain not less than 50 percent of the portion of the windshield periphery on each side of the vehicle longitudinal centreline.

The US FMVSS 212 crash test, while providing one of the relevant performance criteria for the windscreen adhesive, does not of itself validate that all of the OEM’s key structural performance requirement are fully met. This standard only requires that 51% of the windscreen/body bond remain intact after the test.

US FMVSS 216A Roof Crush Resistance is also relevant to windscreen bonding and performance, as this requires the vehicle’s roof to withstand a platen load of 3 times the vehicle mass and, a correctly bonded windscreen can in today’s vehicles improve structural rigidity by up to 40%.

Whilst the roof crush resistance is influenced primarily by the glass used, the use of after-market adhesives that do not meet the OEM specifications obviously compromise crush resistance performance. No after-market adhesive manufacturer markets its compliance with this test.

Most after-market adhesive manufacturers promote the fact that their product is US FMVSS208 frontal impact crash test compliant but as with Euro-NCAP, this test is not relevant and sets no criteria for windscreen retention.

In summary, while it is relevant to cite the adequacy of the windscreen adhesives performance under testing involved in the US FMVSS 212 and 216, these should not be considered as alternative acceptance criteria to that of meeting the OEM’s adhesive specifications.

OEM Adhesive Manufacturers/Suppliers

Adhesive manufacturers/suppliers in Australia make varying claims about being an ‘OEM’ provider which is perhaps designed to provide windscreen repairers with some comfort that using their product will ensure that the customers vehicle will be returned with a windscreen replacement that meets OEM specifications for that particular vehicle; and importantly, returned with its designed safety systems uncompromised.

Some of these ‘OEM’ claims are not relevant to passenger vehicles and relate to perhaps trucks or buses, and others relate to the adhesive used by the OEM and not the adhesive manufactured for the after-market. The OEM and after-market products have distinctly different performance characteristics.

The adhesive used by an OEM has evolved over time to become a multifunctional direct glazing adhesive with the following key requirements which need to be replicated in adhesives used in the after-market:

1. Low Conductivity, to provide protection against electrical and contact corrosion and correct functionality of the rear window defroster;
2. High frequency performance, to ensure no influence on the reception quality of radios, TV, mobile phone and navigation systems with screens fitted with integrated antennas;
3. High shear modulus and tensile strength, to enhance the overall torsional stiffness of vehicle bodies.

Adhesives with a high shear modulus are designed to reinforce the structure of the car body. Due to lightweight construction requirements of modern vehicles the windscreen becomes essential and integral for the overall vehicle torsional stiffness - ensuring passenger safety. The load-bearing components of a car body are special supporting pillars with high strength and stiffness and when coupled with a polyurethane bonded windscreen as a constructive element can improve structural rigidity by up to 40%

Table 1 shows the current after-market products in the Australian market and how they compare to the specifications of major European OEM's. Many fall short of the OEM specifications.

Direct Glazing products in Australia Vs European OEM specifications.

	Adhesive Technology Type	Shear Modulus (DIN EN 14869-2)	Tensile Strength (DIN 53504)	Specific Forward Resistance (DIN IEC 60093)
Product 1	MS	1.8 MPa	2.8 MPa	≥10^8 Ωcm
Product 2	MS	1.6 MPa	2.8 MPa	≥10^8 Ωcm
Product 3	PUR	2.4 MPa	10.3 MPa	≥10^8 Ωcm
Product 4	PUR	2.0 MPa	9.6 MPa	≥10^8 Ωcm
Product 5a	PUR	2.9 MPa	9.5 MPa	≥10^8 Ωcm
Product 5b	PUR	2.7 MPa	8.5 MPa	≥10^8 Ωcm
Product 5c	PUR	2.5 MPa	9.0 MPa	≥10^8 Ωcm

Meets Major European OEM specification

Does Not Meet Major European OEM specification

Table 1- A summary table illustrating current adhesives in the Australian market compares to the key requirements of 5 major European OEM's. (data from Henkel Teroson).

The Australian Standard AS4739-2002 'Direct Glazed Automotive Glass Replacement – Light Vehicles' (Standards Australia, 2002) is currently being reviewed by a Standards Australia industry working group which should result in the clear specification of adhesive properties used in the replacement of windscreens in Australia.

Of note is the incompatibility between Modified Silane (MS) polymer and polyurethane (PUR) based adhesives. When PUR is applied directly over MS adhesive, adhesive failure of the direct glazing adhesive becomes a significant risk as the alcohol byproduct in the MS technology directly affects the adhesion of the PUR technology.

Windscreen Adhesive Specifications currently available

Currently, a windscreen fitter has to take on face value the claims made by adhesive suppliers about being US FMVSS212 or OEM compliance.

Product Data Sheets (PDS) for a number of aftermarket adhesives available in Australia are difficult to reconcile with one another and quote properties like tensile strength, tensile lap shear strength, sheer stress, shear strength, stress, tensile stress, etc. Specifications for these properties are quoted in varying units such as Pa/mm^2, PSI, Pa, kPa, etc.

It is confusing for the industry and after-market adhesive manufacturers need to adopt an agreed set of properties and units that can be easily reconciled with OEM specifications.

Conclusions

The quality of replacement windscreen installations and compliance with AS4739 is dependent on both the correct adhesive being used and that the correct practice is being used by installers.

Neither of these things are assured in the industry currently which is contributing to a growing incidence of placing vehicle occupants at risk in regards to vehicle crashworthiness.

It is recommended that:

1. AS 4739-2002 needs to include the specifications of glass and adhesives used in Australian windscreen replacements;
2. All Vehicles sold in Australia must include a specification sheet in standardised form made available to the windscreen replacement industry, which readily enables identification of adhesives which meet the OEM specifications;
3. Insurance companies and fleet operators need to require the use of glass and adhesives that meet the updated AS4739 specifications;
4. A regulatory regime to be considered by government (or alternatively industry and insurers) requiring all windscreen installer's to be qualified and certified;
5. That windscreen failures (e.g. lack of bonding) be identified in the police collision reports.

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Development and application of a vehicle safety rating score for public transport minibuses

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Abstract

Minibuses are widely used for public transport, particularly in developing countries, yet their safety levels are often poor. This study identified a simple set of active and passive safety measures and 566 minibuses in the United Arab Emirates were inspected. Most vehicles were without seat belts or head restraints and had inadequate seat attachment. Low rates of active and passive safety features were recorded.

The safety rating score assigned weightings to each of the variables in the survey, based on an assessment of their approximate relative risk. Applied to the benchmarking sample, scores (out of 50) ranged from below 10 points for the least safe vehicles to around 40 points for the best. Many vehicles inspected scored below 20 points.

The safety rating score provided a practical assessment of the safety of the UAE minibus vehicle fleet, and could be adapted to other vehicle types. The study outcomes are helping to both justify a new minibus safety standard in the UAE aiming to significantly reduce death and serious injury among the many passengers using this service, as well as to begin the process of removing the least safe vehicles from the fleet.

Background

This study formed one component of a longer term program to improve the safety of minibuses in the United Arab Emirates. An earlier study by Fildes, Logan and El-Sadig (2014) outlined a proposed new safety standard for the UAE to improve the safety of these vehicles, defined in the Emirates as commercial passenger-carrying vehicles for carrying no more than 14 passengers (nine in Abu Dhabi). With the primary project goal being to undertake a benefit-cost analysis to determine the economic impact of implementing a new safety specification, it was first necessary to gain a more detailed understanding of the safety specification and maintenance condition of the existing fleet. To facilitate communication with the stakeholders involved, the decision was made to develop a safety rating score to quantify the outputs of the safety survey.

Currently in the UAE, all motor vehicles, including minibuses, are required to comply with Gulf Cooperation Council standard, UAE.S/GSO 42:2003 (ESMA, 2003), with similar requirements to European standards of the early 21st century. Anecdotally, however, compliance with the standard often appeared poor among in-service vehicles and there are currently no incentives, such as an NCAP program, to encourage consumers to purchase vehicles of better than the minimum regulatory requirements.

Method

The data collection activity was undertaken in the Emirates by local technicians who were able to receive only limited training. Therefore, a set of variables was devised that satisfied three main criteria:

a. to accurately indicate the overall safety level and condition of an in-service minibus;
b. able to be collected from a sample of vehicles by relatively inexperienced data collectors and;
c. able to be obtained primarily through visual inspection, without the need for performance testing or complex measurements.

The parameters were grouped into two main categories: primary safety (crash avoidance) and secondary safety (crashworthiness). Each of these was assigned a relative weighting, summing to one:

$$\sum_{i=1}^{i=n} C_i = 1 \qquad (1)$$

where:

C is the main category
n is the number of main categories to be included; with $n = 2$ in this case

Within each of the main categories, individual parameters were chosen on the basis of expert judgement, while satisfying the restrictions listed at the beginning of this section. In the same way as the main category weightings summed to unity, the individual parameters selected to represent each main category were also required to total one.

$$SR_{norm} = \sum_{i=1}^{i=n} T_i \sum_{j=1}^{j=p} C_i . R_{i,j} \qquad (2)$$

where:

SR_{norm} is the weighted safety rating;
p is the number of individual parameters in category i;
$R_{i,j}$ is the weighting for parameter j within category i;
T_i is the weighting for category i

The weighted safety rating, on a scale from zero to one, was then scaled up by a factor of 50 to yield the Safety Rating Score for each vehicle.

The values for individual weightings were chosen to reflect their relative importance among their respective category. For practical reasons, this process was largely achieved through expert consensus, since amassing sufficient research evidence to objectively compare the relative benefits of different safety features was beyond the scope of the study, even if such evidence was available.

Results

Parameter selection – primary safety

Three safety features were selected for inclusion in the crash avoidance category, as shown in Table 1.

The pseudo-static stability factor was based on static stability factor (SSF), defined in NHTSA (2000). SSF, being based on vehicle track width and the height of the centre of gravity (CofG).

$$\mathrm{SSF} = \frac{T}{2H} \tag{3}$$

where:

SSF is the Static Stability Factor;
T is the track width of the vehicle;
H is the measured height of the centre of gravity;

If the entire mass of the vehicle were concentrated into a point, the CofG location represents the height this point. CofG is normally determined using a tilt table test, in which the tethered vehicle is tilted sideways from the horizontal until the wheels on one side begin to leave the ground at which point the tilt angle is measured. SSF thus represents a measure of propensity to rollover. It was impossible to determine this experimentally, the height of the CofG was determined for this vehicle type by the engineering approximation of the vertical distance from the ground to the base of the driver seat at the seat back pivot.

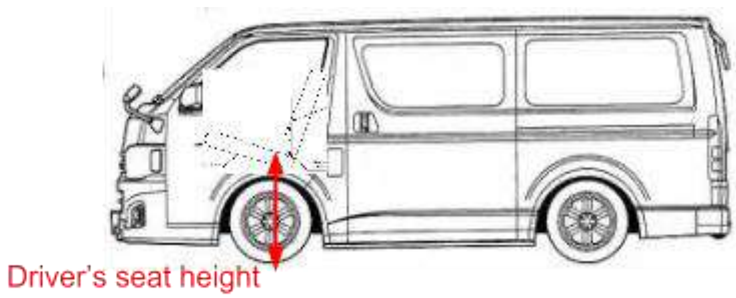

Figure 1. Height measurement for pseudo static stability factor.

Table 1. Primary safety features.

Safety feature/characteristic	**Weighting**
Electronic stability control (ESC)	0.60
Pseudo-static stability factor	0.35
Antilock braking system (ABS)	0.05
Total	1.00

The parameter values for ESC and ABS were set to one when fitted; zero when not fitted. Pseudo-SSF values ranged between zero for pseudo-SSF of 0.6 or lower to one for 0.9 and higher, with the endpoints chosen to approximately represent the range of vehicles surveyed in the study. In between the endpoints linear interpolation was used to determine the value assigned.

Parameter selection – secondary safety

Secondary safety parameters were selected to reflect the prioritisation of minibus passengers in the current UAE environment. Crashworthiness rating (CWR) was derived from Newstead, Watson and Cameron (2013), which statistically evaluates crashworthiness on the basis of real world secondary safety performance from 24 years of police-reported crash data across Australia and New Zealand. The method by Newstead et al relies on a statistically valid sample being available, therefore in the case of vehicles in the study without crashworthiness ratings, engineering judgement was used on the basis of mechanical equivalence (such as Chinese brands based on previous models of Japanese vehicles) or through comparisons of NCAP ratings where available. The parameter values for CWR were on a scale from a CWR of 2.0 representing a zero score, to a score of one for a CWR of 5.0, linearly interpolated between the two endpoints and assigned values of zero or one for scores lower than 2.0 or higher than 5.0 respectively. This parameter was assigned a third of the overall secondary safety weighting.

Experience with observations of the minibus fleet strongly indicated poor seat belt fitment rates, despite the fact that it is a legal requirement. Furthermore, while many vehicles observed had seat belts fitted in the rear compartment, they were often unavailable to passengers by being tucked under the seat, folded or knotted or otherwise made inaccessible. The scores assigned for rear seat belt fitment by position were: zero for no belt or an inaccessible belt, 0.5 for a two-point belt and 1.0 for a three-point belt. The final score was the average of all rear seating positions, since seat belt availability frequently varied between seats.

Three parameters assessing airbag fitment provided 28% of the secondary safety assessment in total, covering frontal airbags (0.5 awarded for fitment of each of driver and passenger airbags), and side or curtain airbags in either or both of the front or rear passenger compartments, with a score of one awarded for fitment of each.

Headrest fitment was evaluated by awarding one point for a seating position with a headrest (either integrated or adjustable) and zero points for a seat without any support above shoulder level. The final value for this parameter was the average of the values for all of the rear seating positions.

The final two parameters were average inter seat spacing and passenger ‘knee room’ (also referred to as ‘foot room’), as shown in Figure 2. Inter seat spacing influences the possibility of passenger to passenger contact during a crash event, particularly when restrained by two-point, lap belts only. The knee room parameter, while correlated with inter-seat spacing, is primarily related to comfort and accessibility but could also influence the risk of lower limb injuries in a frontal impact. Inter seat spacing was scored zero points for 60 cm and below, one point for 90 cm and above and interpolated linearly in between these two end points. The lower limit was derived from ECE R107 Rev 6 Annex 4 (ECE, 2014) and the upper limit based on the torso height of a 50th percentile male (McBride, 2011). The average of the scores for all passenger rows was used to determine the final score. Similarly, knee/foot spacing scores were consistent with ECE (2014), but with allowances made to reflect the current requirements of UAE GSO.S 42 and for consistency with the maximum inter-seat spacing value used. Consequently, the assigned parameter values ranged from 20 cm (zero) to 40 cm (one point), with interpolations in between.

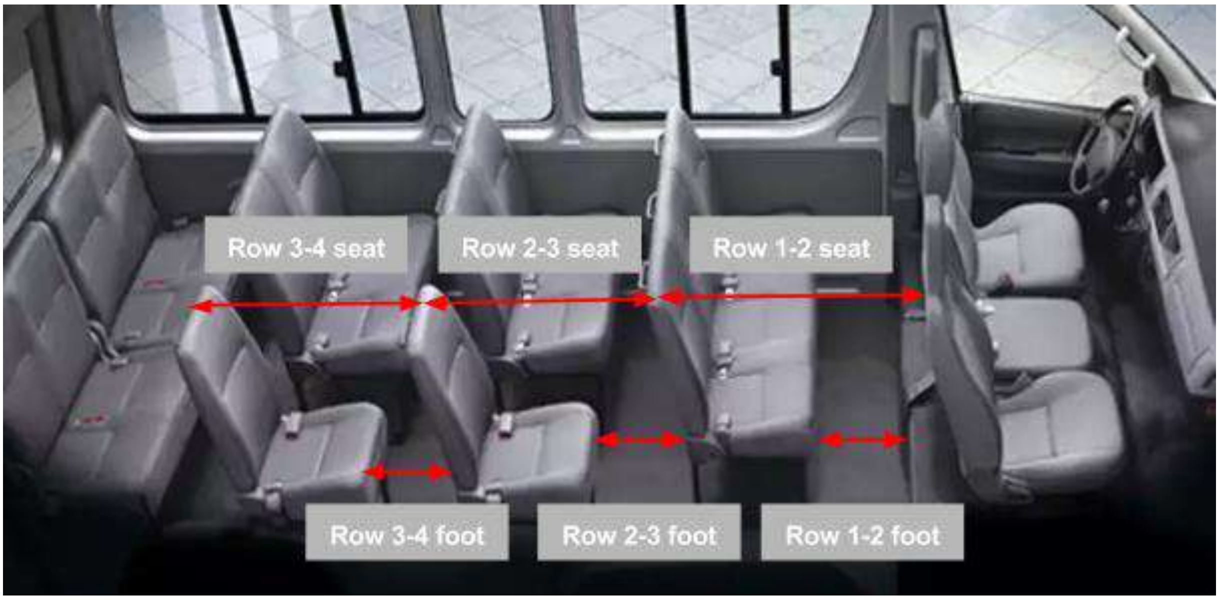

Figure 2. Seat to seat and knee room measurements.

Table 2. Secondary safety features.

Safety feature/characteristic	**Weighting**
CWR (Crashworthiness rating)	0.33
Rear seatbelt fitment (average of all seating positions)	0.33
Front airbag fitment	0.10
Side/curtain airbag fitment (front compartment)	0.09
Side/curtain airbag fitment (rear compartment)	0.09
Rear head restraint fitment (average of all seating positions)	0.04
Average seat-seat spacing (cm)	0.015
Average knee room (cm)	0.005
Total	1.00

Main criteria weighting and general comments

The two categories (primary safety and secondary safety) were combined by assigning weightings of 0.3 and 0.7 respectively, orienting to the relative priorities of each in the Middle Eastern context.

The star rating schema was applied to a selection of vehicles ranging from very poor to very good in order to ensure that the scores awarded were commensurate with a subjective assessment of individual vehicles and gave good discrimination between worse and better performing vehicles.

While the rating system was targeted at discriminating vehicles on the basis of their fundamental specification, in practice the secondary safety component of the score somewhat reflected vehicle operating condition, given that – in particular – a significant proportion of vehicles were not fitted with seat belts in accordance with the standard.

The list of parameters included in the safety rating score was compared qualitatively with the safety-related clauses of UAE.S/GSO 42 and good correlation found between the two, with the exception of the three clauses pertaining to windscreen and windows, speedometer accuracy and tyre specification. Electronic Stability Control was assessed, but is not yet mandatory for minibuses in the Gulf region.

Typical minibus safety rating scores

The study sample was dominated by variants of the Toyota Hiace, which does make up a significant portion of the minibus fleet in the Emirates. Also present were examples of the Nissan Urvan and its newer replacement the NV350. The remaining general use minibuses comprised Mitsubishi, Mazda and Foton vehicles. Also included were a sample of Mercedes-Benz Vito vehicles dedicated by the Abu Dhabi government to transporting airline passengers between Abu Dhabi city and the airport. These were commissioned between 2013 and 2014.

Scores for a selection of the vehicles included in the study are provided in Table 4 below.

Mean safety rating scores clearly differentiate between the less safe and more safe vehicles. The spread between the minimum and maximum scores results from variations in rear seat passenger belt fitment, seat spacing and vehicle condition. The wider track Toyota Hiace has not only a 200 mm wider track, but is often a higher specification model with three-point seat belts and head rests, unless modified by the owner. The Mercedes-Benz vehicles were universally well-maintained and had not been modified in any way. Their mark would have been higher, except for the fact that they are not subject to the 100 km/h speed limiter requirement.

Table 4. Benchmarking study safety rating scores.

		Safety score (0-50)		
Vehicle	**No.**	**Min**	**Mean**	**Max**
Toyota Hiace, 1996-2004	79	6.8	7.6	12.9
Toyota Hiace, 2005-2014 (narrower track)	392	9.7	13.6	23.2
Toyota Hiace, 2005-2014 (wider track)	10	13.1	18.3	24.0
Nissan Urvan, 2001-2012	13	6.5	9.1	13.0
Mercedes-Benz Vito, 2013-2014	35	40.9	40.9	40.9

Discussion

The safety rating schema devised for this study showed good discrimination between vehicle types, reflecting variations in base vehicle design and specification, as well as vehicle fitout and in-service condition. While the inspections of a number of vehicles in this study were undertaken at the government-operated inspection stations in conjunction with their mandatory annual check, the majority were conducted at a central bus station and considerable variation was observed between individual vehicles. Several issues were observed, with the following being of particular note:

- Although two-point seat belts on all rear seating positions are mandatory, a large proportion of vehicles either had no belts fitted, the belts were rolled up or fed between the seat back and squab such that they would be unavailable to passengers;
- In the emirate of Abu Dhabi there is a requirement for minibuses to seat no more than nine occupants in total, compared with the 14-15 seats normally fitted to the most common vehicle, the Toyota Hiace. Consequently, it is necessary for operators to remove one or more of the standard bench seats and refit different seat assemblies to reconfigure the vehicle. It seemed likely that this process is not always carried out with due diligence, since third row seats in many vehicles were inadequately secured or not equipped with seat belts.
- Fitment of frontal airbags for front seat passengers and, in many cases, drivers also was inconsistent, even allowing for vehicle age. This may be an indication of problems with the import approval process.

A safety rating score of around 20 correlated with a vehicle that would be compliant with the current UAE.S/GSO 42:2003. By way of comparison, the study proposed two hypothetical alternative vehicles that would constitute a practical improvement over the existing fleet, using the predominant Toyota Hiace as a case study:

> **Improvement #1**: a safety retrofit program to existing narrow track Toyota Hiace vehicles, currently averaging 13.0 points. A hypothetical maximum safety rating score of 27.5 points could be achieved by retrofitting existing vehicles of 2005 and newer with high-back seats with headrests, three-point seat belts and relocating the seats to provide a minimum of 870

mm inter-seat spacing. This configuration reflects the seat type and layout of Toyota Hiaces available in many international markets, albeit in a narrower track form.

Improvement #2: a replacement Toyota Hiace, based on the 2015 Australian market Hiace Commuter minibus with wide track chassis, fitted with high-back seats, head restraints, and 3-point seat belts as standard equipment, along with Electronic Stability Control (ESC), Anti-lock Brakes (ABS), and Electronic Stability Control (ESC). With fitment of driver and passenger frontal impact airbags, in good condition and with all safety features currently available to all passengers, this would give a Safety Rating of 38.

One limitation of this study is the lack of research evidence to support the relative weightings (and therefore relative risk of crash involvement or serious injury outcome given a crash) between individual safety features and characteristics. However, the values selected, while not necessarily objectively measuring relative risk, certainly provide a strong indication of the relative importance of each to minibus passengers in the Emirati minibus fleet as it stands. Similarly, the relative weightings between primary and secondary safety along with maintenance and condition could be varied to suit the priorities and current safety standards of other jurisdictions. In Australia, for example, a higher weight might be assigned to crash avoidance, acknowledging that vehicle crashworthiness is perhaps of a generally better standard and perhaps more uniform between vehicles. Consequently, disparity among the fleet with regard to primary safety features would be better quantified with more emphasis on this category.

Furthermore, in order to apply this method to other jurisdictions, the individual parameters should be selected and weighted to reflect the current fleet standard and desired vehicle safety outcomes. A future publication is to be prepared documenting the practical application of this method to the Emirates vehicle fleet.

Conclusions

This study set out to develop a safety rating score able to be relatively easily determined from a combination of publicly available information and a visual inspection undertaken by non-expert personnel. The safety rating schema, has the advantage of being transparent and objective with the weights of each safety feature or characteristic and the overall categories highlighting their individual contributions.

Applied to a real-world sample, vehicles scored from below 10 points out of a maximum of 50 up to almost 41 points for the better equipped and maintained minibuses.

The safety rating score is currently being used by the Abu Dhabi Department of Municipal Affairs and Transport to set a threshold score below which vehicles will be progressively phased out of service, with a benefit-cost study indicating the societal benefits of this program aimed at significantly improving the state of minibus safety in the United Arab Emirates.

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Investigation of Conditions for Repeatability/Reproducibility of Vehicle Rollover Crash Tests with Devices Based on the Jordan Rollover System

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Abstract

Vehicle rollovers are particularly dangerous crash modes being responsible for a considerable percentage of the entire vehicle occupant fatalities. Test devices based on the functional principles of the Jordan Rollover System (JRS) may help researchers in investigating what happens to occupants during vehicle rollovers. Repeatability and reproducibility of test outcomes are both paramount requirements for any future successful rollover crash test protocol. Apart from the initial testing conditions, test outcomes may be affected by some boundary conditions as well. Thus, a standardised rollover testing protocol should impose a strict control also on those boundary conditions that could influence the test outcomes.

This research aimed at identifying whether and to what extent some initial and boundary conditions may affect the repeatability and reproducibility of the test results. Such investigation, which was carried out using computer simulations of crash tests with the UNSW JRS, indicated that two conditions which can influence the test outcomes are the roadbed-to-vehicle friction and the initial offset of the roadbed bottom skids from the ground supports.

Introduction

Based on a statistical study on the three Australian states of News South Wales, Victoria and Northern Territory, vehicle rollovers were responsible for around 35 percent of all occupant fatalities that occurred in single-vehicle crashes during the period 2000-2007 (Fréchède, McIntosh, Grzebieta, & Bambach, 2011). Understanding the mechanisms that cause severe injuries during vehicle rollovers is essential to develop effective design countermeasures. A repeatable rollover crash test procedure would be ideal to allow researchers to investigate injury mechanisms during vehicle rollovers. Test devices based on the working principles of the Jordan Rollover System (JRS) (Friedman & Jordan, 2008) appear to be good candidates for conducting repeatable rollover crash tests (Chirwa, Stephenson, Batzer, & Grzebieta, 2010).

In general, the JRS testing principle aims to replicate real-world vehicle rollovers by dropping a vehicle that is spinning around its longitudinal axis onto an approaching sled, or roadbed, which moves at a pre-defined initial speed. The front and rear ends of the tested vehicle are hinged to two separate control arms, which are free to rotate independently and allow the vehicle to drop from an assigned initial height. Testing of a small passenger car (Toyota Yaris) with the University of New South Wales (UNSW) JRS (Grzebieta *et al.*, 2013) is shown in Figure 1.

A recent investigation that was conducted through a subjective assessment of the experimental results indicated that a good level of repeatability was achieved from two rollover crash tests that were conducted using the University of Virginia (UVA) Dynamic Rollover Test System (DRoTS) (Seppi, Toczyski, Crandall & Kerrigan, 2106), which is a JRS-based testing device (Kerrigan *et al.*, 2011). However, in previous research by Mongiardini *et al.* (2014), substantial differences in the measured roll rate and roadbed load were identified between two rollover crash tests with a small passenger car. These tests were conducted under the same nominal conditions but using different JRS-based devices, i.e., the UVA DRoTS and the UNSW JRS.

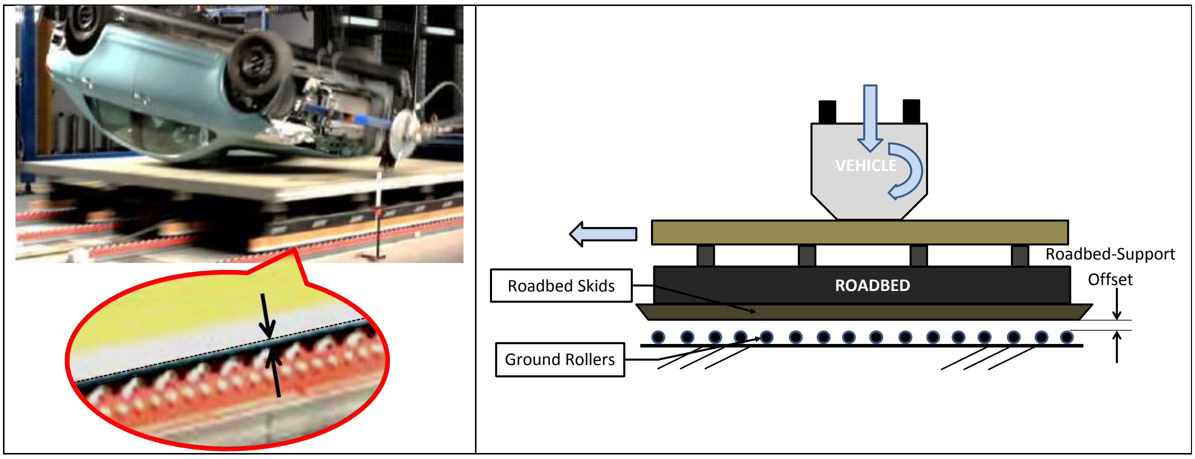

Figure 1. UNSW JRS test with a small car (roadbed-support offset shown in magnified view) (Left) and schematic view of the roadbed support from ground support (Right)

Apart from the testing Initial Conditions (IC's), test outcomes may be affected by some Boundary Conditions (BC's) as well. Thus, to achieve testing repeatability and reproducibility, it is important to identify also those BC's that would determine the test outcomes and impose a rigorous control on those conditions in any future standardised rollover testing protocol. Thus, the objective of this research was to identify relevant IC's/BC's that would affect the repeatability and reproducibility of test results. The investigation was conducted using detailed computer simulations of full-scale rollover crash tests on a small passenger vehicle with the UNSW JRS.

Methods

The two rollover crash tests that were previously conducted using the UVA DRoTS and the UNSW JRS were used as baselines during the comparisons of the simulation results. Finite Element (FE) simulations of full-scale vehicle rollover crash tests with the UNSW JRS were carried out to analyse whether and to what extent the test outcomes would be affected when varying selected testing IC's/BC's. Initially, two simulations were performed to demonstrate that the minor differences between the IC's of the two baseline experimental tests cannot justify all the dissimilarities in the test outcomes. These two simulations were conducted at the same IC's that were recorded for the corresponding baseline tests. Subsequently, a preliminary parametric study was conducted for the following two IC's/BC's of interest: (a) roadbed-vehicle friction and (b) initial roadbed offset from the ground supports. A summary of the IC's/BC's for each of the simulated scenarios is shown in Table 1.

Simulations were performed using LS-DYNA, a non-linear explicit FE solver that is highly suitable for simulating crash events (LSTC, 2015). A validated FE model of the UNSW JRS coupled with a detailed vehicle model of a 2010 Toyota Yaris was used as a basis for all the simulations (Mongiardini, Grzebieta, Mattos, & Bambach, 2016). The FE model is shown in Figure 2.

Figure 2. FE Model of the UNSW JRS coupled with a small passenger car (Toyota Yaris)

Table 1: Matrix of simulated scenarios to investigate relevant IC's/BC's

Investigated Conditions		Configuration Name	IC's Values							BC's Values
			Roll Angle (deg)	**Pitch Angle (deg)**	**Yaw Angle (deg)**	**Drop Height (mm)§**	**Roll Rate (deg/s)**	**Roadbed Speed (km/h)**	**Roadbed Offset (mm)**	**Roadbed Friction***
IC's	JRS/ DRoTS	*IC_JRS_B13037*	**-179.3**	**11.5**	**90.0**	**228.8**	**-263.7**	**29.6**	10.0	.40/.25
IC's	JRS/ DRoTS	*IC_UVA_1519*	**181.0**	**-12.9**	**90.0**	**185.9**	**268.0**	**30.2**	10.0	.40/.25
IC's	Roadbed Offset	*Offset_10mm*	-179.3	11.5	90.0	228.8	-263.7	29.6	**10.0**	.40/.25
IC's	Roadbed Offset	*Offset_7.5mm*	-179.3	11.5	90.0	228.8	-263.7	29.6	**7.5**	.40/.25
IC's	Roadbed Offset	*Offset_5mm*	-179.3	11.5	90.0	228.8	-263.7	29.6	**5.0**	.40/.25
IC's	Roadbed Offset	*Offset_2.5mm*	-179.3	11.5	90.0	228.8	-263.7	29.6	**2.5**	.40/.25
IC's	Roadbed Offset	*Offset_0mm*	-179.3	11.5	90.0	228.8	-263.7	29.6	**0.0**	.40/.25
BC's	Roadbed Friction	*Low_Fric*	-179.3	11.5	90.0	228.8	-263.7	29.6	10.0	**.40/.25**
BC's	Roadbed Friction	*Mid_Fric*	-179.3	11.5	90.0	228.8	-263.7	29.6	10.0	**.60/.45**

*** Static Friction / Dynamic Friction**

§ Equivalent Drop Height Based on Vehicle Speed

Results

Role of the different IC's between the tests

Two scenarios with IC's from either the two experimental tests with the UNSW JRS and the UVA DRoTS were simulated, as summarised in the section *JRS/DRoTS* in Table 1. In the simulated scenario *IC_UVA_1519*, the testing IC's from the UVA test were imposed to the FE model with the UNSW JRS. When imposing those IC's, the simulation did not indicate any significantly better correlation towards the results of the test with the UVA DRoTs. The graphs of the simulated vertical roadbed load and the simulated vehicle roll rate/roll angle are shown in Figures 3 and 4, respectively. The simulated curves for the modelled scenario with the IC's of the test with the UVA DRoTS were practically similar to the curves for the simulated scenario with the IC's of the test with the UNSW JRS. In other words, independently from the different IC's, both simulated scenarios were in significant disagreement with the corresponding curves from the actual experimental test with the UVA DRoTS. This indicated that the different IC's between the tests with the UNSW JRS and the UVA DRoTS were not the main reason for the different test outcomes. Therefore, the observed different outcomes for the two tests were likely caused by differences in either some of the BC's or some of the IC's other than those normally controlled or imposed in the test setup. The most likely IC and BC that may justify the observed different test outcomes were then identified to be the initial offset of the roadbed from the ground supports and the vehicle-roadbed friction, respectively.

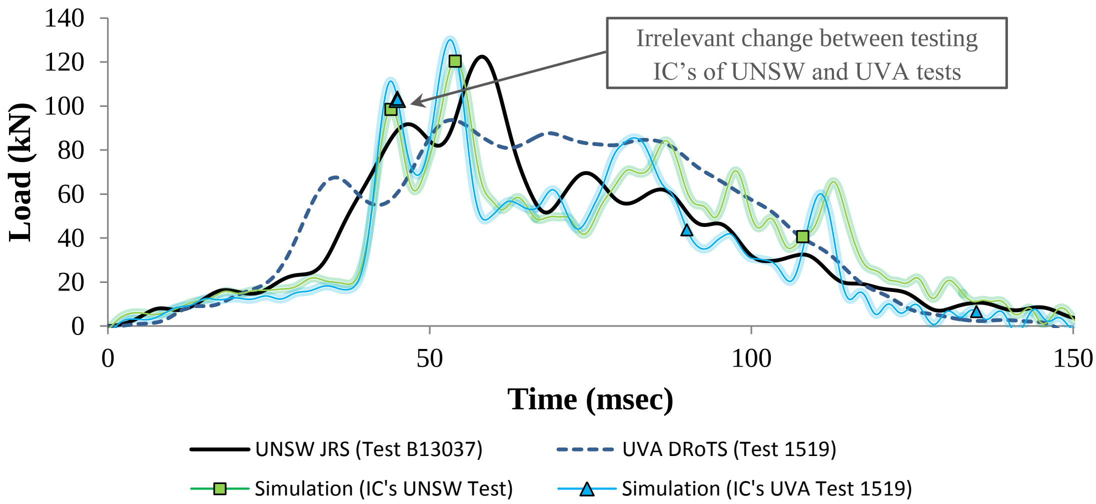

Figure 3: Simulated roadbed load – simulations at same IC's of each of the two tests (compared to experimental results).

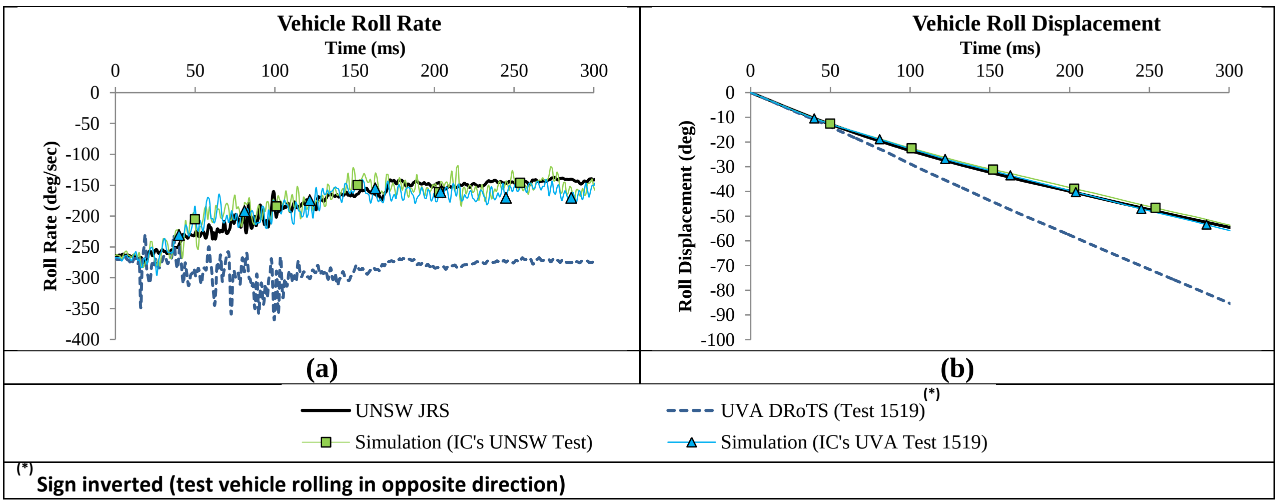

Figure 4: Simulated vehicle roll rate and rotation – simulations at same IC's of each of the two tests (compared to experimental results).

Sensitivity analysis on selected IC's/BC's

A preliminary parametric study was then conducted to investigate the potential role of the following two IC's/BC's of interest on the test outcomes: (a) initial roadbed offset from the ground support and (b) roadbed-vehicle friction.

Initial roadbed offset from ground supports

In previous research related to the development of the FE model of the UNSW JRS, the initial offset of the roadbed from the ground supports was found to have a considerable role on the impact force measured by the load cells that are embedded in the roadbed (Mongiardini *et al.*, 2016). Simulations showed that a larger initial offset between the roadbed and the ground supports can cause a higher peak load as well as a longer fluctuation of the impact force measured by the roadbed load cells. Both these effects are a consequence of the roadbed bottoming out on the ground supports, which ultimately causes the roadbed upper wood surface to apply an inertial force onto the load cells that are located immediately underneath. A smaller roadbed-support offset would likely reduce such inertial load, thus reducing the initial spike of the measured roadbed impact force. To further assess the influence of the roadbed-support initial offset on the force measured by the load cells, a series of simulations were then performed as part of this research by varying such offset between 10 mm and 0 mm, as summarised in the section *Roadbed Offset* in Table 1.

The simulated roadbed load from each investigated scenario as well as the experimental load that was measured during the tests with the UNSW JRS and the UVA DRoTS are shown in Figure 5. The corresponding peak loads are summarised in Table 2. Simulations confirmed that a reduction of the roadbed-support initial offset in the test with the UNSW JRS would have likely contributed to create a roadbed load much more similar to that measured in the test with the UVA DRoTS. In fact, a reduced initial offset between the roadbed and the ground rollers seems to contribute to reducing the first peak load, especially for offset values equal or less than 5 mm. Another general trend that was noticed is that the smaller the roadbed initial offset from the ground supports, the earlier the first peak load occurs. Such phase shift of the first peak load can be justified by an earlier bottom out of the roadbed in the case of a smaller offset.

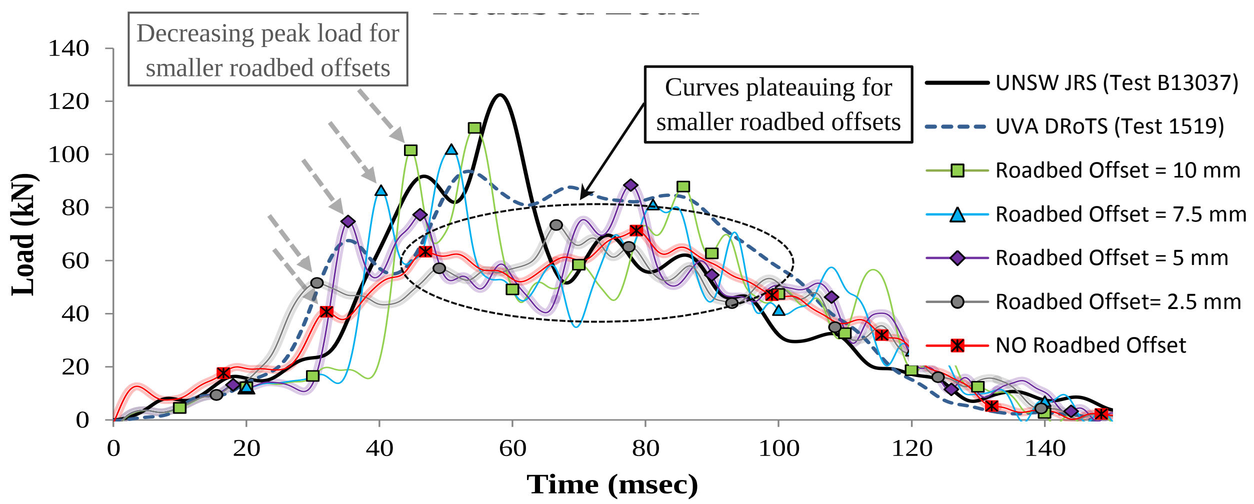

Figure 5: Simulated roadbed load varying the roadbed initial offset from ground support (compared to experimental results).

Table 2: Simulated peak loads varying the initial roadbed offset from the ground supports

Roadbed Offset	1st Peak: Peak Value (kN) [Peak Time (ms)]	1st Peak: Difference to UVA Test* (kN) [ms]	2nd Peak: Peak Value (kN) [Peak Time (ms)]	2nd Peak: Difference to UVA Test* (kN) [ms]	3rd Peak: Peak Value (kN) [Peak Time (ms)]	3rd Peak: Difference to UVA Test* (kN) [ms]
10 mm	101.5 [45]	34.0 [9]	109.9 [54]	16.3 [1]	87.9 [86]	19.3 [17]
7.5 mm	86.5 [40]	19.0 [5]	102.0 [51]	8.4 [-3]	81.0 [81]	12.4 [13]
5 mm	74.8 [35]	7.2 [0]	77.3 [46]	-16.4 [-7]	88.4 [78]	19.8 [9]
2.5 mm	51.6 [31]	-16.0 [-5]	57.1 [49]	-36.5 [-4]	73.4 [67]	4.8 [-2]
0 mm	40.7 [32]	-26.8 [-3]	63.3 [47]	-30.3 [-7]	71.3 [79]	2.7 [10]

***Values in square brackets indicate the peak time**

Further, for offset values smaller than 5 mm, the simulated roadbed load becomes more constant throughout the impact, which is another behaviour similar to what observed in the experimental test with the UVA DRoTS. This plateau of the simulated load curve is particularly evident for initial roadbed offsets from the ground supports equal to 0 mm and 2.5 mm.

In general, an initial offset between 2 mm and 4 mm seems to provide a marginally better match between the simulated roadbed load and the load measured during the test with the UVA DRoTS. However, it should be noted that the load simulated with a roadbed initial offset within the mentioned range appears to be lower than the load that was measured during the experimental test with the UVA DRoTS.

Roadbed-vehicle friction

The FE model of the UNSW JRS was used to simulate the rollover tests for scenarios with either a low or a medium level of friction between the roadbed and the vehicle, as summarised in the section *Roadbed Friction* in Table 1. A comparison of the simulated vehicle roll rate and roll rotations for these two investigated scenarios is provided in Figure 6.

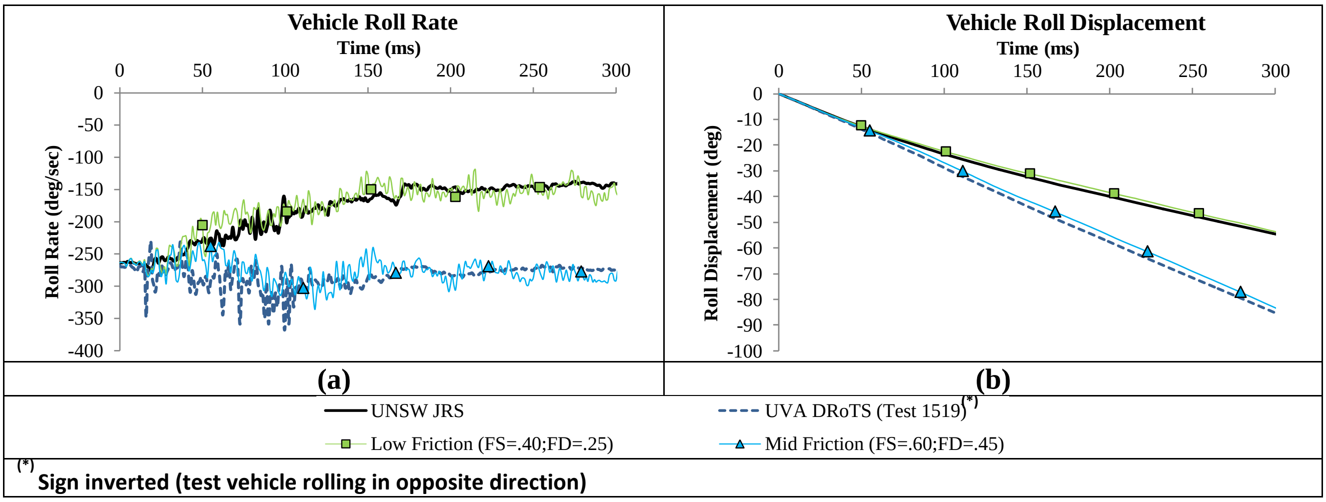

Figure 6: Simulated vehicle roll rate and rotation – scenarios with low and medium roadbed friction (compared to experimental results).

Simulations showed how an increased level of roadbed-vehicle friction would cause a roll rate and a corresponding rotation very similar to those that occurred in the test with the UVA DRoTS; whereas, at low level of roadbed-vehicle friction, the simulated vehicle roll rate and rotations matched well the experimental curves from the test that was conducted with the UNSW JRS.

Further, simulations confirmed the effect of the roadbed-vehicle friction on the vehicle stability during the test, as summarised in Figure 7. The vehicle clearly showed a tendency to bounce off the roadbed in the case of a higher roadbed-vehicle friction in a way very similar to what occurred in the test with the UVA DRoTS. On the other hand, in the case of a low roadbed-vehicle friction, a relative roadbed-vehicle sliding kept the vehicle in contact with the roadbed until the roadbed moved completely downstream, which is exactly what happened in the test with the UNSW JRS.

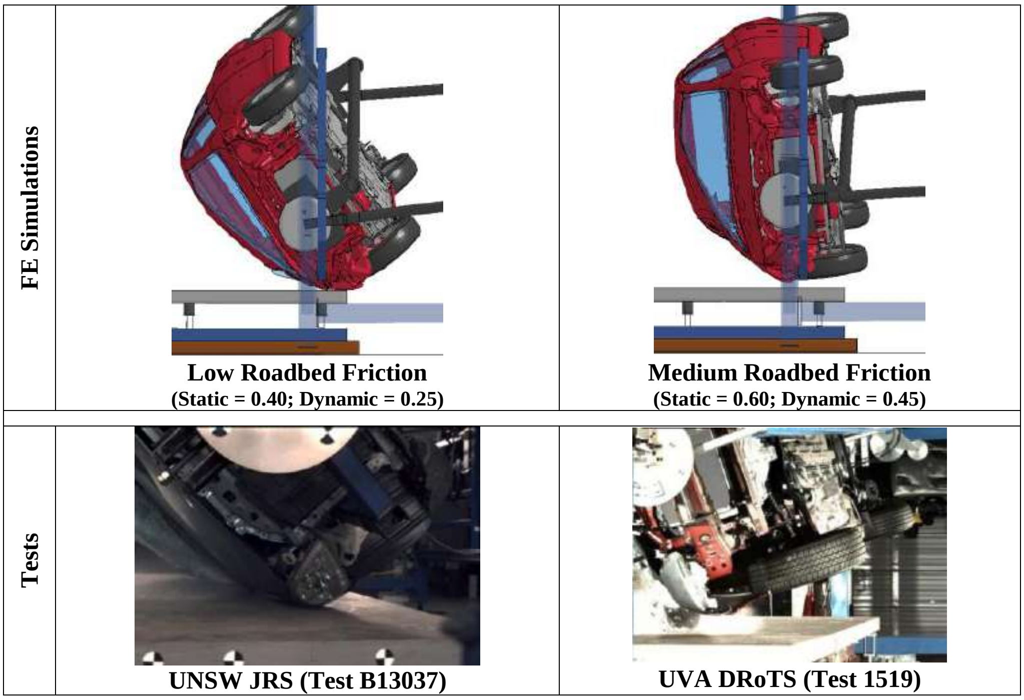

Figure 7: Simulated vehicle kinematics at low and medium roadbed friction.

Conclusions

The objective of this study was to identify relevant IC's/BC's that could affect the repeatability and reproducibility of rollover crash tests conducted using JRS-based devices. Detailed FE models of the UNSW JRS and a small passenger car were used to simulate how test outcomes would change when varying selected IC's/BC's. The results from the simulated scenarios were then compared against each other as well as against the outcomes from two experimental tests that were conducted under the same nominal conditions using similar JRS-based devices.

Initially, simulations confirmed that the slightly different IC's between the tests with the UNSW JRS and the UVA DRoTS cannot not explain alone the identified differences in the test outcomes in terms of both vehicle kinematics and roadbed load. Further, simulations indicated that IC's/BC's such as the initial roadbed offset from the ground and the roadbed-vehicle friction can significantly affect test outcomes. An initial roadbed offset from the ground supports may add a significant inertial component to the load measured by the roadbed load cells; whereas the roadbed-vehicle friction can considerably affect the vehicle roll rate. To improve repeatability and reproducibility of test results, it is then suggested that standard values should be considered for these IC's/BC's in any future rollover crash test protocol for JRS-based devices. Also, it is proposed that a baseline test would be used for calibrating JRS-based devices. A baseline test would facilitate the process of assessing whether a testing device would be able to reproduce results that are comparable to other similar devices. Obviously, the protocol for such baseline calibration test should impose specific values as well as corresponding uncertainty ranges for both the roadbed-vehicle friction and for the initial clearance between the roadbed and the ground supports. The IC's/BC's of the rollover crash test initially conducted by UVA using the DRoTS would be reasonable for a baseline test that aims to calibrate rollover test devices with a small passenger car.

The conclusions found throughout this research are purely based on results obtained using computer simulations. Despite the accuracy of the simulations have been proven through a previous accurate validation of the model, a final confirmation of the main findings from this research should be obtained by means of one or more targeted experimental tests in the future. Also, all the simulated scenarios in this research considered the specific UNSW-JRS configuration, with both control arms that hold the vehicle during the test working under tension. However, the UVA DRoTS has opposite control arms, with the arm that is connected to the front of the of the vehicle working under compression and the other arm working under tension. Further investigation should be carried out to assess any potential influence that such different configuration of the front control arm may have. Finally, the findings that have been described in this paper should be considered as a part of a preliminary investigation. Future investigation should be carried on to identify any other IC's/BC's that may play a relevant role in determining the outcomes of rollover crash tests conducted using JRS-based devices. Examples of IC's/BC's that should be investigated include the initial pitch angle at impact or an undesired offset of the vehicle roll axis.

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Future vehicle safety in Australia and the role of the Australasian New Car Assessment Program

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Abstract

For more than twenty years the Australasian New Car Assessment Programs (ANCAP) has encouraged improvements in vehicle safety beyond the regulatory system.

ANCAP has announced plans to align its safety ratings with those of Euro NCAP from 2018. This will result in greater emphasis on crash avoidance technologies such as autonomous emergency braking (AEB) as well as protection of small occupants, pedestrians and cyclists.

We review the influence of ANCAP on improved crashworthiness of the vehicle fleet and the uptake of key vehicle safety technologies. The trends show that ANCAP can have a substantial influence on the safety of the future Australian light vehicle fleet.

Research Question/Objective

To analyse the trends with improvements to vehicle safety, to identify the possible influence of NCAP safety ratings on the uptake of key safety features and to predict the potential influence on the safety of the future Australian light vehicle fleet.

Methods

Collect historical data on NCAP ratings and fitting rates of key safety features such as head-protecting side airbags, electronic stability control, intelligent speed assistance and autonomous emergency braking. Analyse the trends by year. Identify when various initiatives were introduced by NCAPs, and other sources such as regulations.

Results

NCAPs have contributed improved vehicle safety over the past 15 years and have accelerated the uptake of important safety features. There is potential for this to continue, particularly under the plans to align ratings with those of Euro NCAP. This should result in faster uptake of technologies such as AEB and better protection for small occupants, pedestrians and cyclists, compared with the current ANCAP Road Map.

Limitations

Fitting rates for certain safety features have to be estimated due to the lack of reliable information. There are numerous factors that influence improvements in vehicle safety and so the exact contribution of NCAPs cannot be accurately quantified

Protective Clothing and Impact Protection for Motorcyclists

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Abstract

Impact protectors are worn by motorcyclists to reduce the risk and severity of injuries in crashes, but previous research reports no benefit in terms of preventing fractures. This study examined the performance of impact protectors worn in serious injury crashes and their energy attenuation performance when tested under the European Standard (EN1621-1). Eighty-three percent of impact protectors tested met Standard requirements. While only 4 impact injuries (defined as fractures, dislocations, avulsions) occurred in protected regions, no association between energy attenuation and these injuries was found. Characteristics other than energy attenuation may be important for protection, but further research is needed.

Background

Impact protectors (IP) reduce overall injury risk in motorcycle crashes (de Rome et al., 2011). Nygren (1987) and Otte et al. (2002) have shown IP can attenuate sufficient energy to reduce fracture severities in the laboratory. There is little evidence that the use of IP commonly used in protective equipment for motorcyclists are effective in reducing the risk of fractures. These IP usually comply with the European Standard EN1621-1, which sets minimum energy attenuation requirements. Two studies were conducted to examine (i) the effectiveness of IP worn by Australian riders in crashes, and (ii) the energy attenuation performance of IP, and how this relates to real world injury outcome.

Method

Motorcycle riders (n=90) were recruited as part of a previously reported in-depth study (Brown et al., 2015). Impact injuries, (i.e. fractures, dislocations, avulsions) due to impact to shoulders, elbows, hips and/or knees were identified from medical records. Details of IP worn were collected from interview, and clothing was inspected where possible. Clothing damage and/or presence of impact injury were used to identify body regions impacted. Study 1 examined associations between IP use and impact injury using multi-level regression to control for confounders. (See Figure 1)

In Study 2, IP from clothing (n=76) was categorised by CE certification and the association between CE certification and impact injury was examined using Fisher's Exact test. IPs were tested to energy attenuation requirements of EN1621-1, based on average and maximum transmitted force. (See Figure 1) Associations between energy attenuation and injury were examined using logistic regression accounting for repeated measures.

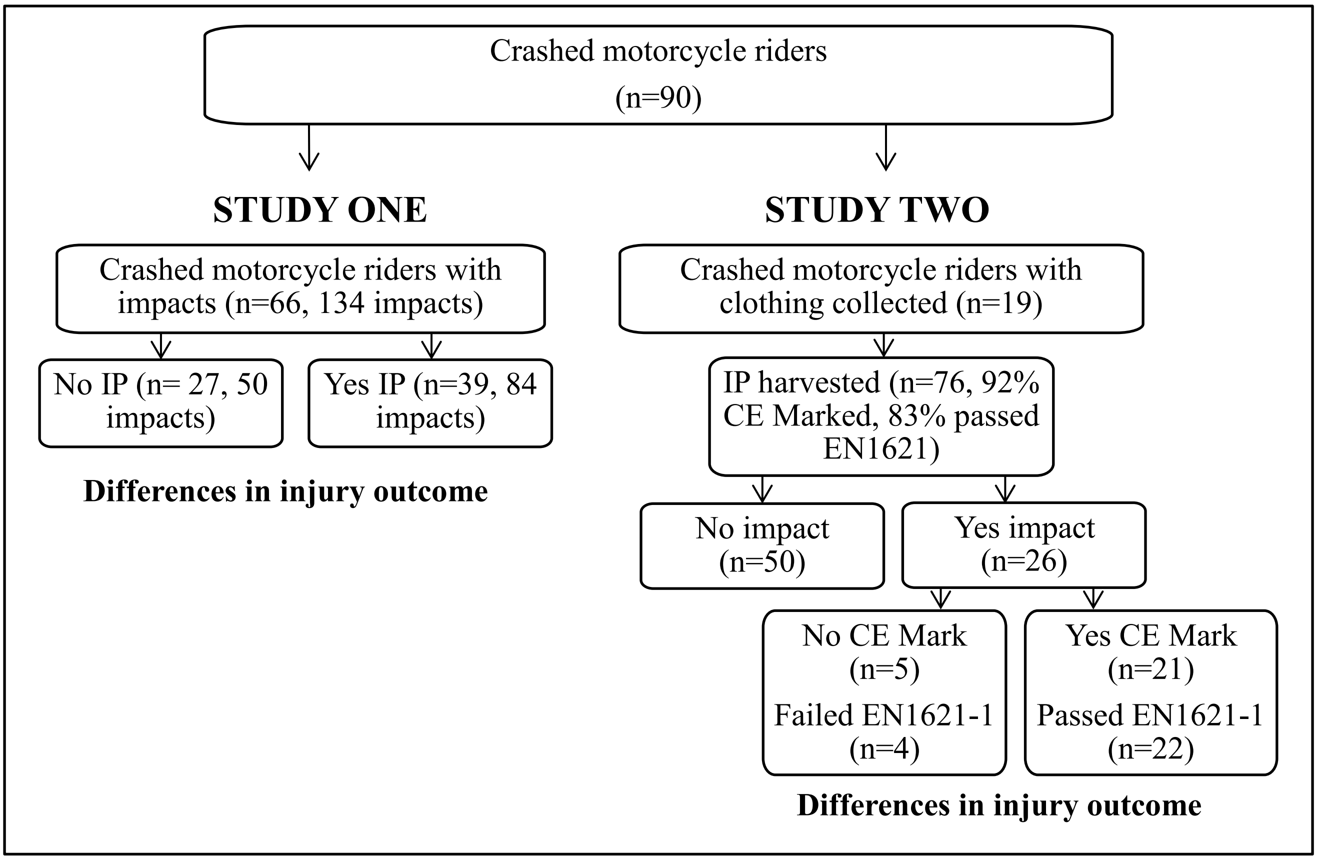

Figure 1: Flowchart of study design

Results

Study 1 identified 134 impacts (66 riders) across IP locations, with 84 impacts (39 riders) identified in regions where IP was present. There was no significant difference between number of impact injuries (OR = 1.28, 95% CI: 0.47-3.53) or injury severity (OR = 0.81, 95% CI: 0.17-3.82) in IP protected and unprotected regions.

Among the 76 IPs harvested from 19 riders in Study 2, four impact injuries occurred out of 26 identified impact locations. Ninety-two percent of harvested IPs were CE marked, and 83% of IPs harvested passed the energy attenuation requirements of EN1621-1. No significant difference was found between CE certification and impact injury (p = 0.6, Fisher's Exact test), or impact injury and meeting EN1621-1 requirements (p = 0.5, Fisher's Exact test). Additionally, there was no association between average force transmitted in the EN1621-1 test and presence of impact injury (OR = 1.1, 95% CI: 0.91-1.24); however, as maximum force transmitted increased, impact injury was more likely (OR = 1.1, 95% CI: 1.01-1.2).

Conclusions

The results confirm findings of de Rome et al (2011). Although most IPs met EN1621-1 requirements for energy attenuation, meeting this requirement was not associated with a reduced likelihood of the injuries studied. Study limitations including the small hospital-recruited sample suggest further study is warranted. Furthermore, the small number of riders with impact injuries in regions covered by IP suggests there may be some benefit, apart from the ability of the impact protector to attenuate energy when tested to EN6121-1.

Table 1: Occurrence of impact injury in riders with impact protection, CE certified impact protection and impact protection which passed EN1621-1 energy attenuation requirements.

		Impact Protection Worn (n=134)		**CE Certified (n=26)**		**Passed EN1621-1 Requirements (n=26)**	
		Yes	**No**	**Yes**	**No**	**Yes**	**No**
Impact Injury	**Yes**	42 (59%)	42 (67%)	3 (14%)	1 (20%)	3 (14%)	1 (25%)
	No	29 (41%)	21(33%)	18 (86%)	4 (80%)	19 (86%)	3 (75%)

Acknowledgments

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Motorcycle protective clothing: impact on cognitive performance and mood when worn in hot conditions

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Abstract

Thermal discomfort is a disincentive to motorcyclists wearing protective clothing in hot conditions. Previous work has established that products currently available to Australian riders potentially impose an uncompensable heat stress upon riders in average Australian summer conditions. This study was designed to examine the potential for the physiological and cognitive concomitants of heat strain to compromise rider safety.

The results demonstrated increased reaction times, perceived workload and mood disturbance associated with increasing heart rate, body core and skin temperatures. These results confirm the importance of establishing the performance thresholds required of motorcycle protective clothing suitable for use in hot conditions.

Background

Motorcycle protective clothing is primarily designed to reduce the risk of injury in contact with the road surface. However, as in many other occupations (e.g. firefighting, military), there is often a compromise between protection and thermal comfort because the materials used are often highly insulating, reducing the body's thermoregulatory system and potentially inducing heat strain (Caldwell, Patterson, & Taylor, 2006; Faerevik & Reinertsen, 2003). Over twenty years ago, thermal discomfort due to protective clothing in hot conditions was first identified as a potential safety risk for motorcyclists, but little work has been done to explore this issue (de Rome, Taylor, Croft, et al., 2015b; EEVC, 1993). The aim of this study was to examine the physiological and cognitive impacts of wearing motorcycle protective clothing in hot conditions.

Method

Eight volunteers completed 90 minute tests under controlled climate conditions (35°C, relative humidity 45%), representing average summer conditions in urban areas in Australia. Participants wore full motorcycle gear including the jackets and trousers previously found to have the lowest thermal permeability of ten tested suits (de Rome, Taylor, Troynikov, et al., 2015a). Sun and wind speed were simulated using overhead, infra-red lamps and fan (velocity 30km.h^{-1}), respectively. Heart rate, body core and skin temperature were continuously monitored. Computer-based cognitive tests of reaction-time, workload -Raw Task Load Index (RTLX(Byers, Bittner, & Hill, 1989)) and mood -Visual Analogue Mood Scale (VAMS(Bond & Lader, 1974)) were conducted at baseline, 30-min intervals and post-trial. Results are presented descriptively.

Results and Conclusions

Over the 90-min trial, heart rate increased by 81% (60 beats.min^{-1}),while body core and skin temperatures rose by 1.7°C and 3.2°C, respectively. Perceptions of workload demand increased by 68% and negative mood scores almost trippled (147%). Reaction time and the number of errors decreased in the first hour by 5% and 37%, but increased in the last 30 min (9%, 25%).

These results demonstrate the potential for heat strain to increase fatigue perception and to negatively affect reaction time and mood. The findings suggest motorcycle protective clothing that impairs thermoregulation may also compromise a rider's capacity to manage the riding task safely under hot conditions.

Acknowledgement

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Development of Ranking Equations for a Protection Level Star Rating System for Motorcycle Clothing

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Abstract

Motorcyclists are one of the most vulnerable road users on Australian roads. Motorcycle protective clothing may reduce the incidence and severity of injury in crashes, however a substantial proportion has been found to fail under crash conditions. The aim of this research was to develop an evidence-based system for rating protective motorcycle clothing to enable motorcyclists to make informed purchasing decisions. A set of equations and weighting systems were developed based on the results of 21 garments tested to the European Standard for protective motorcycle clothing (EN13595:2002). This work provides a first step towards consumer information for protective motorcycle garments.

Background

Usage of motorcycle protective clothing (PPE) may reduce the risk and severity of injury in crashes, however a substantial proportion of garments fail under crash conditions.(L. de Rome et al., 2011) The protection provided by the PPE available in Australia varies widely, is not predicted by cost or brand name nor are there any other indicators of likely protective performance or suitability(L de Rome & Stanford, 2006; Haworth, de Rome, Varnsverry, & Rowden, 2007; Hoare, 2009). Research commissioned by the Motor Accidents Authority of NSW recommended an independent scheme for testing and rating motorcycle protective clothing could reduce injuries and improve the quality of products in the market. (L de Rome et al., 2012)

For such a rating system to be effective it must encompass the different types of clothing damage sustained in crashes, specifically: abrasion, burst, tear, cut and impact and also fastenings failure.(Woods, 1996) The European Standard EN13595:2002 specifies tests to address garments' resistance to each form of damage.(CEN, 2002)

This paper focuses on the derivation of the calculations for impact abrasion resistance, which is the most commonly reported type of damage (L de Rome, Meredith, Ivers, & Brown, 2014). Other types of damage will be addressed in future work.

Methods

The impact abrasion resistance of 21 locally-purchased all-season motorcycle protective jackets and pants (leather=3, textile=18) were tested on a Cambridge impact abrasion tester (Mesdan LAB, Italy) as specified by EN13593-2:2002. Garments consisting of more than one fabric structure were tested in composite and separately for each layer's contribution to impact abrasion resistance.

Under EN13593-2:2002, injury risk is defined into four zones with risk levels highest in zones 1 and 2 and lower in zones 3 and 4. These zones were used to define the area coverage of protection for each garment and for each fabric type separately. A numerical value for the protective value of the garment was calculated using the abrasion resistance test results and percentage of protective coverage, weighted by zone to account for the associated increased injury risk. The resulting scores were validated by visual inspection based on the abrasion resistance test results and areas of coverage by an independent assessor with experience in testing protective clothing.

Results and discussion

There was a strong correlation (r^2=0.95) between the calculated protection factor and visual ratings, indicating that objective measures are available to provide a numerical basis for rating the abrasion damage resistance of motorcycle protective clothing.

The proportion coverage-base as an element of the protection factor is intended to discourage manufacturers from decreasing the coverage area in high risk zones. The protection factor calculations were designed to provide increased importance to protection levels and coverage of zones 1 and 2.

This work successfully demonstrates a means of using the test methods of the EU Standard to evaluate the protective abrasion resistance performance of motorcycle garments. For the star rating system, the protection factor will be based on test results for resistance to each damage type.

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Comparative Performance of the Cambridge Abrasion Machine in Different Laboratories

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Abstract

Motorcycle protective clothing has been well established as an effective means of preventing abrasion injuries to motorcycle riders involved in crashes, yet the performance of this clothing can be variable. The European Standard for motorcycle protective clothing assesses the abrasion resistance quality of motorcycle protective clothing using tightly specified equipment. The absolute time required to abrade a material is reliant on the specifications of the abrasion machine, and it is unknown if measurements taken on machines with different specifications can provide useful information. This study examined the abrasion resistance of materials tested on two different machines built to slightly different specifications. These results confirm machines of different specifications can produce comparable results, and demonstrate capacity to use a non-standard machine to examine comparative performance of materials.

Background

Specifically designed protective clothing has been proven to prevent soft tissue injuries among motorcyclists; however, the performance of this protective clothing in Australia can be variable (de Rome et al., 2011). One International Standard which is designed to assess the performance of motorcycle protective clothing is the European Standard for motorcycle protective clothing, EN13595. EN13595 assesses the ability of materials used in protective clothing to resist the most common types of garment damage: abrasion, burst, cut and tear. While there is a European Standard for motorcycle clothing, there is no Standard in Australia, and garments certified to this Standard are difficult to obtain from motorcycle clothing retail outlets in Australia. While there is an Australian set of guidelines for the construction of motorcycle protective clothing, these are not mandatory and the abrasion guidelines are based on an irrelevant test procedure which applies a very gentle abrasion to the fabric. This tests the normal wear and tear of the material rather than resistance to the level of abrasion that motorcycle clothing would be subjected to when a rider slides across the roadway following a crash. This means that the adequacy of protective clothing available to Australian motorcyclists is unknown and moves are being made to provide information to Australian motorcycle riders on the quality of the clothing being sold.

According to EN13595, abrasion resistance performance must be assessed using a Cambridge abrasion machine and specifications for this machine are contained within the Standard. The Cambridge abrasion machine was a machine that was developed by Woods (1996a) in order to be able to test motorcycle clothing on a Standardised test machine. The Cambridge abrasion machine is a method for assessing abrasion resistance of materials that involves dropping a sample of material onto a moving abrasive belt and timing the length it takes the material to hole, where a hole is any small visible gap opened through the fabric. Woods developed the machine through replicating the damage seen to 32 garments damaged in real-world crashes and during dummy crash tests (Woods, 1996b). Woods manipulated the height that the fabric is dropped, the belt grit, the speed of the abrasive belt, the force at which the material is held onto the abrasive belt and the contact area of the sample on the belt until the damage seen to the clothing in the real-world and dummy tests was replicated. To determine an appropriate drop height, samples were lowered gently onto the belt or dropped from heights of up to 1.5 m. A drop height of 50 mm was deemed to be appropriate and gave results consistent with the dummy tests. For drop heights greater than 50 mm, those materials that had a low tear strength tore on impact. Belt abrasion grits OP24, OP40, OP60 and OP80 were tested. The OP80 belt could not be kept sufficiently clean while, due to the larger grit size of the particles, the OP24 and OP40 belts gave very short abrasion times, so the OP60 belt was the most appropriate. The force on the sample holder was increased progressively from 3 kg (29.4 N) to 5 kg (49 N) while the abraded area was reduced until damage replicated. The final force was chosen to be 49 N and contact area 1963 mm² as this was the force with which the damage was replicated (Woods, 1996a, 1996b).

We have previously demonstrated that the EN13595 method is a valid way to evaluate the abrasion resistance quality of protective clothing designed for motorcyclists where the time taken for materials to abrade when subjected to the Cambridge method is related to the probability of a rider sustaining soft tissue injury (Meredith et al., 2015). However, the absolute time required to abrade any particular material is reliant on the specifications of the abrasion machine. In this study, we have examined the abrasion resistance of materials tested on two different Cambridge abrasion machines built to slightly different specifications.

Method Overview

Testing was conducted on two different machines that were specifically designed to perform in a similar manner to the Cambridge abrasion machine. Machine 1 is located at Neuroscience Research Australia and was built to conduct experiments examining the abrasion resistance performance of clothing worn by Australian motorcycle riders. This machine differed from the Cambridge abrasion machine specified in EN13595 in that it operated at a 40 N (4.1 kg) compressive load on the sample, rather than the 49 N specified in the standard, due to limitations of the equipment. The sample size diameter was also reduced to maintain the same contact pressure (25 kpa). All other specifications including belt grit were the same as that specified in EN13595. Machine 2 (made by Mesdan LAB, Italy) meets all specifications of the test equipment detailed in EN13595 and was purchased as a Cambridge abrasion machine to test clothing to EN13595. It is located at Deakin University, Australia.

This study involved a two-stage method. In stage 1, reference materials were tested on both machines to establish a scaling factor that could be applied to ensure equivalency of results from the two machines. In stage 2, motorcycle garments worn by riders who had crashed were purchased and tested on the two different abrasion test machines and the scaling factor derived from Stage 1 was applied.

Method – Stage 1

A scaling factor was derived from testing reference material on both machines using the EN13595-2 protocol as described in Stage 2. The reference material is a standard canvas specified in EN13595-2. Two layers of the reference fabric were measured for each test. Six samples of reference material were tested, two along the warp, two along the weft and two at 45 degrees to the warp and weft. Once the average abrasion time for the reference material was obtained for both abrasion machines, the ratio between the two abrasion times was computed. This scaling factor could then be used in Stage 2 to scale the abrasion time results obtained from Machine 1.

Method Stage 2

Sample

The data used for this study was collected during in-depth crash investigation (Brown et al., 2015) . In summary, motorcycle riders who had been involved in motorcycle crashes were recruited from two Sydney hospitals and one regional hospital from August 2012. To qualify for the study, riders had to be at least 16 years of age and had crashed on public roads within the study area. Following recruitment, riders were required to complete a face-to-face interview and the hospital medical records were reviewed. The scene where the crash occurred and the motorcycle ridden at the time of the crash were also inspected for crash evidence. Where possible, clothing was inspected and then collected from riders for testing. Clothing was sometimes unable to be inspected or collected due to the clothing having been thrown out, sent to insurance companies or lack of rider consent. If the clothing was inspected but the rider did not consent for the clothing to be kept and tested, the brand name and model of the clothing was recorded and new clothing items were purchased to the same specifications.

Test methodology

Testing was conducted in line with the test procedures outlined in EN13595. In summary, six circular samples of each material in the garment were retrieved from the garment, each with a diameter of 160 mm and containing all layers of fabric in the clothing at that location. Samples were taken from locations where there was no crash damage and where a large enough sample of material was available. Most of the garments did not follow the clothing template in EN13595, so the samples were not cut according to the template. Instead, the zones with which that material formed part of were recorded. If there was not enough material to obtain six samples, as many samples as possible were obtained. Samples were then attached to the sample holder using a hose clamp. Fibres were oriented either along the warp, weft or at 45 degrees to the warp and weft so that there were two samples tested at each fibre direction. If six samples were unavailable, at least one sample was tested in each direction. If only two samples were available, both were tested at 45 degrees. Once the sample was prepared, the motor was then switched on and the abrasive belt brought up to the appropriate speed (8 m/s). The sample holder with the fabric sample attached was then dropped onto the moving belt and the time taken for the fabric to abrade through was measured. As specified in the Standard procedure, after every 10 tests, a reference fabric was tested to adjust the abrasion time to account for wear of the abrasive belt during testing. In Stage 2, materials from 11 upper garments and 11 lower garments were tested on the two abrasion machines, and the scaling factor calculated in Stage 1 was used to adjust the times obtained from Machine 1. This was achieved by dividing the abrasion time to hole result by the scaling factor. Abrasion times measured from Machine 2 were used without any scaling.

Analysis

Data collected using the procedure that was described above was used to examine the relationship between the scaled time-to hole of the materials tested on Machine 1, and the measured time to hole obtained from Machine 2.

This was achieved using inter-rater reliability statistical procedures. A two-way, mixed, intra-class correlation (ICC) was used to assess the inter-rater reliability between the abrasion times of the garments tested on both machines. The single-measures absolute agreement ICC was analysed and given a rating, with ICC values of less than 0.40 being poor, an ICC between 0.40 and 0.59 being fair, an ICC between 0.6 and 0.74 being good and an ICC for values between 0.75 and 1 being excellent (Hallgren, 2012). Following this, the variance was checked visually using a Bland-Altman plot. The Bland Altman plot is a plot of the difference between the two results obtained from each method against the mean or average results from the two methods which gives a visual representation of variance.

Results

The scaling factor derived from testing the reference material in Stage 1 was 6.26. This scaling factor was applied and the adjusted average abrasion time results as measured on the two abrasion machines can be seen in Table 1. The garments lasted typically around the 2.5 second range, with the average values being similar between the two machines.

Table 1. Average abrasion time for the investigated materials as measured on the different abrasion machines

	Machine 1		**Machine 2**	
Clothing item	**Abrasion time (sec)**		**Abrasion time (sec)**	
	Mean (sd)	Range	Mean (sd)	Range
Upper garment	2.53 (2.84)	0.14-8.96	2.33 (2.09)	0.1-6.84
Lower garment	2.50 (4.44)	0.14-20.36	2.55 (3.11)	0.5-13.69

The results of the inter-rater reliability test comparing the scaled times from Machine 1 with the actual times obtained from Machine 2 are displayed in Table 2. The inter-rater reliability was excellent, with an ICC of 0.9 (95%CI: 0.828-0.953).

Table 2. Inter-rater reliability of the abrasion results from the two abrasion machines

Variable	**ICC**	**95% CI**	**p-value**
Abrasion time	0.909	0.828-0.953	<0.0005

The one sample t-test found that there was no significance in the difference between the final abrasion times for each material and zero. The Bland-Altman plot is shown in Figure 1. The data on the difference between abrasion times was evenly distributed above and below the mean of the differences between abrasion times with a 95% confidence interval of -2.884 to 2.75 demonstrating good correlation between the two machines. There is one outlier with an average abrasion time of the two results being 17 seconds which reflects the properties of the material used in this garment – in both tests this material took a much longer time to abrade than the other materials.

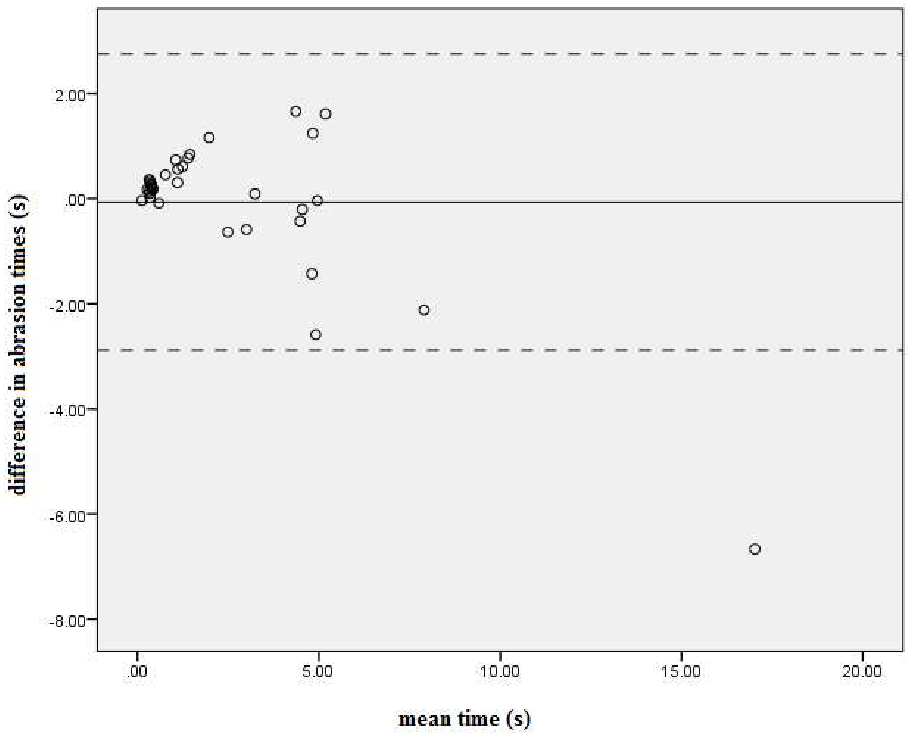

Figure 1. Bland-Altman Plot

Discussion

The key finding of this work was that the correlation between the scaled data on the Machine 1 and Machine 2 was excellent, with an ICC of 0.9. The Bland-Altman diagram supported these findings, with the data being evenly distributed around zero and not significantly different from zero (Figure 1). The average abrasion times for the materials tested in the garments worn by the riders in this study were also similar between the two abrasion machines, with average abrasion times being around 2.5 seconds.

The implication of this finding is that even though a machine may give different times to hole if it is calibrated against a standard machine it can have a calibration factor established for it. This suggests that the abrasion results from Machine 1 were at a set interval from those on Machine 2. This aligns with the observations of Woods in his development of the Cambridge abrasion machine where he reported that the size and pressure of the abrasion head could be scaled to accommodate for measuring samples of different sizes (Woods, 1996a).

Regardless of the differences between the machines, there appears to be inherent variability in the test results within materials tested on the same machine. These small errors may be due to intrinsic problems with the test procedure. The accuracy and sensitivity of the timing mechanism as well as the exact alignment of the fabric, the tautness of the sample on the sample holder and small differences in the abrasive belt may all affect the end result. One way to address this problem may be to add some tolerance levels to the time measurements to allow for these inherent errors.

An additional difference observed between the behaviour of the materials on the different machines was the bursting of some fabrics on Machine 2. This bursting was not observed when the material was subjected to the lower force in Machine 1. The bursting discussed here differs from the bursting identified in the EU Standard as it occurs to the actual material and not the seams of the garment and is characterised by long strips of material in the holing region. This burst damage occurs for some materials as soon as the fabric impacts with the abrasive belt, and the material does not have time to abrade (Blight, Phillips, Hickling, & Hurren, 2015). This lack of bursting in Machine 1 may actually be of benefit for this testing as the garments can be properly ranked in terms of their abrasion resistance. However, this depends on whether or not the burst behavior of these materials on Machine 2 is consistent with what occurs in the real-world. If this is as an accurate representation of the materials' behavior in crashes, the garments may perform better in the laboratory than they really would in the real-world. Further investigation of the behaviour of materials in the real-world is warranted to determine whether the burst behavior is realistic or not.

Other limitations to keep in mind include the small number of garments tested for abrasion time, and that this investigation only compared two abrasion machines differing on the force with which the sample is abraded and the contact area. Other significant variations between machines may have different effects. Despite this, the high correlation between the abrasion times of the different machines does indicate that a scaling factor can successfully be employed. Additionally, while the exact value of the abrasion times were different on the different machines, the materials were ranked in the same order and the difference between the abrasion times of the two machines were at a set interval. This further indicates the applicability of a scaling factor.

Conclusions

These results confirm that Cambridge abrasion machines of different specifications can produce comparable results when a scaling factor is applied to the abrasion time. Furthermore, the results demonstrate the capacity to use a non-standard specific machine to provide a valid examination of the comparative performance of materials designed for motorcycle use. The importance of this is that it shows that even though a machine may give different times to hole if it is calibrated against a standard machine it can have a calibration factor established for it.

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UNECE Regulation 22.05 Motorcycle Helmets in Australia

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Abstract

The recent regulatory shift regarding the motorcycle helmets both approved for sale and approved for use on the road in Australia is likely to lead to significant change. It is now possible to import, sell and use UNECE Regulation 22.05 Protective helmets and their visors for drivers and passengers of motor cycles and mopeds as well as AS/NZS 1698 Protective helmets for vehicle users on the roads in Australia. The question for the Australian consumer is will these significant changes produce simpler, more understandable regulation and cheaper and safer helmets.

Background

The pressure for this change came from several areas of the community. The framework for the change was setup at the Standards Australia Forum on AS/NZS 1698 in 2015, which focussed on:

Harmonisation of regulatory requirements within Australia;

Harmonisation with international standards; and

Related matters of cost, safety, certification and supply.

These aims of this Forum followed and conformed with the Federal Government's desire to cut business red tape such as Australian standards which differ from international standards; to eliminate technical barriers to trade; and, encourage a low cost, business-friendly environment by the acceptance of international standards.

Method

This paper examines the effect of these regulatory changes on safety of motorcycle helmets available to the consumer in Australia.

A major Cochrane Collaboration by Lui et al. (2009) of available helmet effectiveness studies found that motorcycle helmets were 45% effective in reducing fatality risk and 69% effective in reducing the risk of serious injury. There was insufficient evidence to demonstrate whether differences in helmet type confer more or less advantage in injury reduction. This indicated that there was little value in comparing the technical attributes of the helmets defined by the test requirements within the two standards.

Other areas of the standards were reviewed for substantial differences. The responsiveness of each standards setting process was compared for demonstrated adaptable and timeliness in its changes to keep track with helmet developments on the market. The differences in the quality assurance regimes of the two standards were investigated as well as how well these regimes met the **ISO/IEC-17065 Conformity assessment -- Requirements for bodies certifying products, processes and services** and **ISO/IEC-17067 Conformity assessment - Fundamentals of product certification and guidelines for product certification schemes**.

The quality assurance process based on these requirements by a major international helmet manufacturer with a presence in both the European and Australian markets was reviewed. The internal processes used by the manufacturer highlighted the differences required for conformity assessment for each jurisdiction. A substantiation of compliance must be demonstrated by the collection of test and inspection documentation regarding type testing, production qualification and on-going batch testing.

The differences in the production qualification regimes between the standards were investigated. Forty identical Australian certified helmets were tested to the UNECE Regulation 22.05 sampling protocols for comparison and to investigate the statistical variation of the AS/NZS 1698 flat energy attenuation test results.

Results

The test results demonstrated that this Australian certified helmet was unable to meet the production qualification requirements of UNECE Regulation 22.05.

Conclusions

For the Australian consumer, adding helmets meeting UNECE Regulation 22.05 motorcycle helmet approved for sale and use on the road to AS/NZS 1698 helmets will produce simpler more understandable regulation as well as cheaper and safer helmets. For this to be successfully implemented will require a means of proof of substantiation of helmet conformance with the provisions of Australian Consumer Law (ACL).

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Conformity assessment -- Requirements for bodies certifying products, processes and services

Magnitude and risk factors of Road Traffic Injury Disabilities: evidence from Bangladesh Health and Injury Survey

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Abstract

There are indications that RTIs are increasing in Bangladesh; exact magnitude and risk factors of RTI disability in Bangladesh is unknown. A cross sectional study was conducted through multistage cluster sampling to investigate the magnitude and risk factors of RTI disabilities within 819,429 populations. Incidence of fatal and non-fatal was 12.9 and 134.5 per 100,000 population respectively. The incidence rate of RTI disability was 163.5 per 100,000 population. A significantly higher rate was observed among males and rural areas. Most of RTI disabilities found among pedestrians. RTI disabilities are an important public health issue in Bangladesh and need preventive interventions.

Background

Road traffic injuries (RTIs) are a leading cause of morbidity, disability and mortality in Low and Middle Income countries (LMICs). In 2004 nearly 1.3 million people of all ages were killed in road traffic crashes and over 50 million were injured or disabled. Every year, around 80,000 children aged 5-14 in LMICs loses their right to education for a single tragic reason, that of RTIs. Like other LMICs the available data indicate that RTI fatalities and morbidities are increasing in Bangladesh. According to World Health report (WHO) reveals that disability prevalence is much higher in LMICs compared to high income countries and about 15% (over one billion people) of the world's population lives with some sort of disabilities. The main cause is RTI. The exact magnitude and risk factors of RTI disability in Bangladesh is unknown.

Objective

Investigate the magnitude and risk factors of RTIs and its disabilities in Bangladesh.

Methodology

A cross sectional study was conducted between November 2002 and August 2003 in Bangladesh. Multistage cluster sampling method was used to choose a nationally representative sample of 171,366 households from both the rural and urban areas of the country comprising of a total of 819,429 populations. Standard verbal autopsy were administered to determine the cause of deaths or morbidities. Data were collected by face to face interview.

Results

The overall incidence of RTIs fatality was 12.9 per 100,000 population. The mortality rate gradually rose from children under 5 and peaked in the older age group, 55 years and above, (21.4 per 100,000). The overall rate of non-fatal RTI was calculated as 134.5 per 100,000. The highest incidence (165.7 per 100,000) was in the 20-39 years age group. A significantly higher rate of RTI mortality and morbidity was observed among males. The incidence of RTI was found to be three times higher in rural than urban areas. Most RTIs were non-motorized vehicle and pedestrian injuries.

The incidence rate of RTI disability for different duration was 163.5 per 100,000 population. The highest incidence of RTI disability (330.4 per 100,000 population) was observed among the males of the most productive age (30 – 54 years) group. Similar to the RTI fatalities significantly higher rates of disabilities were observed among males than the females in all age groups. Highest proportion of RTI victims suffer from disability for duration of more than one week to less than one month. Most of the disabilities found among pedestrians who were injured.

Conclusions

Road traffic injury is an important public health issue in Bangladesh. Immediate attention should be made to strengthen preventive intervention measures specially disability due to RTIs.

Road Users' Avoidance of Safety Measures: Challenge on Road Safety: An Experience from Nepal

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Abstract

In recent years, Nepal has been progressing on road infrastructures along with adoption of safety measures for promoting safe road usage. However, the frequency of road accidents and fatalities remains high as per the records of the Traffic Police of Nepal. Road users often ignore safety measures such as overhead crossing bridge, zebra cross, lane markers, helmets and seat belts. Swatantrata Abhiyan Nepal has an ongoing study on the barriers for using safety measures on road among road users, that will suggest the barriers on adoption of safety measures among road users and policy and practice recommendations for future interventions.

Background and Methodology

Nepal has high alarming records of road accidents resulting into 2500 deaths/year with 50 thousand plus minor and major injuries as recorded by the Traffic Police of Nepal. Minor accidents go unrecorded as people reconcile on the street. The Ministry of Physical Infrastructure and Transport (MoPIT) has adopted National Road Safety Action Plan. The Traffic Police has been running few campaigns on different occasions and road safety campaigning organizations are also implementing awareness campaign and education as well as policy advocacy on road safety. Yet, there is little progress.

Therefore Swatantrata Abhiyan attempted a study on understanding barriers on road discipline mainly among pedestrians to understand their perspectives and problems on following safe road usage.

The study adopted a mixed methodology with administration of semi-structured questionnaires among 200 road users in major junctions, interview with traffic officials and review of previous studies.

As the study is under the process the findings can be finally shared by end of July 2016.

Socio-Cultural Beliefs and Road Use in a Low Income Country: a Qualitative Investigation of Superstition-Related Road Use Behaviour in Pakistan

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Abstract

In developed countries much research has been conducted on human factors (including attitudes, beliefs and perceptions) contributing to road crashes. Less progress has been made in understanding and addressing human factors contributing to crashes in developing countries. In Pakistan, there are strong worldviews that foster diverse beliefs about crash causes and ways of avoiding them. Socio-cultural beliefs (traditions, customs and religion) impede efforts by developing countries to cope with the pace of modernisation and rapid motorisation. Therefore, to address gaps in our current knowledge about these issues, the current study sought to investigate driver perceptions, attitudes and beliefs towards road crashes and explored how they are linked to road user behaviour. A qualitative study involving 30 in-depth interviews identified superstitious road use behaviours interconnected with religious and superstitious beliefs, and low public credibility of evidence-based explanations. Moving towards the uptake of evidence-based protective behaviours is therefore a challenging, though desirable, task.

Background

It has been argued that countermeasures that are effective in developed countries in reducing road trauma may not be effective in developing countries and vice versa (Hill & Jacobs, 1981). Social and cultural (including religious) perspectives are becoming increasingly important in public health risk research, including road safety, although they are still not fully acknowledged and taken into account when developing interventions, particularly in the case of Pakistan (Kayani, King & Fleiter, 2012). A greater understanding of these perspectives can help people understand the bases of conventional approaches to road safety interventions and can assist in developing novel approaches that are culturally appropriate (Young, Morris, Burrus, Krishnan & Regmi, 2009).

Hess and McKinney (2007) and Forjuoh and Li (1996) argued that understanding the characteristics of a culture, as well as the social and political systems can assist in developing culturally appropriate approaches to unsafe behaviours. King (2005) and Mohan (2003) take up this issue in relation to road safety, arguing that it is naïve to expect that Western road safety interventions can simply be transplanted to developing countries without consideration of the social and cultural context. Two important domains of socio-cultural belief are fatalism and superstition (or belief in the supernatural). *Fatalism* can be described as the notion that struggle against nature is futile because events (e.g., a road crash) are believed to be inevitable and predetermined and (at the least) out of one’s own control (Kayani, King & Fleiter, 2011). *Superstition* is a belief or practice that results from ignorance, fear of the unknown, trust in magic or chance, or a false conception of causation (Foster & Kokko, 2009). All societies show evidence of fatalism and superstition, but differ in the degree of their intensity and their influence on behaviour (Dixey, 1999; Foster & Kokko, 2009; Hira, Fukui, Endoh, Rahman & Maekawa, 1998; Leplat, 1983; Norenzayan & Lee, 2010; Torgler, 2007; Young et al, 2009).

Fatalism has received more research attention than superstition, as a number of studies have examined fatalism in relation to health and protective behaviours in both developed and developing countries; two general findings are that fatalism can lead to the perception that death is inevitable, regardless of an individual’s actions and, that a person is, therefore, less likely to use protective behaviours because of such perceptions (e.g. Coyne, Demian-Popescu & Friend, 2006; Dixey, 1999; Hamdy, 2009; King and King, 2006; Straughan & Seow, 1998; Turkum, 2006; Wilkes, Freeman & Prout, 1994). The concept of "external locus of control" has some similarity to fatalism and Hamdy (2009) argued that fatalism is a major impediment to the applications of scientific knowledge and to the reception of new technologies. We have previously documented research conducted in Pakistan that aimed to develop an understanding about the nature and role of religious and cultural beliefs in the broader context of road safety, and have reported on the role of fatalism (Kayani et al, 2011; 2012). However the role of superstitious beliefs remains poorly examined and reported. We have a paper under review (Kayani, Fleiter & King, under review) that reports on superstitious beliefs in Pakistan that express non-scientific construction of road crash causation. The current paper aims to document another piece of our larger research project by describing the superstitious practices undertaken in Pakistan to avoid road crashes and their consequences. It is expected that a better understanding of these practices and the rationale for them will contribute to the development of approaches to road safety in Pakistan that will be appropriate to the cultural context.

Method

The research context: Pakistan

Pakistan has a population of just over 180 million people and has recently made the transition to the middle income group of countries (WHO, 2015). Road crashes are one of the most prominent social and civic problems in Pakistan, with an estimated annual fatality rate of about 26,000 (WHO, 2015). While Pakistan is one of the largest Muslim countries in the world, conversion to Islam followed centuries of Hinduism (Kayani et al, 2011); in practice, Pakistani culture is diverse with a combination of various ethnic, religious and folkloric ethics that have been evolving in the region for thousands of years (Malik, 2006).

Participants

Using a focused ethnographic approach, 30 in-depth interviews were conducted in the three major cities of Lahore, Islamabad and Rawalpindi. Participants ranged in age from 24 to 63 years, with a median age of 46 years. Twelve were professional drivers recruited at transport depots (3 taxi drivers, 6 truck drivers and 3 bus drivers), there were 5 car drivers, 7 police officers, 4 policy makers and 2 religious orators (added during the research because of issues of interpretation of religion which emerged during the interviews; religious orators lead the five daily Muslim prayers, but often have little education, including education in Islam). Three forms of qualitative sampling were used in this study to obtain the convenience sample: purposive (selecting particular groups); criterion (experienced in road use in Pakistan); and snowball (participants suggested other people to participate who fitted the relevant criteria). The majority of the sample was male, with only two females (a general car driver and a field police officer). In Pakistan, more men than women drive in general, and female drivers are very rare among professional drivers. The police force has only a small female presence. All participants were Muslims with the exception of a Christian driver and a Sikh field police officer. All the professional drivers, one general car driver, one field police officer, and two religious orators, had a high school degree or less, while other participants, such as general car drivers, field police officers, and policy officers, had college and university education. The majority of participants reported having been involved in at least one road crash, and almost all reported that relatives/friends/colleagues had been killed or severely injured in road crashes, as was expected according to the experience of the first author. Road crash involvement was frequent among professional drivers.

Procedure and analysis

All participants were treated in accordance with the requirements of the Queensland University of Technology's Human Research Ethics Committee, which provided ethical clearance for the research. All the interviews were recorded with the consent of participants.

An interview guide with simple prompt questions was developed and participants were interviewed individually for approximately 60 minutes. The prompt questions were designed to elicit discussion of the beliefs that participants had about road crashes and their prevention, and spanned fatalistic, superstitious, religious and cultural beliefs. All interviews were conducted in Urdu, except one in English. Participants were asked to discuss their attitudes and beliefs about driving, crash causation, and road use. This led to participants disclosing information about previous risky or illegal road use. The audio recordings were transcribed and translated by a translator using the concept of meaning translation (Esposito, 2001). The first author checked the translations against the recordings for validity and reliability, and an additional bilingual research assistant checked a random sample of transcripts, one from each of the participant groups, to ensure the validity and integrity of the backward translation process (Beaton, Bombardier, Guillemin & Ferraz, 2000). During the process of translation checking, the researcher also worked with the translator to discuss the content of interviews. Where issues of translation were not resolved (e.g., where sections of the interview were difficult to hear or could be interpreted in different ways), these were noted. The decision was taken to analyse the English versions of the transcripts in order to allow the co-authors to read and understand the concepts as they arose and as analysis continued.

Thematic analysis commenced as soon as the first interviews were transcribed, as it allowed for a continuous re-evaluation of the themes and reflexive adjustment of the question and observation guides in keeping with an iterative approach. Analysis involved searching for the expression of particular ideas within the overall context of the dialogue (Minichiello, Aroni, Timewell & Alexander, 1995), and connecting these ideas into themes that appeared important (Daly, Kellehear & Gliksman, 1997). The data were analysed consistent with the recommendations of Sandberg (2005), i.e. with the intention of understanding and unfolding and not of prediction. Note that comments made by participants about their beliefs are their own and do not constitute any judgement or statement on the part of the authors. No comment is made as to whether these stated beliefs are correct or incorrect.

Findings

A range of measures to prevent road crashes that are associated with religious and superstitious beliefs were described by participants. They are set out below under the following headings:

- *Dua* (a prayer, usually a holy verse)
- Sacred charms
- Practising *sadqa* (charity)
- *Drood* (holy breath)
- Preventive measures against evil eye, bad omens and bad signs
- Preventing the effects of black magic

Dua

The most commonly discussed method used to prevent road crashes was the use of *dua*, the act of praying to God to seek divine help by requesting to be kept safe from all evils and bad happenings. In order to evade danger or to have wishes fulfilled, it was described as imperative to seek God's help through individual *duas* and the *duas* of others (e.g., parents, saints, elders, and the poor, distressed, and ill). *Duas* can be the recitation of religious verses from the *Quran, hadiths* (accounts of Mohammed's words or actions), saints' prayers (from living or dead saints), or more specific prayer rituals.

Interviewer: What are the benefits of dua for travelling? Do you think it will save you if any unexpected thing happens while driving?
Participant: We should take our precautions and leave rest of the things on Allah's will. Ayat-ul-kursi is the best dua. It gives me confidence. When I recite the duas I consider that God is surrounding me with protection.
Interviewer: Can a road accident occur, even if you have recited the duas?
Participant: It can never. It is not possible.
Interviewer: Why?
Participant: The person who recites this does not make a mistake. Police, Masters degree, 36 years, Female, Muslim

Participant responses indicated that after the *dua*, they felt comfortable and relaxed because they believed that God had taken responsibility for their safety. *Duas* were also described as being used to avoid bad omens or bad luck (e.g., avoiding evil eye [malignant look] or avoiding failure in business or personal affairs: a more detailed description of 'evil eye' is in given Kayani et al, under review). Such practices and rituals were seen as so important, that if they were not able to perform them, people felt that something was wrong.

It [dua] saves us from every bad omen and bad luck. It's for our own good travelling and safety from bad happening. It gives us mental peace. Bus driver Middle school education, 55 years, Male, Muslim

Muslim participants noted that there was a *dua* (*dua'e safar*) specifically to keep people safe while travelling. It consists of verses that are supposed to be recited at the start of a journey and/or while travelling.

Whenever I drive I pray. I started driving when I was a child at the age of 16 and I have a habit of praying a specific verse which I believe will save me all the time; "Glory to him who has brought this under our control whereas we are unable to control it. Surely we are to return to our Lord". I have a strong faith, whatever will happen I will be saved. Car driver, Masters degree, 40 years, Male, Muslim

It is commonplace for vehicles to display this travel *dua*, hanging on the rear view mirror or positioned on the front windscreen (see Figure 1), as a reminder to drivers of the need to perform it during their journey. Some participants believed that using the travel *dua* is part of their Islamic understanding of the world and therefore that other preventive measures had no value.

As a Muslim we have a travel dua and we believe in that. We should see what our Prophet and Islam said. But other things have no importance. Policy maker, University education, 59 years, Male, Muslim

Figure 1. Holy verses used in vehicles to prevent road crashes

Professional drivers (i.e., truck, bus, taxi drivers) noted that they have greater exposure to risk and were more likely to express beliefs about the role of divine support for their protection.

> *Yes, I always pray before I drive because we are in the mouth of death all the time. We do not know when we face a death. So we seek for blessing from God*. Bus driver, Middle school education, 39 years, Male, Muslim

> *When we are driving we are in between earth and sky. So we should pray all the time to God to save us and [our] passengers. When we are driving, it's a dangerous task, anything could happen. We should pray for ourselves and everybody else*. Truck driver, Primary school education, 60 years, Male, Muslim

Participants expressed the belief that the prayers of others also had significant protective effects, particularly those of devout or pious people and those who are ill, poor or elderly people. Their *duas* could also be recited verses, but more commonly the practice involves simply wishing or praying to God for the safety of others or for them to enjoy a good life. People are more likely to bestow *duas* upon those who demonstrate good manners and pay respect to children, elders, parents, and the poor; conversely, failure to behave appropriately could bring a curse.

> *Prayers of others for you always helps you in every way. If someone is doing well with other people he gets prayers from them. If he does not care about others and hurts other people's feelings, they put a curse [upon him]. For example if I ever talk harshly to someone and then something bad happens to me, I always blame my bad manners towards that person in case I get in trouble*... Truck driver, No education, 47 years, Male, Muslim

The *duas* of parents were considered to have the potential to change the course of a life that had been otherwise destined by fate. It is relevant to note that Islam in Pakistan gives great importance to the role of parents (second only to God), and for this reason their prayers and good wishes are given enormous importance.

> *Dua from parents has great importance and saves us from any bad happening. I think in Islam parents' blessings play a very vital role in our lives. I had no accident in 12 or 13 years and I think there is a great role of the duas of my parents*." Religious orator, Middle school education, 37 years, Male, Muslim

Sacred charms

The placing of the travel *dua* in vehicles was noted above, as a reminder to recite the *dua* while driving, though it can also be seen as an example of a sacred charm. Drivers, particularly professional drivers, reported using different verses from the *Quran*, *hadiths*, saints' names, the name of the four caliphs (the four most prominent civil and religious leaders of Muslims), and other religious charms. The use of such sacred charms is for broad purposes, such as good luck in business and general protection, and this includes protection from road crashes. Participants also said they use these items to remind themselves to express their religious devotion and keep it in mind at all times. When this was discussed further, participants said that if a crash occurred in spite of their use of religious rituals and charms as preventive measures, they would then regard the crash as their fate:

> *Interviewer: Do you think installing these Quranic verses in your vehicle will prevent road accidents?*
> *Participant: Yes, it takes the driver's attention to Allah and Allah will remain in the heart by watching those verses constantly. And I start my day with Allah's name and*

> *end it with Allah's name. If still something [bad] happens [to me] then I'll consider it my fate*. Truck driver, Primary school, 60 years, Male, Muslim

The protective value of religion was reported as extending to objects associated with religion or religious devotion. The *imamah*, an Islamic turban, is used to express religious identity and can show greater devotion towards religion. As noted by one participant, wearing the *imamah* may not be conducive to wearing a helmet, but is considered to be more important.

> *Interviewer: Do you wear a helmet?*
> *Participant: No I don't wear a helmet.*
> *Interviewer: Why not?*
> *Participant: I wear an imamah, so I can't wear a helmet but don't take it as if I don't respect the law. It's very difficult for me to change the imamah again and again for a helmet.* Religious orator, Middle school education, 37 years, Male, Muslim

Several respondents also implied that by using religious outfits, God would be happy with them and would make them safe in the event of a road crash; even if they had not used other precautionary measures (e.g., a helmet). It is the experience of the first author (who was a traffic police officer in Pakistan) that on many occasions, police officers could be easily manipulated by this religious justification for not wearing a helmet so that no violation was recorded.

Another holy object thought to afford protection underlies the practice of using a piece of green cloth to provide protection for vehicles and prevent road crashes. It is common for people to place large pieces of green cloth at the tombs of saints. Some people remove small portions of the cloth to use in their vehicles as a form of protection from harm.

> *People who follow saints do these kinds of things. They also use green cloth in their vehicle. I also have green big cloth on my vehicle for good omens. When we buy a vehicle we go to saints and distribute food at saints' tomb and take the green cloth. In this way we can keep safe from bad happenings*. Truck driver, No education, 26 years, Male, Muslim

In all of these cases, the protection has value because of the association with religious observance or devotion.

Practising sadqa

The religious ritual of *sadqa* (charity) is a more active approach to protection, as it is performed specifically to avoid any bad happening in the present or the future. Bad events are believed to be avoided by providing money, food, shelter or other things to deserving and needy people (also to animals, birds or other creatures). Performing *sadqa* was discussed in all participant categories as a means of evading any bad events and the impact of evils such as black magic, evil eye and bad omens (discussed below).

> *Interviewer: Some people drive with care, but even then they can have a road accident?*
> *Participant: We should do sadqa. When our owners buy new vehicles they distribute food for good signs and to get prayers [from others]*. Truck driver, Primary school, 60 years, Male, Muslim

In the experience of the first author, it is common for Pakistanis to believe that, when confronted with a small problem (e.g., a minor road crash), giving *sadqa* can ensure larger problems will be avoided. The religious orators interviewed indicated that they encourage people to use different rituals, including *sadqa*, *duas* and recitation of other holy verses in vehicles, to avoid road crashes. The proposition of a crash occurring, even if all the religious-based preventive measures were used, was explored. As illustrated from the quote from a religious orator below, it is clear that fate remained the prevailing attribution nominated for crash involvement, even when all other measures were in place.

> *Interviewer: Many drivers use holy verses on the front of their vehicles. Does it have any importance?"*
> *Participant: Yes surely. They are very beneficial. It saves them from common accidents [preordained by] God.*
> *Interviewer: Even then after using them, what if a road accident occurs?*
> *It is due to God [in their fate]. Verses help to avoid evils in life. Sadqas (charitable acts) also work like that and it saves people from evils and losses in life. The people to whom we give sadqa, they pray for you to save you any loss like accidents. It's a blessing from Allah*. Religious orator, Primary school education, 63 years, Male, Muslim

A policy maker interviewed for this research also expressed the belief that *sadqa* was the only possible solution to evade the possible occurrence of road crashes destined by fate.

> *Interviewer: To what extent can we say that a road accident is fated?*
> *Participant: As far as my knowledge is concerned, sadqa (charity) can avoid something bad in our lives. So this could be the [only] possible solution.* Policy maker, University education, 59 years, Male, Muslim

Drood

Drood refers to the practice of a blowing a holy breath. A person stands in front of a saint or a devout person who recites sacred or holy verses, then gently blows in the direction of the person requiring a blessing and assistance. Some participants described the use of this practice as a way of helping to protect them from any bad happening while travelling, such as disease or road crashes.

> *We go to the pir [saint] for drood for our own satisfaction. Allah also helps. There are certain things which Allah has bestowed to his pious people [pirs]. Allah listens to those who pray for us. I have this belief*. Car driver, Matriculation, 28 years, Male, Muslim

In the experience of the first author, this practice is widely believed to hold great power and it is common for people to visit devout persons or living saints who have a good reputation for performing *drood*. This reputation is generally spread by word of mouth, according to the perceived success of *drood* in the past.

Unlike the 'countermeasures' listed above, *drood* is not necessarily accepted as religious: one of the policy makers interviewed for this research expressed the belief that such practices are inconsistent with the real teachings of the *Quran*. This may be an example of the incorporation of older beliefs and practices, since *drood* (under different names) is also described in areas of Southeast Asia that were Hinduised and have never adopted Islam, e.g. Thailand (King and King, 2014).

Preventive measures against evil eye, bad omens and bad signs

Kayani et al (under review) describe strong beliefs about the existence and impact of crash causes that are unequivocally superstitious, such as evil eye, bad omens such as cats (any colour, crossing one's path), and other bad signs. A range of strategies used to prevent the effects of evil eye were discussed by participants. Commonly, the use of amulets, charms and talisman were described.

> *It is good to use them [amulets, charms]. I believe that when we buy a new vehicle and it is looking beautiful, the evil eyes of others can bring bad luck to us.* Truck driver, No education, 47 years, Male, Muslim

The most commonly discussed amulets were black and red strips of cloth, horses' hooves and hair, peacock feather, wigs, and shoes. Black cloth is usually attached to the outside of the vehicle, a horse's hoof within the body of the vehicle, and red strips and horse hair within the cabin of the vehicle. Amulets placed outside the vehicle are intended to be visible so that other vehicles and the malicious looks or feelings of other people do not harm them. In addition to the vehicle, some charms used by drivers are attached to the body (e.g., worn around the neck) for protection.

> *Interviewer: Do you use these as precautions?*
> *Participant: Yes, when I bought a new van I tied a horse's hoof and an old shoe to it. I also have holy verses in my vehicle. I think it saved me from bad omens*. Truck driver, Primary school education, 60 years, Male, Muslim

Such practices were more common in professional and less educated drivers in the current sample. For professional drivers, it was noted that vehicle owners and/or drivers may take the preventive measure of attaching charms or amulets to a vehicle for protection. For instance, if a driver was not likely to believe in such things, the owner of the vehicle may attach them to the vehicle. The quote below provides an indication of the high prevalence of this type of preventive measures taken by drivers in Pakistan.

> *Interviewer: How many people do you think believe in them (evil eye, bad omens and signs)?*
> *Participant: Many people have belief in them. 80% people in our society believe in them.*
> *Interviewer: How can you say 80%?*
> *Participant: Everyone I know believes this.* Car driver, Matriculation, 28 years, Male, Muslim

Other ways described to combat evil eye involved making the person or vehicle less attractive. People often try to mar the beauty of appearance of people or vehicles in order to avoid evil eye (i.e., reducing the beauty by making a small mark, since it is believed this will reduce the likelihood that someone will have jealous or harmful feelings towards them or their possessions).

> *If you put some mark on something which lessens its beauty then it can save it from the evil eye. This is the truth. Actually the thing is made ugly slightly so that it does not catch evil eye. People use different things to protect from evil eye like they use a horse's hoof*. Truck driver, Middle school education, 40 years, Male, Muslim

Preventing the effects of black magic

As noted in Kayani et al (under review), many Pakistanis believe that black magic can cause road crashes. Participants therefore described a number of measures that are used to prevent black magic from affecting them. Even though belief in black magic is essentially superstition, the measures used against it crossed over with religious beliefs. For example, one approach is to consult a *pir* (a holy man or a living saint) who is considered to have special powers to deal with things such as black magic, superstition, and bad omens.

> *Interviewer: What did you do to escape it [constant mechanical faults in vehicle]?*
> *Participant: I went to a man who has the special knowledge and requested him to pray for me for the break [removal] of that black magic.*
> *Interviewer: Did he help you in this regard?*
> *Participant: He helped me and I managed to escape from it. Now there is no problem*.
> Bus driver, Middle school, 55 years, Male, Muslim

In the first author's experience, people who have been involved in a road crash may consult with a *pir* to seek assistance in preventing this happening again, only to be told that black magic was the reason the crash occurred. Some level of manipulation could be involved in this practice in that people then seek a remedy for the first "case" of black magic and continue consulting the *pir* in future to protect themselves from harm. The *pir* often provides protection in the form of amulets or charms (e.g., a single human hair, a piece of paper with words written on it, a metal nail to affix to a wall).

Another religious measure described as able to protect against the harmful effects of black magic was some verses from the *Quran*. For example:

> *Interviewer: Does it happen often that a person is under a black magic spell and a road traffic accident occurs?*
> *Participant: Yes. It can be.*
> *Interviewer: What do people do for the safety from black magic?*
> *Participant: There are some verses [from the Quran to pray] like four "Quls" and Ayat ul Quran's*. Religious orator, Primary school education, 63 years, Male, Muslim

Discussion

It is clear that drivers in Pakistan exhibit a number of superstitious behaviours that are intended to avoid road crashes. Some of these, such as *duas*, sacred charms and *sadqa*, draw directly on Pakistani interpretations of religion; some, such as *drood* and some of the preventive measures against evil eye, bad omens and black magic, are based on older superstitions; and many exhibit a mix of both approaches. By their very nature, these superstitious behaviours are at odds with the standards and evidence-based countermeasures routinely adopted by developed nations to reduce road crashes. Pakistanis rely on traditional or non-scientific methods instead, e.g. prayers, amulets and superstitions, even among educated road users, police and policy makers. Beliefs in religious and cosmological forces (e.g., black magic, evil eye) appear to have created more trust among people than scientific evidence. Given our earlier finding about the pervasiveness of a belief in divinely ordained fate (Kayani et al, 2012), it is perhaps not surprising that the failure of superstitious behaviours to avoid crashes is interpreted as the ultimate dominance of fate. However, participants also believed that fate could be changed if the right superstitious actions were carried out.

These practices have implications for efforts to achieve safer road use in Pakistan. The strategies and interventions implemented in developing countries are usually adapted from developed countries. In some cases, the implementation of these interventions has improved road safety and appears to be culturally acceptable to a certain extent. Health promotion interventions intended to prevent or minimise the consequences of road crashes have been developed mainly in western, industrialised countries (Dixey, 1999). Although some of these solutions have been applied to less developed countries with success, there are also good reasons why other solutions are ineffective when tried in a different context to that in which they were developed. As health promotion concepts developed in the west have a particular ideological bias, being framed within a secular, individualist and rationalist culture, we should not be surprised that that they are open to failure when taken from one social/cultural/religious context to another (Dixey, 1999). The pattern of superstitious behaviour described here, with its ultimate recourse to fatalism, appears to be resistant to the rational arguments of road safety advocates and health promoters.

In principle, road crash interventions must reflect the requirements and the capacity of local communities and must also consider the relative influence of environmental, social, economic, and demographic factors. To encourage safer behaviours it is important to provide people with a better understanding of why events occur and the increased knowledge and awareness of the cause of risk factors associated with their own actions. However, a persuasive approach requires an understanding of the commonly accepted behaviours, the rationale for them, and the beliefs that underpin them. In the case of Pakistan, where religious belief clearly plays a major role in behaviour, this is a challenge. It is important that a distinction is made between (i) religion as a positive coping method in which people are encouraged to take responsibility for their own choices with the concept of evil and good; and (ii) religion as a means of promoting misconceptions such as fate or predestination for which the individual takes no personal responsibility (Kayani et al. 2011, 2012). One potential mechanism to persuade people is to involve Islamic scholars, who hold sound religious knowledge, to assist with correcting misconceptions, increasing awareness among the population, and help to develop effective road safety policies, strategies and campaigns.

Conclusion

This study provides information on behaviours employed by Pakistani road users to protect themselves against road crashes. Although not representative of the broader population, the information contained in this paper, together with an understanding of the superstitious and fatalistic beliefs underlying these behaviours, can inform strategies aimed at educating people about more effective, evidence-based ways of reducing road crash risk. Adaption of culturally appropriate strategies, combined with policy design and implementation which takes into account the differential influence of cultural, religious, and social values, can enhance the transfer and adoption of evidence-based interventions. The interconnected and resilient nature of religious and superstitious belief and behaviour in Pakistan makes this a challenging task, but nevertheless a desirable one that moves action towards the uptake of evidence-based protective behaviours. In this latter half of the United Nations Decade of Action for Road Safety (2011-2020), it is imperative that efforts continue to identify novel approaches to tackle the road crash burden placed on so many developing countries and their people. The integration of information, such as that contained in this paper, may assist in reducing the road trauma burden by identifying underlying beliefs that currently hinder safer road use practices.

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Speeding among Jordanian Drivers

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Abstract

Speeding is a well-known contributing factor to the severity and frequency of crashes in Jordan. Speed choice decisions among Jordanian drivers were studied using a self-reporting survey questionnaire. Descriptive statistics and logistic regression analysis were carried out in this study. The findings showed that almost half of surveyed drivers reported speeding. Drivers considered safety when deciding their driving speed. A regression analysis showed that previously receiving speeding fines for males appeared to have a significant association with receiving traffic fines in general. Speeding should be targeted through strict enforcement and legislation in Jordan. Gender-differentiated measures from the survey indicate males should be targeted for enforcement. Road safety policy-makers could consider adopting the Safe System Approach to address speeding issues in Jordan.

Background

The issues associated with excessive speed and the consequences of speeding behaviour are of interest to researchers, law and decision makers, traffic police, and the community at large. Speeding is reported to be the number one road safety problem worldwide (OECD, 2006). Excessive speed leads to an increased frequency and severity of road crashes (Anastasopoulos & Mannering, 2016). The management of speed remains one of the biggest challenges facing road safety practitioners. The speed management manual published by the Global Road Safety Partnership (GRSP, 2008) aims to provide advice and guidance for policy-makers and road safety practitioners in low and middle-income countries (including Jordan) and to draw on the experience of a number of countries that have already initiated speed management programmes.

The relationship between speeding and road trauma in Jordan are well accepted (Abojaradeh & Jrew, 2013; Suliman & Awad, 2003). Pedestrians are the most affected group of road users as a result of excessive speeding. Al-Omari (2013) and AL-Omari; Bashar, Ghuzlan, and Hasan (2013) reported that the majority of pedestrian crashes occurred on low speed roads (< 50km/h). Table 1 shows road casualties in Jordan compared to speed limits on those roads. Roads where the speed limit is between 40km/h and 60km/h indicate the highest percentages of casualties.

Table 1. Casualties in Jordan by Speed Limit (Jordan Traffic Institute, 2014)

Speed Limits (km/h)	Fatalities		Severe Injuries		Slight Injuries	
10	1	0%	10	0%	60	0%
20	11	2%	6	0%	65	1%
30	13	2%	41	2%	263	2%
40	129	19%	580	28%	3820	30%
50	105	15%	345	17%	2422	19%
60	186	27%	507	25%	3444	27%
70	79	11%	174	8%	978	8%
80	84	12%	254	12%	1054	8%
90	36	5%	78	4%	256	2%
100	29	4%	45	2%	233	2%
110	15	2%	23	1%	129	1%
120	0	0%	0	0%	3	0%

Most road safety studies carried out in Jordan mainly focus on crash data analysis that links crashes and injuries to the causes of crashes reported by traffic police in their official reports. This study uses data from a self-reported survey to investigate speeding among Jordanian drivers, to explore driver attitudes regarding speeding and whether speeding is significantly associated with crash involvement or receiving traffic fines.

Method

Participants

The final sample included 501 drivers. Drivers' ages ranged between 18 and 69 years with an average of 34.5 years; male drivers accounted for 84% of the total number of drivers in the study. The study sample reported driving an average of 99.42 km per day and being involved in an average of 0.81 crashes per year. Respondents reported receiving 2.56 traffic fines per year on average including 0.78 speeding fines.

Procedure

A self-administered survey questionnaire was developed specifically by the Authors to collect data from Jordanian drivers for this study. Printed copies of the questionnaire were distributed to potential respondents in Jordan personally by the lead Author. The questionnaire was in Arabic. In some cases, the lead Author administered the questionnaire himself but in most cases it was handed out by other recruited assistants. The assistants observed the local cultural and religious requirements pertaining to the place where they collected data and as per the ethics approval requirements from the University of New South Wales.

In this study, the convenience sampling method was used with no rules for choosing respondents or excluding them from participating (Al Reesi et al., 2013; Martinussen, 2013). Approaching potential respondents took place in public places and in places where drivers were relatively concentrated, such as bus and taxi stops, shopping centres, cafes, restaurants and market places. Researchers approached people of both genders in cities and rural areas regardless of their potential license type. Drivers of all age groups were approached in an effort to ensure the sample covered a wide range of driver age. Researchers provided potential respondents as much time as they felt they required to complete the questionnaire after which the questionnaires were later collected in person.

All volunteers were assured of their anonymity and the confidentiality of their response and were encouraged to answer to their best knowledge honestly and frankly. Respondents were encouraged to complete the questionnaire privately to avoid any influence of colleagues or other people around them in order to avoid social desirability bias (Nordfjærn, Jørgensen, & Rundmo, 2011).

Instruments and Measures

The questionnaire was developed using the well-known Manchester Driver Behaviour Questionnaire (DBQ) (Parker, Reason, Manstead, & Stradling, 1995; Reason, Campbell, Baxter, Stradling, & Manstead, 1990), but also contained an extended set of driving violations particularly relevant to Jordan. The extended set of questions was based on some cultural and behavioural considerations as well as observations and practices amongst Jordanian drivers. The questionnaire takes into account the characteristics of the people and the prevailing culture and traditions as well as the driving environment and contained many of the DBQ items but not all of them due to the difference in driving environments (Magableh, Grzebieta, & Job, 2013). Many of the DBQ questions used in this study were re-worded or re-phrased to suite the driving environment in Jordan and to improve clarity. The survey covers basic demographic characteristics, driving habits, traffic law enforcement, attitudes and behaviours on road and the drivers' history of traffic violations and road crashes.

The questionnaire contained open-ended questions as well as closed-ended questions which included multiple choices ranking and Likert scale style questions. Minor modifications were made in order to make the questionnaire appropriate for the Jordanian driving environment (Davey, Freeman, & Wishart, 2008). Opinions of drivers in regards to speeding were explored in terms of factors influencing a driver's decision to speed, their reported speeding and perceptions about speeding.

Statistical Analysis

The logistic regression analysis process included categorising the dependent variable into a dichotomous (0: no incident and 1: incidents of one or more events). This analysis was evaluated at a significance level of $p<0.05$. Univariate and multivariate linear regression analyses were carried out to determine the impacts of selected independent variables on the likelihood of crashing or receiving traffic fines. A backward eliminating method (Al Reesi et al., 2013) with a selected significance level of 0.2 was used to determine the factors that contributed to the outcome of interest at the univariate level and screen those to be included in the multivariate analysis. Variables were eliminated from the full model in an iterative process. The final model, which contained only independent variables that significantly contributed to the outcome was reached when no more variables could be eliminated (Bursac, Gauss, Williams, & Hosmer, 2008). All calculations in this study were performed using SAS 9.3 package

The independent variables used included age, gender, exposure to driving, education level, driving experience, marital status, reported crashes, number of times stopped by Police (for an offence or security checks), reported different fines received, reported crashes, reported violations of traffic signs (e.g., stop signs), reported hazardous lane deviation and reported times of being intimidated by other drivers. Other independent variables used were the factors determined from the PCA analysis.

Results

Received Traffic Fines

Using multiple-choice questions, respondents were asked about the numbers and types of traffic fines they received in the past year. Two out of five respondents (40%) reported receiving speeding fines, 27% parking fines, 25% seatbelt non-compliance fines, 21% using mobile phone while driving fines, 19% using the wrong lane when driving or passing fines, 18% red light running fines and 11% other fines (e.g., vehicle defect fine). In multiple-choice questions, the addition of percentages could be more than 100% because respondents had the option to choose more than one answer.

Factors affect driving speed decision

Using multiple-choice questions, drivers were asked about reasons that would make them reduce their speed. Safety considerations were rated the highest among drivers' choices as shown in Figure 1. Drivers were also asked whether they changed their driving style when approaching Police or traffic cameras. Slightly less than two-thirds (64%) of drivers reported changing their driving style when approaching Police or traffic cameras. A majority (76%) of respondents supported the use of automated speed cameras.

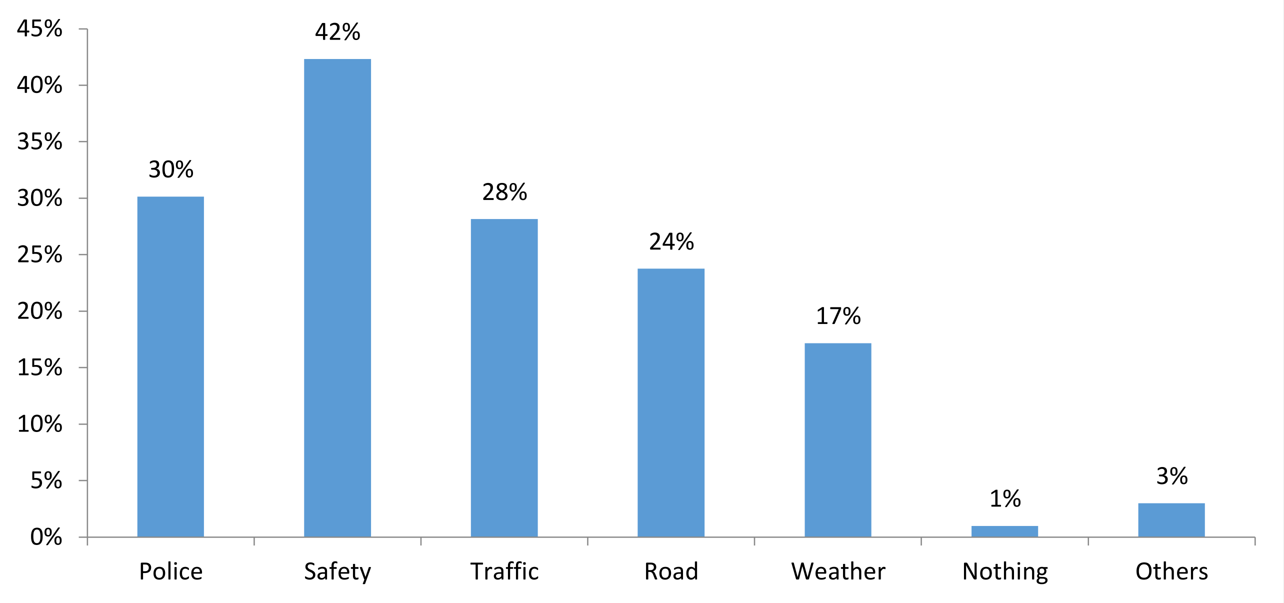

Figure 1 Reasons that made drivers reduce their speed

Speed Limits

Drivers were asked for their opinions on the current speed limits on roads using multiple-choice questions. Only a minority of drivers (12%) supported an increase in speed limits. About one third of the drivers (32%) called for speed limits to be reviewed, 27% agreed with the current speed limit and 20% of drivers wanted speed limits to be decreased. About 7% of drivers were undecided (did not know).

Attitudes towards Speeding

Drivers were also asked to rate the risk hazard presented by speeding committed by other drivers. On a four point scale, responses were very serious risk hazard (61%), serious risk hazard (30%), a minor risk hazard (7%) and not a risk hazard (2%).

Arriving Late to Destination

Drivers were also asked about the reasons that made them arrive late to their destination. Response choices included arriving late because of: traffic conditions, the existence of Police or cameras on the road, for safety reasons, were delayed (other e.g., fuelling, etc.) or for other reasons (e.g., vehicle breakdown). Responses are shown in Figure 2. Traffic conditions and safety considerations were the most cited reasons that make drivers arrive late to their destination. Moreover, the survey revealed that Jordanian drivers reported similar patterns of speeding with 50% of drivers indicating speeding less than 10km/h above the speed limit and 43% indicating speeding more than 10km/h above the speed limit.

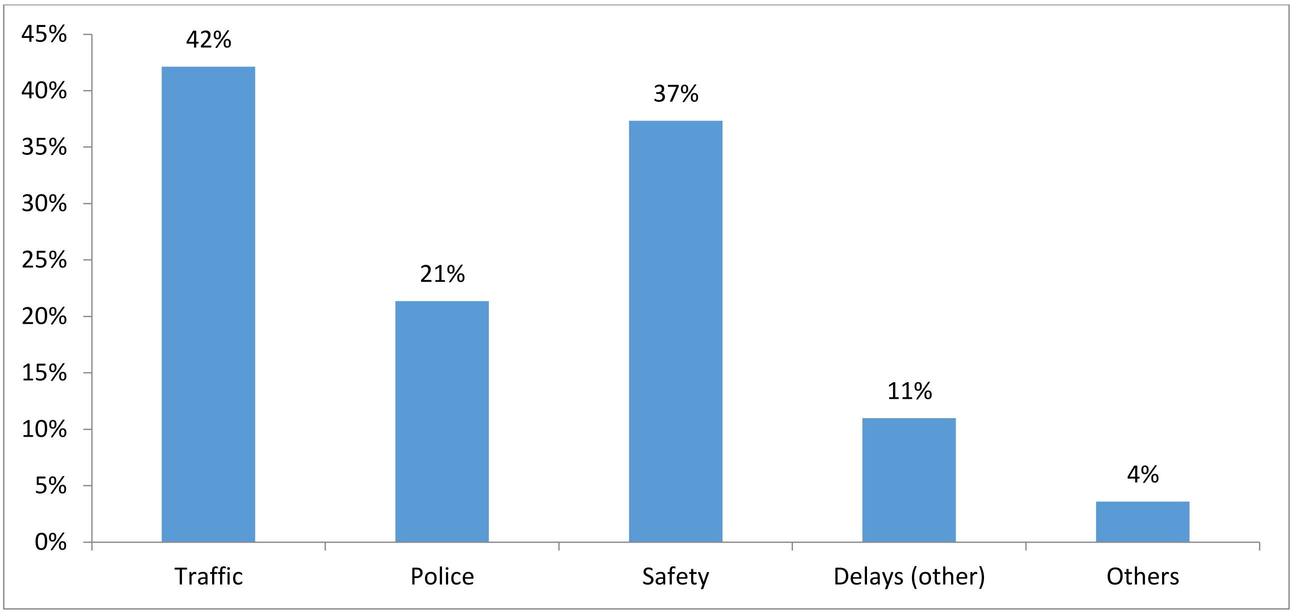

Figure 2 Reasons that made drivers arrive late to their destination

The excuse for 'arriving late at a destination because of safety reasons' by 37% of drivers (Figure 2) is consistent with drivers' reason for reducing speeds by 42% of drivers voluntarily for safety considerations (Figure 1).

Logistic Regression

Logistic regression analysis was carried out to determine the factors that are significantly associated with receiving traffic fines. An initial analysis showed that male and female drivers were affected differently by driving situations suggesting that the impact of various factors, including driving situations, on the outcome was modified by gender. Consequently, a logistic regression analysis was performed on data from surveyed male and female drivers separately even though this stratification was somewhat hindered by the smaller sample size of female drivers.

Receiving traffic fines for male drivers were significantly associated with previously receiving speeding fines, seatbelt non-compliance fines, hazardous lane deviation fines, parking fines, other fines and being involved in crashes. The crude odd ratios for receiving speeding fines for males was 24.78 (CI 11.99-51.4), $p<0.01$. The adjusted odd ratios for receiving speeding fines for males was 21.12 (CI 8.38-53.23), $p<0.01$.

Factors that were significantly associated with receiving traffic fines for female drivers were violating traffic signs, receiving seatbelt non-compliance fines and being stopped by Police. Receiving speeding fines for females was not found to be significantly associated with receiving other fines in general.

Finally, receiving speeding fines was not found to be significantly associated with crash involvement for either males or females.

Discussion

The results showed that speeding among Jordanian drivers seems to be common; almost half of the drivers reported speeding. Moreover, reported speeding fines were the highest percentage of all traffic fines received.

Several possible reasons could explain why Jordanian drivers speed. The high percentages of speeding fines might reflect a practise of Police exclusively focussing on speed violations through targeted enforcement campaigns at the exclusion of other road safety enforcement programs such as for example seat belt wearing or use of mobile phones while driving. This may be because of for example, insufficient Policing resources. Speeding in Jordan is normally detected by automated speed cameras or by manual detection methods using Police patrols or unmarked Police vehicles. This approach might have resulted in increasing the probability of catching and fining violating drivers, which might explain the high number of speeding fines compared to other fine types.

Another reason could be that the respondents might believe that speeding was not a risky hazard to themselves nor to others (similar to what Suliman and Awad (2003) reported about Jordanian drivers). Drivers were reported to have a tendency to speed when they believe that the excess speed does not threaten safety (Mannering, 2009). Another possible explanation might be that drivers were careless about the low probability of being caught and being fined (Porter, 2011), because of the less serious consequences (e.g., low fine value) (Al-Madani, 2004; Lennart Sjöberg, 2000; L. Sjöberg, Rundmo, & Moen, 2004) or when they try to use networking and to cancel fines after they have been issued (Magableh et al., 2013). It is also possible that time urgency might have led drivers to speed similar to what other researchers have reported (Fernandes, Job, & Hatfield, 2007; Hassan & Abdel-Aty, 2013; Lee, Prabhakar, & Job, 1993; Tasca, 2002). Another possible reason could be the lack of signage that show speed limits. Yet another reason for speeding among respondents might be related to authority-rebellion (as a reaction to enforcement decisions) as Fernandes et al. (2007) reported. Speeding drivers might also have more positive attitudes toward speeding and rule violations (Iversen & Rundmo, 2004).

Although half the drivers in the study reported speeding, the majority of respondents considered speeding by other drivers as a serious risk hazard. This is consistent with NHTSA (2004) study which reported that approximately two-thirds (68%) of American drivers felt that other speeding drivers pose a major threat to their personal safety. Moreover, Åberg, Larsen, Glad, and Beilinsson (1997) and Haglund and Lars (2000) found that drivers overestimated other drivers' errors and traffic violations, such as speeding. This could be due to drivers' high self-image (Magableh et al., 2013) and their optimism bias (Chua & Job, 1999; Prabhakar, Lee, & Job, 1996).

The favouring of automated speed cameras by a majority (76%) of drivers might be attributed to several reasons. One reason could be drivers' awareness of the role that such cameras play in road safety. For example, speed cameras were found to have both short and long-term effect on road casualties and crashes (Elliott & Broughton, 2005; Pilkington & Kinra, 2005; Ryeng, 2012; Walter, Broughton, & Knowles, 2011). Automated speed enforcement had proven to be more efficient in reducing the number of crashes than manual speed enforcement (Porter, 2011; Zaidel, 2002). Speed cameras have also been proven to be an effective road safety countermeasure in Australia (Anderson, 2000), Kuwait (Aljassar, Ali, & Al-Anzi, 2004), the UK (Pilkington & Kinra, 2005) and the UAE (Bener & Alwash, 2002; El-Sadig, Nelson Norman, Lloyd, Romilly, & Bener, 2002).

Another reason for drivers' favour of automated speed cameras might reflect drivers' distrust in Police or in the ways they enforce the laws (Fernandes et al., 2007; Gaygisiz, 2010; Magableh, Grzebieta, & Job, 2015). A possible reason could be attributed to drivers' ability to avoid being fined by speed cameras by developing deceptive behaviours towards enforcement by changing their behaviour (e.g., speed) in the vicinity of Police or cameras and then resuming their normal behaviour in order to avoid being caught and fined (Al-Rukaibi, Ali, & Aljassar, 2006a, 2006b; Aljassar et al., 2004; Porter, 2011; Stanojevic, Jovanovic, & Lajunen, 2013). This is evident in this study as almost two-thirds of drivers reported adopting similar behaviour.

Drivers were found to mainly support a reduction or a review of speed limits rather than increasing them. This result is consistent with other research where about one-third of respondents supported lower speed limits (Lahausse, van Nes, Fildes, & Keall, 2010). Speed limits depend on a number of factors including road geometry, driving conditions, traffic density, fleet characteristics, drivers' skills and motives, crash rates and the possibility of the existence of either Police or speed cameras (Elvik, 2009). Many surveyed Jordanian drivers appeared to be aware of risks associated with high speed limits. One out of every five drivers (20%) proposed that speed limits be reduced and 32% that speed limits be reviewed because of incompatibility with one or more of the above factors or the behaviour of other road users (e.g., pedestrians) that make it difficult to drive at higher speeds. The minority (12%) of drivers who wanted to increase speed limits might have felt that these limits were used as traps to generate more revenue (Blais & Dupont, 2005) or believed that speed limits were assigned to roads a long time ago and needed to be updated according to the current fleet and road conditions. Drivers who desired higher speed limits might have thought that this will save time and increase traffic flow or they might not be fully aware of the factors that govern such speed limits decision. However, increasing speed limits might not be always the answer to traffic jams as it was reported that reducing speed limits may increase the traffic flow by reducing the spacing between vehicles (Nielsen, 2007).

Voluntary reduction of speed for safety (safety consideration) was found to be the strongest factor that resulted in reducing drivers' speed. Some drivers reported a cautious driving speed when driving in inclement weather conditions, traffic conditions or because of road conditions, which supports what Al-Balbissi (2003) reported about Jordanian drivers. The safety consideration was also evident when respondents reduce their average speed resulting in arriving late. This may reflect a sense of safety concerns among respondents.

In some cases, Jordanian drivers may be driving with excessive speed to keep up with the traffic flow rather than driving within speed limits (Åberg et al., 1997) or just acting similar to other drivers and following the traffic rhythm (Haglund & Lars, 2000). Moreover, drivers may be feeling that they cannot drive within the speed limit because of pressure from of other drivers, i.e., other drivers demonstrate aggressive behaviour when drivers drive according to formal rules rather than informal rules (Lawton, Parker, Stradling, & Manstead, 1997; Magableh, Grzebieta, Job, & Boufous, 2015). Yet another possible explanation could be that some drivers might think they have the driving skills (Reason et al., 1990) and abilities (high perceptual-motor skills but not necessarily safety skills (Özkan & Lajunen, 2006)) that infer they are "good drivers" (Fleiter, Watson, Lennon, King, & Shi, 2011; Sümer, Lajunen, & Özkan, 2005) and enable them to speed. Drivers might have also considered "safe" speeding to be low-level speeding or speeding in a safer driving environment (Austroads, 2013). They might have viewed themselves as "fast but safe" or "safe drivers" because of their high self-image (Magableh et al., 2013; Magableh, Grzebieta, Job, et al., 2015) and considered their excessive speed as not speeding so long as they are in control of the situation (Fleiter, Watson, Lennon, King, & Shi, 2009).

The significance association between receiving speeding fines and receiving other fines for male drivers could be attributed to a type of driver who is careless about complying with other traffic rules. Females do not have the same speeding tendency as their males counterparts due possibly to males' masculine attitudes of gender superiority and the desire to maintain their self-image (Magableh, Grzebieta, Job, et al., 2015).

Speeding should be targeted through awareness campaigns about their consequences accompanied by strict laws and broad enforcement. Enforcement plays an important role in safety perceptions; being previously stopped for speeding was reported to be a significant factor in determining the speed above the speed limit (Mannering, 2009). In fact, a substantial increase in enforcement was reported to be a major contributor to speed reduction in Norway (Ryeng, 2012) and in reduced crash rates in Australia (Soole, Watson, & Fleiter, 2013) while in the absence of enforcement, drivers were found to speed (Stanojevic et al., 2013). Increasing penalties was viewed as an effective speeding countermeasure in Victoria, Australia (Austroads, 2013). Hössinger and Berger (2012) found that the frequency of speeding was reduced by increasing penalty and/or enforcement density (the probability of being caught and fined).

The findings of this study could help policy makers and campaigners in directing their resources efficiently. Awareness and education campaigns as well as enforcement campaigns could target those drivers with a greater risk of receiving traffic fines (due to their high likelihood of violating traffic laws) and choosing the right enforcement tool (e.g., speed cameras). New traffic rules that are based on scientific evidence can be introduced to address such violations as well.

The Safe System Approach (OECD, 2008) can be implemented in Jordan through design changes or through administrative controls such as reducing speed limits, enforcement and/or changing laws. These aspects of the Safe System Approach would be relevant to Jordan so that if funds are not available to comply with the Safe System Approach requirements in terms of improving road or vehicle design, then laws could be changed and speed limits reduced and enforced until such time as funds for infrastructure improvements are made available (Mooren & Grzebieta, 2010).

Future studies could focus on the psychological, cultural and enforcement practices that influence speeding amongst Jordanian drivers. A systematic evaluation of the effect of speeding countermeasures on driver behaviour is needed to help identifying which measures and practices would be more feasible to implement in the short and long term.

Limitations

The strengths of the study were: the ease with which data was gathered; low cost; low or no researcher subjectivity; good statistical significance; and more importantly it was possible to collect sufficient data about driver attitudes, behaviour, perceptions and driving history to carry out a useful statistical analysis. However, the data were based solely on self-reported behaviours as no observations were made. Thus, this study suffers from the commonly reported limitations associated with measures of behaviours based upon self-reporting (Lajunen, Corry, Summala, & Hartley, 1998; Ulleberg, 2002). However, self-reported driving behaviours are mostly considered a valid measure of actual driving behaviour (Åberg et al., 1997; Lajunen, 1997; Lawton et al., 1997; Prabhakar et al., 1996; Ulleberg, 2002; Walton, 1999; West et al., 1993). Previous research has found that observations of certain driving behaviours (e.g., speeding) were correlated with self-reported driving speed (West et al., 1993) justifying its usefulness (Ulleberg, 2002).

Conclusions

Receiving speeding fines for females was not found to be significantly associated with receiving other fines in general whereas for males it was significantly associated with having previously received fines. Speed appears to be a significant contributor to the frequency and severity of crashes in Jordan for both males and females. Respondents in this study were found to be inclined to speeding and to report more speeding fines than any other type of fines. This could mean less care about traffic rules as a result of inadequate enforcement or drivers are not concerned about the consequences resulting from violating such rules. Jordanian drivers need to be educated about speeding consequences, the factors that control the speed limit decision and the physical limits to the amount of force the human body can tolerate in relation to collision speed as adopted in the Safe System Approach. Gender-differentiated countermeasure that are based on psychological gender related determinants of traffic violations could be adopted by Jordanian authorities to reduce speeding among male drivers. Enforcement should be adaptive to changes in drivers' behaviour in

Jordan. The increase of a drivers' perception of being caught and being fined in Jordan might enhance their compliance with traffic laws more than the increase in fine value.

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The Correlation between Governance Quality and Road Fatalities

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Abstract

As part of the effort to stabilise worldwide road fatality rates the World Health Organization has highlighted the need for comprehensive in-country laws addressing five key risk factors: speed, drink driving, motorcycle helmets, seatbelts and child restraints. However, the effectiveness of laws covering these five key factors may be dependent on the governance of the country implementing these laws.

This study sought to determine if there is a correlation between governance and road fatality rates. To do this, data on six governance indices from the World Bank and road fatality rates from the World Health Organization covering over 176 countries was obtained. A Pearson's correlation analysis was performed on this data. The findings indicate that there is a negative correlation between key governance indices and road fatality rates. The finding from this study highlights the importance of good governance as part of the effort to reduce worldwide fatality rates.

Background

Road trauma is the eighth leading cause of mortality worldwide claiming the lives of approximately 1.25 million people per year (World Health Organization, 2015). Given the current trends, road injury has been projected to become the fifth leading cause of fatalities by 2030 unless action is taken to change this trajectory (World Health Organization, 2015). As part of the effort to stabilise road fatality rates, the World Health Organization (WHO) has highlighted the need for comprehensive in-country laws on key risk factors – speed, drink driving, motorcycle helmets, seatbelts and child restraints (World Health Organization, 2009). Between 2008 and 2011, the WHO reported that 35 countries, representing approximately 10% of the world's population, passed legislation addressing at least one of these five key risk factors. These countries are in addition to the 28 countries, representing 7% of the world's population, which already have laws that addresses all five risk factors (World Health Organization, 2015). Although there has been an increase in the number of countries which have laws addressing the aforementioned five risk factors, a question that needs to be addressed is how effective are governments at implementing and managing these laws.

The term "governance" is widely used amongst scholars and policy makers in relation to societies' way of making decisions regarding collective problems. A single and widely accepted definition of "governance" has yet to be agreed (Hufty, 2011; Kaufmann, Kraay, & Mastruzzi, 2011). Kaufmann et al. (2011) has drawn on the existing notions of governance and defined governance as, "the traditions and institutions by which authority in a country is exercised." They further break this definition down into three key areas and provide two indices of governance corresponding to each of these three areas. These three key areas and their associated indices are listed below:

(1) The process by which governments are selected, monitored and replaced:

(a) Voice and Accountability (VA) - Capturing the perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association and a free media.

(b) Political Stability and Absence of Violence/Terrorism (PV) - capturing perceptions of the likelihood that the government will be destabilised or overthrown by unconstitutional or violent means, including politically motivated violence and terrorism.

(2) The capacity of the government to effectively formulate and implement sound policies:

(a) Government Effectiveness (GE) - capturing perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

(b) Regulatory Quality (RQ) - capturing perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.

(3) The respect of the citizens and the state for the institutions that govern economic and social interactions among them:

(a) Rule of Law (RL) - capturing perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

(b) Control of Corruption (CC) - capturing perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.

The World Governance Indicators (WGI) (Kaufmann & Kraay, 2013) was established in 1996 and is based on the six aforementioned indices. The indices are based on variables obtained from multiple data sources which capture governance perceptions as reported by survey respondents, non-government organisations, commercial business information providers and public sector organisations in each country (Kaufmann et al., 2011). They were developed as broad cross-country indicators to allow governance to be compared for over 170 countries. Readers are referred to the report published by Kaufmann et al. (2011) for more detail on how data is obtained and the indices are calculated for the WGI.

The effectiveness of a country's governance and its relationship with road safety is an area that has not received much attention over the years despite Rodrik (2002) and Licht et al. (2005) having shown that institutions exert a profound influence on economic performance and other measures of development.

Gaygisiz (2010) hypothesised that the quality of governance of institutions is related to the level of a country's road infrastructure, traffic control and road user behaviour. She sought to determine if there is a relationship between the quality of governance, culture and road fatalities in 46 countries. The findings from her study indicate that there is indeed a negative correlation between each of the six indices developed by Kaufmann et al. (2011) and road fatalities per million registered vehicles.

One of the limitations of the study performed by Kaufmann et al. (2011) is that only 46 countries were included in the study due to the limited availability of road fatality figures from a number of countries. This study seeks to overcome that limitation and extend the previous research by determining if there is a correlation between each of the six governance indices and road fatality rates in 176 countries where data for both the six indices and road fatality rates are now available.

Method

The WGI provides a governance score for each of the six aforementioned indices. The governance score for the six indices was obtained for year 2013 for all available countries (n=215) (Kaufmann & Kraay, 2013). The governance score range from -2.5, indicating a low level of governance, to +2.5, indicating a high level of governance (Kaufmann et al., 2011). Data on road fatality rates, measured in road fatalities per 100,000 population, was then obtained from the WHO for year 2013 for all available countries (n=179) (World Health Organization, 2013). Although 2014 WGI data is available, the latest WHO road fatality rates data is only available for 2013. Of the 179 countries with data from both sources, governance data for three countries were not complete and were therefore removed for the analysis. A list of countries with complete data (n=176) is provided in Appendix A.

Pearson's correlation coefficient was used to assess the associations between the governance indicators and the natural logarithm of the road fatality rates. All analyses were performed using R Studio (RStudio Team, 2015).

Results

A correlation matrix of the governance indices and the log road fatality rate is presented in Table 1 and scatterplots of road fatality rates and each of the governance indices is presented in Figure 1. There is a negative correlation between road fatality rate and each of the six indices. That is, the road fatality rate decreases as the governance score increases.

Table 1.

Pearson's Correlation Matrix for WHO Road Fatality Rates and WGI Indices.

Variable	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Log Road Traffic Death/100,000 Population	–						
2. Voice and Accountability	-0.65	–					
3. Political Stability and Absence of Violence/Terrorism	-0.58	0.72	–				
4. Government Effectiveness	-0.68	0.78	0.69	–			
5. Regulatory Control	-0.62	0.77	0.61	0.93	–		
6. Rule of Law	-0.71	0.82	0.77	0.94	0.89	–	
7. Control of Corruption	-0.68	0.77	0.74	0.92	0.84	0.94	–

$*p < 0.001$ in each case

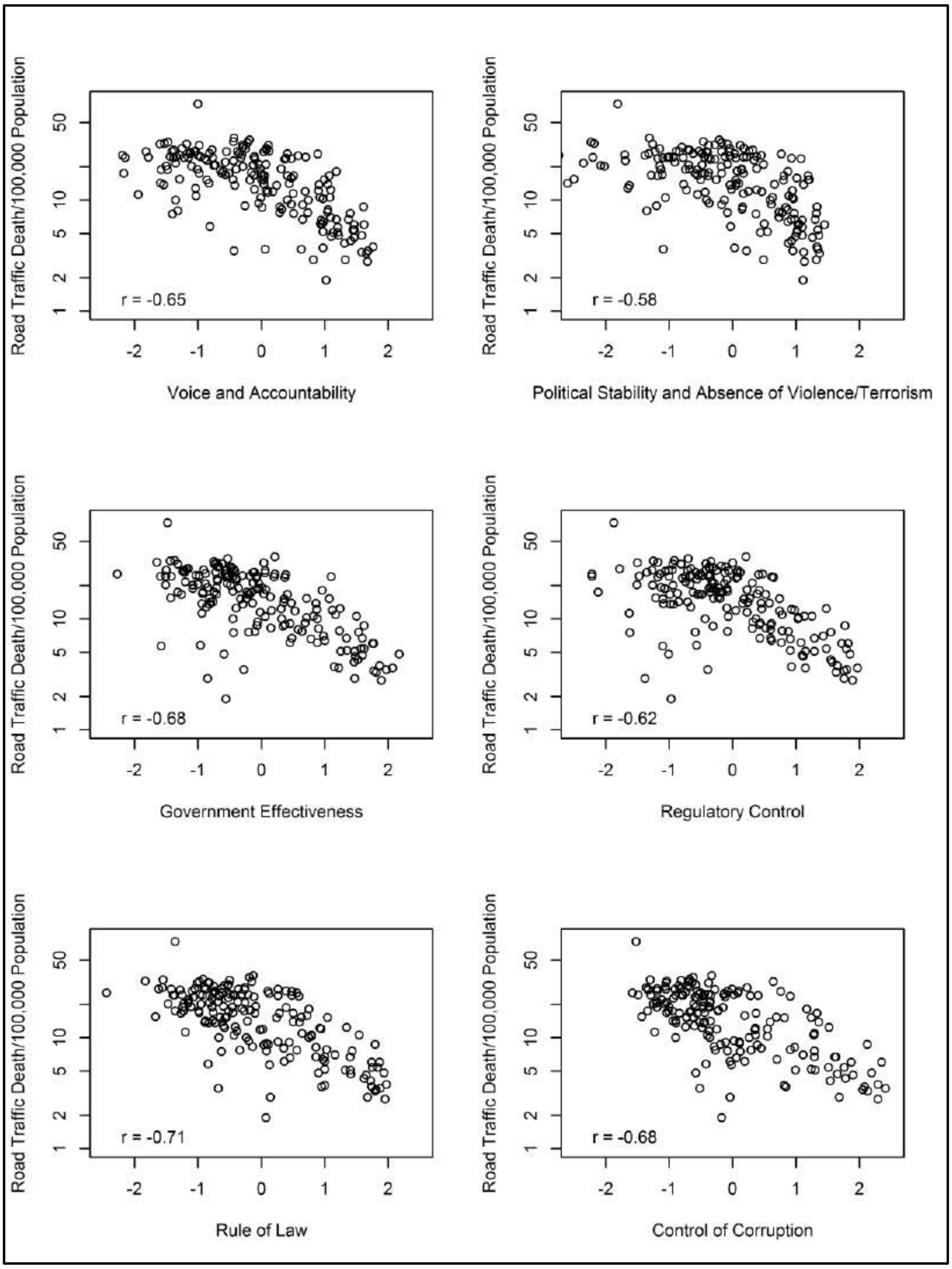

Figure 1.

Scatter plot of the log road fatality rate and each of the 6 governance indices.

Discussion

The results from this study indicate that a country with a government that is stable and responsive to the population has a lower fatality rate compared to a country with an unstable and ineffective government. This finding is similar to that of Gaygisiz (2010) who also found a negative correlation between road traffic fatality rate and all six governance indices. A brief explanation of the associations between road fatality rates and each of the governance indices is provided below.

In this study, voice and accountability was found to have a negative correlation to road fatality rates. Voice and accountability has been identified as a feature in good governance programs by Licht et al. (2007). In essence, it obliges the holder of power to give an account of their decisions or actions to citizens and extends power to citizens to hold officials accountable for their actions (Adserà, Boix, & Payne, 2003; Licht et al., 2007). From a road safety perspective, Bliss and Breen (2012) have found that in the absence of responsible and accountable road safety leadership at country, state and city level, the effort aimed at decreasing road fatality rates will often be unsustainable. A similar view is also shared by Roberts (2004) who found that holding those that build and operate the road system accountable has had a great impact on road safety. The results from this study support the findings by Bliss and Breen (2012) and Roberts (2004). That is, voice and accountability is an important factor in road safety.

Political stability has been identified to have a substantial effect on the quality of government (Adserà et al., 2003), the quantity of existing and new investment and the effectiveness of institutions to govern (Aron, 2000). Further, Bliss and Breen (2012) have found that achieving road safety goals require long-term government ownership, leadership and political will. The findings from this study indicate that political stability is associated with a lower fatality rate thus supports the claim by Bliss and Breen (2012).

Our knowledge on governments and its association with efficiency and effectiveness is still rather limited (Adserà et al., 2003). However, Bliss and Breen (2012) have suggested that an effective government is important to road safety as they are able to identify interests that are competing against road safety thus potentially reducing the effectiveness of road safety programs. Although the results from this study indicate that an effective government is correlated with improved road safety outcomes, the currently available literature does not provide much more of an insight as to how an effective government affects road safety.

Regulatory quality, as defined by the WGI, relates to a government's ability to formulate, develop and implement policies that permit and promote private sector development. It is not clear from the currently available literature as to how regulatory quality relates to road safety. It is suggested that poor regulatory quality of private sector development of infrastructure, such as highways and roads, may result in the design and construction of infrastructure that does not take into account or achieve appropriate safety standards. As such, that piece of infrastructure may unnecessarily expose its users to a higher probability of injury or fatality than if the appropriate safety standard had been implemented.

The willingness of individuals to comply with the rule of law has been found to have a positive effect of road fatalities by Vereeck and Vrolix (2007). Further, their study indicates that the willingness to comply matters more than legal specificity. However, Licht et al (2005) and Gaygisiz (2010), whose studies were based on Schwartz's (1992) and Hofstede's (1984) cultural value dimensions, offers a different view. Their studies suggest that the rule of law is viewed differently by each culture thus compliance with the rule of law is based on culture. Although this study has found a negative correlation between the rule of law and road fatalities, this index might be also be a reflection culture. Gaygisiz (2010) provides a detailed discussion on both culture and corruption and their effects on road safety.

This current study has found a correlation between road fatality rates and corruption. It has been previously suggested that corruption is antithetical to the rule of law and that widespread corruption encourages disrespect for the law (Fisman & Miguel, 2006). Further, corruption results in law enforcement agencies and judiciary becoming ineffective (Herzfeld & Weiss, 2003). Previous studies have cited corruption as a factor that negatively affects road safety (Lagarde, 2007; Nantulya & Reich, 2002; World Health Organization, 2004). Thus the finding from this current study supports these claims. However, a recent study by Hua et al. (2010) have indicated that this is not necessarily true for all countries. They found that for less developed countries a higher level of corruption is associated with a lower number of road fatalities and hypothesised that reducing corruption is likely to help countries improve their economy but could also increase road fatalities. The claim that a higher level of corruption is associated with a lower road fatality rate is a reflection on the low motorisation levels, and thus exposure to road hazards, of the population in less developed countries (Ameratunga, Hijar, & Norton, 2006; Nantulya & Reich, 2002). As less developed countries improve their economy a greater proportion of its population become motorised. This increase in motorisation rate increases the population’s exposure to road hazards resulting in a corresponding increase in road fatality rates (Ameratunga et al., 2006; Nantulya & Reich, 2002) . That is, it cannot be claimed that reducing corruption increases road fatality rates without taking into account the significance of motorisation rate and exposure levels of the population. The discussion on how corruption is associated with road fatality would not be complete without taking into account culture. A study conducted by Licht et al. (2007) found culture to be a major determinant of corruption thus culture needs to be considered in the context of road safety. However, as with the rule of law, culture may be a confounding variable in this analysis and future research should be directed to explore this complex relationship further.

The limitations of this study should be noted. Firstly, the WGI is an aggregate of multiple data sources and, as such, can only provide a proxy for estimating governance quality. Secondly, the cultural aspects of road safety have not been evaluated in detail. Thirdly, the six governance indices are inter-related thus cannot be treated as completely independent to each other. And fourthly, the WHO data used in this study may not adequately address the issue of under reporting of road fatality rates in some countries.

Conclusions

The findings from this study indicate that there is a negative correlation between road fatality rates, measured in fatality per 100,000 population, and the following governance indices: voice and accountability, political stability, governance effectiveness, regulatory quality, rule of law and control of corruption.

This study also highlights the importance of having good governance as part of the global effort to stabilise and then reduce road fatality rates. Future research should be directed to this area as this current study, and those conducted by Gaygisiz (2010), have indicated that there is a correlation between governance and road fatalities.

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Appendix A – List of countries included in this current study.

Afghanistan
Albania
Algeria
Andorra
Angola
Antigua and Barbuda
Argentina
Armenia
Australia
Austria
Azerbaijan
Bahamas
Bahrain
Bangladesh
Barbados
Belarus
Belgium
Belize
Benin
Bhutan
Bolivia (Plurinational State of)
Bosnia and Herzegovina
Botswana
Brazil
Bulgaria
Burkina Faso
Cote d'Ivoire
Cabo Verde
Cambodia
Cameroon
Canada
Central African Republic
Chad
Chile
China
Colombia
Congo
Costa Rica
Croatia
Cuba
Cyprus
Czech Republic
Democratic Republic of the Congo
Denmark
Djibouti
Dominica
Dominican Republic
Ecuador
Egypt
El Salvador
Eritrea
Estonia
Ethiopia
Fiji
Finland
France
Gabon
Gambia
Georgia
Germany
Ghana
Greece
Guatemala
Guinea
Guinea-Bissau
Guyana
Honduras
Hungary
Iceland
India
Indonesia
Iran (Islamic Republic of)
Iraq
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kazakhstan
Kenya
Kiribati
Kuwait
Kyrgyzstan
Lao People's Democratic Republic
Latvia
Lebanon
Lesotho

Liberia
Libya
Lithuania
Luxembourg
Madagascar
Malawi
Malaysia
Maldives
Mali
Malta
Marshall Islands
Mauritania
Mauritius
Mexico
Micronesia (Federated States of)
Mongolia
Montenegro
Morocco
Mozambique
Myanmar
Namibia
Nepal
Netherlands
New Zealand
Nicaragua
Niger
Nigeria
Norway
Oman
Pakistan
Palau
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Qatar
Republic of Korea
Republic of Moldova
Romania
Russian Federation
Rwanda
Saint Lucia
Saint Vincent and the Grenadines
Samoa
Sao Tome and Principe
Saudi Arabia
Senegal
Serbia
Seychelles
Sierra Leone
Singapore
Slovakia
Slovenia
Solomon Islands
Somalia
South Africa
Spain
Sri Lanka
Sudan
Suriname
Swaziland
Sweden
Switzerland
Tajikistan
Thailand
The former Yugoslav republic of Macedonia
Timor-Leste
Togo
Tonga
Trinidad and Tobago
Tunisia
Turkey
Turkmenistan
Uganda
United Arab Emirates
United Kingdom of Great Britain and Northern Ireland
United Republic of Tanzania
United States of America
Uruguay
Uzbekistan
Vanuatu
Viet Nam
Yemen
Zambia
Zimbabwe

Older drivers and rapid deceleration

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Abstract

We examined the relationship between older drivers' Rapid Deceleration Events (RDEs) and visual and cognitive function and driving confidence. Participants aged 75-94 years had their vehicle instrumented for 12-months. Processed accelerometer data identified >750milli-g RDEs. Regression modelling examined associations between RDEs and influential factors, with (i) weeks of monitoring and (ii) distance driven applied as exposure measures. Influential factors included measures of function and driving confidence at baseline and declines over 12-months. Older drivers with a decline in contrast sensitivity and those with lower baseline confidence were found to be at increased risk of involvement in RDEs per distance.

Background

Rapid deceleration has been used as an indicator of near crashes and, in studies including video footage, associated with driver error (af Wahlberg, 2008; Keay et al., 2013; Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2009; Simons-Morton et al., 2009). During 2004-2013 in Australia, fatal crashes involving older drivers increased (BITRE, 2014). Particular concern exists for older drivers with poor or declining visual, cognitive and physical function (Anstey, Horswill, Wood, & Hatherly, 2012; Wong, Smith, & Sullivan, 2012).

Aim

We examined the relationship between older drivers' Rapid Deceleration Events (RDEs) and visual and cognitive function and driving confidence.

Methods

Participants were aged 75+ years and lived in suburban Sydney. Participants' vehicles were instrumented for 12-months with a Global Positioning System and accelerometer. Data processing identified RDEs above 750milli-g. Regression analysis examined associations between RDEs and influential factors, with (i) weeks of monitoring and (ii) distance driven applied as exposure measures.

Influential factors included baseline measures and clinically meaningful changes over 12-months. Contrast sensitivity assesses ability to distinguish an object from its background. DriveSafe/Driveaware evaluated visual attention and self-awareness of driving ability and functional limitations. Trails Making Test Part B assesses visual scanning, psychomotor and executive function. The Driving Confidence Questionnaire assessed confidence during difficult driving situations (0-100 score).

Results

Valid data was recorded for 97% (177/182) of vehicles. Participants were aged 75 to 94 years (median=80), 64% (114/177) were involved in at least one RDE, and 17% to 29% experienced a decline in cognitive and/or visual function during the year. Multivariate modelling per distance driven found RDEs increased by 88% for participants with a decline in contrast sensitivity adjusted for baseline contrast sensitivity (IRR=1.88, p=0.04, 95%CI=1.05-3.36), and 17% for each 10 point lower baseline driving confidence score (IRR=1.17, p=0.003, 95%CI=1.05-1.29). No factors were predictive of involvement in RDEs adjusted for weeks of monitoring.

Discussion

We found older drivers with declining contrast sensitivity and lower driving confidence have greater risk of these events when they are on the road. Associations between poor contrast sensitivity and crash risk have been reported elsewhere (Guo, Fang, & Antin, 2015). Previous research found older drivers only demonstrate increased crash involvement when distance driven is taken into account and raised particular concern for crash involvement for older drivers with lower mileage (Langford et al., 2013). We are seeing a similar relationship for RDEs, and analysis including this cohort has shown confidence reduces with age and functional decline (Coxon et al., 2015), so we may also be demonstrating ‘low mileage bias’.

Research examining 350+ milli-g RDEs during a week from 1425 drivers 67-87 years found those with lower mileage were more likely to be involved in RDEs per distance (Keay et al., 2013). However, drivers involved in RDEs had better vision and cognition compared to those not involved. Differences in findings could be related to RDE thresholds, sample sizes or monitoring periods.

Conclusion

Older drivers who experienced a decline in contrast sensitivity and those with reduced confidence were found to be at increased risk of RDEs.

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Behind the wheel: Process evaluation of a safe-transport program for older drivers delivered in a randomised controlled trial

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Abstract

A process evaluation was conducted to explore relationships between program outcomes, and intervention implementation from a trial evaluating the impact of an individualised safe-transport program, ‘Behind the Wheel’, for older drivers. Relationships were explored using multivariate linear regression and a logic model constructed to explain program inputs, outputs and outcomes. Older drivers who took ownership and planned for retirement from driving were more likely to reduce their driving exposure. A stronger message was delivered to older drivers with lower function and poorer health. Our results suggest ‘Behind the Wheel’ has greatest impact with older, lower functioning drivers through transport planning.

Background

Evaluation of intervention fidelity and implementation in clinical trials has gained momentum in recent decades (Bellg et al., 2004; Oakley, Strange, Bonell, Allen, & Stephenson, 2006; Saunders, Evans, & Joshi, 2005). The impact of a one-on-one education-based safe-transport program designed to enhance self-regulation of driving among community-living older drivers was recently evaluated in a randomized controlled trial(RCT). While the education program was found to increase engagement in the process of self-regulation and retirement from driving, this did not translate to reduced driving exposure between groups.

Aim

A nested process evaluation exploring relationships between program outcomes and quality of intervention implementation was conducted on ‘Behind the wheel’, a one-on-one education-based safe-transport program for older drivers. The process evaluation aimed: 1) to evaluate relationships between what was taught (treatment fidelity, timing of intervention and dose delivered), what was learnt (dose received), what was acceptable to participants (program acceptability) and what actually changed (treatment enactment/outcomes)(Bellg et al., 2004), 2) to explore participant characteristics of program uptake and 3) to explain the inputs, outputs and outcomes of our safe-transport program for older drivers.

Methods

We recruited 380 drivers aged 75 years and over from northwest Sydney to participate in a randomized controlled trial evaluating this program. Trial outcomes were stage of behaviour change measured by the Precaution Adoption Process Model and driving exposure measured objectively by in-vehicle monitoring. Process measures including program fidelity, acceptability, dose delivered and received were obtained from participant interview and educator notes. Relationships between process measures and program outcomes were explored using multivariate linear regression. A logic model was built from the data to explain the inputs, outputs and outcomes of this safe-transport program and relationships confirmed using logistic regression.

Results

High program fidelity was achieved, confirming a homogeneous education program was delivered to 96% of participants. Multivariate regression revealed participants who developed a retirement from driving plan on average reduced their total distance driven by 38.1km/week ($p=0.02$, 95%CI:-7.5- -68.7km) and kilometres driven outside of daylight hours by 7km/week ($p<0.001$, 95%CI:-3.5- -10.4km). Both understanding of program content ($\beta=2.1$,95%CI:0.2-4.1) and achieving a safe mobility plan ($\beta=3.3$,95%CI:1.2-5.5) were important to becoming more engaged in the process of self-regulation. Drivers with poorer function (OR=1.2,95%CI:1.04-1.4) and worse health (OR=1.2,95%CI:1.02-1.5) were more likely to develop safe mobility plans, while older (in age) drivers (OR=1.1,95%CI:1.05-1.3) were more likely to develop retirement from driving plans. Female participants were 2.7 times more likely to develop safe mobility plans than men (95%CI:1.1-6.9).

Conclusion: Older drivers who took ownership over the process of driving self-regulation and retirement from driving to the point where they developed plans, were more likely to reduce their driving exposure. A stronger program message was delivered as intended to older drivers with lower function and poorer health. Results from this analysis suggest 'Behind the Wheel' has greatest impact with older, lower functioning drivers through development of a plan for retirement from driving. The logic model presented will assist development of future programs for older drivers, and help channel resources to those who will benefit most.

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Rapid Deceleration and Crash Events in an RCT Evaluating a Safe Transport Program for Older Drivers

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Abstract

The aim of this project was to determine if education can enhance self-regulation of driving and promote safety of older drivers. As crashes are rare events, rapid deceleration events were used as surrogate safety events and self-reported crashes as a secondary outcome. The randomised controlled trial (RCT) found that an individual education program ('Behind the Wheel') only reduced rapid deceleration events in the drivers with better visual and cognitive functioning and did not have an effect in older drivers with poorer function. It is possible that drivers with better function were better able to implement strategies to promote their safety.

Background

Older people are a large and growing sector of the driving population. Concerns over safety of older drivers have been raised due to increased crash involvement and vulnerability to crash injury.(Meuleners, Harding, Lee, & Legge, 2006) Crash involvement per mile driven and likelihood for driver responsibility begins to increase from age 65 (Williams & Shabanova, 2003) and by age 85 likelihood of crash involvement is approximately 2.5 times higher than that of younger drivers.(Cerrelli, 2007) However, concerns over safety need to be tempered by the fact that driving is an important means to maintain independence and community participation for older people. Loss of driving privileges has been linked to depression and early admission to residential care.(Dickerson et al., 2007)

It was hypothesized that a one-on-one safe-transport program, designed to encourage planning for retirement from driving and self-regulation, could improve the safety of older drivers as measured by rapid deceleration events or 'hard braking'.

Method

The Behind the Wheel program (adapted from the KEYS® program) was evaluated using a randomised controlled trial involving 380 drivers aged 75 years and older, residing in the suburban outskirts of Sydney. Half received the program and half did not. The outcomes for this trial were differences in rapid deceleration events (RDE, > 750 milli-g) and self-reported crashes between groups. General linear models were used to model the impact of the program on the rate of RDEs and self-reported crashes, using distance travelled as an offset. A sub-group was pre-specified based on the cut-off score on the DriveSafe/DriveAware assessment categorising drivers into likely safe and needing further assessment.

Results

We recruited 380 participants (230 men) with an average age of 80 years and 366/380 (96%) completed the 12 month study. The program was delivered to 183/190 (96%) of drivers allocated to the intervention. In vehicle monitoring data was available for 351 participants (92%) for a median of 52 weeks [inter-quartile range (IQR) 44-52] and 5487 [IQR 3294-8641] km of travel. Of the drivers in the trial, 218/351 (62%) drivers had at least one RDE and the median number of RDEs was 1 [IQR 0-4]. Overall, there was no between group difference in the rate of RDEs per distance driven (incident rate ratio (IRR) 0.85, 95% CI 0.61-1.18). Crashes were reported by 14 participants in the intervention and 19 in the control group (p=0.46). Pre-planned sub-group analyses showed that the intervention was effective in significantly reducing RDEs (IRR 0.41, 95% CI 0.20-0.81), in drivers with a DriveSafe/DriveAware score of 96 or higher (fit to continue driving).

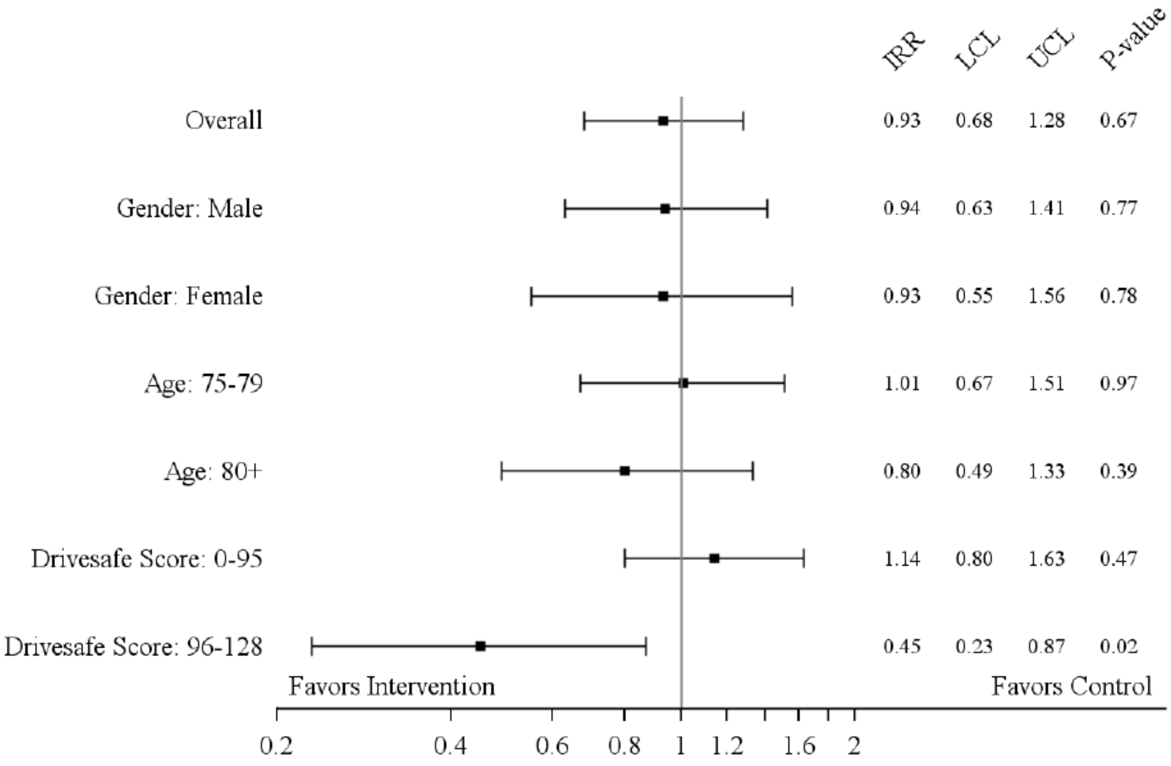

Figure 1: Forest plot showing the incident rate ratio for rapid deceleration events in the intervention compared to the control group stratified by sex, age and DriveSafe/DriveAware Score. IRR=incident rate ratio, LCL=lower 95% confidence limit, UCL=upper 95% confidence limit

Conclusions

Older drivers with good visual and cognitive function are responsive to a one-on-one education program to improve their safety on the road. These drivers reduced their involvement in RDE events by more than half, however this approach was not effective in drivers with poorer function.

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Naturalistic driving study analysing the effect of rainfall on driving behaviour for older drivers

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Abstract

We aimed to determine whether the amount of daily rainfall was predictive of driving behaviour among drivers 75+ years, in regards to driving exposure and the rate at which Rapid Deceleration Events (RDEs) occurred, acting as a surrogate safety event. Naturalistic driving data from 190 drivers aged 75+ years, monitored between one and 12 months was used in this analysis. By applying a T-distribution, we found older drivers tend to drive more during light rainfall (1-2mm] and less during heavy rainfall (10-20mm]. Using logistic regression, we found the rate of RDEs decreases with increasing rainfall, suggesting cautiousness among older drivers.

Background

There has been an increase in road fatalities involving older drivers in Australia, over the last few years. The difficulties faced when driving are exacerbated by rainfall as crash risk increases (Qiu and Nixon, 2014). Further, evidence suggests that the volume normalised accident count on wet days is significantly higher than dry days, with this effect exacerbated by the amount of rainfall that falls on a given day (Keay and Simmonds, 2006). Given the increased risks and incidents associated with wet weather driving, we sought to determine whether drivers aged 75+ years travelled more or less in wet weather and if rainfall influenced their safety on the road.

Methods

A naturalistic driving study was conducted involving 190 older drivers (above 75 years of age) who were monitored for a period of up to one year. Time stamped acceleration and GPS location was gathered from an in-vehicle device (C4D, Mobile Devices Ingenierie, Villejuif, France) which was hardwired to the participant's vehicle, which transmitted this data back to a secure database via telecommunication networks (Greaves et al., 2007). As crash data requires a longer period of analysis and a larger study cohort, Rapid Deceleration Events (RDEs) were used as surrogate safety event measure. Rapid Deceleration Events are defined as deceleration of greater than 750 milli-g at any point the car was in motion. Using the Drivesafe/DriveAware score, an in-office test designed to predict fitness to drive, validated against on-road driving performance (Kay et al., 2009), participants were categorised as either 'safe' or 'needs further testing'. DriveSafe/DriveAware assessed participants' visual attention to the driving environment and awareness of their driving ability and functional limitations.

The average and standard deviation of the number of trips and the total time driven per participant was calculated on a daily basis throughout the duration of the study between June 2012 and May 2014. For each day during the study period, the amount of rainfall was categorized into 6 classes: [0-1mm], (1-2mm], (2-5mm], (5-10mm], (10-20mm] and 20+mm. A T-distribution was applied to determine any differences in driving exposure (number of trips and time driving) with daily rainfall.

Each trip was classed as either a RDE or non-RDE trip based on whether at any point there was deceleration greater than 750mg. Logistic regression was used to determine whether amount of rainfall was predictive of RDE trips adjusting for age, gender and the driver's DriveSafe/DriveAware score.

Results

Among the 190 study participants, average age was 80 years old and 54% were men (102/190) The DriveSafe/DriveAware predicted 43 drivers were 'safe' and 147 as recommended to 'need further testing'. During the 668 days where driving was monitored, on average participants travelled 2.71±0.74 trips per day and drove on average 29.77 ±9.22 minutes per day. . The Geographical distribution of trips is shown in Figure 1, shows the starting location of a given trip, with trips restricted to those starting within the boundaries shown below. The majority of trips started in the Hills Shire.

Table 1. Distribution of Rainfall

Amount of Rainfall (mm)	Number of Days	Percentage of Days
0-1	535	80.09%
1-2	19	2.84%
2-5	37	5.54%
5-10	26	3.89%
10-20	34	5.09%
20+	17	2.54%

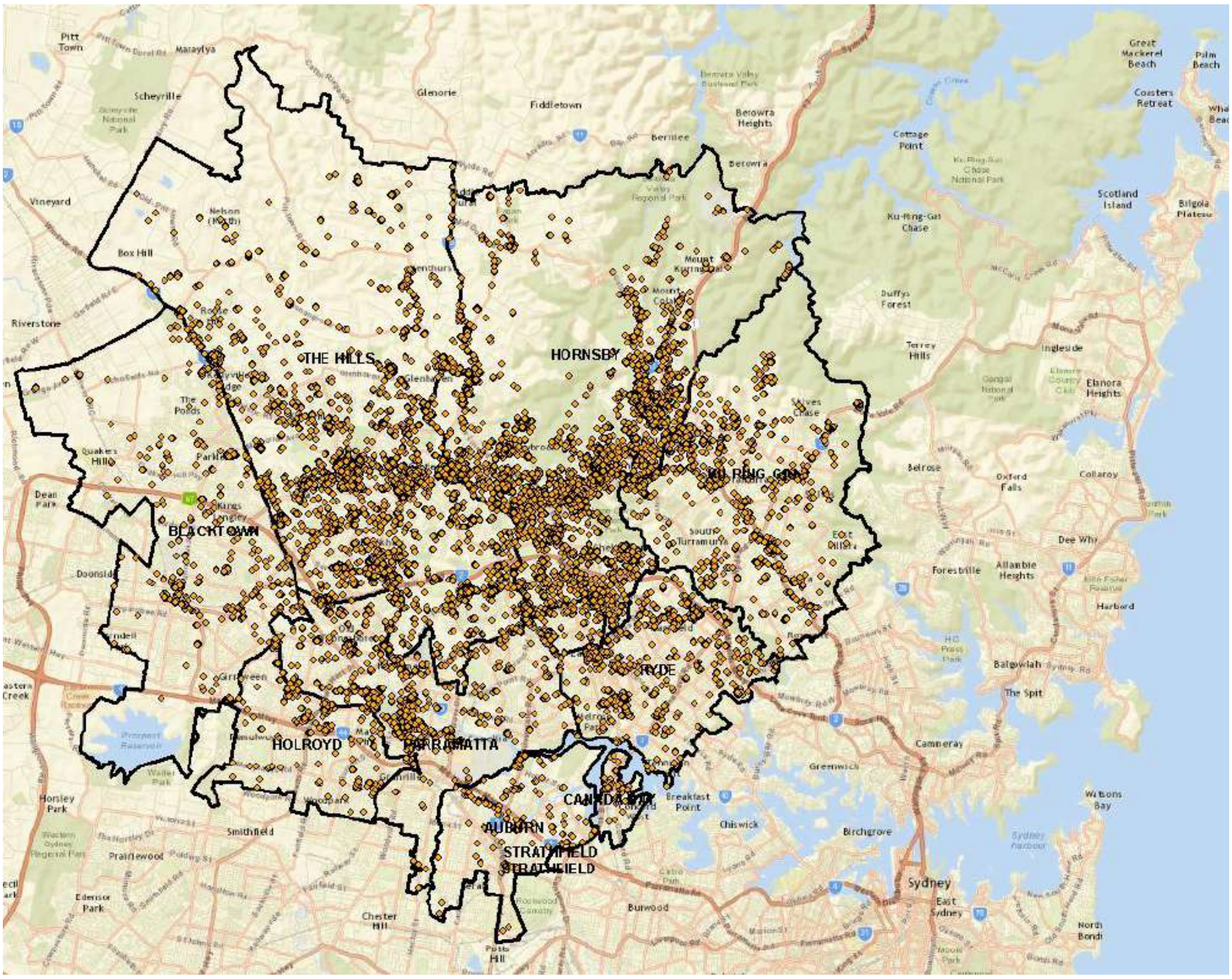

Figure 1. Geographical Distribution of Trips

Participants predicted as ‘safe’ drove more, both in terms of number of trips (2.86±0.95, p-value = 0.0002) and exposure (34.1±13.97minutes, p-value < 0.001) on days of rainfall 0-1mm than days with more rainfall. On the other hand, drivers that ‘need further testing’, had a peak in number of trips (3.35±0.94, p-value = 0.004) and greater driving exposure (36±15.37minutes, p-value = 0.047) on days with rainfall 1-2mm, and less trips (2.38±0.59, p-value = 0.001) and exposure (25.68±6.73minutes, p-value = 0.001) on days with rainfall 10-20mm. Results from the logistic regression indicate that the greater the amount of rainfall, the lower the rate of RDE trips (OR=0.91, CI: 0.85-0.97) and this relationship remained after adjusting for age, gender and DriveSafe/DriveAware score.

Conclusion

In general, older drivers drive more during times with little rainfall (1-2mm) and less during times of heavy rainfall. Given the reducing rate of RDEs with increasing rainfall, this suggests older drivers are more cautious as rainfall increases, regardless of their driving ability.

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Mobility beyond driving – exploring the issues for older non-drivers

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Abstract

Reliable and efficient mobility is essential for the well-being of all Australians. Poor mobility can have serious consequences for older people and can affect their overall well-being. This research aimed to develop a greater understanding of the mobility issues that older non-drivers face in metropolitan and regional Victoria, and considered the impact of not driving on carers of non-drivers. The research involved both qualitative and quantitative phases. The results identify the reasons that older people cease driving and resulting issues and positive impacts with being a non-driver. The research also presents opportunities to support older non-drivers with their mobility.

Background

Reliable, efficient and effective mobility is essential for the well-being of all Australians. Good transport and mobility allows people access to essential services, to participate in social and recreational activities and to have some level of engagement with their community (Harris & Tapsas, 2006).

The primary mode of transport used by most people in Victoria is the private car. However, the provision of adequate transport alternatives for people who are unable to drive is important. Poor transportation and mobility can have serious consequences for older people and can affect their overall well-being. Previous research has identified that transport services available to older people who are unable to drive are inadequate (Congiu & Harris, 2008).

This research aimed to develop a greater understanding of the knowledge, beliefs and perceptions about mobility issues older non-drivers face in both metropolitan and regional Victoria. It also sought to determine current strategies employed by older people to cope with the non-driver experience and identify ways to support older non-drivers to stay mobile. The research also took a broader perspective of the non-driving experience by considering the impact of not driving on carers of non-drivers.

Method

The research was conducted in two stages. The qualitative stage comprised 30 in-depth interviews with older non-drivers (65 years and older), older drivers (75 years and older) and carers of older non-drivers. The quantitative phase involved a self-completion (online and paper) survey of 303 older drivers, non-drivers (65 years and older), and carers of older former drivers.

Results

The transition to non-driving for older people occurs either progressively over many years or abruptly as a result of a significant event such as an illness or injury. Older people reported that they want to retain their dignity when transitioning to non-driving and that this can be achieved through maintaining control over the decision. The time when older people are transitioning to non-driving or have just ceased driving is the most important time for giving them support and providing information about alternative transport. Some of the benefits of ceasing driving were a reduction in stress, empowerment and dignity if the decision was made by the older person themselves. Some of the negative impacts of no longer driving included a loss of independence, difficulty getting to appointments and social isolation. Negative impacts were greatest among those living in rural areas and living alone. Good planning and awareness of alternatives appears to be crucial factors in avoiding negative impacts of not driving.

Conclusions

The results of this research identify the reasons that older people cease driving and highlight resulting issues, barriers and positive impacts with being a non-driver. It also presents opportunities that will help support older non-drivers with their mobility needs, particularly in the areas of supporting older people to transition to non-driving with dignity, improvements to local transport and mobility services, and targeted information on mobility alternatives aimed particularly at those who have most recently stopped driving.

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Trail bike road trauma: intelligence-led approach to reducing community harm

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Abstract

Trail bike riding results in a high number of injuries each year. There are limited initiatives to address this unique road safety issue. Intelligence was sought to understand the nature and extent of the problem. Rider injuries during 2013/14 were identified in police collision data. Collision reports were reviewed and geospatial analysis undertaken. Over 600 injuries were identified, accounting for one-quarter of all police-reported motorcyclist injuries. Intelligence findings informed a 12 month police enforcement operation and facilitated inter-agency partnership, resulting in a local pilot program to investigate environmental solutions at a high risk location, and development of tailored educational material.

Background

Trail bike riding throughout state forests and parks is an increasingly popular recreational pursuit in Victoria, Australia. The associated burden of injury however has attracted significant attention in recent years (Mikocka-Walus, Gabbe & Cameron, 2010; Victorian Auditor-General, 2011; Road Safety Committee, 2012). Whilst there have been numerous motorcycling safety initiatives, including enhancements to the motorcycle licensing system, such initiatives have not addressed riding on unsealed highways to the same extent as for sealed highway environments (Mickocka-Walus et al, 2010).

Road safety legislation still applies on unsealed highways in forest/park settings to ensure public safety. The State Highway Patrol's Solo Unit has a fleet of police equipped trail bikes and provides specialist training to enable members to effectively access unsealed environments to enforce road safety and to help promote safe and responsible road use. While most road users are alert and compliant a minority engage in unsafe and illegal behavior, including unlicensed and under-age riding, impaired riding and unregistered vehicle use. Low level enforcement in remote rural areas likely increases the potential for such high risk behaviour (Boschert, Pyta & Turner, 2008).

The nature and extent of trail bike activity and related trauma was not well understood. Amid police concerns, intelligence was sought to assist Road Policing Command in better understanding and responding to this unique road safety issue.

Method

Police-reported motorcyclist collisions in the 2013/14 financial year were extracted. Recreational trail bike rider collisions were identified using a combination of fields: location type, road surface type, motorcycle make/model, purpose of journey. Collision reports were examined and geospatial analysis undertaken to gain insight into the incident circumstances and contributing factors. Collision data was combined with past enforcement results in similar geographic areas to assess trends.

Results

Over 600 motorcyclist injuries were identified state-wide, representing one-quarter of all police-reported motorcyclist collisions. Police rarely attended incidents (20%). Consequently, the accuracy of incident details reported is unclear and most riders were not subject to alcohol and drug testing.

Injuries were predominantly on weekends during daylight hours. A high proportion occurred over official long weekends. While most incidents were single-vehicle with no collision (67%), incidents involving more than one vehicle (including head-on with a four wheel drive) were associated with more severe rider injuries. Most riders attributed initial loss of control to environment factors: large rocks, fallen branches, loose gravel, dust, washout, ruts. Illegal behaviour was apparent in 10% but likely under-reported. Operational results revealed between 25-40% of intercepted road users had committed an offence.

Discussion

Hospitalization figures suggest injuries are grossly under-reported to police. Contributing factors were mostly consistent with rider survey results (Social Research Institute, 2015). Surveys further revealed fatigue, inappropriate speeds and rider skill being issues, although these were less apparent in police data. Intelligence findings informed the development of a state-wide police operation (*Operation ATME*, all-terrain motorcycle enforcement) targeting priority locations (Figure 1). Recognising the Safe System framework, trauma will not be reduced through behaviour change alone. Importantly, findings facilitated closer engagement with partner agencies which has led to a local pilot program to investigate road environmental solutions at a high risk location. An educational resource is also being developed to assist riders. Collision data, police enforcement outcomes and member observations will be used to evaluate the impact of these initiatives.

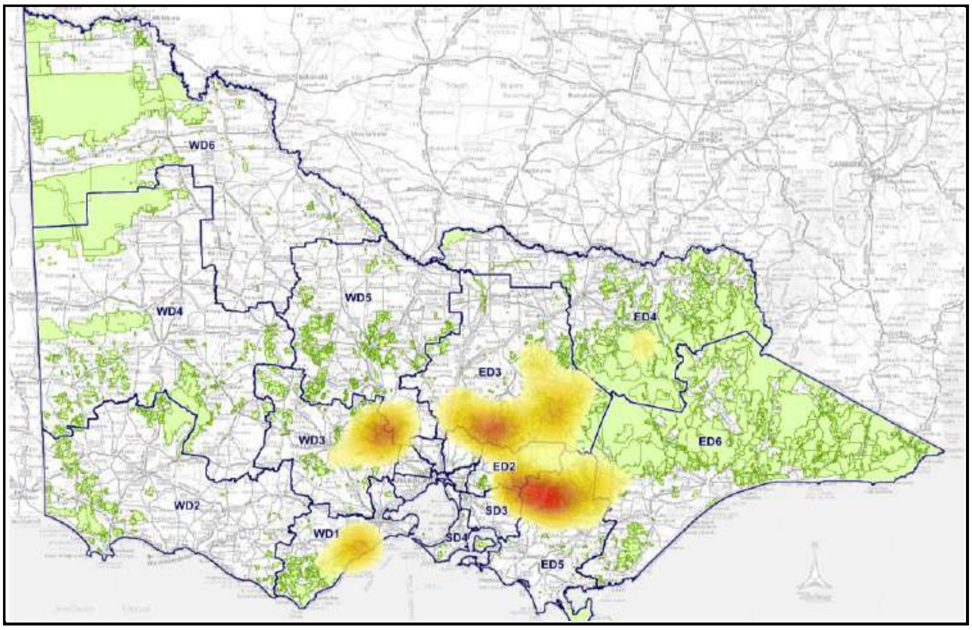

Figure 1. Hot spot analysis of trail bike collisions, Victoria Australia 2013/14

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Toward Automated Enforcement at Active Level Crossings in Australia

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Abstract

Collisions at active level crossings are a growing concern and largely arise from violations. The rail industry is exploring automated enforcement to target these violations. The aim of the study was to obtain a baseline measurement of violations at level crossings. A level crossing was selected for a two-day observation and the installation of monitoring equipment for 1.5 months. Over 1,000 violations were recorded. The monitoring system was installed unobtrusively, but in spite of this, the frequency of violations was disproportionally lower than during the in-situ observations, suggesting the need to consider Australian specificities during the configuration of such equipment to obtain accurate measurements of these violations.

Introduction

In Australia, most railway level crossings in high-traffic road environments are actively protected. Despite this, collisions at these crossings account for two thirds of the costs of collisions at all level crossings. Many of these collisions arise from deliberate violations at level crossings with full protection, and are favoured by congested road conditions. Violations are committed by all road users at level crossings, and include entering the level crossing while active, and stopping on the crossing due to road congestion; all leading to risk of collision with approaching trains.

Australia has trialled and researched many initiatives to increase drivers' awareness of level crossings, and reduce chances of inadvertently ignoring warning infrastructure. However, these approaches do not target deliberate violations and are unlikely to engender lasting change in substantive driver behaviour, and new interventions are necessary. The current road safety strategy is to use the Safe System approach with the aim to build a road transport system that is tolerant to human errors. In this paradigm, road users still have a responsibility to obey road rules. Enforcement is therefore a constitutive part of this strategy to reduce unsafe road behaviours as well as highlight their social unacceptability.

The rail industry is therefore exploring the use of automated enforcement at level crossings to target deliberate violations, largely because it has been shown to be very effective for other road user violations such as speeding. However, very little research has evaluated the potential benefits of such an approach for rail level crossings or provided a sound scientific evidence-base for its utility within Australia.

Method

The aim of the study was to obtain a baseline measurement of violations at level crossings and the purpose of this study is to create a scientific evidence-base to reflect the size of the problem and describe some of the pertinent issues associated with obtaining this. A level crossing close to Melbourne was selected as a study site based on reported congestion issues and reported high violations incidence (see Figure 1). Monitoring equipment (cameras and radar) was installed in an unobtrusive manner for 1.5 months to obtain a baseline dataset of driver violations. A two-day observation study was conducted at the site prior to the installation in order to evaluate the reliability of these data.

Figure 1. Pictures of the level crossing at Aviation road, Laverton, and bird's eye view with researchers' (yellow circle) and equipment (white cross) positions highlighted

Results

The monitoring equipment showed that the level crossing was closed for 75% of the time during peak hours, leading to chronic road congestion issues, long waiting times and high likelihood of transgressions by all types of road users. Over a month and a half the monitoring equipment recorded a total of 626 flashing light violations; 331 of these all occurred within 2s of the activation of the lights at the crossing, and 295 occurred later than 2s after the activation of the crossing. This was an average of 13.3 flashing light violations per day. A further 241 drivers left the crossing before the flashing lights were fully turned off, and 148 drivers encroached over the Stop line while the lights were flashing. The violations observed over the two-day in-situ observations are the following: 16 flashing light violations were observed within 2s of crossing activation, and 29 occurred later than 2s after crossing activation. One cyclist was observed going around the lowered boom gates; 34 drivers left the crossing before it was completely re-opened; 170 vehicles stopped on the crossing, and 145 vehicles stopped on yellow box marking. After normalisation (per hour) of the violations recorded, we found that the number of violations recorded by the monitoring equipment was consistently smaller than the number recorded during the in-situ observations.

Discussion and conclusions

The chosen level crossing was very challenging for testing a monitoring technology, with high level of road, rail and pedestrian traffic, multiple road lanes in each direction, three rail tracks and roundabout on either side of the crossing. The design of the crossing environment led to a large range of violations from all road users. A disproportionately higher number of violations were captured during the observation study. Further observations at the site suggest that this is due to limitations from the monitoring equipment configuration rather than driver behavioural change. Level crossings are a very dynamic intersection between the road and rail networks, with numerous and complex interactions between trains, road vehicles and pedestrians during peak hours. This research shows the need to have a broader understanding of the complex situations at level crossings in order to obtain accurate baseline behaviour measurements with automated monitoring systems, and that technical solutions need to take into account these specificities. Having obtained data in an non-obtrusive manner, the next phase of this project was to install similar equipment in a more conspicuous mode to evaluate the propensity to reduce violations with visible driver behaviour monitoring at that level crossing. The overall research provides an insight into how effective is the use of automated enforcement for reducing level crossing crashes.

The development of an intelligence-based deployment model to enhance Road Policing service delivery: A case study

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New Zealand Police

Abstract

New Zealand Police's Southern District (SD) has been facing increasing and competing demands for Road Policing service delivery. Road Policing (RP) was conducted in silos and it was unclear if activities and deployments reflected risk. An intelligence risk assessment was developed that identified the safety risks and priorities across the district, which was compared with current practice. A deployment model was developed to align with risks, allocate staff and resources based on demand and the integration of RP with other workgroups. This model is put forward as an evidence-based means to aligning deployment and resources to risk and shifting demands.

Background

Geographically, SD is New Zealand's largest district and has a widely dispersed rural population. This being a popular region for tourism means visiting drivers also create substantial seasonal increases in traffic volume. RP staff were split between multiple teams and had four separate reporting lines. RP teams decided where to deploy (often based on 'gut feel' and experience) and did so independently of other groups, which led to parts of the network being saturated and others under-patrolled. This also created shortfalls in equipment and vehicles. Lack of a coordinated approach to deployment meant it was unclear if temporal and spatial risks were being appropriately prioritised, and RP was not aligned well with other work groups.

Intervention

1. Intelligence district road risk profile (DRRP) created to identify risks and priorities.

An intelligence product was developed to identify priorities and top risks in SD, including: long and short term trends, hotspots, top risk factors and key journey routes (Figure 1). This product presented a complete picture by combining data from a wide array of sources, including: traffic crash reports, motor vehicle injury claims data, offence data, behavioural and attitudinal data, GIS crash maps, police reported traffic incidents and vehicle stops, community complaints, hospitalisation data, and the community risk register.

2. Compare and contrast with current practice to seek opportunities to address the risks.

The findings of DRRP were compared against: current practice and activities undertaken, staff allocated to role types, rosters, deployments and taskings across the district, and equipment resourcing.

3. Realignment of staff and resources to address the demand/risk and integrate this with other parts of the business as part of the wider deployment plan.

Mismatch was revealed between what the DRRP identified as risks, and where, how and when staff were being deployed. Non-RP groups were introduced to the findings and included in the development of a deployment model.

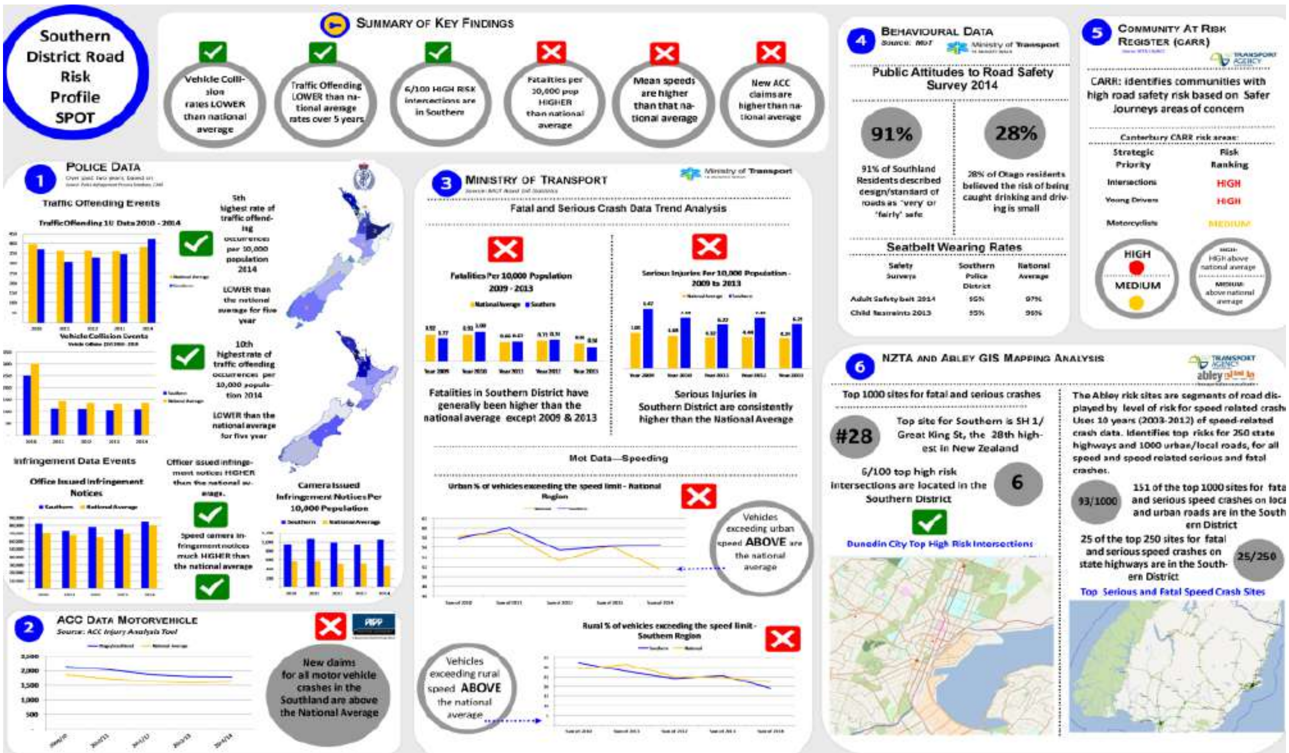

Figure 1. Sample summary page of DRRP intelligence report.

4. Equipment access and type assessed and reallocated

Vehicles and tactical equipment was no longer assigned to areas, workgroups and individuals, but assigned based on shift tasking requirements. This provided staff with access to equipment when and where it was needed to carry out duties and also freed up seven patrol vehicles.

5. Create a deployment model to align with risk and demand

SD RP was restructured so that staff from the all areas reported to the district Road Policing Manager. This allowed for staff to be rostered on for shifts that matched local risk profiles, which varied by type (urban/rural/highway), day of week and time of day. Specific changes made include:

- Shift rosters altered and staff relocated to provide optimum coverage.
- Staff rotated through areas to compensate for moving risk patterns.
- Activities undertaken and role types aligned to local risk profiles.
- RP deployment integrated into other workgroups' deployment.
- Enhanced performance monitoring and reporting across RP and non-RP workgroups.

6. Monitoring, evaluation and adjustment

The structure changes and deployment model were successfully implemented in January 2016. An adjustment period of four months was allowed for where issues and risks are identified and corrected and changes are progressively implemented. The outcomes of the deployment model will be evaluated in 2017 once the final structure has been operating for 12 months. The evaluation will make comparisons against control periods to assess: alignment of officer deployment and activity with the top risks; output levels; traffic offending; crashes and hospitalisations.

Conclusion

This case study provides a practical model of how intelligence and demand data can be used to perform a robust assessment of the current state of practice and deployment against evidence-based priorities and risks. The SD RP deployment model provides a platform for staff and resources to be allocated to best address risk and shifting demands, producing efficiencies and more effective service delivery. The evaluation of the intervention will assess the key outcomes and identify opportunities for improvement, providing a platform for other Police districts to optimise their Road Policing

Identifying optimal sites for static speed cameras in New Zealand – a geospatial approach

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Abstract

In an effort to reduce speed-related crashes, the New Zealand Police is expanding its network of static speed cameras. To help identify optimum sites for speed camera placement, Abley Transportation Consultants undertook an independent, evidence-based assessment using geographic information systems.

Using historic crash data, corridors with relatively high numbers of speed-related or high severity crashes were identified and ranked. Potential social cost reductions were then used to identify optimal camera locations on high risk corridors. The results of the analysis were presented in a web viewer to enable the Police to undertake further desktop scoping of potential camera sites.

Introduction

In 2015 the New Zealand Police (the Police) approached Abley Transportation Consultants to develop a methodology for identifying 600 sites for their speed camera expansion programme. This methodology developed in collaboration with the Police and the NZ Transport Agency.

Methodology

Ten years of injury crash data was extracted from the NZ Transport Agency's Crash Analysis System. For each crash, the estimated death and serious injury crash equivalents (DSi) were calculated (NZ Transport Agency, 2013). The DSi of crashes within the last five years were double-weighted to highlight locations with worsening crash trends.

Using GIS, a New Zealand road dataset was split into 100m segments and crashes within a specified catchment distance of each segment were identified: 500m for rural roads and 250m for urban roads. For each catchment area, the total DSi, number of fatal or serious crashes and number of speed-related crashes were summed. A segment score (SS) was then calculated, which prioritised roads with a high number of speed-related and high severity crashes:

$$\text{SS} = (\text{total speed-related crashes} * 0.4) + (\text{sum DSi} * 0.4) + (\text{total fatal/serious crashes} * 0.2)$$

Additional criteria were also identified to filter potential sites:

- Sites had to be at least 300m long to provide enough room for camera placement.
- Sites could not have a 'tortuous' alignment where drivers were likely to exceed the speed limit.
- At least 25% of crashes had to be speed-related.
- Less than 75% of crashes could be intersection-related (to discount sites where other enforcement measures are more appropriate).

To identify a final list of 600 high-risk corridors, an iterative process was undertaken testing different Segment Scores, dissolving contiguous sections of high-risk segments into high-risk corridors, and removing corridors that did not meet the additional criteria listed above.

The optimal camera location within each high-risk corridor was determined by finding the site that offered the greatest potential social cost reduction. To do this, 'virtual' camera sites (points) were created at 100m intervals on each corridor. The total social cost of crashes with each virtual site catchment area was then calculated using social cost estimates (Ministry of Transport, 2014).

Existing research suggests that crash reductions due to speed cameras installation range between 20% (Mara, Davies and Frith, 1996) and 42% (Transport for NSW, 2015). Using this variance, a range of potential crash reductions were calculated: 100% (full reduction); 42% (optimistic) and 20% (conservative). These potential crash reduction factors were used to calculated potential social cost reduction (SCR) at each virtual site. The virtual site with the highest SCR was identified as the 'site optimum location' – the location where a camera would have the most effect for reducing fatal or serious injury crashes.

The outputs from the assessment were provided to the NZ Police on a webmap viewer (figure 1).

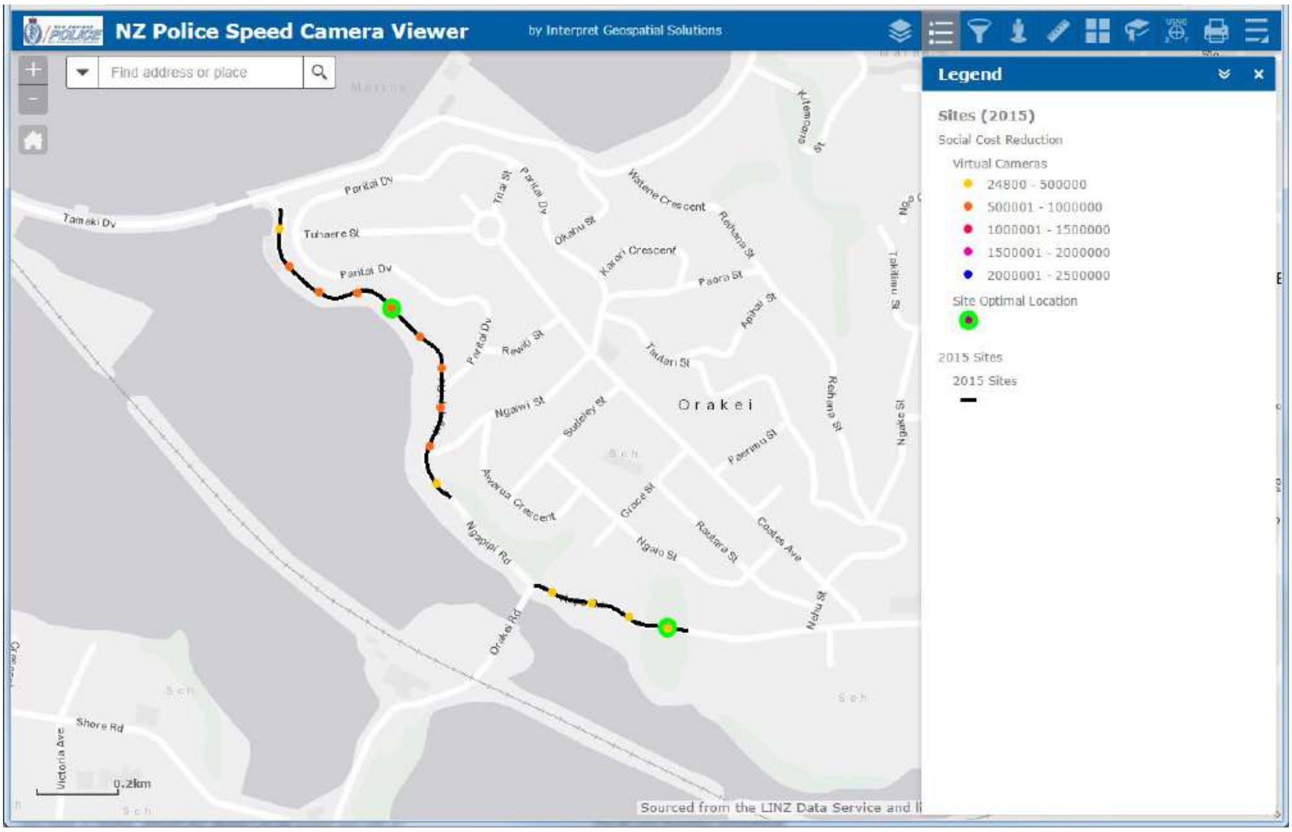

Figure 1. Screenshot of webviewer identifying optimal speed camera sites

Each optimal site is identified along with the key statistics and crash locations. This site is now being used by the Police to undertake further desktop scoping of potential camera sites.

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Community perceptions of speed enforcement tolerances in Queensland

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Abstract

This study explored the changes in community perceptions of speed enforcement tolerances in Queensland. The changes in community perceptions were revealed from an analysis of speeding related questions in an annual online survey commissioned by the Department of Transport and Main Roads, and speeding enforcement data received from the Queensland Police Service. It is envisaged that the impact of community perceptions on speeding behaviour will identify triggers to behaviour change and inform enhancements to speed management in Queensland.

Background

Speeding is a complex social behavioural issue and it still represents a high proportion of contributing factors of road crashes in Queensland. Speed-related crashes contributed to 65 fatalities during 2014, representing more than one in four road deaths in Queensland. In general, motorists believe they can travel within an acceptable speed above the posted speed limit and will not receive a fine. This relates to a perceived enforcement tolerance applied by the Queensland Police Service (QPS), which are not publicised.

The aim of this study was to better understand the attitudes that contribute to the behaviour of motorists to inform ways to address speeding which continues to be one of the 'Fatal Five' driving behaviours.

Method

The Department of Transport and Main Roads commissions the Road Safety Perceptions and Attitudes Tracking Survey to monitor trends over time for a variety of road safety topics. The survey uses an online panel to recruit a representative sample of 600 Queenslanders. Annual data collection typically occurs in April and May.

QPS provides the department with a monthly speeding infringement report that includes the number of vehicles monitored, offences detected, notices issued and hours of camera deployment. The notices issued are broken down into bands of <13 km/h over the limit, 13-20 km/h over the limit, 21-30 km/h over the limit, 31-40 km/h over the limit, and >40 km/h over the limit.

Results

Survey responses to the question "*How far over the speed limit are people generally allowed to drive/ride without being booked for speeding?*" can be interpreted as respondents' perception of enforcement tolerance levels. Response options included no speed over the speed limit, up to 5/10/15/20 km/h over the speed limit, more than 20 km/hr over the speed limit, depends on the speed limit, other (type in), and don't know.

A positive trend in responses to this item has been observed. In 2006 and 2007, 68% of respondents believed they could travel up to 5-10 km/h over the speed limit before being booked for speeding, compared with only 55% in 2013, 51% in 2014 and 45% in 2015. These results are consistent with changes in motorist's perception and awareness of changes to enforcement tolerance levels.

Infringement statistics also suggest that motorists were aware of the changes. Following a publicised reduction in the operational enforcement tolerance, there was an expected spike <13 km/h over the limit in infringements, followed by a steady reduction. This suggests that after an initial learning period, motorists became aware of the changes and adjusted their behaviour.

Conclusions

Community surveys and speeding infringement statistics suggest that Queensland motorists are sensitive to changes to enforcement tolerances and adjust their behaviour accordingly. These findings have implications for identifying the triggers for behaviour change as well as understanding the motivation for specific behaviours such as low level speeding. Future research to profile low level speeders may reduce infringement rates in this category. Collection of attitudinal data will continue to monitor self-reported speed compliance and respective behavioural changes over time.

Driving Safety in Mild Cognitive Impairment Compared with Cognitively Normal Adults Assessed with On-Road Test and Off-Road screening tools

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Abstract

We aimed to evaluate the safety of older drivers with Mild Cognitive Impairment (MCI) compared with cognitively healthy drivers living independently in the community.

Background

It is known that some people with mild dementia can continue to drive safely but that eventually they will need to retire from driving. There is a paucity of data on the road safety of individuals who have cognitive impairment that is not severe enough to meet the criteria for dementia. MCI is the classification given to adults with measurable cognitive impairment but who do not have dementia. Although a high proportion of adults with MCI will progress to dementia, others will revert to cognitive health or remain stable with MCI and not progress to dementia. MCI is more prevalent than dementia, affecting approximately 20% of the population aged 70 and older. Our review identified one paper reporting on-road assessment of drivers with MCI in a sample of 95 participants. MCI drivers made more errors and performed less well on the on-road test (ORT) but did not demonstrate impairment in driving to a degree that would render them unsafe(Wadley et al. 2009).

Method

The sample for this study comprised 302 participants who completed an on-road driving tests, and an off-road assessment (Mallon and Wood 2004). Current drivers aged 65 to 96 (M = 75.3, SD = 6.18, 40% female) were recruited through community advertising as part of an NHMRC Funded study on Driving Ageing Safety and Health (DASH). Participants were screened for dementia with the Mini-Mental State Examination (Folstein, Folstein, and McHugh 1975) and those with probable dementia were excluded from this analysis. The neuropsychological tests (see Strauss, Sherman, and Spreen 2006) included: Digit Span Backward, Stroop Colour Word Test, Boston Naming Test, Benton Visual Retention Test, Letter Fluency, California Verbal Learning Test, and Trail Making Test, as well as Useful Field of View (Ball and Roenker 1998), Game of Dice Task (Brand et al. 2005) and Reading the Mind in the Eyes (Baron-Cohen et al. 2001). We defined cognitively ‘at risk’ psychometrically as scoring more than 1.5 standard deviations below the mean on one or more cognitive domain including complex attention, learning, language, perceptual-motor function, executive function, and social cognition. Of the sample, 86 were identified as cognitively ‘at risk’ and 216 participants were identified as cognitively healthy. Off-road driver screening measures including the Useful Field of View (Ball et al. 2006), Maze test, Drivesafe, the RoadLaw Test (Unsworth et al. 2012), and the Multi-D battery were administered. The Multi-D comprises a measure of sway, colour choice reaction time and balance (Wood et al. 2008). Generalized linear models adjusting for age, sex and education estimated whether those who were cognitively ’at risk’ were less safe than those who were cognitively healthy.

Results

Of the cognitively healthy group, 12.5% were classified as unsafe drivers by an on-road assessment and likely to fail a formal driving test, 48% were assessed as definitely safe, with the remained scoring in a range where they may or may not pass a driving test. Of the cognitively at risk group, 23.25% were assessed as unsafe drivers and 33% were assessed as definitely safe. The average driver safety rating of the MCI group was lower than the cognitively healthy group ($p < .01$) but the distribution of scores across Unsafe, Possibly Unsafe, and Safe categories did not differ. The cognitively at-risk participants had statistically significantly lower scores on all off-road screening measures, and results were unchanged after adjusting for age, sex and education. However, there was a wide range of scores on the off road tests, with some cognitively at risk participants scoring very well and some cognitively healthy participants scoring poorly.

Conclusion

Mild cognitive disorders increase the risk that older drivers will be unsafe and a higher proportion of this group will potentially fail an on-road driving test. However, due to the wide-rang range in performance in this group, a full assessment of driving safety is required with regular follow-ups.

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Fitness-to-drive after mild traumatic brain injury: Mapping the time trajectory of recovery in the acute stages post injury

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Abstract

Mild traumatic brain injuries (mTBI) comprise 70–90% of all traumatic brain injuries sustained, often as a result of motor-vehicle crashes. Despite this, there is little evidence to suggest when individuals are safe to return to driving. In this study, two groups of participants were recruited: patients with mTBI and a control group. Both groups were assessed 24 hours post injury on fitness-to-drive assessments. Two weeks post injury, follow-up occurred to establish driver status. This research confirmed that patients with mTBI should not drive for 24 hours. Further research is required to map factors which predict timely return to driving.

Knowledge Gap

Individuals who sustain a mild traumatic brain injury (mTBI) are commonly treated in an acute hospital, and this is the setting where fitness-to-drive recommendations are made. However, national medical guidelines in Australia reflect that little is known about the recovery trajectory in fitness-to-drive post injury (Austroads, 2012). This means health-care professionals have limited evidence on which to base recommendations about return to driving for the mTBI cohort.

Purpose

To determine fitness-to-drive status of patients with a mTBI at 24 hours and 2 weeks post injury, and to summarise issues reported by the mTBI cohort about return to driving.

Method

Case-control design. Two groups of participants were recruited from an acute hospital in Victoria, Australia: patients with a mTBI (n = 60) and a control group with orthopaedic injuries (n = 60). Both groups were assessed at 24 hours post injury on the OT-DORA Battery (Unsworth et al., 2011) – a fitness-to-drive assessment. Follow-up occurred at 2 weeks post injury to establish driver status, and to determine time to return to driving.

Results

At 24 hours, only one sub-test of the OT-DORA Battery showed a difference in scores between the two groups, with mTBI participants being significantly slower (p = 0.01) to complete the maze sub-test. At the 2 week follow-up, only 26 of the 60 mTBI participants had returned to driving. Injury severity combined with scores from the 24 hour assessment predicted 31% of the variance in time taken to return to driving. Delayed return to driving was reported due to: “not feeling 100% right” (n = 14, 42%), headaches/pain (n = 12, 36%), and dizziness (n = 5, 15%).

Conclusion

Results demonstrate the complex issue of predicting fitness-to-drive. At 24 hours post injury, patients with a mTBI displayed difficulties on only 1 of 5 assessments thought to represent various aspects of fitness-to-drive, yet only one-third of participants went on to return to driving 2 weeks post injury. Existing guidelines which suggest that patients with a mTBI should not drive for at least 24 hours are supported by this study; however, further research is required to map factors which predict return to driving.

"Agility, Innovation, IMPACT!"

This is the first time that patients with a mTBI have been assessed in an acute hospital and followed-up within the expected recovery trajectory. While it might be assumed that drivers return to this activity quickly post mTBI, this study has indicated that a significant proportion of patients do not, and the reason for this delay cannot be explained by factors easily measured. The results of this study support health-care professionals to advise patients not to drive for 24 hours post injury and has better positioned these professionals to provide education to the mTBI cohort about issues they may face in return to driving.

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Australian drivers with disabilities using vehicle modifications: user demographics, human factors and road safety issues

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Abstract

Drivers with disabilities (DWDs) often rely on safe systems applications:safer vehicle-driver interfaces through vehicle modifications (VMs).VMs include alternative primary/secondary vehicle controls and access/egress enhancements. Little is known about Australian DWDs' or their use of VMs.This cohort study investigated DWDs using VMs via a survey which collected demographics, human factors and prescription practice data. Respondent DWDs (n= 97) were mostly older, experienced drivers using low technology VMs who relied on vehicle transportation for community access. Whilst most reported satisfaction with their VMs, breakdown, maintenance and safety concerns identified highlight potential impacts on road safety and the need for in-depth research.

Introduction and Aims

Drivers with disabilities (DWDs) may be considered vulnerable road users. Their driving independence often relies on application of the safe systems approach: optimising and creating safer vehicle-driver interfaces through vehicle modifications (VMs).VMs include alternative primary and secondary vehicle controls and access/egress enhancements. Little is known about DWDs' use of VMs, safety and human factors issues or impacts of independent vehicle transportation. Such information is required to improve risk management and expand the evidence base supporting rehabilitation and licensing/registration policy. Using an action research framework, a cohort study investigated, and captured the views of, DWDs using VMs including demographics, devices used, and opinions regarding independence benefits, safety concerns and VMs prescription practices.

Methods

A literature review, ergonomic and safe systems driving task analysis and project advisory group (including prescribers/suppliers, funding bodies, advocacy groups and DWDs) informed the descriptive cross sectional study design including the development and implementation of a self-completion anonymous survey. Disability, driving recency and exposure, plus VMs requirements formed key study eligibility criteria. Convenience sampling was augmented by survey promotion through several large DWD support groups. Descriptive statistics only are reported here.

Results

The study sample comprised 97 DWDs who were predominantly male (66%), aged 61+ years (64%), cohabitating (68%), metropolitan residents (72%) and rated physical health as good/very good (67%). Commonly, DWDs reported spinal (n=55) or polio (n=18) conditions resulting in leg paralysis (52%) or functional restrictions (27%). Almost all relied on wheelchair mobility (97%), reported driving as their preferred transport method (90%) and very difficult/impossible access to key destinations (employment, health and shopping services, etc.,) without independent vehicle transportation (59% – 81% for different destinations).

Just over half (n=49) reported having professional assessment/input into VMs choice. Some DWDs indicated they designed and built their own VMs. Respondents indicated that a wide range of mostly low technology VMs were used: hand controls to replace foot operated acceleration/brake pedals (n=64), aids to support one-handed steering wheel control (n=48), ramps/hoists enabling wheelchair accomodation/storage (n=26) and modified foot controls (n=23). Those DWDs using primary control VMs had on average used them for 20+years. DWDs required different numbers of VMs: one (n=39), two (n=28) or three+ (n=26). The majority of DWDs were mostly/very satisfied with modifications used, however DWDs reported breakdown concerns (n=37), persistent safety (n=11) and maintenance (n=13) issues potentially impacting on road safety. Prescription practice issues raised included: seeking professional advice, opportunity to trial VMs and talking with DWDs already using similar devices.

Discussion and implications

An increase in the ageing driver population, improvements in health and demands for personal driving independence despite physical disability will lead to more DWDs in the future. Older, experienced DWDs who were the subject of our study rely heavily on independent vehicle transportation to provide access to key services. Whilst many drivers were happy with and received professional help regarding VMs prescription, not all accessed such services. Road safety concerns identified highlight the need for further in-depth investigation related to the nature of initial and ongoing driver assessment and VMs maintenance and viability. This is required to optimise human-control-interface "fit" in the context of changing disability needs and innovations in both vehicle and VMs technology. This first study of Australian DWDs using VMs will impact on the evidence base required to support safety related initiatives for this road user group.

Acknowledgements

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Motor vehicle crashes and dementia: a population-based study

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Abstract

This study aimed to compare the crash risk among older drivers with and without dementia. A retrospective population cohort study was undertaken, including 5,302 participants (1,666 with dementia) who had been involved in a motor vehicle crash from 2001 to 2013. Logistic regression analysis showed that older adults with dementia were significantly more likely to have been involved in a crash in the three years prior to diagnosis than other older adults. Based on the study results, licensing authorities and clinicians need to balance safety considerations with mobility needs for older drivers particularly those with early signs of dementia.

Background

Demographic changes in the Australian population (ABS, 2008) are leading to an increase in the number of older drivers. Driving is a complex task and requires numerous skills. Some cognitive aspects that are essential for driving such as memory, visual perception, attention and judgment ability may be affected by dementia (Lloyd et al., 2001; Wagner, Müri, Nef, & Mosimann, 2011). In the early stages of dementia, the risks associated with driving with dementia may go unnoticed due to an average three year lag between symptoms and diagnosis (Gilley et al., 1991). This study examined the crash risk among older drivers aged 50+ in the three years prior to an index hospital admission with a diagnosis of dementia, compared to a group of older drivers without dementia.

Methods

A retrospective whole-population cohort study was undertaken using de-identified data from the Western Australian Data Linkage System (WADLS) from 2001 to 2013. The outcome of interest was involvement in a crash as the driver in the three years prior to a diagnosis of dementia. Logistic regression analysis was undertaken.

Results

There were 1,666 (31%) individuals with an index hospital admission for dementia and 3,636 (69%) individuals without dementia who had been involved in at least one motor vehicle crash from 2001 to 2013. The results of the logistic regression analysis found the odds of a crash increased by 77% (odds ratio (OR) =1.77, 95% Confidence Interval (CI) =1.57 – 1.99) in the three years prior to a hospital admission for older drivers with a diagnosis of dementia, compared to a group without dementia, after adjusting for relevant confounders.

Conclusions

Based on the study results and given the increasing number of people who will be diagnosed with dementia it is important that licensing authorities and clinicians continue to balance safety considerations with mobility needs for older drivers particularly when the early signs of dementia may manifest.

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Predicting on-road performance of older drivers with cognitive impairment: Brief in-office screening of attention, visuospatial ability, and planning and foresight

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Abstract

The Snellgrove Maze Task (SMT; Snellgrove, 2005) was developed in SA to screen for specific cognitive domains required for safe driving (attention, visuospatial ability, planning and foresight), and discriminated with high accuracy older drivers with mild cognitive impairment (MCI) or early dementia who passed or failed an on-road driving test. Independent US studies have supported the utility of the SMT in predicting on-road pass or fail in older drivers, and those experiencing dementia and stroke. These studies will be presented, with a view to illustrating the potential for brief in-office cognitive screening to identify the most competent and dangerous older drivers without costly on-road driving tests.

Background, Method, Results and Conclusions

The psychometric properties of the SMT were examined using a sample of 115 older drivers with MCI or early dementia. Participants completed the SMT and immediately thereafter a standardized on-road driving test. SMT scores were not influenced by sociodemographic variables, and discriminated with high accuracy those participants who passed a standardized on- road driving test from those who failed the same test. On the basis of these findings, cognitive screening of older drivers in the primary care setting with the SMT has received further independent investigation.

A prospective observational study of the prediction of Washington University Road Test pass or fail in drivers with dementia was conducted in the US (Carr et al., 2011). Ninety-nine community dwelling people with dementia completed tests of visual, motor and cognitive functioning. Visual and motor functioning was not associated with road test failure. The best predictive model with an overall accuracy of 85% included the 8-item Informant Interview to Differentiate Ageing and Dementia, the Clock Drawing Test, and the SMT.

A cross-sectional observational study of the prediction in the office setting of unsafe driving in older adults with normal cognition (n = 47) versus cognitive impairment (n = 75) was conducted in the US (Ott et al., 2013). The Assessment of Driving-related Skills (ADReS) and additional cognitive tests (SMT, Trails A & B, MMSE) were administered, and followed by the Rhode Island Road Test. Although the ADReS and the MMSE was found to have limited utility as an office screen for those who should undergo formal driving assessment, Trails A time, Trails B errors, and SMT time were significantly different between the normal and impaired cognition groups.

A prospective observational study of the prediction of Washington University Road Test pass or fail in 72 drivers who had experienced a stroke was also conducted in the US (Barco et al., 2014). Predictor measures were tests of visual, motor and cognitive functioning. Visual and motor functioning was not associated with road test failure. The best predictive model with an overall accuracy of 87% included Trails A and the SMT.

A random sample of ninety GPs across SA were invited to trial the SMT (Mwanri et al. 2013). Some 58% of GPs trialled the SMT on 119 older patients who presented for license renewal. The SMT was found to be simple, brief to administer and score, acceptable to patients, and had a very high acceptability rate (96%) among GPs.

With high criterion-referenced validity for on-road driving competence in older drivers with cognitive impairment, easy administration and scoring, and independence from sociodemographic factors, the SMT fulfils all essential criteria for a cognitive screening instrument that could be used by a range of professionals, including GPs. Current Australian drivers license renewal practices (where they exist) of physical and visual screening do not tap into those cognitive skills deemed necessary for safe driving. The SMT may eventually serve as an adjunct screening measure in the license renewal process of older drivers in Australia. Requests for the SMT have in the past come from across the US and Europe.

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The True Impact Of Transport Safety Education: Aren't We Forgetting The Young People? A Rail Safety Education Perspective.

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Abstract

Transport safety education research tells us what to consider when developing and measuring education programs to ensure effective pedagogy and optimal impact for young people learning about road or rail safety. There can be a disconnect between research and practice when programs are not developed or run by educators, and measurements of success are driven by funding, outdated top-down policies and antiquated thinking. How can young people be expected to learn or change when they are not involved in the learning process? The TrackSAFE Foundation has addressed this by developing an evidence-based rail safety education program focusing on young people.

Background

Research into road safety education programs for young people highlights what constitutes good practice to achieve the best possible impact on road safety. Since 2009 organisations such as School Drug Education and Road Aware have pioneered a new era of safety education, advocating strengths-based approaches and establishing best practice principles (Government of Western Australia, 2009). A series of fact sheets from the New Zealand Transport Agency (NZTA) (2015; 2015a; 2015b) further synthesises the literature and gives examples of effective road safety education for young people. The body of research is transferable to other transport sectors, such as rail safety education, with similarities in messaging; the psychology behind risk taking behaviour for road and rail users; and the major context link with level crossing safety. Yet despite all of this evidence being available to us, rail safety education practitioners, policy makers and program developers failed to incorporate the research into our practices.

Until 2013, rail safety education programs used top-down, deficit approaches such as presentations of information about risks and consequences, and fear appeals. They were delivered by rail staff such as train drivers, or police, to large groups of students. They had little pedagogical value and saw young people as passive recipients of information. In using these approaches, we were forgetting the very people we are striving to 'educate': the young people.

Agility and innovation

The rail industry realised this had to change to become responsible and remain viable. The TrackSAFE Foundation (TrackSAFE) brought the rail industry together in 2012 and identified deficiencies in Australian rail safety education practice. In 2013 TrackSAFE formed a Reference Group and launched TrackSAFE Education to lead a coordinated, consistent approach to rail safety education. They developed TrackSAFE Education: *Be on the Safe Side*; a suite of curriculum-based learning resources for school students, modelled on road safety education research and principles.

Impact

The focus for rail safety education is finally on young people. Through TrackSAFE's teacher led, student centred resources, young people are viewed as active learners who can make a genuine difference to a safety issue in their own community. Young people, their ideas and voices matter; and they should be involved in the learning process. The focus has shifted to quality pedagogy: on what and how a young person learns. By enabling young people to drive change in their own communities, could they be motivated to ensure they, and others, stay safe around trains, platforms and level crossings?

Discussion

TrackSAFE is continuing to work with the rail industry to implement good practice principles in policy making, program development and practice. TrackSAFE will conduct ongoing outcome and process evaluations, and continuously improve its program to ensure it is pedagogically sound; relevant; and making an impact on rail safety knowledge, skills and attitudes in young people. This new approach could be the beginning of a more effective long term strategy, as part of a safe system approach, to reducing fatalities and injuries on the Australian rail network.

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Exploring young driver and young adult attitudes to drink-driving in NSW: Quantitative and qualitative research

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Abstract

Quantitative and qualitative research was conducted to understand NSW drivers' knowledge, attitudes and behaviour towards drink-driving. Almost 30% of metro and non-metro males aged 17-25 had risked drink-driving in the prior six months, with 20% of metro females aged 17-25 and non-metro males 26-39 years also having risked drink-driving within this timeframe. While most were aware of the risks of drink-driving, at the moment of decision-making they often rationalised the behaviour to avoid inconvenience. The "grey area" of not knowing how much alcohol was too much, also appeared to be a factor in the decision.

Context

Drink-driving is a key contributor to road crashes. In the period from 2010 to 2014, it was a factor in 17% of all fatal crashes in NSW, resulting in 303 deaths. In 2014, the Centre for Road Safety commissioned quantitative research to understand the knowledge, attitudes and behaviours of NSW drivers around drink-driving, and the prevalence of drink-driving in NSW. This was followed by qualitative research involving young drivers (aged 17-25) and young adults (aged 26-39).

Quantitative research

Taverner Research conducted a telephone survey of 1,761 NSW drivers aged between 17 and 69 who drink alcohol, from both metro (Sydney, Newcastle and Wollongong) and non-metro areas. Respondents were recruited by calling validated, randomly generated fixed and mobile phone numbers. The research found that 47% reported driving when they were or might have been over the legal limit at least once. Multivariate analyses identified that respondents most likely to be recent drink drivers were those who justified drink driving, those who drink daily or most days, high-risk demographic groups (particularly young males), and those who believe they are unlikely to be caught. Almost 30% of young metro and non-metro males aged 17-25 had risked drink-driving in the prior six months. However, 20% of metro females aged 17-25 and non-metro males 26-39 years had also risked drink-driving within this timeframe.

Qualitative research

In light of the survey findings, the Centre for Road Safety commissioned qualitative research with a focus on young drivers and young adults, to further understand behaviours, attitudes and prevention strategies regarding drink-driving.

Snapcracker Research & Strategy ran 10 focus groups with metro males and females (aged 17-25) as well as non-metro males (aged 17-39) recruited via agency panels. While most were aware of the risks of drink-driving, both to their safety and licence, avoiding inconvenience often won out when making the decision to drink drive. Rationales included: not being certain they were over the limit; excessive cost of and/or limited access to alternative transport; feeling unsafe waiting alone for alternative transport (particularly females); and the need to take the car home to meet commitments the next day. Regular drink drivers cited money as the key issue: the cost of transport to get home was unjustifiable, especially in rural or outer metro areas. The risk of enforcement was often discounted, with drivers reporting avoidance strategies such as using the ‘backstreets’, driving cautiously and knowing where police are enforcing (particularly in regional areas).

Drink-driving was reportedly more likely to happen on a night not intended for heavy drinking, where they were less likely to plan ahead. Moving from a zero alcohol condition to an unrestricted licence appeared to introduce a “grey area”, where young drivers could consume alcohol but were uncertain how much put them over the limit. Provisional drivers were less likely to report drink-driving, suggesting uncertainty may be a factor in the decision to drink drive.

Implications of this research will be discussed, such as improving education to assist young adult drivers to separate drinking from driving.

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Road Safety Education Intervention For Primary Schools in Malaysia: Any Reduction in Traffic Casualties?

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Abstract

Malaysia records high number of road crashes and deaths as compared to the population and country size. In 2014, there were 476,196 reported road crashes with 6,674 road deaths. The government is committed to ensure that the road crash fatalities be reduced and towards achieving this aim, various strategies and plan have been formulated for implementation under the Malaysia Road Safety Plan 2006-2010. One such strategy was in implementing a Road Safety Education program in primary schools within Malaysia. Findings show road safety education is showing a promising sign on declining trend of road casualties over the period.

Background

Road Safety Education (RSE) intervention is a joint effort between Ministry of Transport Malaysia and Ministry of Education Malaysia. RSE was implemented in stages from 2007 to nationwide rollout in all standards and in all primary schools in the country by 2010. The RSE knowledge is embedded in the existing curriculum through the Bahasa Malaysia subject. RSE was taught once a week (40 minutes exposure) in the classroom by the Bahasa Malaysia teachers whom have undergone special 3 days training on RSE module. The RSE modules are developed appropriately tailored to the age-range of the students. The question that trigers in everyones mind: Is this education intervention reducing traffic casualties? There is a tremendous need to study the effectiveness of this important program especially in a developing country since much less is known about the role of RSE in reducing RTI. Carrying out this kind of study in a developing country is vital as most similar studies are only carried out within high-income countries. The findings from this study will add new knowledge in terms of its impact on RTI.

Methods

A prospective intervention-control study following children who are exposed and not exposed to RSE program for 2 years and observing whether they are involved in road traffic injuries (RTI) over the period of time. Children with intervention in this study will be taken from schools where new RSE program is to be implemented. There will be matched controls from neighbouring districts with schools where program not implemented. This gives a ratio of 1:1 between intervention and control. For this study, Quasi Experimental-interrupted time series design with comparison group was applied since random allocation was not possible. Six intervention districts and six comparison districts was selected as per Education District List under the Ministry of Education Malaysia. Total sample size of 67,232 children for both years involved in study (33,616 per arm). Minimum sample of 33,616 children from 6 intervention districts and 33,616 children from control districts of Standard 2 (age 8) and 4 (age 10) were required. A simple checklist was developed to determine school children involvement in road crash.

Results

Health Outcome based study was conducted for two years (2008-2009) for different targets groups. Total students sampled for the study are 20,396 among year 2 (age 8) and 19,721 year 4 (age 10). Results from injury surveillance study showed a significant reduction in number of crashes in intervention districts with RSE program compared to control districts without RSE program for both year 2 (age 8) and 4 (age 10) students after following up for two years. Next, results from police crash data showed a reduction in number of road crashes for pedestrian age group 7-12 years in intervention districts as compared to control districts comparing year 2007 and 2009. During this two years of study period, the researchers did not notice any other major road safety interventions specifically happening in the intervention districts only other than RSE.

Conclusions

The study has shown from the injury surveillance study, a decliing trend in number of children road crashes recorded for year 2 (age 8) and 4 (age 10) students whom receive RSE intervention as compared to those who did not receive the intervention.

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Social Voices – Evaluation of the RACV Safe Mates road safety for secondary schools pilot program

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Abstract

Road safety education can play an important role in young people becoming safer road users. The RACV Safe Mates program was piloted in 2015 to give students an opportunity to have a voice in their road safety by developing social media campaigns. The pilot program was developed with good practice road safety education principles and promoted to all Victorian secondary schools. The evaluation shows the pilot program has been well received within school communities; that there were 500,000 views of the students' road safety messages; and the program can have a positive impact on road safety attitudes of young people.

Background

Road safety education can be important in ensuring young people adopt safe road user behaviours and develop responsible attitudes to sharing our roads (State Government Victoria, 2015). A valuable use of social media is to purposefully engage with young people by valuing their input into real outcomes (Rose & Mostyn, 2013). In light of this, RACV piloted the RACV Safe Mates secondary school social media program in 2015.

The program was developed to promote road safety in Victorian secondary schools; provide student-centred learning opportunities that enable students to share road safety messages with their peers through social media; and encourage young people to be safer road users. The program's objectives and activities were designed to align with the Principles of School Road Safety Education (Government of Western Australia, 2009); the Road Safety Education in Senior Secondary Schools Good Practice Guide (State Government Victoria, 2015) and the Victorian AusVELS curriculum to ensure that the program was based on the good practice and to assist teachers utilise the program.

Pilot Program

All Victorian secondary schools were invited to participate in the program via email and direct mail-out. Students worked in groups to research a road safety issue and created a social media road safety campaign. The finalists were selected by a judging panel and worked with road safety and advertising professionals to fine-tune their work before their campaigns were run on the RACV Young Driver Facebook page. The winning concept was determined by a set of criteria that looked at innovation, creativity and impact of the social media campaign. Cash prizes were on offer for both students and schools.

Evaluation and Results of Pilot Program

The anticipated outcomes of the pilot program were to receive a minimum of 50 entries from Victorian secondary schools; and increase awareness of road safety issues among a broader audience of young people through social media. The pilot program received 94 entries from a range of secondary schools; and finalists were able to successfully engage with the broader community with their messages seen over half a million times, with 75,000 video plays and 8,125 likes, shares or comments.

All teachers who registered for the program and all students who participated in the program were invited to complete feedback surveys. The teacher evaluation survey (N=23/93) found that the RACV Safe Mates program was an attractive (57%) or very attractive (43%) program and 91% agreed or strongly agreed that through the program students learnt about road safety. The student evaluation survey focused on students' road safety knowledge and attitudes. In total, 440 students from 34 schools completed the initial survey and 39 of these students completed the follow-up survey. On 17 of the 19 questions, students showed an improvement in their road safety knowledge and attitudes over the course of the program.

Conclusion

The results from the RACV Safe Mates pilot program show the program has been well received within school communities and there are early indications that the program can have a positive impact on road safety knowledge and attitudes of young people.

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Development of a learning to drive framework for Victoria

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Abstract

The Victorian Government has made a commitment to further reduce young driver crash rates, and to maintain Victoria’s leadership in youth road safety. This will be achieved through the development and delivery of a suite of education and training initiatives, referred to as the Young Driver Safety Package (YSDP). This includes establishment of a road safety education complex and creation of a practical safe driving program. These are important components of Victoria's road safety strategy, *Towards Zero*, with its vision of zero deaths and zero serious injuries on Victorian roads.

To inform the development of these initiatives a learning to drive framework for education and training requirements in Victoria was commissioned by the Transport Accident Commission (TAC) and VicRoads. This learning framework recognises that young people need to develop specific knowledge, skills and behaviours for them to be able to use the road system safely. The framework also recognises the important role that parents/significant adults and other stakeholders play in youth road safety.

Background

Analysis of Victorian crash data shows that between the 5 year periods of 2001-2005 and 2009-2013, the rate of deaths of drivers aged 18 to 25 years reduced by 46% (from 9.1 per 100,000 persons to 4.9 per 100,000 persons). With the aim of improving youth road safety, a number of complementary initiatives have been introduced in Victoria. In developing these initiatives, an evidence-based approach has been taken that ensures resources are targeted towards strategies that are based on rigorous and systematic research, and best practice, and that will yield demonstrable road safety benefits.

At the core of these initiatives is Victoria’s Graduated Licensing System (GLS), which includes the requirement for learner drivers to accrue a minimum of 120 hours of supervised driving practice. Supporting Victoria’s GLS is an extensive range of road safety education programs and resources for children, young people, and their parents/carers.

Despite the reduction in the rate of young driver lives lost, young novice drivers still represent a high-risk group with 22% of drivers killed in 2015 aged 18 to 25 years. Road crashes continue to constitute one of the leading causes of death for young people in this age group. The Victorian Government has made a commitment to further reduce young driver crash rates, and to maintain Victoria’s leadership in youth road safety. This will be achieved through the development and delivery of a suite of education and training initiatives, referred to as the Young Driver Safety Package (YSDP). The YDSP is made up of a suite of initiatives comprising: Road Safety Education Complex; Practical Safe Driving Program (PSDP); L2P – learner driver mentor program; the Free licence scheme; and Youth grants, communication opportunities and student forums.

The Road Safety Education Complex and PSDP are two major initiatives under the YDSP. The Road Safety Education Complex represents a global hub for road safety, featuring evidence-based and best practice programs to extend, enhance and engage young people and the community in the prevention of road trauma, consistent with the Safe System. The overarching goal of the PSDP is to provide beginner drivers and supervising drivers with the capabilities to lay the foundations for safe driving, helping to support and enhance Victoria's GLS.

A learning to drive framework was developed to guide design and development of the Young Driver Safety Package initiatives, the Road Safety Education Complex and PSDP, in particular. The framework is based on the Victorian GLS, and the relationship between opportunities in road safety education and training, and the school curricula in Victoria is demonstrated.

Method

The key government agencies responsible for young novice driver initiatives in Victoria, the TAC and VicRoads, commissioned the development of a learning framework to inform the development of the Young Driver Safety Package for Victoria.

Experts in curriculum development, adult learning, road safety and instructional design were convened to form the development team. The framework was developed in an iterative process with input and feedback from key road safety staff at the TAC and VicRoads.

The framework development was undertaken in three stages:

- Review of:
    - relevant literature in driver training and education, and in effecting positive behaviours and behaviour change
    - the Victorian GLS
    - the Victorian education curriculum framework
    - existing best practice road safety education resources and programs.
- Identification of the knowledge, skills and behaviours required at the pre-Learner, Learner and Probationary licencing stages for young people and their parents/carers (in their role as supervising drivers).
- Creation of a young driver learning model and the detailed learning framework.

Following the development of the learning framework, existing young driver training and education programs and initiatives were mapped to the framework, and gaps and opportunities identified.

Learning framework

The framework has been designed to take into consideration what road safety research, behaviour change theory, and best practice in road safety education and training tells us about how we can help young people to become safer drivers. The framework considers:

- the target knowledge, skills and behaviours required by young drivers and their supervising drivers
- the requirements of the Victorian GLS
- the Victorian education curriculum frameworks.

The learning framework recognises that young people need to develop specific knowledge, skills and behaviours for them to be able to use the road system safely. In addition to more familiar driver learning goals, the framework also recognises the need for skills to review own safe driving performance and cope with internal and external influences that could adversely affect safe driving behaviours. These knowledge, skills and behaviours develop over time: before the young person enters the system as a driver; while they are learning to drive; and once they are fully licensed and more experienced drivers. While some of this development occurs through learning efforts that can be best described as incidental and informal, there are specific periods or stages when the development of key knowledge, skills and behaviours might benefit from more active learning efforts, as might be realised through education and training.

While the focus of the framework is on 15 – 26 year old young people, the role of parents/carers and other significant adults are also taken into account.

Current education and training initiatives, gaps and opportunities

Existing young driver education and training initiatives developed and/or supported by TAC and VicRoads have been mapped to the framework. The framework will also be a useful tool for mapping other existing Victorian Government school, community, education programs and resources that focus on young drivers, and their parents/carers and other significant adults.

This mapping allows for determining the extent to which existing programs and resources support the development of target knowledge, skills and behaviours. The framework also allows for the identification of potential opportunities for consolidation and/or redevelopment of existing young driver programs and for the identification of gaps where new programs may be required. Most importantly, it informs the Young Driver Safety Package initiatives – the Road Safety Education Complex and PSDP in particular.

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Evidence-based approach to manage the 1 risk of working near traffic to optimise safety, efficiency and road user journeys through worksites

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Roads and Maritime Services

Abstract

Roads and Maritime Services, in partnership with industry, optimises safety, efficiency and customer journeys at road worksites through a risk management approach. We seek elimination of risk before minimisation and ensure the highest level of control consistent with contemporary practice is applied when elimination cannot be achieved. The program is underpinned by quality data collection and analysis as a foundation for continuous improvement. The program provided new insights into hazards, risks, worker and road user behavior when interacting with different worksites and risk controls. Implications for road maintenance and construction will be discussed.

Extended abstract

Working near traffic is a hazardous activity for the road construction and maintenance industry, affecting workers and it may also put road users at risk. Despite developments in engineering, traffic control design and work practices, controls designed to separate traffic from worksites can fail. The consequences of such failures have human, legal, financial and reputational dimensions and the issue of improving safety at worksites is of national and international concern. Roads and Maritime must eliminate, so far as is reasonably practicable, the risk of working near traffic for its workers and the public.

Early success with eliminating the risk where practicable by closing the road for all traffic to carry out a range of road maintenance activities has made it apparent that there are opportunities to reap safety, journey management and efficiency benefits from the process. Roads and Maritime proceeded to map and better understand the levels of risk where elimination is not practicable. Safety Risk Management and Assurance were central to the program of work.

The Safety Risk Management Program has resulted in an Agency Safety Risk Register. This, supported by bow-tie analyses, consolidates information on hazardous events and risk controls used in Roads and Maritime. The Safety Assurance activities focussed on verifying that risks controls are in-fact effective and that risk is minimised to acceptable levels through appropriate measures that will identify potential threats to safety.

The focus has been on quality data collection and analysis using naturalistic studies to ensure we have an improved understanding of our risk of working near traffic, a baseline understanding of the effectiveness of controls and when introducing new controls are able to understand if risk has been further minimised and no unintended risk has been introduced. Implementing actions without valid data supporting it could result in ineffective controls with unintended consequences such as the introduction of new hazards and cost the organisation a lot of resources and effort.

We propose to share the findings from our pilot projects. The presentation will outline how data was collected and analysis helped us to determine the effectiveness of existing controls aimed at managing the risk of working near traffic as well as determining the differential effectiveness when introducing other controls to the existing control set. The results will be discussed from a practitioner's point of view, from a road user's point of view driving through the worksite and from a worker's point of view working near passing traffic. We will also discuss opportunities to work towards national and international better practice.

Identifying the organisational determinants of work-related road traffic injury

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Abstract

Road traffic injury is the leading cause of work-related death in Australia. Despite this, many organisations are unaware of the factors within their organisations that influence potential reductions in injury and deaths. This study aims to explore the relationship between management practices and driver behaviour and the role of safety climate in moderating these relationships. Surveys were completed by 911 drivers, 161 supervisors and 83 senior level managers. The findings of this study both refute and extend past research. The results of this study offer practical guidance for organisations in designing and implementing management practices to support safe driver behaviour.

Background

Road traffic injury is the leading cause of work-related death in Australia. It has been estimated that one-third of all work-related deaths occur while driving for work-related purposes (Driscoll et al., 2005). This emerging public health issue is not unique to Australia, with work-related road traffic deaths estimated to account for 22% of work fatalities in the United States and 16% in New Zealand. Despite this, many organisations are unaware of the management practices within their organisations that may act to reduce work-related road traffic injury and deaths. This study aims to address this issue by identifying the management practices that improve driver behaviour. This study will also explore how drivers' perception of the value and priority given to safety plays a role in creating safe driving practices.

Method

A total of n =83 organisations were recruited through the Victorian Work Authority (VWA) for this research study. Senior managers, fleet vehicle drivers and supervisors of fleet vehicle drivers participated in one-on-one interviews, telephone surveys, and on-line surveys, respectively. All data was matched in a multilevel structure, where possible.

Drivers were asked questions relating to their perceptions of safety at the organisational level, as well as kilometres driven and demographic information (age and gender). Senior managers and supervisors were asked questions relating to their knowledge of nine practices that support operational activities within their organisation, incluidng remuneration, job and work design, staff development, selection, communication, promotion, job secturity and retention. an organisations safety culture. Surveys were completed by 911 drivers, 161 supervisors and 83 interviews were conducted with senior level managers.

Findings

Multi-level modelling was applied to identify the significant organisational determinants associated with work-related road traffic injury in organisations. This study found no direct relationship between remuneration practices and driver behaviour. However, this study found that safety climate moderated this relationship. Under conditions of high investment in remuneration, drivers reported safer behaviour when they perceived their managers valued and prioritised safety, as opposed to conditions where they perceived that safety was not valued or prioritised by management. Thus, contrary to past research, the results of this study suggest that remuneration encourages safe driver behaviour, but only under conditions of high commitment to safety.

The results also found significant relationships between driver behaviour and several management practices, including job and work design, selection and communication. These results indicated that higher investment in these practices was associated with poorer driver behaviour. These results appear somewhat surprising; however, when interpreted within the context of the current state of workplace road safety in Australia (and internationally), the findings offer clear guidance on directions forward in the safety management of work-related drivers.

Conclusion

This is the first study to consider the organisational context in relation to workplace road safety and take account of the complex system when identifying the management practices associated with work-related driving behaviour. A further strength of this study was that almost all research related to organisations and workplace road safety to date has been undertaken within single organisations. A limitation of these studies is that it is unknown if the key safety factors identified within each organisation generalise to other organisations with differing business activities. The results of this study both refute and extend past research, but most importantly, offer practical guidance for organisations in designing and implementing management systems designed to support safe driving behaviour and reduce death and injury.

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‘Safer Together’ – Aligning Queensland’s Natural Gas E&P Industry ‘Safe Systems Approach’ for Improved Road Safety Outcomes

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Abstract

Formed in 2014, Queensland’s Natural Gas E&P Industry Safety Forum (‘Safer Together’) is comprised of CSG Operators and 80+ Contractor partners. Travelling 100 million kilometres (estimated) annually and an overall occupational injury frequency rate (IFR), per million hours worked, at 3.9 (2013) - improved safety standards were necessary including road safety. The industry has targeted an IFR of <1.0 by 2018 in addition to reducing life threatening incidents.

Through aligned industry standards targeting fleet and telematics – including a common industry road data set and tracking of key driving risks - safer outcomes for reduced spend, are attainable. Safety performance is measured not just in reducing incident numbers, but also using leading indicators reflecting driver behaviours.

Background

Unlike more conventional mining operations, Queensland’s CSG industry is spread over vast areas of the State, with the majority of vehicle movements occurring across south-west Queensland (the ‘Upstream’ area). The industry works collaboratively with landholders, often positioning CSG facilities amongst farming operations. In addition to the 11,596 km of public roads comprising the Upstream (1), are thousands of private roads where industry vehicles and communities interact.

Based on community road crash statistics, industry lassitude would result in 14.7 hospitalisations / 100 million vehicle kilometres travelled (2). This was an unacceptable position. CSG Operators implemented individual vehicle safety programs delivering reduced safety incidents compared to the statistical norm. However, as peak construction concludes, the industry identified the opportunity to collaborate, clarify and standardize – achieving improved safety and efficiencies.

With leadership core to its success, Safer Together set out with a charter to review the current road safety strategy – aimed at improving safety and countering the negative portrayal of poor driving attributable to industry (3).

A whole of industry review identified inconsistent fleet requirements; driving expectations (speed and other); In Vehicle Monitoring Systems (IVMS) exception parameters and reporting – leading to both contractor confusion and frustration – and ultimately eroding the cornerstones comprising the Safe Systems approach.

Working groups comprised of key personnel from Operators and Contractors focused on clarifying and standardising across key areas:

Safe Vehicles – minimum standards for both light and heavy vehicles developed – achieving contractually imposed vehicle specifications.

Safe Driver/Speed – IVMS is an industry critical safety control - yet rules were inconsistently measured and reported.

Safe Journey – non-existent mapping of common industry roads encouraged potential non-compliance by drivers. A common industry map-set was a foundation piece for safer roads. Some telematics systems couldn't accommodate the volume of data-points necessary to map all common industry roads. Innovation was required.

Working groups engaged with telematics providers and other key stakeholders to develop an industry IVMS technical specification standard underpinned by Transport Certification Australia's National Telematics Framework. Launched on 1 December 2015, the IVMS Standard provides clear direction to industry participants on:

- Telematics system requirements, including data structures, system set-up;
- Industry speed limits;
- Consistent IVMS exception parameters for critical safety areas (eg. speed, seat belts, fatigue);
- Monthly industry reporting on all driving data (eg. kilometres driven; sub-contractors utilised; and individual IVMS exception data).

Common vehicle standards (light and heavy vehicles) have been developed and published.

With thousands of drivers engaged in the CSG Industry, success of the initiative is dependent on effective education and information reaching all tiers of an organisation. A fully detailed communications strategy encompassing top down implementation by Safer Together leaders has launched, along with an industry website.

The elimination of death and serious injury on roads utilised by the CSG Industry is a target worthy of investing (4). Yet, arguably it does not require a significant financial investment rather a collective will to engage; consult; share learnings and collaborate for solutions.

Safer Together members may contend for business, but they stand side-by-side in achieving safety solutions. With many organisations engaged in other industries, opportunities to further standardise and simplify driving requirements would achieve more agile, innovative, effective and safer outcomes at a reduced cost.

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Best practice versus 'in practice': Insights into Improving Australian Industry Road Safety Management

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Abstract

In Australia, more than 30% of the traffic volume can be attributed to work-related vehicles (Haworth et al., 2000). Despite increasing attention in the scientific literature, it is uncertain how well this knowledge has been translated into industry practice. The aim of this research was to map current practice in workplace road safety against an established best practice (ie., benchmarking) framework. Overall, the results suggested there were opportunities for a greater level of maturity in the implementation of workplace road safety practices in the areas of journey management, road safety management, safer vehicles, safer road users and post-crash response.

Background

Despite development of the ISO 39001 to provide guidelines for organisations to manage risk on the road, no evidence-based benchmarking tool has been established in Australia. The lack of an evidence-based foundation means that the term "best practice" is often used with little understanding of the practices that constitute effectiveness or fulfilment of a best practice criteria. The National Road Safety Partnership Program (NRSPP); an initiative that constitutes a network of organisations and academics working together to develop a positive road safety culture recently developed a national fleet benchmarking tool based on the WHO Five Pillars of Road Safety (Carslake & Van Dam, 2014).

Method

A total of 83 organisations were recruited through the Worksafe Victoria for this research study. The majority of organisations were Victorian-based, with national recruitment involving organisations in metropolitan Sydney, New South Wales. The organisations ranged in organisational size, from microbusiness (N=1, 1%), small (N=2, 2.5%), medium (N=19, 23%) large (N=8, 10%) to enterprise (N=53, 64%) employees. A senior manager representative with Occupational Health and Safety and/or fleet management knowledge was approached to participate in a one-on-one interview. Semi-structured interview questions aimed to elicit information on current organisational practices, as well as policy and procedures around work-related driving within the organisation.

Results and Conclusions

The data from the coded transcripts were mapped onto the framework. Of the key themes that were identified in the research, the practical implications and recommendations are of great significance. Recommendations focus on the need to clarify the roles and responsibilities of those involved in the management of workplace road safety as well as the increased use of technology in managing safe driver behaviour. The results of this study are unique in that it offers, for the first time, a snapshot of Australian workplace road safety management across organisational size and industry types, as well as, identifying gaps and limitations in current organisational approaches to reducing death and injury in this critical safety domain. Some practical implications and recommendations are provided.

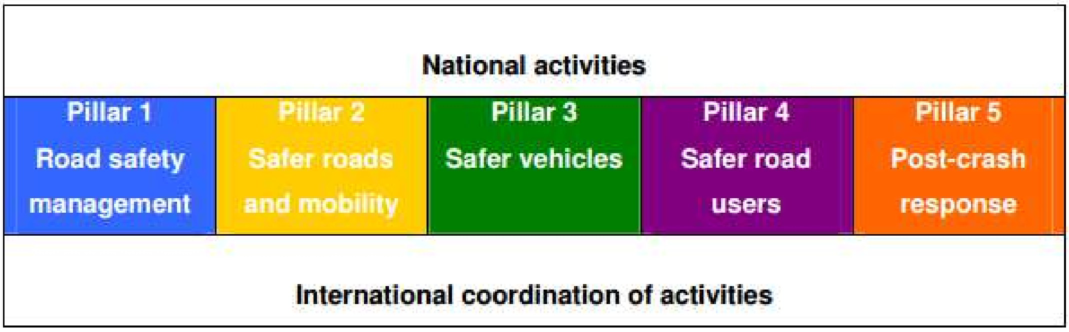

Figure 1. The Five Pillars that form the basis of the Benchmarking Framework (WHO, 2013).

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A longitudinal study evaluating work driving safety interventions implemented by a number of organisations

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Abstract

Driving for work is potentially one of the riskiest activities undertaken in the course of a person's day. This paper reports on a longitudinal study involving four organisations that participated in a work driving safety program. Each organisation implemented a range of driving safety strategies and interventions designed to improve work driving safety. This research investigated the impact of the range of work driving safety intervention strategies implemented by each organisation over a number of years. The practical implications and limitations of the results obtained in this study will be discussed.

Background

Driving for work is potentially one of the riskiest activities undertaken in the course of a person's work, which is evidenced by the over representation of work related crashes and injuries involving the operation of motor vehicles while undertaking work activities (World Health Organization, 2013). In Australia, road trauma is the most common form of work-related death, injury and absence from work (Haworth, Tingvall & Kowadlo 2000; Safe Work Australia, 2015). In contrast to other risks and hazards within the workplace, research indicates that many organisations are failing to adequately manage risks associated with work driving (Haworth, Greig & Wishart, 2008; Wishart, 2015). Consequently, work-related road safety and risk management is an area within road safety that is gaining increased attention due to the substantial physical, emotional, and economic costs to the community that are associated with work-related road crashes. In an effort to improve work driving safety organisations often implement various intervention strategies without comprehensively evaluating the success (or otherwise) of interventions. This research consists of a longitudinal study involving four organisations that implemented a range of different work driving safety strategies specifically to improve work driving safety within their light vehicle fleets.

Methods and Results

Four organisations operating light vehicle fleets participated in the study. A number of self-report surveys were administered to the employees of each organisation over a three year period. Survey measures included self-report driving behaviours, attitudes and safety climate. Vehicle crash data of each organisation was also collated longitudinally.

The results from the survey indicated that each participating organisation demonstrated a decline in self-reported aberrant driving behaviours and unsafe driving attitudes over the period of the study. Results also indicated that two organisations showed an improvement in their safety climate.

The results from the crash data indicated that two organisations reported a reduction in crashes and crash costs over time. In contrast, one organisation demonstrated an increase in the frequency of crashes and costs while another organisation, although increasing the frequency of crashes, a decrease in overall crash costs over time.

Conclusion

The results of this study provide a number of implications for further research within the work driving setting, particularly in regards to the use of both self-report data and actual crash data in evaluating intervention strategies to improve work related driving safety. The practical implications for industries associated with the results of this program of research will also be discussed, along with the limitations of the study.

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Establishment of a formal trauma system in NZ to improve post-crash outcomes for trauma patients: Challenges and Achievements

Ian Civil and Siobhan Isles

Major Trauma National Clinical Network

Abstract

In 2012 the Ministry of Health (MOH) and the Accident Compensation Corporation (ACC) in NZ established a Major Trauma National Clinical Network (MTNCN). The objectives of the Network were to ensure that there was a planned and consistent approach to the provision of major trauma services across New Zealand. Key concepts necessary to achieve those goals required a cultural change within the community of trauma care providers to focus on optimal outcomes rather than convenience or past expectations. Progress and achievements of these goals has been steady and the challenges and achievements will be outlined in this presentation.

Background

Major trauma can result in a both loss of life and substantial disability. Road traffic crashes and falls are the predominant mechanisms of injury resulting in major trauma. Trauma care in NZ prior to 2012 was largely provided on an "ad hoc" system and there was no measuring tool to determine whether the quality of that care and the outcomes were consistent with results in other jurisdictions in similar healthcare environments. In an era of quality and safety in healthcare the MOH and the ACC agreed to establish a MTNCN with objectives including improving the quality and safety of trauma care and benchmarking the results. Key objectives included determining the capacity and capability of trauma receiving hospitals, formulating and instituting prehospital destination policies and describing guidelines for clinical care. The use of a National Health Index number in NZ allows the potential of seamlessly following patient care and outcome from incident (via the prehospital e-Patient Report Form) thorough hospital care to rehabilitation. Capturing this information through development of a national major trauma registry was essential to determine incidence and outcomes following major trauma.

Method

Development of the Network involved appointment of a Clinical Leader and a Program Coordinator. Together these appointees were responsible for interacting with the wider trauma care community as well as non-clinical stake holders such as the Automobile Association, and the public at large. Presentations at all trauma receiving hospitals and collaboration with key clinicians and administrators were used as the prime methodology to inform and encourage change. Development of a National Major Trauma Registry was linked to an already functional web-based regional trauma registry. The minimum data set was matched to that used by the Australian Trauma Registry for benchmarking and subsequent integration.

Results

Over a three year period a systematic change was initiated such that every hospitals capability to receive major trauma patients was determined and destination policies enacted such that where possible patients were preferentially taken to those hospitals able to effectively manage their immediate episode of care. Different regions took slightly different approaches standardized guidelines were used where possible. A National Major Trauma Registry was established so that data on all major trauma patients was entered from 1 July 2015.

Conclusions

All these initiatives required substantial cultural change both among hospital administrators and trauma care providers. No single approach was universally successful in resulting in change. A combination of personal advocacy, clinical presentation, scientific research and financial planning were all needed to move clinicians and administrators towards achieving the goals of the Network. As with all cultural change the process needed considerable effort to initiate and will require ongoing efforts over a number of years until the concrete goals of the Network can be shown to have been achieved

Factors Influencing Social and Health Outcomes after Land Transport Injury: recruitment and participant characteristics, and interim results

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Abstract

This abstract presents the interim results from a large inception cohort study being conducted across New South Wales to identify predictors of recovery following a mild to moderate land transport injuries. Participants were recruited from multiple sites and data sources such as hospitals, physiotherapists, general practitioners and insurance data. A high proportion of injuries from urban hospitals were reported for bicyclists (36%) whilst a large proportion of motorbike injuries were from rural hospitals. At the first interview, most participants were experiencing worse health status (EQ5D) compared to pre-injury; despite less than half reporting admission to hospital because of their injury.

Background

The Factors Influencing Social and Health Outcomes after Land Transport Injuries (FISH) aims to identify predictors of recovery after mild to moderate land transport injuries. There has been a substantial work on prognostic factors associated with recovery from particular types of injuries including traumatic brain injury, spinal cord injury, musculoskeletal injuries, and whiplash. Research on outcomes of the above listed injuries have established that socio-demographic, pre-injury health, psychological, social, crash related factors, health care systems and compensation system all play a pivotal role in recovery after injury. The aim is to a) describe key characteristics of the cohort (compensable and non- compensable) injured in a land transport injury, with an emphasis on socio-demographics and general health before injury and soon afterwards (within 28 days of injury) b) present interim results of the cohort, with a huge proportion of bicyclists injury c) explains the changes to the previously reported intended methods of the FISH study(Jagnoor et al., 2014).

Methods

777 participants aged ≥17 years involved in a land transport crash and who had sustained a mild – moderate injury diagnosed by a medical practitioner or registered health practitioner were interviewed. A telephone-administered questionnaire obtained information on socio-economic, pre-injury health, and crash-related characteristics. These participants are followed up with a telephonic interview at 6, 12 and 24 months.

Results

Over one- fourth (215; 27.3%) of the participants were born outside Australia, 67% were males, and 79.5% were in paid employment at the time of injury. The data source/ hospital was significantly associated with the distribution of mode of transport injuries and major differences were observed for urban hospitals with 35.9% (232/647) of the cohort being bicyclists whilst a high proportion of motorbike riding injuries (51.6%; 48/93) were reported from rural hospitals. At the first interview, most participants were experiencing worse health status (EQ5D a mean difference of -0.539; <0.0001) compared to pre-injury health status; despite less than half reporting admission to hospital because of their injury. Return to work was reported by 65% whilst only 36% reported being able to return to their usual social activities. Analysis of outcome predictors related to post-injury function, disability and return-to-work soon after injury and 6 months later is now under way. The cyclists were more likely to be male than car occupants, as well as having a higher frequency of tertiary education and pre-injury paid work, a lower frequency of being overweight, a lower frequency of comorbidities, greater self-reported pre-injury health ratings and were also less likely to report a large perceived danger of death.

Conclusion

The interim analysis of the cohort reported a very high proportion of bicycle related injuries. The results highlight the impact of mild to moderate injuries in both compensable and non- compensable cohort in the first 4 weeks after injury. And the bi-cyclists clearly reported better recovery as compared to injuries amongst motorized vehicle users.

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Function, health related quality of life and cost after injury in a city of North India: Interim results

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Abstract

The abstract presents the interim results from a multi-site cohort study reporting impact of non-fatal injuries requiring hospitalisation. Participants were recruited from two secondary and one tertiary level hospitals in a North Indian city. The results highlight the huge health, social, and economic impact of non-fatal injuries in a low and middle income setting.

Background

There are no comprehensive studies in existence that document the burden of non-fatal injuries in India. The burden of traumatic injury in India is certainly high, but remains ill-defined and poorly quantified. Whilst progress has been made in improving mortality data, our undersatnding of non-fatal injuries and their impact remains limited. Cost of road traffic injuries in India is estimated to be 3% of the GDP, much higher if all injuries are considered (Mohan, 2008). The potential catastrophic effects of injuries on families due to out of pocket (OOP) expenditure for medical care, particularly those of low socioeconomic status, has generated a need to document burden in economic terms. This research works aims to measure the impact of traumatic injuries on functioning and health-related quality-of-life (HRQoL), to identify predictors of poor outcomes post-injury and assess the OOP expenditures and financial risk protection for hospitalisation due to injuries.

Methods

A prospective observational study was conducted at three hospital sites for all ages admitted for more than 24 hours with an injury. Consent was sought and participants were followed at 1, 2, 4 and 12 months after injury collecting information on socio-demographics, circumstances of injury, cost associated with injury, disability, function and health related quality of life (Jagnoor et al., 2015).

Results

The results presented here are based on interim- analysis. 2950 (90%/3255 eligible) participants were recruited, with a follow-up rate of 74% (2180) at 4 months; 12 months follow up is under way. Road traffic injuries (55%/1622) followed by falls (31%/914) and burns (13%/ 383) were the leading cause of injury; 86% of participants were male, 79.5% were in paid employment at the time of injury. At the first interview, most participants were experiencing worse health status (EQ5D a mean difference of -0.679; <0.0001) as compared to their pre-injury status, whilst high disability proportions were reported on GOSE (73% upper or lower extremity) at 4 months follow up. Return to work was reported by 71% (1526) with the prevalence of catastrophic expenditure 30% (95% CI 26·95–31·05), which was significantly associated with those in the lowest income quartile (OR 23·3 [95% CI 5·7–73·9]; p <0·01), inpatient stay greater than 7 days (OR 8·8 [95% CI 3·8–20·6);

p<0·01), major surgery (OR 4·9 [95% CI 2·7–8·4]; p<0·01), and occupation as wage labourers (OR 8·1 [95% CI 1·6–24.6]; p=0·01).

Conclusion

This is one of the first studies reporting health related quality of life after injury in India. The health services expenditure in India is not well documented however with a health budget of less than 1% of GDP most of the expenses are out of pocket. The results highlight the catastrophic effect of injury, both in terms of health and cost for the injured and their families. The results highlight the need for major national investment in public health insurance schemes and better, affortable acute care and rehabilitation.

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A systems approach to monitoring trauma system performance

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Abstract

With the goal to provide the basis for future analytic studies we established a set of equations using integral calculus that could be used to monitor whole-of-system effectiveness of trauma systems. We report, for a given external cause category (ie road traffic injury), the descriptive epidemiology of trauma in all six states of Australia from 2000 to 2015, to demonstrate time trends in severe injury and deaths in the context of changes to societal level factors observed in the pre injury, acute care and rehabilitation environments.

Background

Trauma systems function within the public health framework as “a pre-planned, comprehensive, and coordinated statewide and local injury response network.” (HRSA 2006:1) Their goals are “to reduce the incidence and severity of injury as well as to improve health outcomes for those who are injured.” (HRSA 2006:3) The continuum of care is an excellent conceptual model, however its scope crosses boundaries of physical and social environments, organizational and professional structures, lines of funding and responsibility, and ownership and access to data. As a result, the whole system is rarely visualized or operationalized in its entirety. While it might not be necessary to formalize a single governance and funding structure for the entire injury system, it is important to undertake a whole-of-system evaluation. This is because, analogous to biological results observed *in vitro* versus the observed *in vivo* effects, the overall performance of a trauma system cannot be anticipated on the basis of known behaviors of its component parts.

Methods, Results & Discussion

Each of the trauma performance indicators was described for Australia by state and year. A qualitative model was developed representing the continuum of population patient states with a trauma system. This qualitative model was quantified using integral calculus to provide mathematical representation of the injury continuum, in a manner that enabled a calculation of five performance indicators on the basic of algebraic functions derived from systemic component causes. Empirical data was obtained relating to the prevalence of the systemic factors, and the known associations between these factors and trauma system indicators. All empirical causal factor data, and trauma system outcome data were combined into one data set that was then split into two sets; one comprising even numbered years, the other being odd numbered years. The model was run on even year data, one year at a time, and the model’s constants set so that the model accurately results in the observed indicators. This final model was validated by running the model one year at a time for the odd numbered years and comparing the models estimated outcomes with the true outcome indicators observed for that year. The model was generalized for the entire study period by inserting summary values of the input data (eg annual percent increase in population over the study period, instead of year by year actual changes) and the model run as a simulation model to for a 14 year simulation to estimate trauma system outcomes over this period.

These analyses demonstrated a reliable, structured mechanism for bringing together data from multiple sources, and linking into mass social data systems on real time basis. The stocks and flows approach retains "memory" of the states within the modelled system so that the population under consideration is modelled to evolve, as real populations do, with the changes they undergo. Importantly it also provides the bridge to enable the application of systems-based analytic methods for population level public health analyses..

References

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Application of social network analysis to the study of post-injury rehabilitation and health service utilisation

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Abstract

Increasingly used in medical domains such as epidemiology to understand and describe the topology of illness and disease pathways, Social Network Analysis (SNA) has not been used in the context of post-crash rehabilitation and care. In this study, we demonstrate the utility of using SNA to study post-crash treatment pathways among a large group of injured persons compensated and treated under the Victorian Transport Accident Commission scheme. We demonstrate that, with minor conceptual adaptation, SNA can provide new insights for rehabilitation researchers and injury compensation scheme managers attempting to effectively understand and predict individual and population-level patterns of recovery.

Background

Social network analysis (SNA) is a technique that has gained considerable attention in recent years in part due to the increasing connection of individuals through electronic communication channels (e.g. the internet) and the growth in availability of data and computing power at researchers' disposal (Otte & Rousseau, 2002). Primarily, SNA has been used to understand the topology of complex social networks and information exchange; however it is also being adapted in epidemiological contexts to study transfer of disease or illness in areas such as HIV (Du Toit & Craig, 2015).

SNA and its associated analytical techniques are yet to be adopted within post-crash injury and rehabilitation medicine. This is despite the widespread understanding that rehabilitation often occurs in a complex post-acute environment involving multiple service providers and relationships that extend over long periods of time (Wissel, Olver, & Sunnerhagen, 2013); conditions well suited to SNA. SNA offers physical rehabilitation researchers not only an innovative way to visualise and better understand entire rehabilitation processes of injured populations, but enables application of new methods of statistical analysis leading to individual and population injury management insights not possible through more traditionally applied techniques.

Method, Results & Discussion

To explore the potential utility of SNA in post-injury rehabilitation, we present an analysis of a large cohort of clients (N=16,000) injured in transport accidents who received compensation and treatment services through the Victorian Transport Accident Commission.

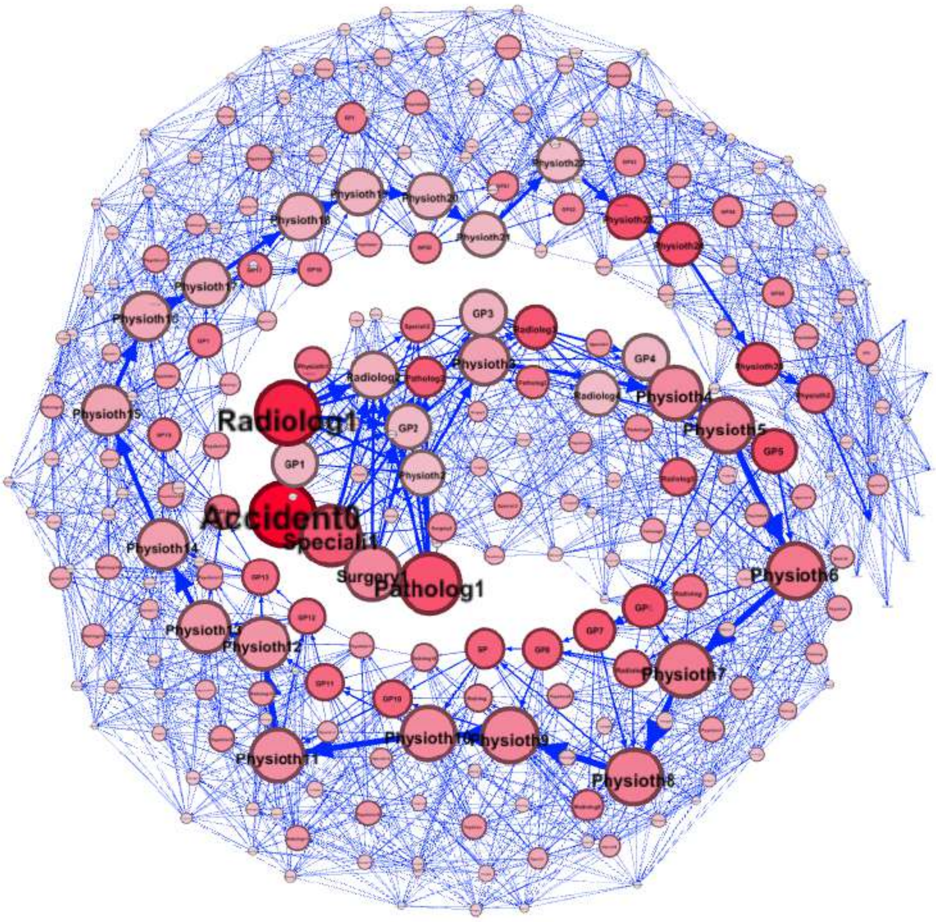

Figure 1. Social network analysis map of post-injury service use pathways from accident to 6 months post-accident from an original cohort of 16000 injured persons

Using SNA to map post-injury service use pathways over 6 months (see Figure 1), we demonstrate a bi-modal pattern of service utilisation for the injured population that peaks between weeks 1 and 2 immediately post accident, and again in weeks 6 to 7. This pattern indicates that, for a significant proportion of injured clients who do not recover within a few weeks after injury, the number and variety of treatment services accessed continues to expand for up to 2 months post-accident before beginning to decline. Further, analysis of individual service-type usage patterns (e.g., Radiologists, GPs, specialists, physiotherapists, psychologists) shows differences likely reflecting inter and intra-service referral patterns as well as stages of recovery.

We conclude that SNA may be an effective and efficient method for rehabilitation researchers and compensation scheme managers to understand, describe, and predict both individual and population-level patterns of post-injury recovery. The use of SNA and associated statistical techniques may lead to significant insight into 'typical' patterns of post-injury service access and recovery that are currently poorly understood.

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A Crash Testing Evaluation of Motorcyclist Protection Systems for use on Steel W-Beam Safety Barriers

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Abstract

Safety barriers are a popular and proven countermeasure used to protect vehicle occupants from roadside hazards. However, international and Australian research demonstrates that safety barriers can pose significant safety risks to motorcyclists in the event of a crash. The Centre for Road Safety (CRS) undertook a series of crash tests of currently available Motorcyclist Protection Systems (MPS) to investigate their suitability for use on NSW roads. The objectives were to assess whether the addition of MPS to a standard W-Beam reduces the injury risk for an impacting motorcyclist, without compromising the safety of other road users.

Background

There is a growing concern about the safety of motorcyclists on NSW roads. While total fatalities on NSW roads decreased by 23 percent between 2009 and 2015, motorcyclist fatalities have remained fairly stable averaging 63 per year (NSW Centre for Road Safety, unpub; Transport for NSW, 2015). Motorcyclists are overrepresented in road trauma, representing 16 percent of fatalities and 17 percent of serious injuries between 2009 and 2013, yet only 4 percent of motor vehicle registrations in NSW (Australian Bureau of Statistics, 2009, 2010, 2011, 2012, 2013; NSW Centre for Road Safety unpub; Transport for NSW, 2015). Motorcyclists are approximately 30 times more likely to be fatally injured and 41 times more likely to be seriously injured than car occupants per kilometre travelled (Department of Infrastructure Transport Regional Development and Local Government, 2008).

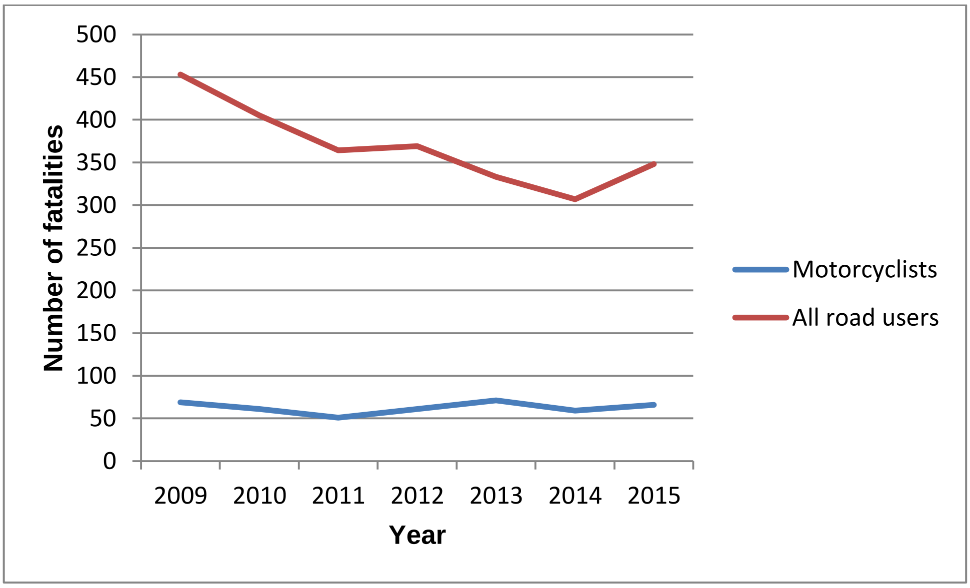

Figure 1. Number of fatalities on NSW roads, 2009-2015

The increasing number of motorcyclists on NSW roads and their overrepresentation in road trauma highlights the need to develop effective countermeasures which reduce the likelihood and severity of motorcycle crashes.

Safety barriers are an effective measure for reducing injury risk to vehicle occupants by protecting them from impacts with roadside hazards, such as trees, poles and embankments. While safety barriers also reduce the risk of serious injury to motorcyclists compared to roadside hazards such as trees and poles, they can still pose significant injury risks to motorcyclists (Elvik 1995; Gabler 2007; Bambach, Grzebieta & McIntosh, 2010; Bambach, Grzebieta, Tebecis, & Friswell, 2012; Bambach, Mitchell & Grzebiata, 2012). Internationally, impacts with a safety barrier are a factor in between 8 and 16 percent of motorcycle fatalities (EuroRAP, 2008). Similar results have been found in Australia, with around 8 percent of motorcycle fatalities in NSW between 2001 and 2006 involving an impact with a safety barrier (Jama, Grzebieta, Friswell & McIntosh, 2011). Motorcyclists are far more likely to be fatally injured upon impact with a safety barrier compared with car occupants. Gabler (2007) found, based on a study of US crashes between 2000 and 2005, that approximately one in eight motorcyclists impacting a safety barrier were fatally injured, compared with only one or two of every 1000 car occupants. European research suggests that motorcyclists are 15 times more likely to be fatally injured in crashes with barriers than a car occupant (EuroRAP, 2008).

The nature of injuries sustained by a motorcyclist during an impact with a safety barrier depends on the manner in which the motorcyclist impacts the barrier. The most common scenarios involve the motorcyclist and motorcycle impacting the safety barrier together in an upright position, and the motorcyclist impacting the safety barrier after sliding along the ground, either while still in contact with the motorcycle or after separation has occurred (Bambach et al., 2010; Ruiz et al., 2010). A number of studies have shown that motorcyclist impacts with safety barriers are split approximately equally between upright and sliding impacts (Berg et al., 2005; Bambach et al. 2010). An impact in the upright position leaves the motorcyclist exposed to sharp edges and protrusions connected to the upper areas of the safety barrier, whereas an impact in the sliding position exposes the motorcyclist to a significant chance of impact with the barrier posts (Gibson & Benetatos, 2000; Peldschus et al., 2007). Barrier posts present a substantial risk of fatal and serious injury to motorcyclists upon impact due to their rigid nature, relatively small impact area, sharp pointed edges and installation that is perpendicular to the expected impact trajectory. These combine to result in higher stresses inflicted on the body of the motorcyclist.

Jama et al. (2011) in an in-depth study of motorcycle crashes in Australia and New Zealand demonstrated that motorcyclist fatalities involving an impact with a barrier predominantly occurred on curves and involved a steel W-Beam barrier (around 70 percent). Relatively few involved a concrete barrier or a wire rope barrier. The high number of impacts involving W-Beam barriers is likely to reflect their extensive use throughout the road network and particularly on curves, where motorcyclists are more likely to impact a barrier. Fatalities tended to occur during daylight hours, on clear days with dry road surface conditions, and frequently on a weekend, suggesting recreational riding. Speeding or alcohol were also recorded as being a factor in a significant number of the fatalities, and drug use was evident in a small number of cases.

Motorcyclists tend to have been overlooked in the design of safety barriers, due to both their underrepresentation as road users and the challenges in developing protective technologies for these road users. In recognition of the need to improve motorcycle safety, a range of motorcycle friendly barriers or Motorcyclist Protection Systems (MPS) have been developed. There are two main types of MPS - continuous systems, which consist of an additional rail that fits between the barrier rail and the ground, and discontinuous systems, which consist of a protective ‘cushion’ that surrounds the individual posts that support the barrier. These products are intended to absorb kinetic energy through deformation during an impact, therefore helping to reduce the risk of injuries due to rapid deceleration. Upon impact the brackets of the MPS deflect and deform to absorb some of the impact energy, while the panel surface, also absorbing energy, functions as a continuous guide to redirect the motorcyclist along the barrier. The function of the MPS is to protect sliding motorcyclists from impacting support posts, continuing underneath the existing barrier and into other hazards, and/or to minimise re-entry into the lane of traffic after interaction.

Crash testing of MPS undertaken in Europe has produced promising results in terms of reduced injury risk to motorcyclists impacting safety barriers, without an adverse impact on the injury risk to passenger car occupants. Work by Bambach, Grzebiata, Olivier and McIntosh (2011) also indicates that the installation of MPS has the potential to reduce injuries that would normally be fatal to more minor injuries. The likelihood of head injury following a barrier impact is more than halved for either an upright or sliding impact with a continuous system. The deceleration forces for a chest impact are almost halved when impacting a discontinuous system.

This project explores the risks posed to motorcyclists by safety barriers and evaluates three MPS developed to reduce the injury risk to motorcyclists arising from barrier impacts. It represents the first full-scale crash testing of MPS in Australia.

Method

Three continuous MPS - Ingal MPR, HIASA and a public domain product, shown in Figures 2 to 4 - were crash tested to evaluate the injury risks posed to an impacting motorcyclist as well as to vehicle occupants. These MPS are able to be fitted to a standard W-beam barrier which is used widely across the NSW road network and were available on the Australian market at the time of the study. A standard G4 W-Beam barrier alone served as a comparison (control baseline measure). All testing was carried out at Crashlab, a commercial business unit of NSW Roads and Maritime.

Figure 2: The Ingal MPR

Figure 3: HIASA MPS

Figure 4: Public domain MP

Motorcyclist crash tests

Twelve crash tests evaluated the injury risks posed to an impacting motorcyclist by each of the MPS and the W-Beam alone. Testing was carried out in accordance with the European test specification CEN/TS 1317-8:2012, which is seen as current industry best practice for evaluating MPS.

These test procedures simulate a sliding motorcyclist impacting the barrier head first, using a modified anthropomorphic device (ATD) or crash test dummy (as shown in Figure 5). The modifications enable the ATD to behave more like a sliding motorcyclist (rather than a seated vehicle occupant) and to better simulate motorcyclist trajectory and injuries. Testing is required to be carried out for two different points of impact with the MPS (post-centred and mid-span), with an impact speed of either 60 km/h or 70 km/h, and an impact angle of 30°. This corresponds to test configurations 1.60, 1.70, 3.60 and 3.70 set out in CEN/TS 1317-8:2012. The impact configuration represents severe rather than typical impact conditions and enables test repeatability and use of well-established measurement criteria. MPS are assessed against a range of criteria. These include injury risk to the head and neck, and the behaviour of the MPS (in terms of damage to the barrier) and the ATD (in terms of injury damage or protrusion beyond the barrier).

Figure 5: Set up used in the motorcyclist crash tests

A standard G4 W-beam barrier was installed in accordance with AS/NZS 3845:1999 for each motorcyclist test. The W-beam was 42m in length (including trailing terminals at each end), with 21 steel posts spaced 2m apart. Panels of MPS were fitted below the existing W-beam rails and were attached through the use of brackets attached to either the c-block (in the case of the HIASA and the public domain) or the W-beam post (in the case of the Ingal MPR). The public domain MPS attachment to the W-beam is shown in Figure 6. The height of the MPS above the ground at the nominal point of impact ranged between 50mm and 64mm for the Ingal MPR, 31mm and 35mm for the HIASA and 53mm and 59mm for the public domain product.

Figure 6: The Public domain MPS attached to the W-Beam barrier

A modified Hybrid III 50th percentile male ATD was used in testing. The total mass of the test ATD, including instrumentation, helmet and protective clothing, was approximately 86.5 kg. The helmet used in the testing complied with Australian Standard AS/NZS 1698:2006 and the performance requirements of European standard CEN/TS 1317-8:2012 Annex F.

Early crash test results conducted at 70 km/h indicated that a number of the injury risk measures were higher than expected (exceeding Severity I levels), and may have been due to differences in soil conditions or in the structure and installation of barriers, in Australia compared with Europe. Subsequent crash tests, particularly the post-centred tests, were therefore generally run with the lower impact speed of 60 km/h.

Passenger car occupant crash tests

Four crash tests evaluated the injury risks posed to passenger car occupants by each of the MPS and a W-beam alone. Passenger car tests were carried out in accordance with the Australian and New Zealand standard for barrier testing and installation AS/NZS 3845:1999 and in particular Test 3-11 of the recommended testing procedures in the United States National Cooperative Highway Research Program (NCHRP) Report 350, which the Australian standard references. These test procedures stipulate that a 2000 kg pickup truck travelling at a speed of 100 km/h impact a barrier installation at an angle of 25°. In the current study the 2000 kg pickup truck was replaced with the optional 1600 kg sedan, permitted under AS/NZS 3845:1999 as it represented the most common vehicle travelling on Australian roads at the time the standard was released. The barrier is assessed against criteria relating to structural adequacy of the barrier, occupant injury risk and the vehicle trajectory after the collision.

These criteria ensure that the barrier performs as it was designed and contains and redirects the vehicle without subjecting the vehicle occupants to undue injury risk, or to subsequent crash risk or hazards. The barrier should preferably prevent the vehicle from being redirected back into the traffic lanes. Occupant injury risk is measured by instrumentation within the vehicle and is based on the velocity at which a hypothetical unrestrained occupant would strike some part of the vehicle interior.

A 1600 kg Holden VT Commodore sedan (models ranged from 1998 to 2000) was used as the test vehicle. A Hybrid III 50^{th} percentile male ATD with a mass of 88 kg was placed in the driver seating position.

A standard G4 W-beam was installed in accordance with AS/NZS 3845:1999 for each passenger car occupant test. The barrier was 68 m in length, including trailing terminals at each end, with 35 steel posts spaced 2m apart. The top edge of the rail was 710 mm high. The Ingal MPR was installed on W-beam barrier 60m in length with 31 steel posts, spaced 2 m apart and the top of the rail was 720 mm high.

Results

The key findings of the crash tests are presented in this section. Full details are available in the individual crash test reports available from the Centre for Road Safety (Crashlab, unpub).

Tables 1 to 4 show the results of the motorcyclist crash tests for each of the three MPS and the W-beam alone against the standard evaluation criteria set out in CEN/TS 1317-8:2012. Tolerances for impact speed, impact angle and impact point were met in all twelve tests.

Motorcyclist crash tests

Table 1. Ingal MPR - motorcyclist test results

	Mid-Span 60 km/h	**Post-centred 60 km/h**	**Mid-span 70 km/h**	**Post-centred 70 km/h**	***Severity Level I criteria***	***Severity Level II criteria***
Head Injury Criterion	160	169	284	406	***650***	***1000***
Neck shear (kN)	1.5	1.7	2.4	2.0	***1.9***	***3.1***
Neck tension (kN)	1.4	2.0	1.7	2.0	***2.7***	***3.3***
Neck compression (kN)	2.3	2.5	3.1	2.7	***3.2***	***4.0***
Neck lateral bending (N-m)	-59.2	-51.0	45.2	-90.8	***134.0***	***134.0***
Neck extension (N-m)	30.2	24.0	31.7	38.2	***42.0***	***57.0***
Neck flexion (N-m)	67.9	76.1	111.3	100.9	***190.0***	***190.0***
Injury criteria	Severity I	Severity 1	Severity II	Severity II		
ATD criteria	Met	Met	Met	Not met		
MPS criteria	Met	Met	Met	Met		
Overall test	Met	Met	Met	Not met		

As shown in Table 1, the Ingal MPR met all performance requirements at 60 km/h for both the mid-span and post-centred impact at the Severity I (less serious) injury levels. The Ingal MPR therefore demonstrated an acceptable level of injury risk to a sliding motorcyclist. At 70 km/h the Ingal MPR did not meet the performance requirements for the post-centred impact - the ATD criteria were not met with lacerations evident to the left chest, neck and shoulder area of the ATD.

Table 2. HIASA - motorcyclist test results

	Mid-span 60 km/h	**Post-centred 60 km/h**	**Mid-span 70 km/h**	***Severity I criteria***	***Severity II criteria***
Head Injury Criterion	169	114	742	***650***	***1000***
Neck shear (kN)	0.3	0.9	1.1	***1.9***	***3.1***
Neck tension (kN)	1.8	1.4	2.8	***2.7***	***3.3***
Neck compression (kN)	1.8	1.7	2.4	***3.2***	***4.0***
Neck lateral bending (N-m)	-58.7	-58.5	77.8	***134.0***	***134.0***
Neck extension (N-m)	25.7	30.7	47.6	***42.0***	***57.0***
Neck flexion (N-m)	22.7	51.6	49.6	***190.0***	***190.0***
Injury criteria	Severity I	Severity I	Severity II		
ATD criteria	Met	Met	Not met		
MPS criteria	Met	Met	Met		
Overall test	Met	Met	Not met		

Table 2 shows the HIASA met all performance requirements at 60 km/h for both the mid-span and post-centred impact at the Severity I (less serious) injury levels. This MPS also demonstrated an acceptable level of injury to a sliding motorcyclist. At 70 km/h the MPS did not meet the performance requirements for the mid-span impact - the ATD criteria were not met due to the left foot of the ATD protruding beyond the MPS.

Table 3. Public domain – motorcyclist test results

	Mid-span 60 km/h	**Post-centred 60 km/h**	**Mid-span 70 km/h**	***Severity I criteria***	***Severity II criteria***
Head Injury Criterion	344	492	487	***650***	***1000***
Neck shear (kN)	0.6	-0.4	1.0	***1.9***	***3.1***
Neck tension (kN)	1.8	2.3	4.0	***2.7***	***3.3***
Neck compression (kN)	5.9	3.6	6.3	***3.2***	***4.0***
Neck lateral bending (N-m)	96.3	-66.2	104.5	***134.0***	***134.0***
Neck extension (N-m)	13.2	25.6	24.4	***42.0***	***57.0***
Neck flexion (N-m)	14.4	24.8	38.0	***190.0***	***190.0***
Injury criteria	Not met	Severity II	Not met		
ATD criteria	Not met	Not met	Not met		
MPS criteria	Met	Met	Met		
Overall test	Not met	Not met	Not met		

From Table 3 it can be seen that the public domain product did not meet the performance requirements at either 60 km/h or 70 km/h. The maximum allowable injury levels (Severity II) were exceeded in the mid-span test at both 60 km/h and 70 km/h. The ATD criteria were also not met due to the ATD protruding beyond the MPS.

Table 4. W-beam – motorcyclist test results

	Post-centred 60 km/h	**Mid-span 70 km/h**	***Severity I criteria***	***Severity II criteria***
Head Injury Criterion	7985	194	***650***	***1000***
Neck shear (kN)	>8.2	-0.6	***1.9***	***3.1***
Neck tension (kN)	1.5	5.1	***2.7***	***3.3***
Neck compression (kN)	>15.7	0.9	***3.2***	***4.0***
Neck lateral bending (N-m)	>502.1	63.5	***134.0***	***134.0***
Neck extension (N-m)	167.4	31.8	***42.0***	***57.0***
Neck flexion (N-m)	100.2	35.7	***190.0***	***190.0***
Injury criteria	Not met	Not met		
ATD criteria	Not met	Not met		
MPS criteria	Met	Met		
Overall test	Not met	Not met		

The W-beam alone similarly did not meet the performance requirements at 60 km/h or 70 km/h. The maximum allowable injury levels (Severity II) were exceeded in the post-centred test at 60 km/h and the mid-span test at 70 km/h. The ATD criteria were also not met due to lacerations to the ATD. The post-centred impact with the W-Beam alone resulted in a number of injury measures exceeding the maximum recordable levels, indicating that a motorcyclist who impacted the post would most likely be fatally injured.

While not a testing requirement under CEN/TS 1317-8:2012 it was noteworthy that in all twelve motorcycle tests the frangible screws, which form part of the ATD’s modified shoulder, failed (generally on the left side) and there was evidence of deformation to several of the ribs (also generally on the left side). Research by Bambach et al. (2010) suggests that the thorax features prominently in fatal motorcycle barrier crashes, with the highest incidence of injury and the highest incidence of maximum injury in the thorax region, followed by the head region. The need for further development of thorax injury criteria indicative of injury risk for a motorcyclist impact of this type which has been discussed by Grzebiata, Bamabach and McIntosh (2013) is clearly supported by the findings of this study.

Passenger car crash test results

Tables 5 to 8 show the results of the passenger car crash tests for each of the three MPS and the W-beam alone against the standard evaluation criteria set out in AS/NZS 3845:1999 via NCHRP Report 350. Tolerances for impact speed and impact angle were met in all four tests.

Table 5.Passenger car test results – vehicle measures

	Ingal MPR	HIASA	Public domain	W-beam only
Impact downstream of post no.	8	9	9	8
Impact speed (km/h)	99.3	99.2	99.6	99.0
Exit speed (km/h)	30.6	48.7	48.8	46.3
Impact angle (◦)	25.8	24.6	25.4	25.1
Exit angle (◦)	12.6	-4.2	3.4	1.3
Exit angle as a % of impact angle	48.8	-17.1	13.4	5.2
Maximum roll (◦)	-20.1	-36.1	-4.1	9.9
Maximum pitch(◦)	-5.4	8.1	2.5	-3.3
Maximum yaw (◦)	-31.4	-30.3	-33.2	-40.1

Table 6.Passenger car test results - simulated injury risk

	Ingal MPR	HIASA	Public domain	W-beam only	Criteria	
					Preferred value	***Maximum value***
Mandatory requirements						
Occupant Impact velocity, x (m/s)	6.7	4.2	5.0	4.7	***9***	***12***
Ridedown Acceleration, x (g)	-11.1	-13.9	-10.1	-10.5	***15***	***20***
Non-mandatory requirements						
Occupant Impact Velocity, y (m/s)	4.1	5.3	5.2	4.5	***9***	***12***
Theoretical Head impact velocity (km/h)	26.7	24	24.5	23	***NA***	***30***
Ridedown Acceleration, y (g)	-7.9	-10.4	-7.2	-12.1	***15***	***20***
Acceleration Severity Index	0.79	0.83	0.72	0.79	***1***	***1.9***
Post Head Deceleration (g)	12.7	14.2	10.1	15.9	***NA***	***NA***
Impact Severity (kJ)	116.2	105.3	112.7	108.9	***101.7***	***119.3***

There are two key values of interest for the simulated injury risk. The first is the Occupant Impact Velocity in the longitudinal direction (x or horizontal plane) which is the velocity with which the occupant would strike part of the car's interior. The second is the Ridedown Acceleration in the longitudinal direction (x or horizontal plane) which is the vehicle acceleration transferred to the vehicle occupant after interior impact is made. The other values, while not requirements under NCHRP Report 350, are reported for comprehensiveness and to enable comparison with other testing.

It can be seen that the injury risks to passenger car occupants for each of the three MPS and the control W-Beam were all within acceptable levels. In all four tests the Occupant Impact Velocity values were below both the preferred and maximum values of 9m/s and 12m/s, respectively and the Ridedown Acceleration values were below the preferred and maximum values of 15g and 20g, respectively.

Table 7.Passenger car test results – assessment against evaluation criteria

	Ingal MPR	HIASA	Public domain	W-beam only
Structural adequacy of barrier				
Barrier contains and redirects vehicle	Pass	Pass	Pass	Pass
Occupant risk				
Minimal intrusion into occupant compartment	Pass	Pass	Pass	Pass*
Vehicle remains upright	Pass	Pass	Pass	Pass
Vehicle trajectory				
Vehicle preferably should not intrude into adjacent traffic lanes	Pass	Pass	Pass	Marginal
Occupant Impact Velocity ≤ 12m/s and Occupant ridedown acceleration ≤ 20g	Pass	Pass	Pass	Pass
Vehicle exit angle < 60% of impact angle	Pass	Pass	Pass	Pass

- Note that the assessment of occupant risk for the W-beam only differs from that presented in the crash test report where the assessment was reported as “Marginal”. This was due to part of the barrier being projected 26m down the barrier and being considered a potential hazard to other traffic, pedestrians or personnel in a work zone.

While some destruction of the barrier was evident, and parts of the barrier (blockout or stiffener plates) were projected down the installation, in each case, it can be seen from Table 7 that the Ingal MPR, HIASA and public domain product all demonstrated acceptable levels of structural adequacy, occupant risk and vehicle trajectory. Each of the MPS was able to satisfactorily contain and redirect the vehicle, without the vehicle penetrating the barrier. There was minimal deformation and intrusion into the occupant compartment and vehicles remained upright during and following the impact in each case.

The W-beam alone demonstrated an acceptable level of structural adequacy and occupant injury risk, but a marginal level of vehicle trajectory. Vehicle trajectory was considered marginal because the vehicle could potentially enter adjacent traffic lanes following impact with the barrier.

Table 8 shows the degree of barrier deflection for each of the four tests. Whilst this is not a requirement of the testing, the findings are reported for comprehensiveness and comparison. It can be seen that the control W-Beam tended to have the highest degree of barrier deflection.

Table 8.Passenger car test results – barrier deflection

	Ingal MPR	HIASA	Public domain	W-beam only
Dynamic rail deflection, y (m)	0.88	0.87	0.89	0.98
Permanent rail deflection, y (m)	0.64	0.56	0.60	0.66
Permanent working width, y (m)	0.80	0.89	1.10	1.02
Permanent defection, either end, x (m)	0.00	0.00	0/03	0.03

Conclusion

Two of the MPS tested – the Ingal MPR and the HIASA – demonstrated acceptable levels of injury risk to a sliding motorcyclist impacting at 60 km/h, with all test requirements for injury risk, MPS and ATD behaviour being met for both mid-span and post-centred impacts at this test speed. The Severity I (lesser) injury criteria were met in all cases. None of the MPS demonstrated any adverse impact on the injury risk to vehicle occupants, with all vehicle test requirements met.

This research highlights that the addtion of MPS to standard W-beam can be effective in reducing the risk of fatality and serious injury to sliding motorcyclists, without compromising the safety of other road users. Given that motorcycle impacts with roadside barriers are more prevalent on curves, it makes sense to target the installation of MPS initially toward the outside of curved alignments on popular motorcycle recreational routes or where there is a history of motorcycle crashes.

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Decompartmentalising road safety barrier stiffness in the context of vehicle occupant risk

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Abstract

Road safety barriers are selected for deployment on the basis of four basic criteria; costs, deflection performance, containment capacity, and severity outcomes. System specific severity risk to occupants of errant vehicles is not well established. Contemporary technical governance in the Australian context recognises three generic barrier types discerned by relative stiffness: rigid, semi-rigid, and flexible. This study explores how the occupant severity indicator Acceleration Severity Index (ASI) varies as a function of impact configuration and system stiffness. This study demonstrates that systems available to road safety practitioners may be better served by a continuum rather than a generic classification system.

Introduction

Road safety barriers are selected for deployment on the basis of four basic criteria:

- Costs
- Deflection performance
- Containment capacity
- Severity outcomes

Information regarding device-specific deflections and containment capacity is readily available to practitioners. Reasonable estimates of capital, maintenance and repair costs for any system can be relatively easily established. However device specific severity risk to occupants of errant vehicles is less well established.

Contemporary technical governance in the Australian context recognises three generic barrier types, discerned by relative stiffness. According to the Guide to Road Design Part 6 (Austroads, 2009) road safety barriers are described as flexible, semi-rigid or rigid. Australian/New Zealand Standard AS/NZS 3845.1:2015 (Standards Australia, 2015) is complicit in this regard. By such definitions, the rigid classification includes concrete barriers and steel bridge rail barriers. Flexible barriers are typically wire rope (cable) barriers, while semi-rigid barriers include post-mounted steel rail systems. Thereafter, in terms of vehicle occupant severity Jurewicz et al (2014) provide Fatal and Serious Injury (FSI) ratios for each of these three generic road safety barrier types, albeit noting that the differences between values are "*not statistically significant*". Likewise, the Australian National Risk Assessment Model (ANRAM) (Jurewicz, Steinmetz, & Turner, 2014) provides risk factors for three generic barrier types, viz, 'concrete', 'metal' and 'wire rope'.

However the assumption that different barriers and the occupant risk they present can be placed into such discrete categories may be an over-simplification. Rather it may be appropriate to observe that barriers present a continuum of stiffness, and that occupant severity outcomes are as much a function of the stiffness of the barrier as the configuration of the impact.

This study is an exploration of how the occupant severity indicator Acceleration Severity Index (ASI) measured during crash testing might be expected to vary as a function of barrier stiffness and the configuration of the impact.

Background

Road safety barriers deployed by Australian road authorities are homologated against established test protocols that prescribe the requirements for full-scale crash testing. Such testing is a function of both the test vehicle in terms of mass and shape, and the impact conditions: speed and angle of incidence. Australian/New Zealand Standard AS/NZS 3845.1:2015 (Standards Australia, 2015) nominates the Manual for Assessing Safety Hardware (MASH) (AASHTO, 2009) as the preferred test protocol for the homologation of road safety barriers. MASH provides that a road safety barrier intended for the containment of light passenger vehicles (i.e., cars) is tested using a 2270 kg pick-up (a utility) and an 1100 kg small car. The larger vehicle test is a test of the capacity of the barrier, while the smaller vehicle test is intended to show that the road safety barrier does not present undue risk to the occupants of smaller/lighter vehicles.

Since a light vehicle is used to test for occupant risk, it is reasonable to expect that a slightly heavier vehicle would present a lower level of occupant risk, and that (notwithstanding other confounding factors such as vehicle age and vehicle safety rating) for the same impact conditions a continuum of occupant risk would exist as a function of vehicle mass. Further, it is reasonable to expect that occupant risk is a function of the Impact Severity, or kinetic energy of the impact. And since speed and angle are components of Impact Severity, occupant risk is also a function of speed and angle of impact. This is supported variously throughout published literature.

For example, Monash University conducted a series of crash tests using identical vehicles to impact three barrier systems (F-shape concrete (rigid), U-section post guardrail with 2.5 m post-spacings (semi-rigid) and an unidentified proprietary wire rope system with 2.5 m post-spacings and unspecified rope tension (flexible)) each at 80 km/h and 45 degrees and at 110 km/h at 20 degrees (Corben et al., 2000; Grzebieta et al., 2002). Ydenius et al. (2001) report that impact with the concrete barrier at 80 km/h and 45 degrees was the most severe impact configuration in terms of all metrics employed, but that "*at slight impact angles (< 20°) the perpendicular forces on the barrier are relatively small, which most likely leads to a moderate vehicle crash severity*".

Similarly, Hammonds and Troutbeck (2012) report on parametric comparison testing of three barrier systems (F-shape concrete (rigid), C-section post guardrail with 2.0 m post-spacings (semi-rigid) and an unidentified proprietary wire rope system with 2.5 m post-spacings and rope tension 20 kN (flexible)). Each barrier type was subjected to impact at 100 km/h and 20 degrees by four vehicles: an 1100 kg small car (Daihatsu Charade), an 1850 kg intermediate car (Holden Commodore), a 2500 kg larger passenger car (Toyota Landcruiser), and an 8000 kg single unit truck (Mitsubishi). Hammonds and Troutbeck report (among other things) that "*when designing for reduced occupant injury, there is little practical difference between wire rope and W-Beam*", but that the occupant severity indicators measured during impacts with the concrete barrier, while more severe than for the other two barrier types, were still within acceptable limits, and "*well below those recorded in the ANCAP tests*". Importantly, in the context of this study, Hammonds and Troutbeck propose that for non-rigid systems, "*the 'apparent' stiffness of the barrier is affected by the mass of the impacting vehicle and the manner in which it interacts with the barrier*" (Hammonds & Troutbeck, 2012).

Michie et al (1971) observe that in terms of lateral acceleration, a rigid barrier was found to perform favourably when compared to semi-rigid systems in shallow angle (less than 15 degrees) impacts, and that in operator-driven tests where the barrier was repeatedly struck at 50 mph at 8 degrees "*no vehicle damage or driver injuries were observed*". The authors caution however that in large angle (> 20°) impacts, vehicle redirection is "*abrupt*". This is consistent with Bronstad et al (1987) who report on the evaluation of an array of longitudinal road safety barriers tested against the provisions of the US test protocol NCHRP Report 230 (Michie, 1981), finding that 15 degree impacts are not a discerning test for occupant risk, but that 20 degree impacts are a discerning test.

Consistent with Ydenius et al (2001), Michie et al (1971) find that vehicle mass is "*a most important parameter*", and that lighter vehicles are likely to experience more severe redirection.

The intent of this study is to explore how one particular occupant severity indicator measured during crash testing is observed to vary as a function of the conditions of impact and barrier stiffness.

Acceleration Severity Index

Acceleration Severity Index (ASI) is a non-dimensional occupant severity indicator calculated from orthogonal time-averaged time-acceleration traces measured during crash testing at the centre of mass of the impacting vehicle. ASI is calculated according to the expression in Equation 1:

$$\mathrm{ASI} = \max\left[\left(\frac{a_x}{\hat{a}_x}\right)^2 + \left(\frac{a_y}{\hat{a}_y}\right)^2 + \left(\frac{a_z}{\hat{a}_z}\right)^2\right]^{\frac{1}{2}} \qquad \text{Equation 1}$$

where $a_{x,y,z}$ are average component vehicle accelerations respectively in the longitudinal, lateral and vertical direction measured over a prescribed time interval (50 milliseconds), and $\hat{a}_{x,y,z}$ are corresponding threshold values for the respective component accelerations (Gabauer & Gabler, 2005). The denominator values for the component threshold accelerations $\hat{a}_{x,y,z}$ as adopted in both the US and European test protocols are respectively $\hat{a}_x = 12\text{g}$, $\hat{a}_y = 9\text{g}$ and $\hat{a}_z = 10\text{g}$ (and g = acceleration due to gravity). These threshold values are consistent with those presented by Weaver et al (1975) for lap-belted occupants, and are notably equivalent to approximately 60% of the threshold values proposed for the lap and shoulder belt restraint condition. ASI is a mandatory measure under the European test protocol EN1317-1/EN1317-2 (European Committee for Standardization, 2010a, 2010b) which use ASI (among other things) to classify barriers according to occupant severity. ASI is also required to be measured under Australian/New Zealand Standard AS/NZS 3845.1:2015 (Standards Australia, 2015), but there are no mandatory performance criteria.

Objectives

In summary, it is reasonable to hypothesise that occupant severity indicator ASI may be expected to increase as a function of:

- Decreasing vehicle mass
- Increasing impact speed
- Increasing impact angle
- Increasing barrier stiffness

The aim of this study is to present an argument that:

(i) generic road safety barrier types cannot be categorised generically, but comprise a continuum of solutions in terms of barrier stiffness, and,
(ii) occupant injury risk as a function of barrier stiffness is similarly a continuum, and a function of the configuration (mass, speed and angle) of the impacting vehicle.

The objective of this study is to present a graphical analysis of the results of full scale crash testing to demonstrate that both occupant risk indicator ASI results and barrier stiffness are represented by a continuum and are not categorical.

Methodology

Vehicle mass, impact speed, impact angle, dynamic deflection and ASI are each recorded for 63 road safety barrier hardware crash tests sourced (mainly) from the FHWA website (US Department of Transportation Federal Highway Administration) supplemented with a small amount of other limited literature obtained from the public domain. This data is tabulated in TABLE 1.

Impact severity for each impact is calculated in accordance with the expression at Equation 2 (Sicking & Ross Jr, 1986), and is measured in terms of energy.

$$IS = {}^{1}/_{2}\, m(v.\sin\theta)^2 \qquad \text{Equation 2}$$

where

IS	=	Impact Severity (kJ)
m	=	mass (t)
v	=	vehicle speed (m/s)
θ	=	angle of incidence (degrees)

In terms of road safety barrier characteristics, the term 'stiffness' represents resistance to deformation, which is also the decelerating force imposed on an impacting vehicle. And since energy is the product of force and distance, so barrier stiffness (as resistive force) is energy per unit of displacement. However, because rigid barriers by definition exhibit practically zero dynamic deflection and hence effectively an infinite stiffness which is inconvenient in calculation, the term 'flexibility' is coined here as the reciprocal of 'stiffness'. For the purpose of this study, barrier 'flexibility' is calculated in accordance with the expression at Equation 3.

$$Flexibility = \frac{DD}{IS} \qquad \text{Equation 3}$$

where DD is dynamic deflection (m). Hence, ASI can be plotted against 'flexibility' for all 63 records.

Firstly, the data is disaggregated by generic barrier type, according to the following classifications:

Bridge rail (BR)
Transitions (TR)
Strong Post W-Beam (SPWB)
Thrie-beam (TB)
Weak Post (WPWB)
Wire rope (WR)

Secondly, the data is disaggregated according to the nominal configuration (mass, speed, angle) of the crash test. Three nominal crash test configurations (NCHRP Report 350 test 3-10, 3-11 and 4-12) dominate the impact conditions in the data set, together representing 60 of the 63 sets of test results. For the sake of this study, transition tests designated 3-21 and 4-22 are considered equivalent in terms of configuration to 3-11 and 4-12 tests. Descriptive data of these tests are provided in TABLE 2.

TABLE 1 Crash test data (63 crash tests)

Barrier type	Test ref.	Test designation	Mass	Speed	Angle	Dynamic deflection	ASI	Source (refer footnotes)
BR	421323-1	4-12	8009	81.4	14.3	0.000	0.56	(2)
BR	421323-2	4-11	2063	98.3	26.4	0.000	1.86	(2)
BR	TTI 404251-2	3-11	2000	99.4	25.4	0.000	1.70	FHWA b066
BR	TTI 404251-3	4-12	8000	79.6	14.9	0.010	0.50	FHWA b066
BR	TTI 404311-1	3-10	820	100.0	20.8	0.000	1.80	FHWA b055
BR	TTI 404311-2	3-11	2000	100.7	25.8	0.040	1.66	FHWA b055

Barrier type	Test ref.	Test designation	Mass	Speed	Angle	Dynamic deflection	ASI	Source (refer footnotes)
BR	TTI 404311-3	4-12	8000	78.7	14.9	0.005	0.51	FHWA b055
BR	418049-7	3-11	2000	101.4	24.8	0.005	1.50	FHWA b224
BR	400001-SCW1	3-11	2000	101.60	25.2	0.000	1.60	FHWA b073
TR	404211-12	3-21	2000	101.3	24.2	0.070	1.85	FHWA B065
TR	404211-9	3-21	2000	100.8	25.6	0.077	1.68	FHWA B077
TR	TTI 401181-1	4-21	2135	102.3	24.9	0.200	1.74	FHWA b146
TR	TTI 401181-2	4-21	2108	96.9	25.2	0.060	1.73	FHWA b146
TR	TTI 401181-3	4-22	8106	80.8	13.6	0.180	0.34	FHWA b146
SPWB	400001-CF11	3-11	2000	101.40	26.3	0.811	0.81	FHWA b080
SPWB	471470-26	3-11	2000	100.8	24.3	0.820	0.95	(3)
SPWB	41-1655-001	3-11	1992	100.40	25	1.300	0.90	FHWA b080a
SPWB	41-1655-002	3-10	816	101.80	20	0.500	1.10	FHWA b080a
SPWB	53-0017-001	3-11	1995	99.70	25	0.900	0.70	FHWA b109b
SPWB	MGSNB-1	3-11	2273	100.9	24.7	0.867	0.86	(4)
SPWB	MGSNB-2	3-10	1092 (5)	101.4	25.5	0.740	0.97	(4)
TB	220570-5	3-10	877	102.60	19.8	0.340	1.26	FHWA b148
TB	220570-6	4-12	8192	78.80	15.3	0.810	0.26	FHWA b148
TB	220570-7	3-11	2290	99.00	24.5	0.630	1.43	FHWA b148
WPWB	-	3-10	906 (6)	101.70	20.0	1.020	0.63	FHWA b229
WPWB	-	3-11	2258	99.70	25.0	1.670	0.58	FHWA b229
WPWB	220570-4	3-11	825	102.10	20.3	0.490	1.05	FHWA b140
WPWB	57073101	3-10	837	102.20	20.3	0.680	0.66	FHWA b162
WPWB	57073112	3-11	2233	98.00	24.5	1.050	0.59	FHWA b162
WPWB	5707b3111	3-11	2053	100.50	24.5	1.150	0.56	FHWA b162
WPWB	570734121	4-12	8050	78.30	15.0	1.220	0.22	FHWA b162b
WPWB	102350.97.05.1.5.2	3-10	1110 (5)	100.80	25.0	0.960	0.73	FHWA b229
WPWB	102350.97.05.1.5.1	3-11	2273	99.00	25.0	1.280	0.58	FHWA b229
WR	MIRA-99-436009	3-11	1999	99.40	26.0	2.400	0.36	FHWA b082
WR	MIRA-99-436008	3-10	898	101.00	20.0	1.040	0.55	FHWA b082
WR	400001-MSC2	3-11	2040	100.70	25.3	1.990	0.60	FHWA b096
WR	400001-TCR1	3-11	2045	100.60	24.2	2.400	0.37	FHWA b119
WR	400001-TCR2	3-11	2050	99.40	25.7	2.800	0.36	FHWA b119a
WR	MIRA-05-D0002	4-10	807	100.80	21.3	1.350	0.55	FHWA b082b
WR	400001-SFR4	3-11	2074	99.30	25.7	1.800	0.49	FHWA b096a
WR	-	3-10	827	100.20	20.0	0.762	0.66	FHWA b137
WR	-	3-11	2065	102.40	25.0	2.620	0.33	FHWA b137
WR	400001-TCR8	3-11	2106	96.50	24.7	2.360	0.45	FHWA b141
WR	400001-SFR5	3-11	2123	98.10	26.4	2.310	0.42	FHWA b096a
WR	400001-TCR9	4-12	8196	82.50	14.1	2.205	0.14	FHWA b141
WR	MIRA-05-c0050	4-12	8050	79.70	15.8	2.210	0.18	FHWA b082b
WR	TR-P26021-01-A	3-11	2020	99.85	25.0	2.000	0.44	FHWA b137b
WR	TR-P26028-01-B	3-11	2020	101.50	25.0	2.800	0.44	FHWA b137b
WR	400001-TCR12	3-11	2102	102.60	24.9	3.410	0.40	FHWA b141b
WR	P26133-01	3-10	812	97.51	25.0	1.500	0.84	FHWA b137c
WR	P26133-03	3-11	2222	97.05	25.0	2.610	0.35	FHWA b137c
WR	P26133-04	3-10	845	101.63	20.0	1.430	0.63	FHWA b137c

Barrier type	Test ref.	Test designation	Mass	Speed	Angle	Dynamic deflection	ASI	Source (refer footnotes)
WR	570723102	4-10	829	100.50	20.1	1.400	0.54	FHWA b167
WR	50724121	4-12	8050	84.50	15.0	2.290	0.15	FHWA b167
WR	570723118	3-11	2080	99.50	25.0	2.550	0.46	FHWA b184a
WR	400001-NSM10	3-11	2313	101.71	26.6	2.926	0.40	FHWA b193 rev.
WR	400001-NSM11	3-10	816	99.50	21.4	0.985	0.50	FHWA b193 rev.
WR	405160-11-1	3-11	2051	100.26	25.4	3.109	0.67	FHWA b227
WR	102350.02-6-311	3-11	2044	97.60	25.0	1.540	0.44	FHWA b222
WR	102350.02-6-412	4-12	8050	82.50	15.0	1.650	0.17	FHWA b222
WR	102350.02-6 T3	3-10	834.5	99.70	20.0	1.280	0.60	FHWA b222
WR	400001-TCR40	3-11	2288	100.58	25.8	2.926	0.36	FHWA b232
WR	400001-TCR41	3-10	1091 (5)	74.35	26.1	2.286	0.72	FHWA b232

Footnotes

1. All FHWA references are sourced from FHWA website (US Department of Transportation Federal Highway Administration)
2. Alberson et al (2004)
3. Mak et al (1999) / Plaxico et al (2000)
4. Reid et al (2013)
5. MASH 3-10 tests employ a nominal 1100 kg vehicle and impact at a nominal 25 degrees.
6. 906 kg is recorded as a gross test vehicle weight, rather than a test inertial weight

TABLE 2 Combined descriptive data for 60 of 63 crash tests

Nominal crash test	Mass (kg)		Speed (km/h)		Angle (degrees)		Count
	Nominal	Range	Nominal	Range	Nominal	Range	
3-10	820	807 - 906	100	97.5 - 102.6	20	19.8 - 25.0	14
3-11	2000	1992 - 2313	100	96.5 - 102.6	25	24.2 - 26.6	36
4-12	8000	8000 - 8196	80	78.3 - 84.5	15	13.6 - 15.8	10

Limitations

Firstly, the study takes the crash test data at face value as is presented in the crash test summary sheets. It may be that some of the mass/speed/angle data is reported as nominal values rather than accurately recorded.

Secondly, it is observed that the European and US methods for calculating ASI are subtly different (Naish & Burbridge, 2015). Further, Anghileri (2003) reports on variations in reported ASI from round-robin testing of ASI conducted at six European laboratories, suggesting that variations in both the tests themselves and the process of evaluation may be responsible for some variation in calculated/reported ASI value.

Results

The results of plotting ASI against ‘flexibility’ are depicted in FIGURE 1. FIGURE 2 depicts the same data disaggregated respectively according to the six generic barrier classifications nominated above. FIGURE 3 depicts the same data (with three records removed) disaggregated according to the configuration of the common nominal impact conditions (in terms of mass, speed and angle) adopted in the respective crash test.

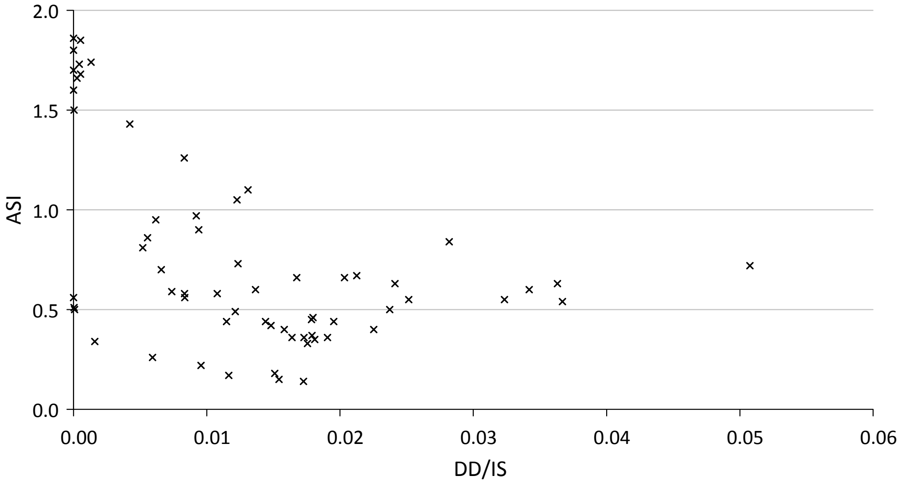

FIGURE 1 ASI v Flexibility (Dynamic Deflection/Impact Severity) for results from 63 crash tests

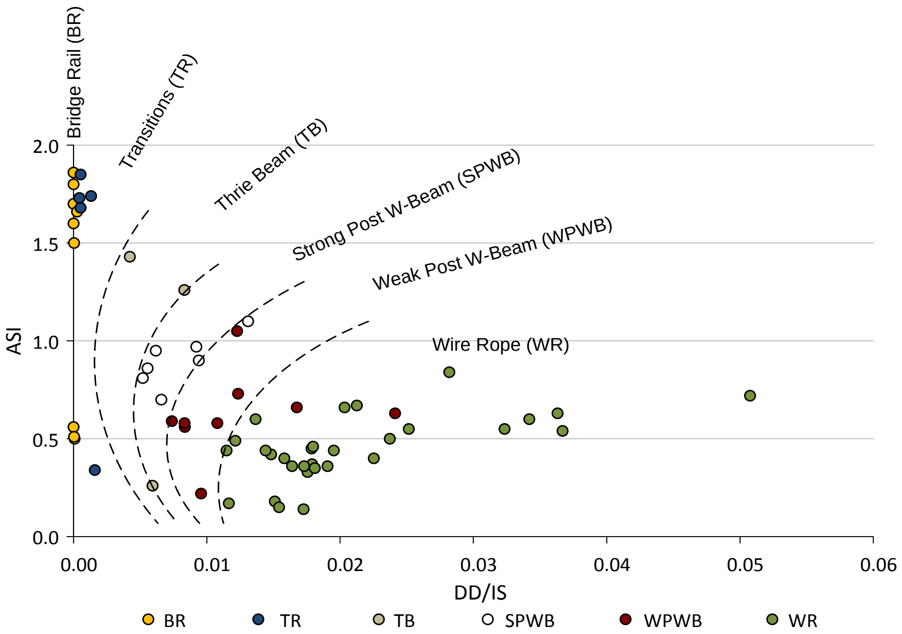

FIGURE 2 ASI v Flexibility (Dynamic Deflection/Impact Severity) for results from 63 crash tests disaggregated according to generic barrier classification

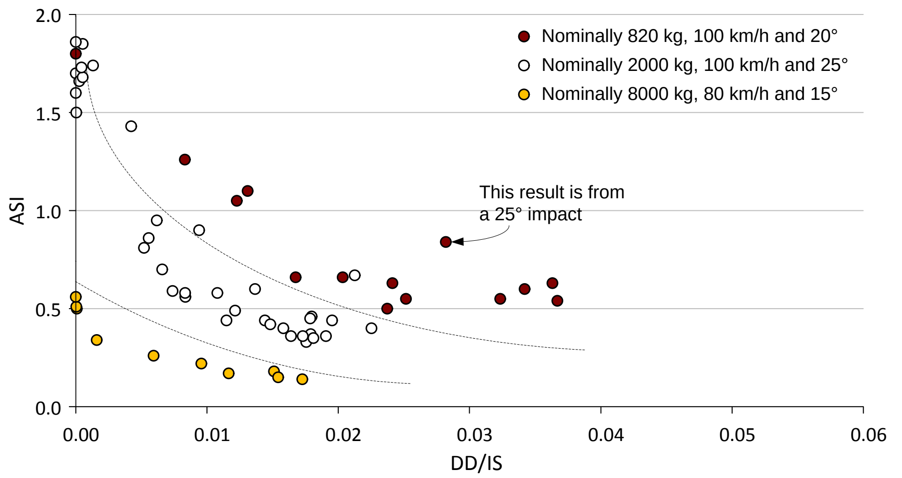

FIGURE 3 ASI v Flexibility (Dynamic Deflection/Impact Severity) for results from 60 crash tests disaggregated according to configuration of nominal impact conditions (mass, speed and angle)

With regard to FIGURE 1 and TABLE 3 it is apparent that the range of ASI values is broadest where the flexibility is zero (i.e., the barrier is most stiff). At the y-axis, ASI values range from 0.50 to 1.86. However, the spread of data generally diminishes as barrier flexibility increases.

TABLE 3 Summary of ASI results disaggregated by generic barrier type

	BR	**TR**	**TB**	**SPWB**	**WPWB**	**WR**
Max	1.86	1.85	1.43	1.10	1.05	0.84
Min	0.50	0.34	0.26	0.70	0.22	0.14
Count	**9**	**5**	**3**	**7**	**9**	**30**

Moreover, there is a diminution in the ASI values recorded as the impacted systems become less stiff. FIGURE 2 and TABLE 3 indicate (as should be expected) that there is a stiffness hierarchy in terms of barrier classification, ranging from bridge rail (stiffest) to wire rope (least stiff). And generally, the wire rope returns the lowest values of occupant risk indicator ASI, while bridge rail returns the highest values. FIGURE 3 indicates that increase in barrier flexibility is associated with a decrease in recorded ASI value for each of the three crash test configurations.

Most obviously there are three distinct bands of results. The ASI value for the nominal 8000 kg, 80 km/h, 15 degree tests clearly represent the lower bound of the results, whereas the results from the nominal 800 kg, 100 km/h 20 degree tests generally represent the upper bound. Also notably, the results from the nominal 2000 kg, 100 km/h 25 degree are generally sandwiched between the results from the two other test configurations, but it is evident that as barrier flexibility approaches zero (near to the y-axis) the ASI results from this test configuration appear to rise sharply.

Discussion

The results from all of the crash tests depicted in FIGURE 1 suggest that there may be a relationship between barrier flexibility and the ASI value recorded during crash testing, and moreover that ASI appears to be inversely proportional to barrier flexibility, perhaps represented by an exponential form. The results as depicted in FIGURE 3 reiterate this notion, but also suggest that the shape of the relationship curve is a function of the configuration of the impact. The results for the nominal 8000 kg, 80 km/h, 15 degree tests for example indicate a distinct decay curve, as do the results from the two other nominal crash test configurations. The following observations are apparent:

a. ASI is highest for the lightest (kg) vehicle impacts (typically 100 km/h and 20 degrees).
b. ASI is lowest for the heaviest (kg) vehicle impacts (typically 80 km/h and 15 degrees).

Notably the lowest values of ASI are also returned from impacts with the lowest impact speeds and highest for the highest impact speeds.

Also, the effect of the flexibility (or stiffness) of the barrier is evident in the shape of the curve for each impact configuration. This is consistent with Anghileri, Luminari and Williams (2005) who report a "*weak correlation between ... ASI and dynamic deflection*". In this regard, the following observations are suggested from the data:

a. The shape of the ASI-flexibility curve is flattest for the lowest angle impact (15 degrees).
b. The shape of the ASI-flexibility curve is steepest for the highest angle impact (25 degrees).

Together, these findings are consistent with the hypothesis proposed earlier that ASI may be expected to increase as a function of decreasing vehicle mass, increasing impact speed, increasing impact angle, and increasing barrier stiffness. Moreover, it is observed that the spread of occupant severity outcomes associated with more flexible systems is much narrower than the spread of occupant severity outcomes associated with stiffer systems, suggesting that occupant outcomes from impacts with more flexible systems are less susceptible to variation in the impact conditions than are occupant outcomes from impacts with stiffer systems. Further analysis of the effect of vehicle mass, impact speed, impact angle and barrier stiffness on the value of the occupant risk indicator is likely to be the subject of future work.

Apparent from FIGURE 2 is that barrier classifications are not fully discrete, but rather suggest some degree of overlap between systems. In the context of "*decompartmentalising road safety barrier stiffness*" the data suggests for example that weak post w-beam systems are likely to be more forgiving in terms of occupant injury than are strong post systems. Hence it is arguable that it is inappropriate to represent the spectrum of steel beam systems within a single barrier classification. At the other end of the steel beam spectrum, the data suggests that thrie beam and transition systems are generally less flexible than strong post w-beam systems and return higher values for the occupant risk indicator ASI. Since these are also steel beam systems, the point that it is inappropriate to represent the spectrum of systems within a single barrier classification is reiterated by the data. Indeed, it is arguable that combined, the suite of barrier solutions are better described by a continuum than the three generic barrier types 'concrete', 'metal' and 'wire rope'.

The results also suggest then that it would be appropriate in empirical studies of in-service performance to report the detail of the barrier in terms of the factors that might be expected to influence stiffness (for example post spacing, post type, rope configuration and tension).

Moreover, the results suggest that more specific detail about the impact configuration contributing to a given occupant outcome is necessary to make objective observations about the aggressiveness of any system.

Conclusions

The objective of this study was to present a graphical analysis of the results of full scale crash testing to demonstrate that both occupant risk indicator ASI results and barrier stiffness are represented by a continuum and are not categorical. This is achieved in FIGURE 2. The study has demonstrated that occupant risk measured in terms of ASI is likely to be a function of the speed, mass and angle of the impact as well as the stiffness of the system. The results suggest that it would be appropriate in empirical studies of in-service performance to report the detail of the barrier in terms of the factors that might be expected to influence stiffness of the system (for example post spacing, post type, rope configuration and tension) as well as the configuration of the impact (vehicle mass, impact speed and impact angle).

Acknowledgement

The data gathering assistance of Jonathon Manton and Samuel Altermann is gratefully acknowledged.

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A study of the mass-frequency distribution of the registered light vehicle fleet in Queensland

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Abstract

Road safety barrier performance is a function of the mass of the impacting vehicle. However, knowledge of the mass-frequency distribution of the registered light vehicle fleet in Queensland is limited. A quantitative analysis of the mass of a proportion of the predominant vehicle body types comprising the light vehicle fleet is presented. While the masses of light vehicles appear to be increasing with year of registration, the testing protocol for road safety barriers preferred by Australian/New Zealand Standard AS/NZS 3845.1:2015 (Standards Australia, 2015) is appropriate in terms of the mass of the test vehicle for both occupant severity and for barrier capacity.

Introduction

Risk in the context of road safety barrier performance is (in part) a function of the mass of the impacting vehicle. All else being equal, a heavier vehicle is more likely than a lighter vehicle to exceed the containment capacity of and consequently breach a road safety barrier. Meanwhile in the event of an impact the occupants of lighter vehicles may be expected to be at some increased exposure to injury than are the occupants of heavier vehicles due to higher decelerations experienced during the impact. It follows therefore that quantification of site-specific residual risk associated with road safety barrier impact requires quantitative understanding of site-specific traffic composition, and specifically the mass-frequency distribution of the local traffic population. Such knowledge should be fundamental to those responsible for the assessment and selection of road safety barriers. Australian/New Zealand Standard AS/NZS 3845.1:2015 (Standards Australia, 2015) promotes the use of the United States (US) document the Manual for Assessing Safety Hardware (AASHTO, 2009) as the preferred test protocol for the homologation of road safety barriers, but also recognises the existence of other dominant test protocols NCHRP Report 350 (Ross et al., 1993) and European Normative EN1317 (European Committee for Standardization, 2010a, 2010b). Hence, an understanding of the extent to which the various test protocols are representative in terms of the in-service vehicle fleet is appropriate.

This paper begins with an exploration of published literature regarding the mass characteristics of vehicle fleets generally, and determines that the extent of contemporary knowledge of the mass-frequency distribution of the registered light vehicle fleet in Australia is limited. It then presents a snapshot study of a contemporary proportion of the registered light vehicle fleet in Queensland, and provides some commentary on the extent to which the test protocols are representative of that vehicle fleet.

Background

The Manual for Assessing Safety Hardware (MASH) (AASHTO, 2009), which has replaced NCHRP Report 350 (Ross, et al., 1993) in the United States as the preferred test protocol for roadside safety devices including road safety barriers, prescribes test vehicles that are heavier than were specified previously. For most devices, MASH prescribes two vehicles to represent the light vehicle fleet. The underlying philosophy is that “*if a safety feature performs satisfactorily for both the smallest and largest passenger vehicles, it should perform adequately for all vehicle sizes in between*”. At the lower end of a mass spectrum, an 1100 kg vehicle is nominated to represent the second percentile of the US light vehicle fleet, while at the heavier end of the spectrum, a 2270 kg pick-up is nominated to represent the 90th percentile vehicle. For comparison, the predecessor document NCHRP Report 350 nominated respectively an 820 kg vehicle and a 2000 kg vehicle. In simple summary, it has been recognised that the US passenger vehicle fleet is getting heavier, and in response the conformance testing requirements have been modified to require heavier test vehicles.

Similarly, according to the International Council on Clean Transportation (ICCT) (2013) the mass of the European vehicle fleet is increasing. The ICCT document states: "*The average mass of new cars in the EU in 2012 was 1400 kg, which represents a return, after a brief hiatus, to the recent historical pattern of annual increases*". ICCT also reports on average mass by nation and shows that the average mass (of new cars in 2012 in running order) ranged from 1252 kg in Holland to 1580 kg in Sweden. In terms of a comparison, Stigson, Ydenius & Kullgren (2006) found that in 2005 "*the average kerb weight of the new sold passenger vehicles in the US were 1750 kg compared to 1420 kg in Sweden*".

This point is important with respect to the testing and selection of a road safety barrier, since road safety barriers commonly deployed in Australia are most commonly homologated against the US test protocols, and less commonly against the European test protocol. Notably the European test protocol EN1317-2 (European Committee for Standardization, 2010b) prescribes test vehicles of mass 900, 1300 and 1500 kg, suggesting that in Europe barrier capacity is tested to suit an average vehicle mass.

Hence, understanding the extent to which the respective test protocol represents the vehicle fleet in service is important. However, contemporary Australian literature on this subject is limited. Troutbeck (1991) reported that the median tare mass of the Australian light passenger vehicle fleet increased from 1070 kg in 1983-84 to 1210 kg in 1989-90. However no additional data that could describe the shape of the mass distributions is provided. Newstead et al (2004) report that "*Sales trends in new vehicles in Australia over the past ten years have seen a polarisation of the vehicle fleet into large and small vehicles, with sales in the medium segment showing a rapid decline*". The study classifies the light passenger vehicle fleet in terms of eight market groups. However, the widths of mass classification bins (where provided) are broad, while some vehicle classifications are not described at all by mass. Keall and Newstead (2010) subsequently refine the classifications used by Newstead et al (2004) by introducing three sub classifications of the four-wheel drive (off-road vehicles with raised ride height) classification, which are discriminated by mass. However, as previously, the mass bins are broad while some vehicle classifications are not described at all by mass.

More recently, Anderson et al (2013) report that "*The average mass of new vehicles has increased by around 150 kg since the late 1990s*", and while the authors do not expressly state any value, an average kerb mass of around 1,505 kg for single-quarter vehicle sales in New South Wales in 2009 can be established from Figure 6.4 of that study. Further, a very coarse approximation to the distribution of 2009 single-quarterly new vehicle sales in New South Wales (as derived from the same study) suggests that the most commonly occurring kerb mass range was 1,200-1,400 kg, and that around 40% of vehicles sold were lighter than 1,400 kg. However no data that could describe the shape of the fleet mass-distribution is provided. Notably, Anderson et al (2013) reiterate the observations of Newstead et al (2004) that there is a trend towards polarisation of the vehicle fleet: "*the popularity of vehicles in the 'Large' market segment has been declining sharply, as they are replaced by more in the Light, Small and Medium segments and by pick-up/cab chassis vehicles and SUVs*".

In summary, knowledge of the range of vehicles (and their mass) that may be expected to impact a road safety barrier is shown to be important in the process of assessment of road safety barrier performance, and so equally must be important to predicting barrier in-service performance.

However, there is no identified detailed analysis of the mass distribution of the registered vehicle fleet either in Australia generally or in Queensland specifically.

Objectives

The aim of this study is to establish a level of understanding of the extent to which the dominant test protocols adopted by Australian road authorities for the homologation of road safety barriers are representative of the registered vehicle fleet in Queensland Australia.

The objective of this study is to present a quantitative analysis of the mass-frequency distribution of the registered vehicle fleet in Queensland Australia for comparison with the mass-frequency distribution of the vehicles prescribed in the dominant road safety barrier crash test protocols. This is achieved primarily through exploration of the registration database of the Queensland Government Department of Transport and Main Roads.

Methodology

Registration data (dated 31 August 2012) was obtained from the Queensland Department of Transport and Main Roads. Data was provided in the form a comma-delimited text file, with the following fields:

1. Year and Month of data extraction
2. Year of Manufacture
3. Number of Cylinders
4. Fuel Type
5. Weight (GVM)
6. Body type
7. Make
8. Model
9. Count of registrations

Trailers (which require separate registration) were not included in the data set. Notably neither 'tare mass' nor 'kerb mass' (or weight) were included as a data field, although the database contained some Gross Vehicle Mass (GVM) data for some but not for all entries. The point here is that no consistent mass data is recorded for vehicles comprising the light vehicle fleet in Queensland's registered motor vehicle register.

Cleansing the data set

The raw (uncleansed) data set comprised 3,721,861 registered entries disaggregated to 160 vehicle body types, 1,715 vehicle makes (marques), and 10,095 vehicle models. The data set was cleansed as follows:

- 2,949 vehicle entries are of unrecorded date of manufacture, and these were removed.
- Three (3) are pre-1901 (year of registration = 1098, 1657, 1734) and these were removed.
- 104 vehicle entries of unrecorded or unknown <MAKE> were removed.
- 51,310 vehicle entries of unknown <MODEL> were removed.

This reduced the number of registered entries to 3,667,495, and the number of body types to 159. Further since the data set contained only part of the 2012 year of registration cohort, post-2011 year of registration data was removed reducing the number of registered entries to 3,553,174.

Three vehicle body types (Hatchback, Sedan and Wagon) comprise 66.69% of the remaining registrations. Notably the dataset does not distinguish between 'conventional' stationwagon and SUV-type vehicles, both of which are included in the Wagon body type. Utility (as an aggregation of seven of the 159 vehicle shapes in the cleansed data set) comprise 17.51% of registrations. Together, four vehicle body types (Hatchback, Sedan, Utility and Wagon) comprise 84.20% of registrations in the 1901-2011 dataset. Of the remainder, 10.37% are trucks, vans and motorcycles, leaving 5.37% categorised as miscellaneous other body types.

In terms of vehicle age, analysis of the registration dataset indicates that more than half of vehicles registered 1901-2011 are denoted with year of registration from 2003 onwards, and that two thirds of vehicles are denoted with year of registration from 2000 onwards. As such, the focus of this study is the mass of vehicles of body type Hatchback, Sedan, Utility and Wagon with year of registration from 2000 to 2011. For context, TABLE 1 summarises the total number of vehicle registrations and variants for each of the selected body types in the whole data set, and in the curtailed (2000-2011) data set.

TABLE 1 Numbers of vehicle variants and vehicle registrations of selected body types on the Queensland register with year of registration 1901-2011 and 2000-2011.

Body Type	Registered Vehicles			
	No. on register (1901-2011)		No. with year of registration 2000-2011	
	Variants	Registrations	Variants	Registrations
Hatchback	1,890	576,501	930	496,918
Sedan	9,761	1,054,883	1,613	660,440
Utility	4,211	622,189	766	437,242
Wagon	4,743	738,329	1,734	545,028
Total	**20,605**	**2,991,902**	**5,043**	**2,139,628**

Body Type and Year of Registration

Each of the four dominant vehicle body types (Hatchback, Sedan, Utility and Wagon) were analysed separately. Firstly the data set was disaggregated to each body type and then disaggregated by year of registration. For each vehicle body type, the data subset was sorted according to the most prevalent vehicle model. In this regard (for ease of processing) fuel type, number of cylinders and any GVM data were disregarded. The data was then combined to a unique vehicle variant, as follows:

<YEAR><MAKE><MODEL><BODY TYPE> <COUNT>

Assigning mass to LCV

The primary source of vehicle mass data was a commercial website (CarPoint Australia), accessed manually during the period April 2013 to June 2015. This website lists vehicle variants by year, make, model, and body type as well as other attributes, and provides detailed specifications about each vehicle, including ‘tare mass’ and ‘kerb weight’. Notably the number of results for each vehicle variant varies. For example, there are 14 sub-variants listed for the 2011 Toyota Corolla Hatchback and 12 sub-variants listed for the 2008 Audi A8 Sedan. Hence, in order to limit the size of the manual data collection task, it was decided to restrict the data capture to the following:

- Vehicle variants individually representing 5% of the respective <YEAR><BODY TYPE> data set.
- Vehicle variants comprising any part of the upper 50th percentile of the respective <YEAR><BODY TYPE> data set when ranked by percentage of registrations.

For example, an extract for the cleansed data set comprising “2008 Sedans” and ranked according to proportion of registrations in that subcategory is provided in TABLE 2. The nine vehicle variants listed each comprise more than 5% and together comprise more than half of the 2008 Sedan data set. Tare mass data was collected for each of the sub-variants of each of these vehicle variants and an arithmetic mean for each variant was computed.

TABLE 2 Sample from the data set for vehicle category "2008 Sedans" showing the nine top ranked vehicle variants representing 68.62% of the 2008 Sedan data set. The full data set of 2008 Sedans contains 137 combinations of <MAKE> and <MODEL>

Rank	Description (2008 Sedans)	No.	%	Cumulative %
1	2008 Holden Commodore Sedan	5912	11.17%	11.17%
2	2008 Mazda 3 Sedan	5081	9.60%	20.77%
3	2008 Ford Falcon Sedan	4502	8.50%	29.27%
4	2008 Toyota Camry Sedan	4211	7.95%	37.23%
5	2008 Toyota Corolla Sedan	4051	7.65%	44.88%
6	2008 Mitsubishi Lancer Sedan	3927	7.42%	52.30%
7	2008 Honda Accord Sedan	3247	6.13%	58.43%
8	2008 Toyota Aurion Sedan	2721	5.14%	63.57%
9	2008 Honda Civic Sedan	2672	5.05%	68.62%

This process was repeated for each of the 12 years (2000-2011) of registration and for each of the four body types. TABLE 3 indicates the extent to which a relatively small number of vehicle variants represent a large proportion of the registered vehicle fleet. For example, 85 variants of the Hatchback body type out of 1,890 Hatchback variants on the register (1901-2011) represent 45.8% of all Hatchback registrations. Overall, for year of registration 2000-2011, 353 out of 5043 (7%) vehicle variants that are of the body type Hatchback, Sedan, Utility or Wagon represent 60% of those vehicle body types.

TABLE 3 Number of vehicle variants representing registration numbers by body type.

Body Type	No. of vehicles with mass assigned		
	Variants	Registrations	Percentage of 1901-2011 dataset
Hatchback	85	263,985	45.8%
Sedan	79	392,716	37.2%
Utility	85	348,095	55.9%
Wagon	104	285,946	38.7%

The computed mean tare mass data for each vehicle variant was then combined with its respective vehicle registration volume in order to determine a weighted mean tare mass for each year of registration. The body type datasets for the years 2000-2011 were then combined into a single light vehicle dataset. Second, fifth, 50^{th}, 90^{th} and 95^{th} percentile tare masses for the combined dataset based on the minimum, mean, and maximum tare mass data for each vehicle variant, were then calculated.

Assumptions/Limitations

The tare mass data derived from the commercial website is taken at face value. Notwithstanding that there is some possibility of inaccuracy or incompleteness in the commercial data, the distribution of registrations of each vehicle variant are unknown. For example, ten sub-variants of the 2003 Toyota Corolla Hatchback were identified with a minimum mass of 1100 kg and a maximum mass of 1224 kg. The registration database indicates that the 2003 Toyota Corolla Hatchback is the top registered hatchback for 2003 with 3332 registrations. However it is not known whether these 3332 registered vehicles are evenly represented by the ten vehicle sub-variants, or (for example) are skewed towards the heavier or the lighter vehicles. In this study, the mean mass is generally reported, but effort is made to report upper and lower recorded values (refer FIGURE 3 and TABLE 5).

A further assumption is that the vehicle variants described in TABLE 3 are representative of the whole cohort, in terms of both body type and mass. However it is not known whether the vehicles with most frequent current registration numbers are (i) representative, (ii) heavier, or (iii) lighter than the entire cohort.

Results

Weighted mean tare mass for each vehicle body type in the light vehicle group is tabulated in TABLE 4, and plotted in FIGURE 1. In terms of individual body type members comprising the light vehicle, the data indicates that the average tare mass of the Hatchback body type increased from 1058 kg to 1211 kg (14.4%) by year of registration between 2000 and 2011, while the average tare mass of the Utility body type has increased from 1584 kg to 1797 kg (13.5%). When combined into one single light vehicle dataset, the data indicates that the average tare mass of vehicles registered in the light vehicle cohort increased from 1509 kg in 2000 to 1591 kg in 2011: an increase of 5.43%.

TABLE 4 Weighted average tare mass (kg) by year (2000-2011) for light vehicle body types

YEAR	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Hatchback	1058	1117	1091	1062	1096	1156	1132	1124	1175	1196	1179	1211
Sedan	1465	1469	1526	1535	1478	1433	1464	1463	1496	1518	1517	1497
Utility	1584	1610	1605	1619	1638	1675	1753	1724	1764	1746	1766	1797
Wagon	1876	1855	1854	1928	1964	1904	1897	1835	1927	1882	1954	1945
Combined, weighted by volume of registrations	1509	1521	1547	1555	1568	1544	1549	1530	1588	1583	1589	1591
Growth (%) (from 2000)	**-**	**0.82**	**2.53**	**3.05**	**3.90**	**2.32**	**2.67**	**1.40**	**5.27**	**4.89**	**5.31**	**5.43**

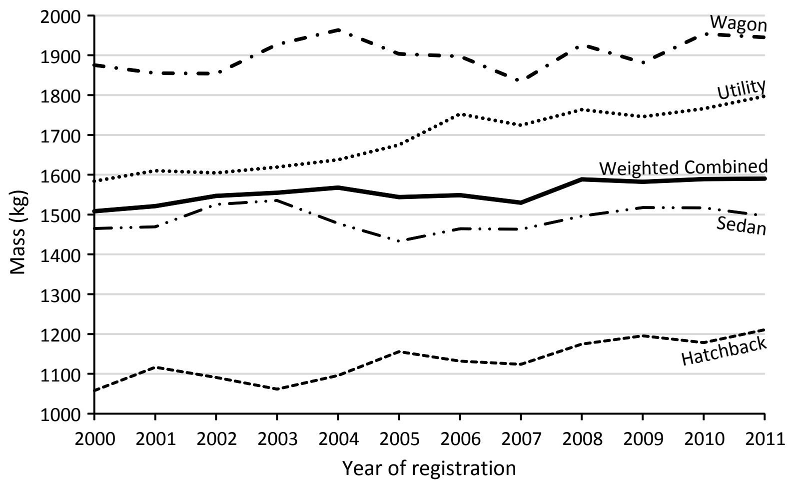

FIGURE 1 Vehicle tare mass (kg) by year (2000-2011) for dataset of light vehicle body types

Analysis of separate body types indicates that the distribution of mean tare mass of the Hatchback body type is within the range 800 to 1400 kg, the tare mass of Sedans is within the range 1000 to 1800 kg and for Utilities is within the range 1400 to 2100 kg. However the Wagon body type has a broader tare mass distribution ranging from 1300 to 2600 kg. This is depicted in FIGURE 2. FIGURE 3 is a mass-frequency histogram for tare-mass of the combined dataset. The distribution is broadly bell-shaped as one might expect with a modal frequency in the order of 1500 to 1600 kg. However there are indications of subsidiary frequency peaks at around 1100 to 1300 kg and at 2400 to 2500 kg.

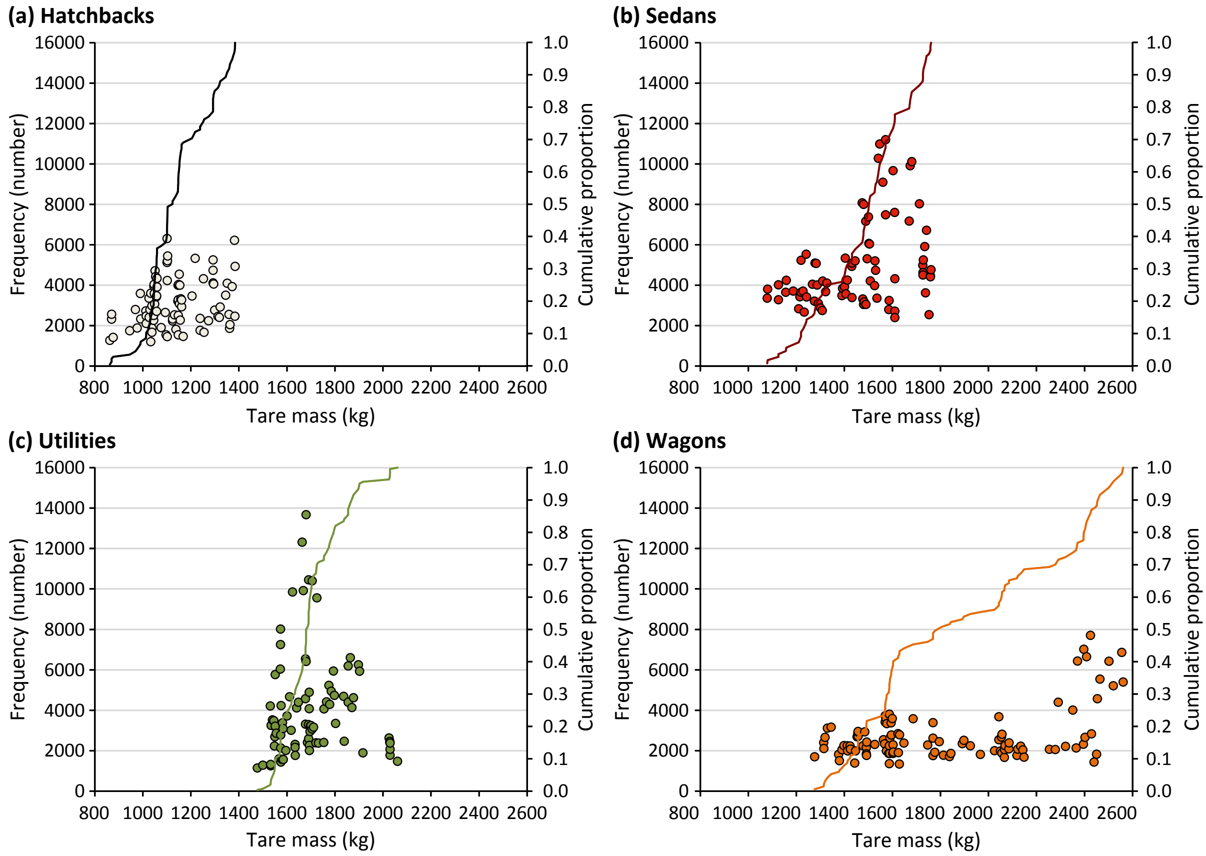

FIGURE 2 Frequency scatter-plots of mean tare mass for each vehicle variant for each of the four studied vehicle body types.

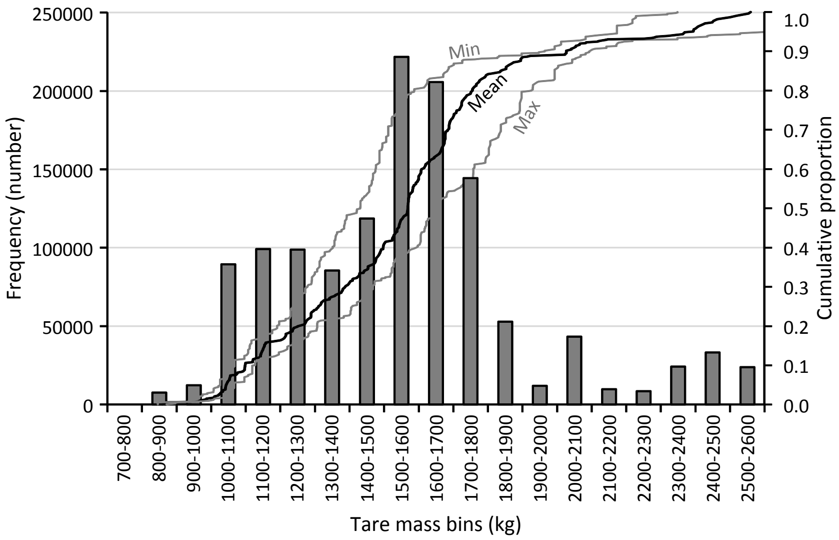

FIGURE 3 Mass-frequency histogram for mean tare-mass of selected vehicles on the Queensland registration database (2000-2011), with cumulative density shown for mean, minimum and maximum tare-mass values.

Values for second, fifth, 50th, 90th and 95th percentile tare masses for the light vehicle segment based on the mean computed and the maximum recorded vehicle sub-variant mass are presented in TABLE 5. Of the vehicles studied the lightest vehicle was the 2000 Toyota Echo Hatchback, with a tare mass range of 850 kg to 875 kg, while the second percentile tare mass of the combined 2000-2011 dataset of light vehicles is calculated to be in the range 970 kg to 1047 kg (1014 kg based on mean vehicle variant tare mass). At the heavy end of the vehicle mass spectrum, the data indicates that the 90th percentile tare mass is in the range 1967 kg to 2104 kg (2029 kg based on mean mass), while the 95th percentile tare mass is in the range 2175 kg to 2645 kg (2395 kg based on mean mass).

TABLE 5 Tare mass percentiles calculated for light vehicle segment (registered 2000-2011)

Percentile	Min (kg)	Mean (kg)	Max (kg)
2	970	1014	1047
5	1030	1048	1070
50	1434	1572	1664
90	1967	2029	2104
95	2175	2395	2645

Discussion

In terms of predicting road safety barrier performance, analysis of the vehicle fleet by allocation of tare mass to vehicle registration data may be misleading for two reasons. In the first instance, vehicle registrations or sales are not necessarily representative of vehicle usage. This study could imply an assumption that vehicle usage is homogenous across the road network. However, this is unlikely to be so. Some vehicles or vehicle types may be used more or less frequently than others, and some vehicle variants or vehicle types may be more or less prevalent on certain parts of the road network. As such, using registrations (or sales) may not represent true exposure. Second, the effective inertial mass of an impacting vehicle is almost certainly higher than the recorded tare mass. In-service vehicle payload, including restrained occupants, cargo, fuel and fluids, and any after-sale modifications (e.g., bull bars, roof racks, toolboxes) may represent a significant additional contribution to the inertial mass during a barrier impact. A more realistic measure might be obtained from site-specific weigh-in-motion data.

At the light end of the mass spectrum, the data indicates that the Hatchback body type is the fastest growing body type in terms of both the number of registrations and mass. Registrations of hatchbacks comprised 18.59% of light vehicle registrations from 2000 and 30.77% from 2011 while the mean mass of hatchbacks has increased over the same period from 1058 kg to 1211 kg. Notably, a mass-frequency peak is observed in the total data set at 1100-1300 kg (refer FIGURE 3).

This is important in terms of the crash test protocol selected to determine the effectiveness of a road safety barrier. NCHRP Report 350 prescribes an 820 kg vehicle as the test for occupant severity, whereas this has increased under the MASH test protocol to 1100 kg. Noting again that in-service mass is likely to be heavier than both tare and kerb mass, it is reasonable to determine that testing with an 820 kg vehicle is an extreme test, whereas an 1100 kg test is a more representative test of a road safety barrier's capacity to safely contain new small vehicles entering the vehicle fleet. This is consistent with the findings of Mak and Bligh (2002) who, in a prelude to the adoption of larger test vehicles in MASH, determined that the 820 kg test vehicle was no longer a realistic test vehicle on account of its availability. According to MASH, the 1,100 kg small car test vehicle is representative of the 2nd percentile light passenger vehicle fleet in the United States. In this regard, it is reasonable for the Queensland Department of Transport and Main Roads to consider the small car tests undertaken to the MASH test protocol to be appropriate tests for occupant severity, while corresponding tests conducted to NCHRP Report 350 remain a valid, albeit more exacting, test.

In terms of barrier capacity, it is notable that a 2270 kg pick-up is nominated in MASH as representing the 90th percentile vehicle. According to this current study, a 2270 kg vehicle approximates to a vehicle lying between the 93rd and 99th percentile suggesting that the MASH test protocol may be slightly more conservative for the Australian context than the US context. Conversely the NCHRP Report 350 test protocol prescribes a 2000 kg test vehicle for the capacity test, which itself represents a vehicle mass that is between the 85th and 92nd percentile according to this analysis. On this basis it is reasonable to conclude that both the MASH and NCHRP report 350 test protocols prescribe appropriate tests for barrier capacity. However, it is axiomatic that the MASH test protocol is a more conservative test of barrier capacity.

Comparison with the European test protocol is less clear, since European Normative EN1317-2 prescribes 900 kg, 1300 kg and 1500 kg test vehicles, which is a challenge for road safety barrier practitioners. Work has been presented by Hubbell (2013) which suggests that some interchangeability of test standards may be possible on the basis of test energy, although the author does concede that a thorough analysis would need to include investigation of (among other things) "*vehicle type, centers of gravity, vehicle occupant risk, and vehicle bevavior post impact*" (Hubbell, 2013).

In this study, no consideration has been given to variations in the height of vehicular centre of gravity, which is a defining parameter for the vehicles selected for crash testing, and would be expected to influence vehicle-barrier interaction. Also, it is noted that the capacity test US vehicles in both US test protocols are Utilities, not Wagons. The heaviest vehicles identified in this study are variants of the Toyota Landcruiser Wagon, which have tare mass exceeding 2700 kg. This value is close to 19% heavier than the MASH test level TL-3 capacity test vehicle (2270 kg). In terms of post impact trajectory, Hammonds and Troutbeck (2012) discuss the elevated propensity of a 2000 model Landcruiser to rollover when evaluating safety barriers, which is more especially relevant because the Toyota Landcruiser is found to be consistently the most registered Wagon variant on the registration database.

This study has also established that the Wagon body type classification in the registration database includes both conventional stationwagons as well as SUVs. Analysis of the Wagon body type indicates that the mass-frequency distribution has peaks at 1500 to 1600 kg and at 2400 to 2500 kg. This observation is likely to contribute to the observation of a third mass-frequency peak for the combined data set at around 2400 to 2500 kg. Combined with observations of the mass-frequency shape of the Hatchback body type, this is consistent with the conclusions reached by Anderson et al (2013) and Newstead et al (2004) that the fleet may be polarising.

Conclusions

The aim of this study was to establish a level of understanding of the extent to which the dominant test protocols adopted by Australian road authorities for the homologation of road safety barriers are representative of the mass-frequency distribution of the registered vehicle fleet in Queensland Australia. This study concludes that in terms of vehicle mass, the US Manual for Assessing Safety Hardware, which is the preferred testing protocol of Australian/New Zealand Standard AS/NZS 3845.1:2015 is an appropriate test standard. NCHRP Report 350 is also considered an appropriate test standard, although it is recognised that the residual risk associated with exceeding the capacity of a barrier tested to NCHRP Report 350 test may be marginally higher than the residual risk associated with exceeding the capacity of a barrier tested to the equivalent MASH test. However, it may be appropriate in future to consider whether a heavy Wagon test rather than a heavy Utility test would be more appropriate barrier capacity test for application to the Australian vehicle fleet. Further useful work would also include establishment of a level of understanding of the heights of vehicular centres of gravity of the in-service vehicle fleet, compared with the prescribed test vehicles. Otherwise, adoption of road safety barriers tested to the European test standard is regarded as more of a challenge, and is likely to require development of additional design guidance.

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Better than nothing? Safety barriers in construction zones principles and practice

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Abstract

Safety barriers have limited capability to contain and redirect even when installed in a manner that is fully consistent with testing, manufacturer specifications and first principles. Design tolerances for criteria such as impact speed, vehicle type/mass, and impact angles are finite. Crash testing is limited and only covers idealised setup conditions. Such conditions are rarely mimicked in roadwork construction zones for a variety of reasons.

When modified or installed incorrectly, they can fail to protect workers, as well as creating hazards to the public from features such as incorrect end terminals, unconnected longitudinal units, and various improvised configurations.

The author's observations are that minor and significant safety barrier compromises are extremely common in construction zones. This paper shows a sample of common system design/installation issues, discusses design principles and practical installation considerations, and examines how well these are communicated within easily available literature for practitioners.

Background

Temporary safety barriers have evolved rapidly in Australia from around the year 2000. Factors include: the proliferation of proprietary barrier and terminal types; (and hence) the implications of 'reasonably practicable' at law; a changing OHS culture towards 'positive protection'; the formation of Austroads' National Safety Barrier Assessment Panel (ANSBAP); the phasing out of non-tested longitudinal barriers; strict limitations on water-filled end terminals; greater adoption of barriers at building constructors in inner urban / CBD environments; and the desirability of barrier designers/suppliers to meet the newer testing standard of MASH 2009.

In working with small-to-large contractors daily in all road environments, the author rarely observes barrier installations that are consistent with first principles, testing conditions, manufacturer guidelines or road authority guidelines. At times the layouts are the best that can be provided, however, some layouts are so substandard for workers behind them or to the travelling public that the question arises: "are they better than nothing?" (i.e. good delineation/channelisation). As noted in MASH (ASSHTO, 2009), "Seemingly insignificant site conditions such as kerbs, slopes and soft soils can contribute to the unsuccessful performance of a safety feature for some impact conditions".

Aim

Examine safety barrier design principles and practical installation considerations for temporary work zones. Review the type, availability, and quality of relevant guidance material on safety barriers. Comment on issues and gaps in this niche area, and suggest avenues for industry improvement that could lead to safer work sites.

Method

1. List the commonly available safety barrier guidelines, manuals and information sources.
2. Review sources and extract safety barrier first principles and installation guidance / issues.
3. Survey the author's most recent on-site road safety audits (covering a minimum of 20 separate projects and 100 audits) to extract other safety barrier system design / installation issues not covered in the literature review.
4. List and briefly explain the findings, categorised into: 1. first-principles, 2. 'installation design' (Standards Australia, 2015) and, 3. component combinations and other site conditions issues.
5. Provide an indicative quality* rating of how well the safety barrier guidelines and manuals cover first principles and installation issues. **i.e. rigor / length / clarity / ease of use.*
6. Provide general commentary on the literature, principle, and practice, and identify specific problems or gaps.
7. Provide comment on possible strategies for improvements.

Scope

Examine first-principles, common scenarios and common guidelines, from the perspective of an average practitioner making decisions on safety barrier layouts. The intent is not to analyse the consequences of particular issues / compromises, or to raise theoretical esoteric unknowns such as: 'what is the threshold quantity of spider cobweb that can be tolerated in WRSB prior to adverse effect on deflection and energy dissipation?'. It is written from the Australian perspective, with its roots in adopting U.S. test criteria (MASH).

Figure 1. Wildlife nest within wire rope safety barrier

Results (step 1)

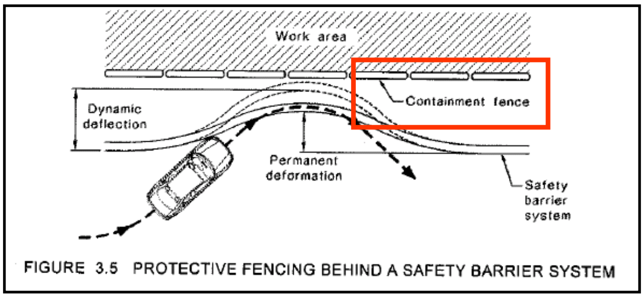
Table 1. Commonly available safety barrier guidelines, manuals and information sources.

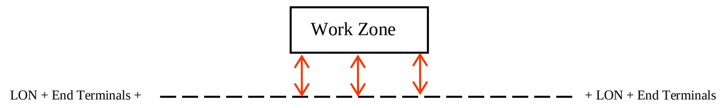
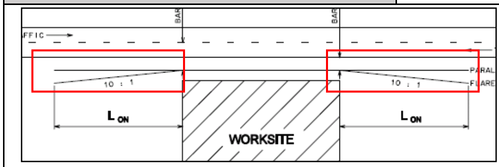
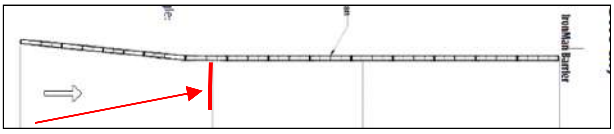
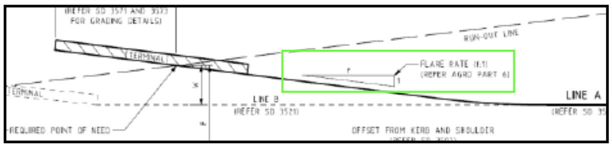
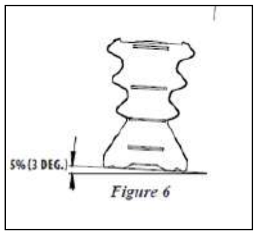
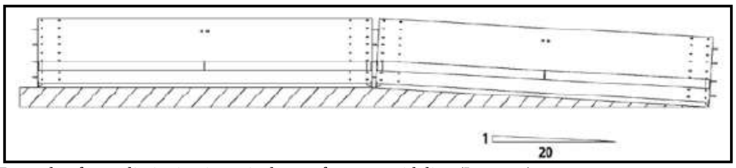
First- Principles and Primary Industry Guides *OA* = Open Access (free)	**Secondary or Specialised Industry Guides**	**Formal and Informal Guidance Specifically Within <u>Roadworks Traffic Management</u>**	**Other Research and Guidance**
MASH (The AASHTO Manual for Assessing Safety Hardware)	Austroads 'Safety Barrier System Conditions' sheets and state-based supplements. *OA*	AS 1742.3 2009. Australian Standard Manual of Uniform Traffic Control Devices. Part 3: Traffic Control for Works on Roads.	Research reports from major research institutions such as TRL (U.K.) and NCHRP (U.S.).
US Department of Transport FHA (Federal Highway Administration) safety barrier approval letters. *OA*	Austroads Guide to Road Design Part 6: Road Design, Safety and Barriers.	State-based codes of practices / guides for works on roads (e.g. Victoria: Road Management Act 2004 Code of Practice 2004 Worksite Safety - Traffic Management (2010)). *OA*	Research reports from leading state departments of transport such as Texas Transport Institute.
AASHTO Road Design Guide 2011 (4th Edition)	Road authority supplements to road design guides. *OA*	Road authority issued worksite traffic management fact sheets, hazard reports, newsletters etc. (e.g. Vicroads Worksite Safety Updates). *OA*	Research from specialised road safety institutions such as ARRB, MUARC, and CARRS-Q.
Manufacturer installation guidelines. *OA*	Road authority technical notes/guides on specific barrier classes and particular topics. (e.g. Vicroads Road Design Note 6-08: The Use of Guard Fence). *OA*		Published and unpublished reports and essays from practitioners or companies, and conference proceedings. *OA*
AS/NZS 3845: 2015. Australian / New Zealand Standard Road Safety Barrier Systems and Devices Part 1: Road Safety Barrier Systems.	Road authority standard barrier layout drawings (e.g. Vicroads Standard drawing 3500: Terminology Shorthand and General Requirements for Safety Barriers). *OA*		Specialised training (e.g. IRF SRD2 and SRD3 modules) and non-specialised training (e.g. road safety audit courses).

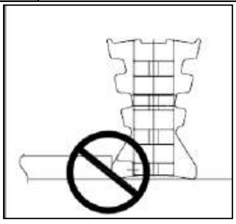
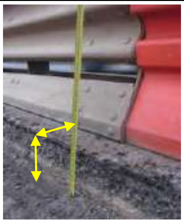
Results (Steps 2-4) – Safety Barrier System Design Principles and Considerations

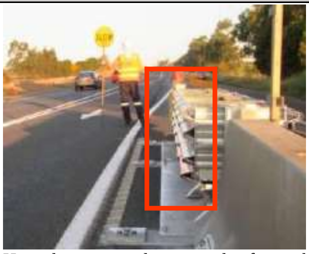
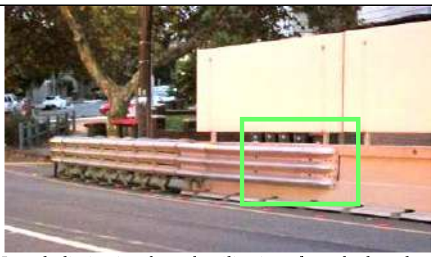
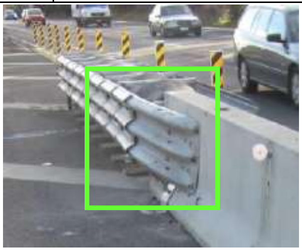
Note: many of the 33 below are related and affect each other but are deliberately deconstructed and isolated to highlight the specific individual principles and considerations at their core. This is not an exhaustive list but attempts to highlight the key principles and considerations.

Table 2. Safety Barrier System Design Principles and Considerations

	Description	**Performance implication mainly affecting: *workers* or *public***
A. First Principles		
1. Impact speed	Maximum speed the system can be impacted for the design vehicle.	Primarily: Workers Secondary: Public
2. Vehicle mass	Maximum vehicle mass tolerance of the system in accordance with MASH TL categories (i.e. small car, pickup truck, single unit van, trucks).	Workers
 Free-standing single slope barrier  Fixed TL-6 (‘truck’) barrier  Transitions between containment levels catering to vehicle mass/height		
3. Impact angle	Maximum angle at which the longitudinal barrier, end terminal or special areas can be struck by an errant vehicle.	Both
 Testing a critical transition point  End terminal installed well beyond maximum angles of the system design		
4. Deflection / working width	To workers or excavation / batter-drops.	Workers
   Plant, materials, equipment and facilities within barrier deflection area		
 AS1742.3 2009 indicating the requirement for a containment fence   Examples of containment fences		

5. Minimum system length	The length in advance, through, and on departure of the work zone - necessary to provide the deflection along the work zone as per manufacturer guidelines – not including length of need and not including end terminals. Failure to understand this principle can result in total system failure such as barriers tipping over (image below-right). Often numerically equivalent to: manufacturer’s test length + work zone length.	Primarily: workers Secondary: public
	 Short run of light barriers tipped over	
6. Point of need / length of need	Length of barrier in advance of the work site to shield workers and worksite hazards.	Workers
 Vicroads Bridge technical Note 2005 / 08 (no longer in use)	 LON protecting workers from errant vehicle	 Bunting defining the LON limit
7. Point of redirection	Point closest to its end at which the barrier is *effective* by containing and redirecting the test vehicle.	Workers
 1.Ironman manual: POC=48m downstream at 70km/h	 2. POC is 20-30m downstream of unpinned barriers behing crash cushion.	 3. POC is immediate with pinned barriers
8. System flare rate	Longitudinal angle to road.	Public
 Example of longitudinal barrier flaring	 Shown schematically in Vicroads Standard Drawing SD3500	
9. Cross slopes	Tolerance of barrier on cross slopes (typically 5%). Can be dependent on whether the cross slope is ‘hinged’ to the roadway or a constant steep superelevation.	Both
  Barrier with pronounced lean towards work zone with soft surface and inadequate deflection width		 Typical manufacturer guideline (Ironman)
10. Longitudinal slope / crests / ditches	Tolerance of barrier on longitudinal (constant) slopes, or more sudden crests and ditches. Typically 5%.	Both
 Barrier on a crest due to earth mound	 Example of crest limitation in typical manufacturer guideline (Ironman)	

11. Ground surface	Barriers are tested on hard surfaces where they can slide under low friction, not on soft verges which have the increased potential to affect the lateral movement and rotation of the barrier.	Both
 Temporary barriers on the edge of a very soft surface	 Typical hard surface of test environment.	
12. Kerbs, steps, obstructions	Elements which can affect vehicle stability upon impact, or more severe outcomes such as vaulting, snagging or connection rupture.	Both
 Barriers and terminal hard up against kerb  Typical manufacturer guideline (Ironman)	 Step down behind barriers	 High mass object alongside barriers
13. End-terminal run-out area	Area for a safe and snag-free recovery.	Public
 Rare example of temporary run-out area 'pad'	 Example of workers, plant and materials in the terminal runout area.	
B. Installation design		**Workers / public**
14. Effect on / by other barrier systems in proximity	In isolation a system design might be appropriate, however there are interaction issues with other systems. 'Ultimate' design example provided.	Both
 Departure-side terminal in the space where the extruding ET2000 rail curls away	 ET2000 crash test	
15. Appropriateness of terminal type with barrier type	It is not necessarily the case that every terminal type is suitable for every barrier type. For example, a water-filled terminal attached to barriers restrained to the pavement could lead to excess ride-down forces or exacerbated coffin-corner at the connection point.	Public
16. Transitions between barrier types of differing rigidity	Similar to a guard rail transition to a bridge parapet but utilising temporary safety barriers. Usually a non-approved system resulting from improvisation.	Both
		
Improvised systems transitioning from concrete, to water-filled, back to concrete. Some unconnected.		

<table>
<tr><td>17. Directionality of traffic</td><td>A system might be appropriate in one traffic direction but not the other.</td><td>Public</td></tr>
<tr><td colspan="3">  
Hazardous exposed rear panels of a crash cushion Hazard-elimination through utilization of standard product accessory</td></tr>
<tr><td>18. Offset to traffic lane (shy-line)</td><td>Terminals and longitudinal barriers can create a shy-line effect.</td><td>Public</td></tr>
<tr><td colspan="3"> 
Barriers and end terminal hard up against traffic Terminal tapered away from traffic.</td></tr>
<tr><td>19. Carriageway cross section</td><td>Barriers on either side of the road can somewhat affect the cross section and vehicle tracking positions. However, barriers installed on both sides of the road and at higher speed can have greater effects on shy-line and the swept path of vehicles.</td><td>Public</td></tr>
<tr><td colspan="3">
Bus encroaching into adjacent lane around a corner due to reduced cross section and barriers on both sides with narrow left lane.</td></tr>
<tr><td>20. Sight distance past barriers and barrier screens</td><td>Barriers and their attachments can obscure sight lines.</td><td>Public</td></tr>
<tr><td colspan="3"> 
Single slope barriers obscuring sight line to approaching traffic Barrier screens and site compound fencing obscuring sight line</td></tr>
<tr><td>21. Barrier screens obstructing visibility to signs.</td><td>Barriers and their attachments can obscure sight lines to signs.</td><td>Public</td></tr>
<tr><td colspan="3"> 
Variable speed limit sign Navigational sign</td></tr>
<tr><td>22. Barrier condition</td><td>Leads to a reduced system effectiveness e.g. containment through capture instead of redirection, or, greater deflections, or, total system failure through end terminal failure or pocketing.</td><td>Both</td></tr>
<tr><td colspan="3"> </td></tr>
</table>

23. Vulnerable road users - pedestrians	Barriers can block natural pedestrian desire-lines, and attachments such as barrier screens can affect sight distance.	Public
 Pedestrians jumping barriers and / or walking along road due to the absence of any realistic alternative		
24. Vulnerable road users - motorcyclists	Protrusions and surface inconsistencies can snag errant vehicles, especially motorcyclists.	Public
 Bolts from (unused) tie-down plates protruding from lower slope of F-shape concrete barrier		
25. Delineation / visibility	Visual notification to drivers of the presence of barriers and shoulder width reduction.	Both
 Tactile edge line, closely-spaced RRPMs, channelisers, diagonal pavement markings	 Strong edge-line and barrier-mounted RRPMs	
C. Component combinations, alterations, and site conditions.		**Workers / public**
26. Permanent barrier to temporary barrier: Direct connection	Site conditions / issues may contribute to highly customised non-approved systems that attempt to mimic crash-tested systems. The example below could lead to an increased likelihood of pocketing due to the free-standing barriers.	Both
 Existing guard rail is connected into free-standing temporary barriers with transitional stiffening.		
27. Permanent barrier to existing temporary barrier: No direct connection	A typical scenario will see a temporary barrier without an end terminal tucked behind an existing system. This raises the issue of 'point of redirection'. i.e the temporary barrier only 'contains and redirects' from a set location upstream of its commencement.	Both
 Short overlap introduces a section of unknown effectiveness	 Overlap correctly taken to a point beyond the 'point of redirection'	

28. Permanent *severed* barrier overlapping existing barrier: No direct connection	A typical scenario will see a temporary barrier without an end terminal tucked behind an existing system *that has been severed* and lacks the system-anchorage and tension that an end-terminal normally provides.	Public (mostly)

The severed guard rail could lead to excessive deflections resulting in a potentially catastrophic crash outcome from snagging or pocketing.

29. Layering / overlaps of barriers	A. Laying one barrier type along-side the same barrier-type. In high-speed environments this could increase the risk of vehicle-roll (and barrier vaulting) due to increased pivoting around the base. B. Energy dissipation modes differ dramatically between systems. The combination of two gives rise to potentially significant vehicle stability issues.	Both



A. Same barrier type B. Concrete + WRSB = Different barrier type / crash mechanism

30. Customisation with *strong* safety barrier engineering and design input	Refer examples below.	Public


A. *Transitional* pinning of free-standing system B. Special transition cap to connect two concrete barrier runs prior to the crash cushion

31. Customisation / modification *without* strong safety barrier engineering and design input	Refer examples below.	Both




Worker containment rail has hazardous detachable horizontal rails ‘Walk-way’ on top of barriers Two abutting water-filled terminals

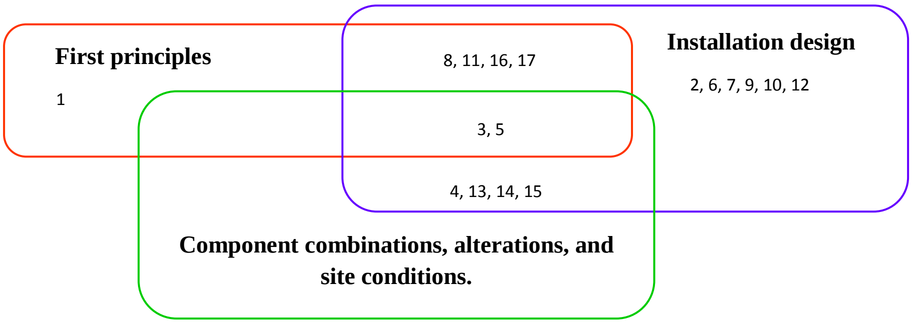


Single water-filled module in front of hazard Gantries supporting offices/sheds connected to barriers Concrete barrier ‘end terminal’

32. Installation and supply mistakes	As well as innocent mistakes, these include *deliberate* acts such as omitting the reinforcing connector in the Queensland (public domain) single-slope barrier connection.	Both
  Unconnected barriers due to different connections	 Incorrect TL barrieer type supplied	 Unconnected top-wire  Wrong orientation
33. Administrative processes	Workers using barrier and terminals as chairs.	Workers
		

Results (Step 5) – Safety barrier design coverage and quality in guidelines

Figure 2 – Coverage of the three key design areas within guidelines



Quality of coverage (Very Good / Good / Nominal) based on rigor / relevance / clarity / ease of use.

1. MASH: <u>GOOD</u>. Detailed but not written for a work zone barrier installation designer and unlikely to ever be accessed by one.
2. FHA approval letters: <u>NOMINAL</u>. Informative on specific limitations and cautions.
3. ASSHTO RDG 2011: <u>GOOD</u>. Brief coverage of principles. Strong coverage of barrier types and historic development.
4. Manufacturer installation guidelines: <u>VARIABLE</u>. Reviewed: Ironman/JJ-Hooks/Absorb350/BG800. Some 'list' 5-10 key design criteria whereas others explain them in detail.
5. AS/NZS3845.1 2015: <u>GOOD</u>. Excellent broad coverage. Brief coverage of specific topics. Not a practical document for day-to-day use for a work zone barrier installation designer.
6. Road authority standard drawings: e.g. Vicroads SD3501/3500/3502/similar. <u>VERY GOOD</u>. Focus is on *permanent* design.
7. Austroads 'Safety barrier System Conditions' sheets: <u>VERY GOOD</u>. Very practical but solely limited to 'installation design' criteria.
8. Austroads GRD6: <u>VERY GOOD</u>. Excellent broad coverage of the two key criteria types in a practical easy to read format.
9. Road authority supplements to Austroads GRD6: <u>VARIES/ NOMINAL</u>. Clarifies local practices. Expands on some topics.
10. Road authority technical guides: e.g. Vicroads RDN-6-02. <u>VERY GOOD</u>. Robustly expands on particular barriers.
11. AS1742.3 2009: <u>NOMINAL</u>. Brief coverage of small number of key principles.
12. State-based construction traffic management codes of practice: <u>VARIES/ NOMINAL</u>. Clarifies local practices.
13. Road authority issued work site hazard fact sheets: <u>NOMINAL</u>. Discusses one topic in a clear and practical way.
14. Research reports: <u>GOOD</u>. Typically on specific highly technical non-practical installation design topics.
15. Published / unpublished reports and essays from practitioners: <u>GOOD</u>. Typically on specific highly specific and technical installation design topics such as Troutbeck's (2008) technical paper on barriers on top of kerb. Papers covering more general barrier topics and history: <u>VERY GOOD</u> such as work by Grzebieta, Jiang & Carey (2005).
16. Specialised training by IRF: <u>NOMINAL</u>-<u>GOOD</u>. Lengthy / robust training on principles and products.
17. Specialised training in road safety audit courses: <u>NOMINAL</u>. Brief training on principles and products.

Commentary

Whether safety barriers are 'better than nothing' really depends on the quality of the system design and installation and is highly site-specific. At times the compromises and risks to workers and the public may outweigh the benefits. Some barrier *installation design* experts ask 'how do we get them wrong so often?'. Maybe the question should be reframed as 'how do we ever get them right?'. Research by Gambatese and Johnson (2014) looked into this question. It indicated that quality / consistency / safety of construction zone setups were higher on projects where constructability and design reviews had been conducted and where the project manager and traffic plan designer had more years of experience and had undergone specialised training. This is not suprising, however, it also found that the construction zone designers and construction engineers implementing the setup rated the quality of the setup very differently. The discrepancy between the two perspectives related to how well the original design matched field conditions. In the Australian context this could be critical due to the lack of guidelines covering one particular barrier design criteria in this paper: *3. component combinations, alterations, and site conditions.*

The author's opinion on the issues and obstacles to improved quality of *sytem design*:

- *Training*: Lack of dedicated training robustly covering all three design areas at certificate or diploma level.
- *Information availability*: Absence of a consolidated barrier guide or information 'map' for a practitioner.
- *Language*: International language differences: e.g. 'Length of need' and 'clear zone' have different meanings in the U.S. and Australian vernacular.
- *Plans*: Barrier details often lacking on plans (sometimes just a single line on a page).
- *Key principle*: Point of need / length of need is a critical first principle criteria yet it is not well covered within day-to-day installation guidelies.
- *Knowledge*: People acting as 'system designers' don't necessarily have more than a basic knowledge of first principles, testing, energy transfer, barrier failure mechanisms, individual products, product combinations etc.
- *Industry*: Unions / company policies / OHS framework demand 'positive protection'. This can result in grossly inadequate or outright dangerous barrier setups for workers or the public, i.e. through the perception that any barrier system is 'better than nothing'.
- *Industry*: Anecdotally, the author hears incorrect design justifications from site engineers such as 'we've done it that way before' or 'the site on XYZ Street does it like that'.
- *Practical issues*: Containment fences demarcating the barrier deflection area are rarely implemented.
- *Practical issues:* Existing features such as kerbs cannot be easily removed and the practical availability of clear runout areas and full lengths-of-need are often rare.
- *Road authority issues*: The project's speed limit is often defined by the road authority in a contract, i.e. potentially resulting in a mismatch with barrier capabilities, creating work site vulnerabilities.
- *Road authority issues*: The retiring of technical guidelines can throw the baby out with the bath water, e.g. Vicroads' (retired and redundant) Bridge Technical Note 2005/08 had a highly user-friendly and easy to follow table indicating lengths of need.
- Note: Installation sign-offs from suppliers will help with quality of installation, but not necessarily *system design*.

Recommendations

The author's opinion on the most powerful potential methods of improving the quality of *system design* and therefore worker and public safety:

- Certificate-level or above training for certification in *safety barrier system installation design* covering the three broad criteria areas raised in this paper.
- A review process requiring the desktop and on-site review by a *system installation designer.*
- The availability of a single consolidated and rigorous guide on barriers covering the three broad criteria areas raised in this paper: first principles, installation design, and component combinations, alterations, and site conditions.
- More flexible and progressive road authority attitudes towards low-risk crash-tested elements such as ramped concrete end terminals in low-speed areas.

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Using the Australian / New Zealand Standard to review barriers for Australian and New Zealand roads

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Abstract

The Australian / New Zealand Standard AS/NZS 3845.1:2015 was published last year although the procedures outlined in this standard revision have been implemented for some time. The Standard documents the procedure to demonstrate the suitability of new barrier systems for use on Australian and New Zealand roads. This includes the requirements for documentation, supply, erection and maintenance of those new systems. This paper will describe the development of the 2015 Standard and changes from the 1999 edition. The paper critically evaluates the value of the proposed procedure for evaluating barrier systems, as well as highlighting the importance of close control of installation and maintenance procedures to ensure barriers work effectively and as designed and tested.

Why assess safety barriers?

The community has been demanding a higher level of road safety driven by the Decade of Action and encompassed in the National Road Safety Strategy (ATC, 2015). The strong support for the Safe System approach that has been incorporated into the National Road Safety Strategy looks towards barriers to provide the safer roadsides (Jurewicz, Steinmetz, Phillips, Cairney, Veith & McLean, 2014). Within this environment, it is appropriate that the barriers that we use on our roads are fit for purpose and have been assessed competently.

In the US, the Federal Highway Administration (FHWA) reviews crash testing undertaken on a safety barrier and issues a letter of eligibility for reimbursement of federal funds when used on federally funded projects (FHWA, 2015). The FHWA indicates that the states should undertake their own assessment of safety barriers to determine if they are appropriate for their roads. Many states simply rely on the FHWA eligibility letter as evidence of the barrier's acceptability.

The Europeans used the CE Mark to indicate that the safety product has been tested to the CEN1317 requirements. This multipart standard does not assess durability of the product and this is left to the purchaser to quantify. Unfortunately within the European Union, it is sometimes difficult to exclude products because of their durability. (Everitt, 2103)

It was considered in Australia by the Standards Australia Committee CE33 that there should be a thorough assessment of barriers systems that covers a range of characteristics and uses. Part 1 of the Australian and New Zealand Standard AS/NZS 3845.1: 2015 provides guidance on this topic.

First edition of the Standard

The first edition of the Australian Standard AS/NZS 3845: 1999 provided the Australian Road Agencies with a common statement as to what constitutes an acceptable barrier. The principal method of assessment documented in AS/NZS 3845: 1999 was through full scale testing results to NCHRP 350 protocol (Ross, Sicking, Zimmer & Michie, 1993). The Standard lists the requirements for documentation to accompany a safety barrier. This list is useful to road agencies as the requirements assist installation design and maintenance procedures.

The Standard was produced at a time when a number of authorities were using a standard W-beam mounted on steel block-outs and steel posts. This Australian design had been developed from the

US standard design G4S, but used a block-out and post with a different cross section. At the time the standard was published, the Australian design had not been tested to the prevailing test protocol in AS/NZS 3845: 1999 which was the same as the test protocol in NCHRP 350. As a consequence, the Standards Australia Committee, CE33, chose to make the Australian W-beam system "deemed to comply" at NCHRP Test Level 3 without any full scale testing to establish its worth [1].

On the face of it this may seem to be irresponsible, however, the experience with the system was that the barrier was performing satisfactorily and there are advantages in having common components. There were few if any reports of vehicles breaching the system when it was considered that the barrier should have contained them. At the time of writing the first edition, the engineering profession generally accepted the "deemed to comply" status of these steel barriers.

Another issue in the development of the 1999 edition of the Standard was the use of test level 0. This was criticised internationally as being too weak to be a barrier and general international comment was that NCHRP 350 TL1 should be the minimum standard. In the 2015 edition, TL0 barriers were discontinued although these barriers could become "Longitudinal Channelising Devices" under the proposed AS/NZS 3845.2.

Development of the second edition of the Standard

The 2015 edition of the Standard (AS/NZS 3845.1: 2015) is based on the 1999 version. Much of the content is very similar to the earlier edition but based on more current thinking. However, the major changes were the deletion of any reference to barriers being considered 'deemed to comply" to a test level, the removal of the specifications public domain barriers and components and an enlarged section on the assessment of the safety barriers.

Deemed to comply notation was removed because the committee considered that all barrier systems should be evaluated against the same standard and test protocol. A barrier should not be accepted as performing to a particular level without full-scale testing. In service performance may demonstrate weaknesses in a barrier system but it does not predict a performance test level that can be used for comparison. AS/NZS 3845.1 2015 recommends conducting in-service performance evaluations using the processes in Chapter 7 of MASH (AASHTO, 2009) or Ray, Plaxico and Anghileri, (2010). Unfortunately, in the author's opinion, in service performance evaluations are rarely done to an acceptable standard anywhere. So long as inferior products are included in the Standard, there was insufficient impetus for road agencies to either use better performing systems or for manufacturers to develop better systems (Wallace, 2015). Since this aspect was removed from the standard, additional MASH TL3 steel barriers have be designed and tested enabling more competition in the market place and potentially lower prices for W-beam systems.

Assessment process for safety barriers in AS/NZS 3845.1: 2015

AS/NZS 3845.1 2015 clearly states that: *"A successful full-scale testing program alone does not qualify a road safety system as suitable."*

In section 4.6, the standard states that the evaluation of a barrier system should consider:

"(a) Documentation supplied in accordance with this Standard.

(b) Any full-scale test results that are not in accordance with Clause 4.5 or verified using engineering calculations, computer simulation analysis, laboratory testing, bogie or

[1] Testing in the US demonstrated that the Australian barrier failed to meet NCHRP 350 TL3 testing protocol with a 2000 kg vehicle. Later testing of a public domain steel barrier with plastic block-outs and mid-post splices has passed NCHRP 350 TL3 testing protocol. This barrier has also been evaluated with non-compliance testing by a number of Australian Road Agencies and universities.

pendulum tests or component structural tests in the case of modification in accordance with Clause 4.4.2.

(c) Reasons to waive the required tests by this Standard.

(d) The expected ability to withstand a second impact before being repaired.

(e) Whether the road safety barrier system can reduce the severity of injuries to vulnerable road users.

(f) The durability of components.

(g) Workplace, health and safety requirements during installation and maintenance.

(h) The ease with which maintenance can be undertaken including the requirement to use specialized tools and the expected time to replace damaged components after an impact.

(i) Whether the road safety barrier system can be installed on a range of foundations or whether posts can be used in a range of foundation conditions."

Some of these issues could cause the barrier system to be unacceptable but in most cases the consideration of these points informs users. This list is also a prompt to manufacturers when designing a barrier system or promoting the use of a system. Interestingly, some manufacturers have looked at a barrier's ability to redirect a second impact (albeit at a lower energy level than the first). The commentary to the Standard (section D4.6) lists second order issues that a road agency could consider. However, these are more for interest rather than for evaluation.

The current standard indicates that MASH is the *"basis of testing procedures for road safety barrier systems"*. However, the Standard leaves the way open for the evaluation of barrier systems tested to EN1317. The test levels should be seen as a continuum. A barrier tested to EN1317 might give the assessor the view that the barrier system is performing better than a MASH TL3 but not as well as a TL4 system. It is noted that energy and vehicle differences need to be accounted for in quantifying the performance of the barrier to the Standard. To some engineers this is a difficult concept, as they would prefer to not make this comparison. However, the CE33 Committee did not want to preclude European products from entering the Australian market place, but felt that the barrier's performance needs to be described on a common basis with other accepted products. It may be that it is not necessary to provide a notional MASH performance level, but simply state the types of locations where installations would be acceptable. This position is also acceptable to the author.

An important addition to the Standard is the recommended testing of motorcyclist protection devices. The standard utilises the CEN Technical Specification CEN/TS 1317-8 developed by the CEN Technical Committee CEN/TC 226. However, the Australian standard also included measurements of thorax compression (Grzebieta, Bambach & McIntosh, 2013 and Bambach, Grzebieta & McIntosh, 2012) as it was found that approximately half the riders tended to be upright on the bike during impact and not sliding along the ground as in tests specified by the TS1317.8.

Application of the evaluation process outlined in the Standard

Using test results from a similar product

It is argued that the best evaluation should include all available information. This then leads to a question as to whether tests from other devices that act in a similar way should be used in the evaluation. It might be reasonably expected that they will operate similarly, but small differences in the design can make a difference to the test outcome. It would seem to be wrong to fail or condition a product based on the test of another product. Therefore the results from another product should not be used to fail a system.

On the other hand if one product shows a major concern, it would be appropriate to check if the concern is likely to occur in similar products. In my view, if the concern is serious then it would be worthwhile investigating with the manufacturer the issue and establishing if the concern is warranted. In any case it is not appropriate to share confidential information from one manufacturer to another, and this discussion needs to be done carefully and respectful of confidentiality.

At times there is a need to assess a family of products belonging to the same family. Crash cushions are a typical example. Often a manufacturer will propose a number of different configurations to cover a range of impact conditions and hazard widths. Not all configurations will be tested and the assessment will need to look at the justification for extending crash tests across the family of products. A well-documented case with energy and momentum calculations will assist in the assessment.

In recent times, some manufacturers have provided non-compliance testing to assist the evaluation. These tests may or may not have acceleration plots, but will generally have good video footage. They do provide another view of the operation of the barrier system. It has been said that a manufacturer needs to have testing to establish compliance with a testing protocol as well as other testing which documents the performance of the system over a broader range of site and impact conditions (warranty testing). This latter testing gives the manufacture peace of mind and an ability to better describe unfavourable site conditions and what to do about it. In many respects this warranty testing is as important as compliance testing. The warranty testing could also be gained from an in-depth assessment of crashes into the barrier system. Either way it is important that manufacturers gathers information about a broader range of impacts than those in the compliance testing and use this information to inform designers and installers.

The question whether the non-compliance tests should be used in the assessment. R&D tests are not required to be reported, yet are important for the manufacturer in the development stage. These R&D tests are generally provided if they show a positive aspect of the product, the manufacturer may offer non-compliance tests to be considered in the assessment. Non-compliance tests can also be used to explain an issue for the assessors, although this should be used infrequently. Undoubtedly, there is always an issue that could be tested. However, this becomes onerous to the manufacturer and only compliance testing should be requested by the assessor. Occasionally, the Road Agencies will perform full scale testing on a barrier system in order to develop a broad understanding of the performance of the systems (Hammonds and Troutbeck, 2012). Again, it is the author’s opinion that this testing should not be under compliance testing standards, as the task is not to know whether a particular barrier is acceptable or not, but to rather gain an insight as to the performance of a type of barrier system.

Waived tests

Full scale testing is expensive and at times a manufacturer will not undergo a full testing program as specified in AS/NZS3845.1: 2015 and indeed MASH. If the product is for the US market, then in the past the FHWA entered into dialogue with the testing agency and may have agreed that some tests are not required, based on the testing of other safety barrier systems or previous tests on the same device. There would seem to be nothing wrong in allowing tests to be waived, but there is a risk that the estimated performance of the system would not be correct. Any request for waiving a test must be comprehensive and in many cases it may be easier to undertake the test rather than provide an acceptable reasoned argument.

Learnings from barrier system assessments

Installations on embankments and in weaker soils

In the design of roads we use the concepts of “normal design domain” and “extended design domain”. The normal design domain describes the required attributes of a road to produce a rational and safe design according to establish local and international practices. The extended design domain establishes the practices that are acceptable given qualifying road characteristics. For instance the normal design domain specifies the minimum paved width of a road for different design (or operating) speeds. If the sight distances are adequate, then in some cases it may be acceptable to have a narrower paved area; the conditions under which this would be acceptable are given in the extended design domain (DTMR, 2013).

When installing barrier systems, it is assumed that the soil conditions will match the AASHTO standard soils used in the testing. Essentially the testing is only pertinent to installations with similar to the soil conditions used in the tests. It is generally accepted that the soil, foundations or footings characteristics significantly affect the performance of a barrier. A test can be easily made to fail if posts are not embedded in material that can resist the forces. When the material used in the foundations or footings differs from that used in the testing then this is an "extended design domain" issue, and additional information provide by the barrier system supplier or the road agency should specify the characteristics of the appropriate foundation material. The footings should be designed using this information

Where this becomes particularly important is the installation of barriers at the hinge point or on an embankment. Some barrier system suppliers have tested their product in this way and it has been found to meet the testing protocol. However, the expected performance of the barrier will be a function of the soil characteristics on the embankment, which is often not compacted to the same extent as the shoulder. Accordingly there is a greater variation of the ability of the embankment to resist post loads and for the barrier system to operate as expected, and it is the right of a road agency to specify the conditions where barriers can be installed on embankments or not at all. Conversely, it is appropriate for the barrier system manufacturers to develop systems that allow the barriers to be located further from the travelled lanes as this can reduce the cost of road construction or reduce the cost of road upgrades.

Installations in weaker soils, still needs attention. Some systems are more tolerant when installed in softer soils depending on the post footings. There needs to a greater effort to provide more information on this issue. Clause 2.5.4 of the Australian Standard states:

"(d) For systems that contain posts, the documentation shall include the load to which the post can be tested that ensures that it provides the necessary support to the system.

(e) For tests on wire rope barriers, the documentation shall include a test load to be exerted on the anchors to confirm their adequacy."

The Standard continues in Clause 4.3.2 and requires Section 3.3.2 of MASH to apply with the additional requirement:

"*For all road safety barrier systems that utilize posts, a load/deformation plot shall be provided based on the same soil conditions used for the crash testing. The post shall be loaded until it yields."*

Greater understanding of the post soil interaction will assist in providing more effective barrier system designs.

Design of post fittings

Following the comments above, there is a growing concern that adequate designs of post footings are not undertaken. The New Zealand Transport Agency has issued a Technical Advice Note 16-01 in February 2016 on the "Wire Rope Safety Barrier systems – post footing issues". The advice points out that the footings have failed because the "*installation locations are inappropriate for the* *soil conditions. This may result from a combination of inadequate site investigation during design, poor soil compaction during earthworks operations and/or poor installation practices. Additionally, limited in situ testing of WRSB installations may have masked any installation issues*."

The Technical Advice Note states that inadequate footings are likely to results in a poorer barrier performance, increased chance of injury and increased maintenance costs. The Technical Advice note provides two photographs to illustrate the issue. These comments are not specific to a particular barrier type but rather to wire rope safety barriers as a whole. These are reproduced below.


Figure 1. Post failures shown in NZTA TAN 16-01

The New Zealand Transport Agency, through the TAN, recommends:

1. That only approved barriers be used and that these are installed *"compliant with the crash tested design or the road safety hardware system configuration granted acceptance by the Transport Agency, as listed on the Transport Agency M23 webpage".*

2. That installation designers have *"attended and passed the Transport Agency Road Safety Barrier Design Course within the last five years."*

3. That "*the Installation Designer must confirm the ground conditions at the installation site as part of the design process".*

4. That the *"System Supplier must have available the design horizontal force(s) and/or bending moment(s) at a nominated height and at an angle of 90° to the barrier as measured from data recorded during crash testing of the WRSB system."*

The requirements in these recommendations are aimed at reducing the probability of post footing failures and ensuring the barrier is more able to withstand the impact loads. The reader will note that the responsibility is shared between the Installation Designer, the Supplier and the Installer.

The comments in this Technical Advice Note are applicable to Australia as well as New Zealand.

System Deflection

When performing full-scale tests, a testing house often measures and records the deflection to the millimetre. In fact the deflection is a measurement applicable the conditions that exist at testing. It is noted that while the broad outcomes of a test are repeatable, the precise deflection is not. The foundation conditions alone could affect the deflections.

Wire rope barrier systems are even more susceptible to variation in deflection from one impact to another. The posts have to keep the ropes at a height so that they will engage with the vehicle. Mazougui, Mahadevaiah, Tahan, Kan, McGinnis and Powers (2012) have demonstrated that ropes lower than the lower edge of a bumper bar will be forced under the vehicle and ropes that are higher than the lower edge of the sloping part of the bonnet will ride over the vehicle. It is not uncommon for two out of four ropes to not engage with a vehicle and at times only one rope does so. The deflection of a wire rope barrier is dependent on the number of ropes that engage and the tension in the ropes.

The tension in wire rope systems has been increasing over time from a nominal 15 kN to 25 kN (O'Callighan, 2015). Increased tension affects test deflection and the deflection in the field will be a function of the deflection in the system which is based on the temperature of the day. This aspect also influences the design of the cable anchors. Again consultation between the barrier suppliers and the installation designers is required to ensure that the anchorages are appropriately designed.

It is important that installation designers consider system deflections as notional and not a precise absolute value. The deflection of a system in real installations will depend on the impact angle and speed and the mass of the vehicle, While MASH and hence the Australian and New Zealand Standard expects test conditions to be reasonably extreme, deflections in the real installations can be greater than those recorded in the full scale tests. Installation designers should not accept hazards just a little further away from the barrier than the design deflection.

Eliminating unsatisfactory installations

Unsatisfactory installations occur if the type of barrier used is not appropriate for the situation, if the barrier is not located appropriately or the barrier is not installed correctly. Austroads Road Design Guide Part 6 (Austroads, 2010) describes the appropriate barrier type for different situations and also their appropriate length and location. Grzebieta, Zou, Jiang and Carey (2005) have illustrated examples of poor barrier installations. To eliminate unsatisfactory installations, the installation designers and installers need to be conversant with both the Austroads guidelines, and the installation requirements of different barriers.

The Australian and New Zealand Standard AS/NZS 3845.1:2015 outlines the requirements for installation manuals for each barrier system. However, these manuals are of no use unless they are read and understood.

Davis (2015) undertook a survey of barrier installations on three sections of State Highway 2 in New Zealand, namely from Woodville to Hastings, SH33 to Matata and Athenree to Katikati. He classified the deficiencies in the barrier installation on the design of the installation (the length relative to the hazard, the location of the terminals; the clear area behind terminals and the appropriateness of the terminal); the installation compliance with the supplier's requirements and the general condition of the maintenance.

Davis commented:

"The likelihood of barrier hardware performing as designed, tested and accepted becomes increasingly questionable as the installation conditions vary further from those that were tested. As technical advances in barrier hardware and design have not been well understood by practitioners significant faults that will affect performance continue to be common place."

Davis found that:

"About 86% of the surveyed installations had significant or serious installation deficiencies. However, most installation deficiencies are readily repairable. Typically these include end treatment issues associated with height, grading, or missing or incorrect terminal bolting patterns.

About 75% of installations had issues relating to outstanding end treatment maintenance, and about 20% of installations had barrier maintenance issues. Most of the significant and serious maintenance issues could be easily identified and remedied. Typical examples include anchor cable tightening. It could be that network managers or contractors were not trained to identify appropriate maintenance issues, or are avoiding contractual obligations."

Davis made a number of recommendations that affect the installation and maintenance. Some of these have been paraphrased as:

- Establish performance measures in design, installation, and maintenance contracts to achieve road safety barrier quality assurance system and to monitor and report progress.
- Develop an industry training regime that addresses design, installation, and maintenance issues
- Improve quality assurance regime through appropriately trained designers and installers of barrier systems and an audit program of design, installation and maintenance.
- Develop a road safety barrier installation and maintenance manual to cover the identification, installation and maintenance checklists for common barrier hardware.
- Installation deficiencies of incorrect bolting patterns, missing bolts, delineation and grading and so on should be rectified in routine maintenance programs
- Maintenance contract documents to reinforce the need for routine rather than random maintenance.

Cassar (2015) has documented a number of examples in which it would appear that the installer was not aware of the correct procedures or to purposely "cut corners' in order to finish the installation quickly. Two examples in Cassar (2015) are shown in Figure 2 in which the details of the design of extruding terminals were not understood and the installation made the terminal ineffective if impacted head on. Cassar has provided examples where posts are not driven to the required depth and the intention is to cut off the posts (Figure 3). These posts will obviously not function as expected.

At times an installer will be a little too innovative. Figure 4 shows two examples where an installer has formed a non-standard anchorage and where the barrier system has been repaired using posts from another system (affecting the rope heights and orientation).

Both Davis and Cassar have indicated that some installations are so poor that the performance of the barrier would be severely affected. There is no purpose installing barriers if they are ineffective or become worse than impacting the hazard. It is incumbent on the road agencies, the suppliers and the installers to have the highest standard of safety barrier installations.

Daniel Cassar has been working diligently with industry to establish an installer accreditation and training scheme. He indicated the importance of installation being compliant with the tested configuration and with supplier's requirements. A sentiment also reflected by Davis. This must be an imperative if non-compliant installations are to be a thing of the past.

Figure 2. Incorrect installations from Cassar (2015)

Figure 3. Posts not embedded to the correct depth from Cassar (2015)

Figure 4. Inappropriate wire rope barrier installations from Cassar (2015)

Concluding remarks

The community deserves safer roads and roadsides. They assume road agencies are providing the best available. The Australian and New Zealand Standard AS/NZS 3845.1; 2015 has described a process for evaluating safety barriers in which the results of full scale testing is one element. The standard lists a number of other attributes, which the assessor should consider. These have been listed above. The standard also provides details for testing motorcyclist protection systems including thorax measures for riders who are upright when colliding with a barrier.

This evaluation testing and assessment protocol in the current Standard has set the standard for industry and as a consequence, the promulgation of the public domain steel W beam barrier on steel posts and block-outs can no longer be justified as being deemed to comply with NCHRP 350 Test level 3 without testing to the Standard's protocol.

This paper describes the information that should be included in the assessment. It is argued that the prime information is the results from full-scale tests, but other testing should be used to inform but not fail a barrier. A poor performance for a non-compliance test, or from another similar product would give reason for discussion with a manufacturer. Tests should only be waived if there is solid evidence that the outcome is likely to be successful and it is always better to run the test

Installations on embankments and in weaker soils need to be more closely examined and designed. In general these should not be part of "normal" design and should be considered to be in the extended design domain or as a design exception. This would then require more justification and explanation.

The design of safety barrier installations needs to be more comprehensive and include designing for the soil characteristics at the site. The New Zealand Transport Agency has produced a Technical Advice Note to address this issue. It is applicable to safety barrier designers and installers in Australia as well.

The paper warns that system deflection should be taken as notional as soil characteristics and rope tension have a significant influence.

Finally many installations are sub-standard and not compliant with the tested configuration or the supplier's requirements. The installations should be audited and the installers trained and accredited.

Personal view

Professor Troutbeck is employed as an independent member on the Austroads Safety Barrier Assessment Panel (ASBAP). However, this paper provides a personal view of appropriate assessment practices and does not necessarily represent the views of Austroads, ASBAP or any road agency.

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Safer cycling: An in-depth crash study in Melbourne, Australia

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Abstract

Despite increasing participation, cyclists remain vulnerable road users. This study aimed to describe crash characteristics and patient outcomes of a sample of cycling crashes occurring in Melbourne, Australia. A structured interview was conducted and in-hospital and long-term outcomes were extracted from the VSTR and VOTOR registries. 186 cyclists participated in the study. Cycling crashes commonly occurred during daylight hours and in clear weather conditions. 72% of crashes occurred on road, of which 22% occurred in dedicated bicycle lanes. While 76% of cases were classified as major trauma, 93% of injured cyclists had returned to work at 6-months post injury.

Background

Cycling participation is increasing in Australia (Australian Sports Commission, 2010) and is seen as a form of sustainable transport with associated health benefits (Better Health Victoria, 2007). However, cyclists remain vulnerable road users and injury rates are increasing (Henley and Harrison, 2012; Sikic et al., 2009). Efforts to identify factors associated with cycling crashes are needed to inform targeted interventions. The aim of this study was to describe the crash characteristics and patient outcomes of a sample of cycling crashes occurring in Melbourne, Australia.

Methods

Cycling-related trauma patients were recruited from two adult major trauma centres in Melbourne (The Alfred Hospital and the Royal Melbourne Hospital) during the 2013 calendar year. Patients were invited to participate if they met the following criteria: emergency admission to The Alfred or Royal Melbourne Hospital for >24 hours, admitted for management of a cycling-related injury, and eligible for registration on the Victorian State Trauma Registry (VSTR) or the Victorian Orthopaedic Trauma Outcomes Registry (VOTOR). Enrolled patients completed a structured interview during their hospital stay, which included demographics, details of the crash circumstance, specific risk factors, and events leading to the crash. Injury, in-hospital outcomes and 6 and 12-month post-discharge information was extracted from the VSTR and VOTOR. Descriptive statistics were used to provide an overview of the patient profile, crash circumstances, injury patterns and outcomes.

Results

186 cyclists (81% male) were enrolled in the study with a median age of 44 years (interquartile range, IQR: 34-54). At the time of the crash, cyclists were commonly riding for recreation, fitness or training (n=95, 51%) or commuting (n=50, 27%). Events generally occurred in clear weather conditions (n=144, 79%) and during daylight hours (n=145, 81%). There were 40 cyclists (22%) whose crashes occurred whilst riding in a bunch.

128 cyclists (72%) had crash events on-road while 50 occurred off-road (28%). Of the on-road crashes, 52% (n=65) involved another road user and 22% (n=25) occurred while the cyclists was riding in a dedicated bicycle lane. The majority of off-road crashes occurred on bicycle paths (n=26, 61%) and were single bicycle crashes (n=40, 82%).

Cyclists commonly sustained isolated upper extremity (n=45, 24%), spinal (n=35, 19%) or isolated lower extremity injuries (n=29, 16%). 76% of cases (n=142) were classified as major trauma. Helmets were worn in 97% of cases. Median hospital length of stay was 3.7 days (IQR: 2.2-6.0). 93% of injured cyclists returned to work at 6 months, and this increased to 96% at 12 months post-injury. Despite this, only 34% (n=56) of participants had complete recovery (Glasgow Outcome Scale-Extended = 8) at 6 months and 46% (n=77) at 12 months post-injury.

Conclusions

In this sample of cycling crashes, events commonly occurred during daylight hours and in clear weather conditions. Approximately one quarter of on-road cycling crashes occurred while the cyclist was riding in a dedicated bicycle lane. Despite the majority of cases being classified as major trauma, nearly all cyclists had returned to work at 6 months post-injury. These data can be used to identify targeted interventions to reduce injury in cyclists.

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Learning to drive with bikes: insights and lessons about how learner drivers are taught to share the road with cyclists in the ACT

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Abstract

Learning to drive a car is a critical time to learn safe driving skills including how to safely share the road with other road users, including cyclists. In this study we investigated the learner driver process in the Australian Capital Territory to identify the content about sharing the road with cyclists including: *Road Ready* program resources and classroom course, and; on-road driving lessons with professional instructors. We found minimal content about cyclists in the entire driver training process. Findings discuss the current gaps and opportunities for teaching new drivers safe driving skills when sharing the road with cyclists.

Background

The majority of serious cyclist crashes, that result in death or serious injury, involve a motor vehicle (AIHW, 2012). What is not well known is how Australian drivers are taught to interact safely with cyclists on the road. The learner driver process is the most intensive period of instruction and monitoring across a person's driving life (Mitchell et al, 2015; SEnserrick & Williams, 2015). Knowledge learned and skills and habits developed during this stage are likely to influence a lifetime of driving and widespread efforts with Graduated Driver Licensing Schemes (GDLS) have been made in Australia to create safe drivers and minimise crash involvement (Bates et al, 2014; Begg et al, 2014; Buckis et al, 2015; Senserrick & Williams, 2015). However, little reseach has investigated the emphasis in the learner driver process on how to safely drive with cyclists. The aim of this study is to understand how learner drivers are taught to share the road safely with cyclists.

Method

The study was undertaken in two stages. The first stage was a qualitative content analysis informed by the social constructionist view that individuals do not make up their own meanings about the world but the cultural context in which individuals are located shapes how they can understand their world including activities such as driving a car, walking or cycling. Six documents were analysed, namely: Road Rules Handbook, Preparing your Pre-learner for driving, Towards your P's in the ACT, Learning through Practice, Supervising your learner driver and, Student Workbook, Teacher Resource.

The second stage was a series of observational studies. The first of the observations was a two-day Road Ready classroom course, followed by nine one-hour learner driver lessons with professional driving instructors. Student drivers with various levels of experience were observed, from the first lesson to skill development (hill starts) to the final assessment. Participants were not informed that the focus of the study was specifically about cyclists. The silent observer (MJ) sat in the rear seat, discussions between the driving instructor/learner driver were recorded and notes were taken.

Results

Road Ready program

Cyclists are mentioned six times across all four of the *Road Ready* education and training documents. These mentions include: linking cyclists to pedestrians ('Where can we expect pedestrians or cyclists to appear from?'), gendering cyclists as male ('…it's a good idea to give *him* a bit more space.' (emphasis added), identifying cyclists as disobedient/illegal road users ('…observe and comment on drivers or cyclists disobeying traffic signals and speed limit signs'), or use of the car horn to 'alert' driver, cyclists or pedestrians.

In the classroom, cyclists were mentioned as other road users that might be encountered. No content specifically referred to how to interact with cyclists on the road. In response to a query about new minimum overtaking distance road rules in the ACT, the course instructor said, 'they have beautiful lanes for themselves and they don't pay registration. That's seriously annoying to me'.

Driving lesson observations

Nine one-hour learner driver lessons were observed with student drivers at varying stages. Cyclists were infrequently encountered (17 individual cyclists, a group of 6 cyclists). Only one instructor drew attention to the cyclists (group). Safe behaviour when sharing the road with cyclists was mentioned twice, no mentioned was made of safe/legal behaviour and cycling infrastructure.

Conclusions

The formal representation of cyclists in the learn-to-drive documents is problematic (hazards, error spotting). From the observations, it is evidence that cyclist-specific training content is needed for course instructors, driving instructors and as part of the driving licence assessment process (including testing) to ensure cyclists are included in the training process and to minimise personal anti-cyclist sentiment. All road users including cyclists, pedestrians, small wheeled vehicle users, motor cyclists etc. need to be included as driving skills competencies and included as examples in written, in-class and on-road activities. Inclusion of cyclists as compulsory, standardised content for all learner driver will help to normalise cyclists to new drivers and contribute to safer driving behaviour around cyclists.

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Factors in cyclist fatality crashes: outcomes from an analysis of medico-legal investigations in Victoria

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Abstract

Death investigations generate the most comprehensive information for sudden and unexpected deaths, including fatalities that result from road trauma. However, these data have not been analysed in Victoria to understand cyclist fatality crash factors. This study examined the coroner's records for all cyclist fatalities in Victoria from 1 January 2000 to December 2014 (n=137). The majority of crashes involved adult cyclists (86.1%) and 8 times as many males as female cyclists. The majority of crashes involved a motor vehicle (77.3%) or were a cyclist-only crash (14.5%). Crash factors were analysed in depth and priority areas for action were identified.

Background

Medico-legal investigations of road fatality crashes are routinely conducted in Australia in accordance with state and territory coronial legislation. However, these reports have been under-utilised in Australia to identify the presence of risk factors for cyclist fatality crashes.

Internationally, coronial data has been examined to understand factors in cyclist fatality crashes (Johnson et al. In Press). Previous studies have recommended helmet use (Oström et al. 1993, Sjöegren et al. 1993, Bajanowski et al. 1994), reported a relationship between substance impairment, particularly alcohol and fatalities (Olkkonen et al. 1993, Rowe et al. 1995) and an increased likelihood crash risk at night or low light conditions (Rowe et al. 1995, Bíl et al. 2010). Heavy vehicles were overrepresented (McCarthy and Gilbert 1996, Moore-Bridger 2009) and speed has been identified as a major contributing factor (Bíl et al. 2010).

The aim of this study was to examine the coronial records for all cyclist fatality crashes, including on- and off-road, in Victoria, Australia from 2000 to 2014 to identify the presence and pattern of contributing factors and to identify priority areas for action.

Method

This study was a retrospective population-based case series study of fatal cyclist crashes that occurred in Victoria, Australia. The coroners' record was reviewed by three authors (AL, MJ and LB) and consensus on eligibility of complex cases was reached by discussion between LB and MJ.

Data analysis

A series of univariate and bivariate descriptive statistical analyses were performed to describe the: frequency of deaths over time and as a proportion of all fatal transport crashes; socio-demographics of the cyclist and counterpart (where relevant); crash characteristics; and presence and contribution of individual factors, speed, vehicle and road and road sides.

Expert consultation forum

An expert consultation forum was convened with representatives from the Coroners Court of Victoria (CCOV), transport industry including heavy vehicles, and road safety policy to determine the application of the findings to road safety policy and programs and identify priority areas for action.

Results

In total, 156 cyclist deaths were reported to CCOV during the study period. Nineteen deaths were excluded (ongoing case: n=11; natural cause death: n=4; cyclist not astride, n=2; crash outside Victoria, n=1; crash outside study period, n=1).

Total cases were examined for 137 cyclist deaths. The majority (n=115, 83.9%) involved a counterpart (motor vehicle: 92.2%; train/tram: 4.3%; other cyclist: 3.5%) and 22 deaths involved no counterpart with most cyclist only (n=20) and 2 involving a fixed/stationary object. Heavy vehicles were overrepresented.

The majority of fatal crashes occurred in daylight, in clear, dry conditions and one in five crashes involved a cyclist being hit from behind. Males were overrepresented, both as cyclists and drivers. For the cyclists this is likely to be a function of exposure. While this may also contribute to higher involvement of male drivers, in attitudinal research about speeding, male drivers report being less concerned about being fined or involved in a crash compared to female drivers (Lewis et al. 2013).

Conclusions

This study and the discussions in the expert forum identified ten priority areas for action, including: safe driver intersection with cyclists; regional areas; cyclist conspicuity; child cycling skills; and cycling infrastructure. Special mention was made for the need to engage male drivers and cyclists in behaviour change programs.

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Evaluation of The Queensland Minimum Passing Distance Rule – Overview of Results

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Abstract

Minimum passing distance laws aim to prevent crashes occurring when motorists overtake cyclists. This study evaluated the 2-year trial in Queensland. Motorists were more aware of cyclists when driving on the road and most motorists and cyclists had observed motorists giving cyclists more space when overtaking than before the rule. Non-compliance rates were 12% at low speed and 21% at high speed sites. Delays in crash and injury data prevented assessment of road safety benefits but the initial findings suggest that the road rule may encourage motorists to provide more space to cyclists and as such, improve cyclist safety.

Background

Cyclists have a higher risk of serious injury and death compared with motor vehicle occupants (e.g., Bíl, Bílová, & Müller, 2010; Scholten, Polinder, Panneman, van Beeck, & Haagsma, 2015), with rear-end crashes and sideswipes being two major crash types that result in serious injury or even death of cyclists (Australian Transport Safety Bureau, 2006). Minimum passing distance (MPD) laws have been enacted in the U.S. and some European counties (e.g., France, Portugal, and Spain), to reduce crash risk and the severity of crashes between motorists and cyclists. In Australia, a 2-year trial of a MPD rule was introduced in Queensland on 7 April, 2014.

The aim of the current research was to evaluate the effectiveness of the trial Queensland MPD road rule in terms of (i) practical implication, (ii) impact on road users' behaviour, knowledge, awareness and perceptions, and (iii) road safety benefits.

Method

The evaluation comprised five components: (i) review of written correspondence received by TMR (ii) interviews and focus groups with Queensland Police Service Officers, (iii) online cyclist and motorist survey (Bicycle Queensland and RACQ members), (iv) observational study, and (v) analysis of crash, injury, and infringement data.

Results

Review of correspondence

Most of the 145 items of correspondence was received from drivers who were unhappy with the MPD rule, with a smaller amount from cyclists who were generally supportive of the rule but were dissatisfied with the severity of the penalty or the extent of enforcement. Most items of correspondence were received in the first 12 months, suggesting that attitudes to the rule stabilised over time. About half of the correspondents appeared to clearly understand the rule.

Interviews with Queensland Police Service officers

Interviews and focus groups about the practicability of enforcement of the MPD road rule were conducted with three QPS officers who had issued MPD Traffic Infringement Notices (TINs) and 18 who had not. Officers commented that drivers may not be aware of the road rule or may have forgotten it, and called for further public education. Despite these concerns and the limited extent of enforcement, most officers believed that drivers were giving riders more space (and perhaps much more than is required by the road rule because it is difficult to judge) and that cyclists may have become less cautious.

Cyclist and motorist survey

Online surveys of 3013 riders and 4332 drivers found that 25.3% of riders and 36.0% of drivers reported that drivers failed to comply with the MPD on roads with a speed limit of 60 km/h or less "most of the time" or "almost always". Similar levels of noncompliance were reported on roads with speed limits of greater than 60 km/h. Most riders (73.2%) and drivers (59.5%) agreed or strongly agreed that they have observed motorists giving bicycle riders more room when overtaking than they used to. Only 1.5% of cyclists and 5.2% of drivers said they did not know that the MPD road rule had been introduced but there was a lower level of knowledge about the new rule allowing the crossing of a continuous line, when safe to do so, particularly among drivers. Cyclists were more likely than drivers to agree or strongly agree with the MPD road rule (94.7% versus 52.5%). One-third of drivers and two-thirds of cyclists said that the rule has made it safer for cyclists.

Observational study

The actual distance left between cyclists and passing vehicles was estimated from video observations at 15 sites. The overall non-compliance rate across the seven low-speed sites was 12.1%. While the passing distances at the high-speed sites were generally greater than those at the low-speed sites, the overall non-compliance rate across the five high-speed sites was 20.9.

Crash, injury and infringement data

Finalised crash records for non-fatal crashes, hospital admission and emergency department presentation data were not yet available for the period from commencement of the MPD trial. Analyses of the preliminary police crash data suggest that 48.5 fewer serious (fatal and hospitalization) bicycle crashes occurred in the first 18 months after the MPD rule was introduced than would have been expected based on extrapolation from the pre-trial trend. The extent to which this reduction can be attributed to the commencement of the MPD road rule trial is unclear.

There were 60 MPD infringements following the introduction of the road rule until 30 June 2015, comprising 0.7% of all bicycle-related infringements.

Conclusions

The MPD rule has been difficult for police to enforce and drivers have expressed concern about the ease of compliance on narrow and windy roads and where there is adjacent or oncoming traffic. Both the survey and published visual perception research suggest drivers find it hard to accurately estimate lateral distances. Despite the problems of practical implementation, drivers reported being more aware of bicycle riders when driving on the road than 12 months ago. Most riders and drivers surveyed had observed motorists giving bicycle riders more room when overtaking than they used to. The higher level of observed than self-reported compliance may reflect drivers thinking that they haven't left enough space, when they actually have, because they are unable to accurately estimate the lateral distance.

It is premature to draw conclusions regarding the road safety benefits of the road rule until detailed official crash and hospital data become available. In addition, lack of suitable data prevented an analysis of the potential impacts of changes in cycling participation and rider behaviour due to changes to other cycling rules.

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From the couch to the bike: an evaluation of a cycling skills training program for women

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Abstract

Safety concerns is the major barrier to cycling participation in Australia, particularly for women. This is an evaluation study of *Wheel Women* a cycling skills and group ride program designed to encourage safe and regular cycling for women. Currently underway, the study includes: 1) analysis of Wheel Women participants (n=150) (e.g. demographics, cycling skills training, skills and fitness progression, cycling frequency); 2) an online survey of participants and non-participants, and; 3) in-depth interviews. Findings will determine the effectiveness of the program to: provide skills training, improve safe cycling skills, increased cycling participation and identify improvements to further increase safe cycling.

Background

Research has established why women do not ride and concerns about safety has been repeatedly identified as the main barrier (Garrard et al. 2006, Garrard et al. 2008). These concerns, both actual and perceived, keep women from riding and often result in them discouraging, restricting or preventing their children from riding (Haworth 2012). Further, as Bonham and Wilson reported, life events often interrupt cycling for women as other priorities (e.g. social relationships, the ‘cool’ factor, becoming a mother) lead to them choosing to decrease or stop cycling (2012). While the barriers to cycling are well researched, there has been little attention on what is needed to support adult women to ride bicycles.

It is likely that cycling skills and training programs could assist women to overcome their concerns about cycling and increase female cycling participation in Australia. However, it is important to determine the effectiveness of programs. This study is an evaluation one female-specific cycling training program called Wheel Women, based in Melbourne, Victoria. The aims of this study are to:

- determine if the program provide safe cycling skills and training
- identify if the program lead to ongoing behaviour change with measurable increases in cycling activity
- clarify if the program is more or less successful among different women and how the program may be modified to further increase women cycling participation.

Method

This study is an outcome evaluation of the Wheel Women program using a quasi-experimental time-series design that is being conducted in three stages. Stage 1 is review of the participation and skill progression of women participants from January 2013 to December 2015. De-identified data for all women who have participated in a Wheel Women program were analysed including demographics and baseline cycling skills level and progression during their engagement with Wheel Women. Stage 2 is an online survey of Wheel Women participants. All the women who have completed a Wheel Women program were invited to participate. The survey is still open and preliminary results are presented here. Final analyses will include details on non-respondents. Stage 3 are in-depth semi-structured interviews with women who have completed the online survey and agreed to participate. This stage and the analysis yet to be completed.

Results

Since the inception of *Wheel Women* in 2013, 426 females have completed a ride or program. This includes women who have participated in a skills training program and built their skills and experience over numerous group rides, as well as women who have participated in a single ride event. The analysis of the data from Stage 1 is currently underway and will be completed by July 2016.

To date, 60 women have responded to the online survey. The majority were aged between 41-60 years (78.3%) and prior to joining Wheel Women, half (53.3%) rode a bicycle a infrequently (a few times a year or less often) including 10 women who had no ridden a bicycle as an adult, 2 of whom did not know how to ride a bicycle. The main barriers to cycling were: I had no one to ride with (43.4%), concerns about safety (39.1%) and lack of skills (36.9%).

Benefits of cycling were reported in a range of variables including: improved fitness (84.6%), weight loss (38.0%), improvements to mental health (82.0%), increased social interaction (86.5%) and half the women reported feeling more confident in their life off the bike (48.0%). These women also represent an economic boon, in 2015, over a third (35%) spent over $1,000 on cycling gear excluding a bicycle, including 12 women who spent over $2,000 each. Further, over half the women had purchases a new bicycle since joining Wheel Women, totaling $83,249 with an average purchase price of $2,312.

Conclusions

Adult women are largely missing from the cycling population in Australia. Wheel Women is a program that is addressing the needs of these latent cyclists by facilitating regular group rides and providing the training and support needed for women to feel confident to cycle. The program is provided individual benefits including improved health outcomes (physical and mental health) with many reporting increased confidence off the bicycle. Further, the economic potential of women is largely untapped with substantial demand from women who are supported to cycle. The final interview stage of this study will contribute further insights and outcomes from this study will provide insights into how to successfully engage with women and these findings may be useful for those program seeking to target a similar audience.

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Modeling Crash Spatial Heterogeneity using Semi-Parametric Geographically Weighted Poisson Regression

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Abstract

Crash data are typically collected with reference to location dimension. Such data suffer from spatial (unobserved) heterogeneity. The use of generalized linear models (GLMs) to model the relationship between crashes and other explanatory variables when spatial heterogeneity is present might be inefficient, as they produce fixed global estimates. The objective of this paper is twofold: (1) to develop macro-level crash prediction models using the Semi-Parametric Geographically Weighted Poisson Regression (S-GWPR) to address the issue of spatial heterogeneity and (2) compare the performance of the S-GWPR models with GLM models. The result indicates that by accounting for spatial heterogeneity, the S-GWPR models performed better than the GLM models with a lower mean absolute deviation (MAD) and Akaiki information criterion (AIC). The results of the study have important planning implications, as accounting for spatial heterogeneity will give policymakers more reliable information to make accurate decisions.

Background

Road traffic accidents roughly claim more than 1.2 million lives worldwide each year. In addition, road traffic injuries are the leading cause of death among young people aged between 15 and 29 years with over 300,000 deaths every year (World Health Organization, 2015). The estimated global cost of road traffic accidents is approximately 3% of the worlds GDP.

In Australia, although there is 50 per cent growth in population and a two-fold increase in registered motor vehicles over the last 30 years, there has been substantial reductions in road crash fatalities (ATC, 2011). Annual road fatality rate has declined from 22.3 to 6.1 deaths per 100,000 people between 1980 and 2010 (ATC, 2011). Despite this envious achievements, the number of fatalities recorded on Australia's roads are still unacceptably high. Each year, road crashes kill about 1,400 Australians and hospitalise another 32,500, with an estimated cost of $27 billion to the Australian society.

From a road safety policy perspective, the most challenging side of road traffic crashes is the inability to adequately predict road crashes in order to propose appropriate counter-measures that will drastically reduce these high numbers. In the past, researchers have attempted to investigate the negative effects of growing travel demand on traffic safety by predicting the number of crashes based on the pattern they have learnt from crashes that occurred in the past (Pirdavani, Bellemans, Brijs, & Wets, 2014). These crash prediction models are however, not compatible with travel demand management (TDM) policies. This is because, TDM policies are developed at the planning or macro level, whereas, these crash prediction models are developed at the micro-level. The desire to integrate crash prediction models to TDM policies led to the development of macro-level crash prediction models.

The first step regarding macro-level crash prediction model is the choice of an appropriate spatial unit for modeling purposes. In previous literature numerous spatial units have been explored. A number of studies used traffic analysis zones (TAZ) (Abdel-Aty, Lee, Siddiqui, & Choi, 2013; Abdel-Aty, Siddiqui, Huang, & Wang, 2011; Duddu & Pulugurtha, 2012), census tracts (Abdel-Aty et al., 2013; Wier, Weintraub, Humphreys, Seto, & Bhatia, 2009), statistical areas (Amoh-Gyimah, Saberi, & Sarvi, 2016a; Amoh-Gyimah, Saberi, & Sarvi, 2016b) and census wards (Dissanayake, Aryaija, & Wedagama, 2009; Quddus, 2008; C. Wang, Quddus, & Ison, 2009), as common units of analysis. Other units of analysis include block groups (Levine, Kim, & Nitz, 1995), counties (Huang, Abdel-Aty, & Darwiche, 2010; L. Li, Zhu, & Sui, 2007), enumeration districts (Wedagama, Bird, & Metcalfe, 2006) and states (Robert B. Noland, 2003).

Although macro-level crash prediction models were first developed using linear regression models (Levine et al., 1995), the most common modeling framework has been the use of the generalized linear modeling (GLM) approach (Lord & Mannering, 2010; Mannering & Bhat, 2014; Washington, Karlaftis, & Mannering, 2010). The GLM models, such as Poisson and negative binomial (NB) have been very useful in safety research over the past years. However, the GLM models are unable to deal with the two major problems that characterizes crash data. According to LeSage (1999), since crash data is typically collected with reference to location dimension, they suffer from two main problems, (1) spatial autocorrelation and (2) spatial (unobserved) heterogeneity.

Spatial autocorrelation exists when there is spatial dependencies between observations (Xu & Huang, 2015). The presence of spatial correlation in crash data violates the Gauss-Markov assumption used in regression modeling. Since the GLM models are unable to account for spatial correlation, different modeling techniques have been applied by different researchers in crash prediction modeling to account for spatial correlation. These models include the autologistic models, conditional autoregression (CAR) models, simultaneous autoregression (SAR) models spatial error models (SEMs), full-Bayesian spatial models and Bayesian Poisson-lognormal models (Aguero-Valverde & Jovanis, 2006; Huang & Abdel-Aty, 2010; Quddus, 2008; Siddiqui, Abdel-Aty, & Choi, 2012; Xu, Huang, Dong, & Abdel-Aty, 2014; Zeng & Huang, 2014).

Spatial (unobserved) heterogeneity on the other hand is present on individual observations when significant random parameters are found. In such a situation, models that produce fixed-parameter outputs are inadequate for modeling crashes. Both the GLM models as well as the models that consider spatial correlation can all be thought of as global or semi-local, as the outputs from these models consist of a set of fixed parameter estimates across the region of analysis (Xu & Huang, 2015). The inability of these models to capture spatial heterogeneity means that the impact of predicting a variable on crash counts is restricted to be same in each zone. However, accounting for spatial heterogeneity by allowing for parameters to vary spatially will eliminate bias and give a more predictive model.

To account for spatial heterogeneity, random parameter models are mostly used (Amoh-Gyimah, Saberi, & Sarvi, 2016; Xu & Huang, 2015). Another solution for taking into consideration spatial heterogeneity is the use of the geographically weighted Poisson regression (GWPR) model. The geographically weighted Poisson regression approach has mainly been followed in health, economics, urban studies and transportation studies. In traffic studies, only few researchers have applied the GWPR approach (A. Hadayeghi, Shalaby, & Persaud, 2010; Pirdavani et al., 2014). The regression coefficients of the GWPR models developed in previous safety studies in the literature with the exception of Xu and Huang (2015) were all assumed to vary geographically. Indeed, in some situations, not every explanatory variable in the model will have significant random parameter or will be varying. This clearly shows the need to further develop a GWPR that is capable of combining both significant and non-significant random parameters in the same model. This new model is the semi-parametric geographically weighted Poisson regression (S-GWPR), which is the interest of this research.

The objective of this paper is twofold: (1) to develop macro-level crash prediction models using the Semi-Parametric Geographically Weighted Poisson Regression (S-GWPR) to address the issue of spatial heterogeneity and (2) compare the performance of the S-GWPR models (local models) with non-spatial GLM models (Global models). It is expected that the results would provide a greater insight into the effect of spatial heterogeneity on macro-level crash prediction models and help us better understand the various factors that influence crash occurrence.

The remainder of the paper is organized as follows. In section two, we provide a brief description of the data, spatial unit and study area used in this study. Section three explains the modeling technique whereas section four summarizes the modeling results and includes a discussion. The last section provides conclusions and recommendations.

Study Area and Data Description

Study Area

The study used data from Melbourne metropolitan area; the capital of the Victorian state in Australia. Melbourne is a large metropolis of 4.3 million people and has the largest population growth than any Australian city in 2013. Melbourne covers an area of about 10,000 km^2 and includes 31 local government areas which houses nearly three-quarters of all Victorians. The 2011 census shows that the Victorian state consist of 436 Statistical Area level 2 (SA2) zones, among which 289 SA2 zones are within the Melbourne metropolitan area. SA2's have a population range of 3,000 to 25,000 persons, and have an average population of about 10,000 persons. The 289 SA2 zones in the Melbourne metropolitan area were used for this study.

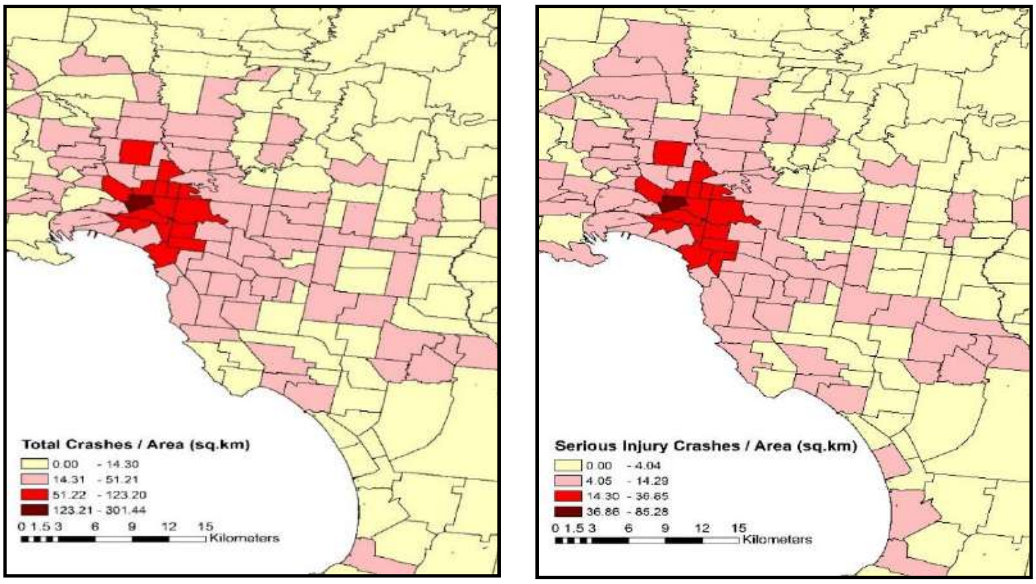

Fig.1. Total and serious injury crash distribution in SA2 zones in Melbourne Metropolitan Area (2010-2012)

The crash data for the years 2010 to 2012 are used for the study. It was obtained from the Victorian State Road Agency (VicRoads). These data are supplied by the police when they attend scenes of each accident that occur in the state. The data is geo-referenced and consist of the details of all casualties, fatal, serious injury, other injury crashes, etc. In this study we are interested in total crashes and serious injury crashes. In Victoria, total crashes is defined as crashes resulting in death or injury, but not non-injury crashes. Figure 1 shows the distribution of total and serious injury crashes per land area (sq.km) from 2010 to 2012.

Socio-Economic, Demographic and Land-use Data

The socio-economic and demographic data was obtained from the 2011 Australian Population and Housing Census (ABS, 2011). The data on social characteristics included information on the number of people in various levels of education, household income, number of vehicles owned by households, etc. The demographic variables included male and female population, total population and median age. Other variables were constructed from the demographic data such young population, young adult population, adult population, elderly population and population density.

The land-use data is based on the functional definition of land-use. This definition is based on the activity taking place on the land, for instance, residential, offices, agriculture or industry. The data for land-use was also obtained from the Australian Bureau of Statistics (ABS). The land-use data included land area for activities such as residential housing, agriculture, industry, education, health, park and transport. A land-use index known as land-use balance index (equation 1) was constructed from the land-use data. The land-use index is defined as:

$$BAL = 1 - \frac{|X - aY|}{X + aY} \qquad (1)$$

where X is the land area used for residential purposes, Y is the land area used for non-residential purposes, and $a = \frac{X^*}{Y^*}$ is an adjustment factor. The adjustment factor reflects the relative balance of land uses X and Y at a larger geographical scale and it is used as a benchmark for a reasonable level of balance (Song, Merlin, & Rodriguez, 2013). The index measures the degree which two different types of land-uses or activities exist in balance of with each other within the zone (in this study we used residential and non-residential parcels of land). The index ranges from the value of 0 to 1, with higher values associated with greater land-use mix and lower values associated with more homogeneous zones. Table 1 shows the list of the selected variables, their definition and descriptive statistics used in the study.

Table 1: Variable Summary and Descriptive Statistics

Category	**Variables**	Statistical area level 2 (N = 289)			
		Mean	S.D.	Min.	Max.
Crashes	Total crashes (all crashes)	106.17	76.08	0	714
	Serious crashes	30.94	23.44	0	202
Exposure	Log of average VKT (VKT)	4.37	0.09	0	6.36
	Log of total pop (LOP)	9.28	1.31	0	10.55
Traffic & Network	Average posted speed (SPD)	51.98	13.65	0	77.1
	No. of signalized intersections (SI)	14.58	13.15	0	95
	No. of bus stops (BS)	61.56	40.30	0	229
	No. of tram stops (TS)	5.95	13.88	0	96
	No. of primary and high schools (SCH)	4.44	2.68	0	13
Socio-economic & Demography	% of young pop (below 19 years) (YP)	22.69	5.99	0	36.26
	% of elderly pop (above 65 years) (OP)	12.12	5.27	0	50.0
	Weekly household income < $1000 (HH1)	31.69	9.15	0	58.89
Land Use	% of residential area (/sq.km) (RES)	60.46	27.05	0	100
	% of commercial area (/sq.km) (COM)	5.17	10.14	0	92.76
	Land use balance mix index (BAL)	0.22	0.24	0	0.99

Note: % means percentage, pop means population

Exposure and Network Data

The AADT data contains the traffic volumes for freeways (excluding toll roads) and arterial roads in Victoria derived from surveys and estimates. The AADT data contains information for all vehicles including cars, light commercial vehicles, motorcycles, rigid trucks, articulated trucks, and buses. From the AADT data, a weighted average vehicle kilometers traveled (VKT) by link length is estimated for each zone in SA2. The log of total population is also included as an additional exposure variable because performance of VKT as an exposure variable is sometimes questionable (Lee, Abdel-Aty, & Jiang, 2015; Zhang, Bigham, Ragland, & Chen, 2015). The literature, therefore, suggests that variables such as population and employment could be used as important exposure proxies to compensate for the limitations or lack of data that often affect the calculation of VKT. The logarithmic transformation of the estimated VKT and total population in each geographic unit is used as exposure variables in this study. Five additional network and spatial characteristics are also obtained from VicRoads including the number of primary & secondary schools, number of signalized intersections, number of bus and tram stops, and average posted speed limit.

Modeling

The section starts with the procedure for selecting the variables used in the study. The description of the GLM and S-GWPR as well as the criteria for model performance comparison is also given in this section.

Variable Selection

To select appropriate explanatory variables to be included in the model, the Pearson coefficient of correlation for all the explanatory variables are calculated. This is done to check for the possible presence of multicollinearity. In this study, correlation coefficient greater than ±0.70 between two explanatory variables is considered to be strong and one of such variables need to be dropped out of the model. However, from the Pearson correlation matrix (see table 2 in appendix A), the highest correlation coefficient is 0.64 which is less than the set criteria of ±0.70. We therefore used all the explanatory variables described in table 1 to develop the models.

Generalized Linear Model (Global Model)

The generalized linear model is the most common and popular technique for crash analysis. Reviewing the literature for different model forms showed that the following model has been widely applied in different studies (Abdel-Aty et al., 2011; A. Hadayeghi, 2009; G. Lovegrove, Lim, & Sayed, 2010):

$$\lambda_i = \beta_0 \, \mathrm{x} \, (Exposure)^{\beta_k} * \exp \sum_{k=1}^{p} \beta_k x_{ik} \qquad (2)$$

where λ_i is the expected number of total or serious injury crashes in Statistical Area i, $\beta_0, \beta_1, ..., \beta_p$ are model parameters, Exposure is the exposure variables (such as VKT, Population and employment), x_{ik} are the remaining explanatory variables. The logarithmic transformation of equation (2) when considering the two exposure variables used in this study yeilds

$$\ln(\lambda_i) = \beta_0 + \beta_1 \ln(VKT) + \beta_2 \ln(LOP) + \sum_{k=3}^{p} \beta_k x_{ik} \qquad (3)$$

where VKT is log of vehicle kilometres travelled and LOP is log of total population. Although the GLM model in equation (3), is basically the Poisson regression model, and it is a useful starting point to model crash outcomes.

Semi-Parametric geographically weighted Poisson regression model (Local Model)

In spite of the capabilities of the GLM model, it is unable to account for the presence of spatial heterogeneity that is still a substantial methodological issue in the field of traffic safety. To account for spatial heterogeneity in our models, the semi-parametric geographically weighted Poisson regression (S-GWPR) model is used in this study. The semi-parametric formulation is an extension of the GWPR model to allow for a mixture of fixed and spatially varying coefficients. Since the S-GWPR is an extension of the GWPR, we first introduce the GWPR and thereafter introduce the S-GWPR. The model specification of the GWPR is expressed as:

$$\ln(\lambda_i) = \beta_0(u_i) + \beta_1(u_i)\ln(VKT) + \beta_2(u_i)\ln(LOP) + \sum_{k=3}^{p}\beta_k(u_i)x_{ik} \tag{4}$$

where the coefficient of the estimated parameters β_k is a function of location $u_i = (u_{xi}, u_{yi})$ denoting the coordinates of the *i*th point (centroid of SA2 as used in this study) in space and is a vector of two dimensional coordinates describing the location of *i* with *x* and *y* coordinates.

In the S-GWPR framework, Equation 4 can be re-written as;

$$\ln(\lambda_i) = \beta_0(u_i) + \beta_1(u_i)\ln(VKT) + \beta_2(u_i)\ln(LOP) + \sum_{m=3}^{j}\beta_m x_{im} + \sum_{k=j+1}^{p}\beta_k(u_i)x_{ik} \tag{5}$$

where β_m is the *m*th global coefficient and all other parameters are as defined previously. Note that in the models where there are no global coefficients, the S-GWPR model and the GWPR model are equivalent.

In the S-GWPR modeling framework, a regression equation is estimated for each zone based on the observations in nearby zones. The S-GWPR modeling approach attempts to capture spatial heterogeneity (spatial variation) by fitting a regression model in each zone. The basic underlying principle is to place a kernel around each zone and estimate the local parameters of β' using all the data inside the kernel window. Observations closer to zone *i* where the regression is fit would carry more weight and thus, have greater influence on the estimated parameter $\hat{\beta}(u_i)$ than observation farther away. This impact can be expressed by a weighting function which is conditioned on the location *i* and changes for each location (Fotheringham, Brunsdon, & Charlton, 2002). The weights are derived from a weighting scheme that is commonly referred to as a kernel. There are two main kernels that are frequently used to generate the weighting scheme; the Gaussian and the bi-square (adaptive) functions. The two kernels are defined as

Gaussian: $w_{ij} = e^{-0.5(\frac{d_{ij}}{b})^2}$ (6)

Adaptive bi-square: $w_{ij} = \begin{cases} (1-(\frac{d_{ij}}{b_{i(k)}}^2))^2 & \forall\, d_{ij} \le b_{i(k)} \\ 0 & \forall\, d_{ij} > b_{i(k)} \end{cases}$ (7)

Where w_{ij} is the weight and represents the measure of contribution of zone (location) *j* when calibrating the regression model for zone *i*, d_{ij} is the Euclidean distance between the centroid of zone *i* (which is the regression point) and the data point *j*, *b* is the fixed bandwidth and $b_{i(k)}$ is an adaptive bandwidth size defined by the k^{th} nearest neighbour distance (Fotheringham et al., 2002).

It is evident from the literature that the selection of the spatial kernel function and the bandwidth used in the model fitting process impact the S-GWPR coefficient estimates (Guo, Ma, & Zhang, 2008; A. Hadayeghi et al., 2010). The selection of the spatial kernel function and consequently, bandwidth, is therefore an important step in the implementation of S-GWPR as the model might be sensitive to this selection (Guo et al., 2008). Fixed kernel size with a Gaussian function suffers from bias when the data or sample locations are dense or when sample locations are sparse (Fotheringham et al., 2002). Therefore, adaptive bi-square function is used in this study as it is capable to adapt to the sample locations. That is it tends to have larger bandwidths where sample locations are sparser and smaller bandwidths for denser sample locations. The selection of an optimal weighting function and a bandwidth can be determined using either corrected Akaiki information criterion (AIC_c) or a cross-validation (CV) approach. The AIC_c was used and the decision is that a model with a lower AIC_c is preferred (Fotheringham et al., 2002; Nakaya, Fotheringham, Brunsdon, & Charlton, 2005).

The S-GWPR models in the present study are estimated using the "GWR 4.08" software (Nakaya, Charlton, Lewis, Fortheringham, & Brunsdon, 2012). It must be noted that although it is preferred to estimate the geographically weighted regression (GWR) with a negative binomial (NB) error structure, the GWR 4.08 software does not support such calibration. The Poisson regression error structure was therefore adopted in this study. The use of the Poisson error structure can underestimate the variance of the parameters (Lord & Mannering, 2010). However, it does not produce largely inaccurate estimates compared to NB structure since the model coefficients are similar for the two error distributions (A. Hadayeghi et al., 2010; Miaou, 1994).

Testing for spatial non-stationarity

The approach used to test whether significant random parameters exist is based on a conventional approach suggested by Fotheringham et al. (2002) and has been widely used in other studies (Chen, Wu, Yang, & Su, 2010; Cheng, Atkinson, & Shahani, 2011; Saefuddin, Saepudin, & Kusumaningrum, 2013). In this approach, the stationarity of a GWPR parameter is determined by comparing the local inter-quartile range (IQR) of the GWPR model with the standard error of the global model (i.e., the traditional Poisson regression model). The decision rule is that if the value of the local IQR is twice or more than the value of the global standard error, then spatial heterogeneity is present and the variable is non-stationary and requires a non-stationary model to adequately represent it.

Measures of goodness of fit

The performance of the GLM and S-GWPR models are compared using the mean absolute deviation (MAD) and Akaike Information Criterion (AIC). The formulation of the MAD is as follows;

$$\text{MAD} = \frac{1}{n}\sum_{i=1}^{n}|e_i| \tag{8}$$

where n is the number of observations (which is the number of zones in this study) and e_i is the error (which is the difference between the observed crashes and the predicted crashes).The decision rule is that a smaller value of MAD is better than a larger value. Therefore on the average, a smaller MAD value predicts the observed data better than a larger MAD value.

Another important method is the Akaike Information Criterion (AIC), which provides a method for assessing the quality of the model through comparison of related models. It's based on the deviance but penalizes for complicated models. The AIC is defined as;

$$AIC = D + 2K \tag{9}$$

where D and K are respectively the deviance and the number of parameters estimated in the model. The deviance of the Poisson regression model is defined as (Greene, 2011);

$$D = 2\sum_{i=1}^{n}\left[y_i ln\left(\frac{y_i}{\hat{u}_i}\right) + (\hat{u}_i - y_i)\right] \tag{10}$$

where y_i is a dependent variable for the i^{th} observation and $\hat{u}_i$ is the expected value of the Poisson distribution for i^{th} observation. In the GWPR framework, since the number of parameters, K, is meaningless, the effective number of parameters is therefore used. The effective number of parameters is defined as $K=tr(S)$ where $tr(S)$ denotes the trace of the hat matrix (see Fotheringham et al., 2002 for details).

Results and Discussions

The result and discussion section is divided into three parts; model comparison, analysis of the GLM estimated parameters and analysis of the S-GWPR results.

Model Comparison

Table 3 gives the results of the two measures, MAD and AIC used to assess the performance of GLM and S-GWPR models. In all the models, it can be confirmed that the MAD value for the GLM models were high compared to that of the S-GWPR models. For instance, the MAD value for the GLM total crash model is 23.19 whereas the S-GWPR value for the same model is 16.33. Therefore the S-GWPR models predict far better than the GLM models. The likely reason for this result is the ability for the S-GWPR models to address the issue of spatial heterogeneity. This has greatly improved the predictive performance of the S-GWPR models for both the total crash and serious injury crash models. This results is further confirmed by Figure 2 (see appendix B for figure 2), which shows the observed crashes against the projected crashes for both models.

Table 3 Comparison of model performance

Model	Total crash models		Serious injury crash models	
	MAD	AIC	MAD	AIC
GLM	23.19	2767.63	7.88	1028.53
S-GWPR	16.33	1635.03	5.40	679.73

The AIC criterion also shows that the S-GWPR models are better than the GLM models. The difference between the AIC values for the S-GWPR and GLM models are large (for example, the difference between the AIC values for the S-GWPR and GLM serious injury crash models is almost two times). As already mentioned, a lower MAD and AIC is preferred. This result is expected as it confirm the few studies that have addressed the issue of spatial heterogeneity in safety research (Amoh-Gyimah et al., 2016; Mannering, Shankar, & Bhat, 2016; Xu & Huang, 2015). These studies found that by incorporating spatial heterogeneity into our models, we achieve greater model performance than models that neglect the issue of spatial heterogeneity.

Analysis of the GLM estimated parameters

Tables 4 and 5 in appendix D summarize the GLM model estimation results for total and serious injury crashes. VKT is positively related to total crashes in both the total and serious injury crashes. From literature, the expectation is for VKT to have a positive relation with crashes (Huang et al., 2010; Z. Li, Wang, Liu, Bigham, & Ragland, 2013), this is because, any increase in travel exposes drivers and passengers to greater risk of traffic crashes. The other exposure variable, total population was positively associated with total/serious injury crashes as expected. This means that as population of a given zone increases, the likelihood of crashes also increases. The finding confirm previous research (G. R. Lovegrove & Sayed, 2006; R. B. Noland & Quddus, 2004).

All the network explanatory variables (SPD, SI, BS, TS and SCH) are positively related to the total/serious injury crashes in the GLM models. This means that an increase in these variables could result in more traffic crashes. This confirms a number of studies in the literature that also found a positive association between the frequency of crashes and explanatory variables such as the number of bus stops, average speed, number of intersections and number of schools (A. Hadayeghi et al., 2010; Kim, Pant, & Yamashita, 2010; Pirdavani et al., 2014; X. Wang, Wu, Abdel-Aty, & Tremont, 2013; Zhang et al., 2015). The number of tram stops is also found to have a positive relationship with crash frequency as expected.

Two of the socio-economic and demographic variables were negatively associated with total/serious injury crashes. Young and elderly population both have the potential of decreasing road crashes. This confirms findings of Ladrón de Guevara, Washington, and Oh (2004) that an increase in the young population is likely to reduce the frequency of crashes but contradicts findings of Aguero-Valverde and Jovanis (2006). Young people below the age of 18 are not allowed to drive by law in Australia and are therefore less exposed to road crashes. Also, the percentage of households with weekly income < $1,000 has a positive relationship with total and serious injury crashes. Thus, an increase in households with a weekly income < $1,000 will likely increase the frequency of crashes.

Commercial and mixed land use activities are statistically significant in both the total and serious injury crash models. Although resdential activity is statistically significant in the total crash model, it is not in the serious injury crash model. Commercial activities are found to attract people and therefore the likely increase in road crashes in commercial areas. It was observed in a study by Kim et al. (2010) that business and commercial areas are strongly associated with increased total as well as serious injury and fatal crashes. Results from this study also support findings of Alireza Hadayeghi, Shalaby, and Persaud (2007) on the positive association between crashes and residential land use. Increased land use mixed reduces travel distances between local destinations, reduces vehicle travel and significantly increases the number of pedestrians (Ewing & Cervero, 2010; Frank, Greenwald, Kavage, & Devlin, 2011). This therefore increases the risk of pedestrians as walking will replace motorized transport for most journeys.

Analysis of the S-GWPR results

The results of the global models (GLM models) in tables 4 and 5 (see appendix D) shows all the explanatory variables are positively related to both total and serious injury crashes across the study region apart from young population and elderly population that have a negative relationship with crashes. However, there is a huge amount of variance on both total and serious injury crashes which is still unexplained. This fact and the presence of unobserved heterogeneity in most of the GLM regression parameters means that the models does not adequately represent the real relationship between crashes and the explanatory variables.

By accommodating spatial heterogeneity into the model, the S-GWPR analysis allowed the parameters of the models to vary in space and showed considerable stronger relationships with both the total and serious injury crashes than from the GLM models. From figure 2 in appendix B, the R^2 of the global models moved from 0.744 to 0.922 in the S-GWPR total crash models and from 0.672 to 0.900 in the serious injury crash model when spatial heterogeneity was accommodated.

The results of the S-GWPR models in tables 4 and 5 (see appendix D) are presented as a set of locally estimated coefficients often referred to as 5-member summaries (i.e., minimum, maximum, lower quartile, median and upper quartile). The mean estimate is also presented. Significant random parameters (SRP) which shows the presence of spatial heterogeneity is also presented in tables 4 and 5. From the total crash mode (table 4), unobserved heterogeneity is present on all the individual explanatory variables. This means that the parameters of these explanatory variables vary across the study area and are not fixed. In the serious injury crash model however, spatial heterogeneity is present on eight parameters whereas six of the parameters are found to be fixed.

A comparison of the parameter estimates of the GLM models and mean estimate of the S-GWPR models show that the signs are in line with our expectations. This result is not like other studies (A.

Hadayeghi et al., 2010) which reported unexpected signs in the GWPR models. However, the local estimates in the S-GWPR models shows that the signs for explanatory variables are not always the same. The issue of having counterintuitive signs or unexpected signs is not uncommon in geographically weighted regression models (Chow, Zhao, Liu, Li, & Ubaka, 2006; A. Hadayeghi et al., 2010).

To have a better view of these differences, the local explanatory variable estimates are mapped in figures 3 and 4 (refer to appendix C). The local estimates of the total crash model in figure 3 (see appendix C) shows that only the number of intersections is the most significant variable which always has a positive sign for all local estimates. In the serious injury crash model, the map of the local estimates shows that it is the number of intersections and households with income < \$1000 that are the most significant variable which always has a positive sign for all local estimates. However, the signs for all the remaining coefficients in both models are always not the same. They might range from negative to positive local estimates.

One reason for this situation will be the existence of multicollinearity among some of the explanatory variables for some specific locations. It is quite possible that some explanatory variables at some locations are locally correlated, although from table 2 (see appendix A), no global multicollinearity was observed.

Another possible reason might be due to the basis of calibrating S-GWPR. Presumably, for some locations, some of the explanatory variables might not be significant. It is therefore possible that the local models produced some unexpected explanatory variable signs for those insignificant explanatory variables. The local *t*-values can be computed to examine where there are significant relationship and where there are not. Lastly, the inability to account for over-dispersion in the S-GWPR models could also be a factor in the counterintuitive signs with significant *t*-values.

Conclusions

The application of generalized linear models (GLMs) to model crashes at the macro-level results in fixed coefficient estimates that represent the average relationship between the dependent variables and other explanatory variables for all locations. The conclusion from these fixed models is that the relationship between the dependent and explanatory variables are constant across space. However, if significant random parameters are found, then the coefficient estimates for these explanatory variables will rather vary and not fixed across space.

This study intended to investigate spatial (unobserved) heterogeneity in macro-level crash modeling. The S-GWPR model was used instead of the GWPR to allow for a mixture of fixed and spatially varying coefficients. The S-GWPR modeling approach was employed to account for the presence of unobserved heterogeneity on individual explanatory variables in a total crash and serious injury crash models. Unobserved heterogeneity or non-stationarity of a parameter is determined by comparing the local inter-quartile range (IQR) of the S-GWPR (local model) model with the standard error of the GLM model (global model).

A comparison on the S-GWPR models with the GLM models shows that the S-GWPR models performed better in terms of the two main criteria, MAD and AIC. A comparison of the percentage deviance explained by the two models also shows that the S-GWPR models outperformed the GLM models. This means that accounting for unobserved heterogeneity leads to better model performance. Global models (GLMs) are not capable of predicting local changes properly. For the purposes of planning at the metropolitan or local level, local S-GWPR models seem to be more appropriate, since the global models might fail in capturing local changes. Again, since global models are averages, their predictions are more likely to either over or under estimate road traffic crashes.

In the total crash model, unobserved heterogeneity was present on all the fourteen explanatory variables (including the intercept). This shows that using a fixed output model like the GLM to model will not be capable to fully account for this relationship between total crashes and the other explanatory variables. Unobserved heterogeneity was present on eight out of the fourteen explanatory variables (including the intercept) in the serious injury crash model. The remaining six explanatory variables are found to be fixed across space.

The global model parameter estimates shows that apart from young population and elderly population that have negative relationship with total/serious injury crashes, all the other explanatory variables are positively related to crashes. This shows the likely probability of increases in crashes in the Melbourne area should any of these variables increases. It is important for policy makers to be mindful of the implication on road safety when providing more network factors such as bus stops, schools, tram stops and signalized intersections. Another important factor for policy marker to address is the interest to create mixed land use communities. With all the benefits association with mixed land use developments, safety measure should be adequate to reduce the level of traffic crashes.

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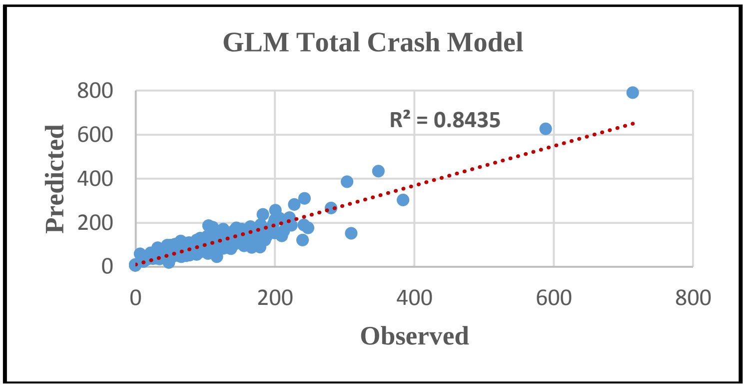
Appendix A

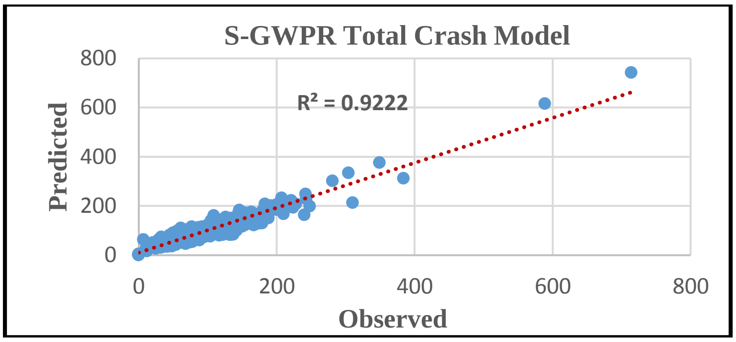
Table 2 Pearson correlation matrix for the explanatory variables used in the study

	VKT	LOP	SPD	SI	BS	TS	SCH	YP	OP	HH1	RES	COM	BAL
VKT	1												
LOP	0.09	1											
SPD	0.50	-0.10	1										
SI	0.40	0.15	0.07	1									
BS	0.31	0.40	0.28	0.34	1								
TS	0.15	0.09	-0.12	0.59	-0.17	1							
SCH	0.27	0.47	0.26	0.31	0.64	0.04	1						
YP	-0.27	0.43	0.06	-0.45	0.14	-0.47	0.17	1					
OP	0.10	0.16	-0.07	-0.00	0.24	-0.08	0.14	-0.07	1				
HH1	-0.05	0.40	-0.15	0.01	0.29	-0.21	0.21	0.11	0.37	1			
RES	0.23	0.19	0.19	0.09	0.22	0.07	0.23	0.03	0.05	-0.09	1		
COM	0.18	-0.01	-0.05	0.49	-0.11	0.52	-0.08	-0.43	-0.15	-0.03	-0.12	1	
BAL	0.08	-0.11	0.24	-0.02	-0.03	-0.08	-0.06	-0.02	-0.04	-0.03	-0.59	0.08	1

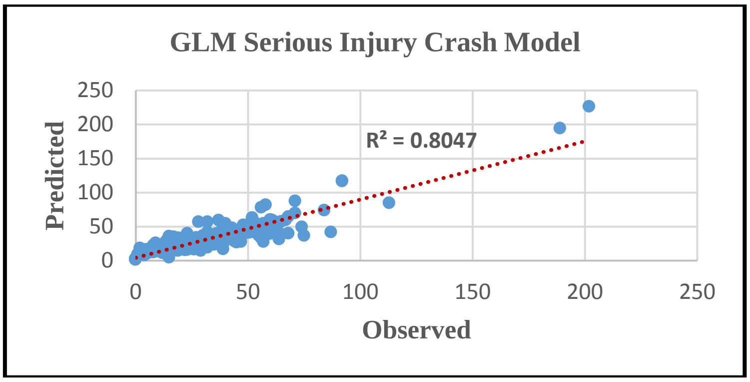
Appendix B



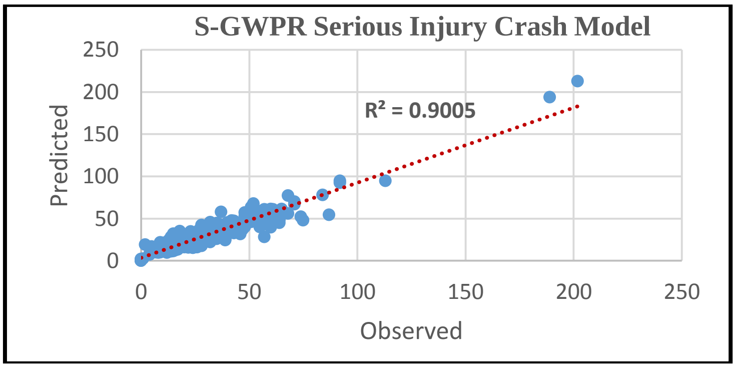
(A)



(B)



(C)



(D)

Fig. 2. (A) and (B) compares the prediction performance of the GLM and S-GWPR total crash models; (c) and (D) compares the prediction performance of the serious injury crash models

Appendix C

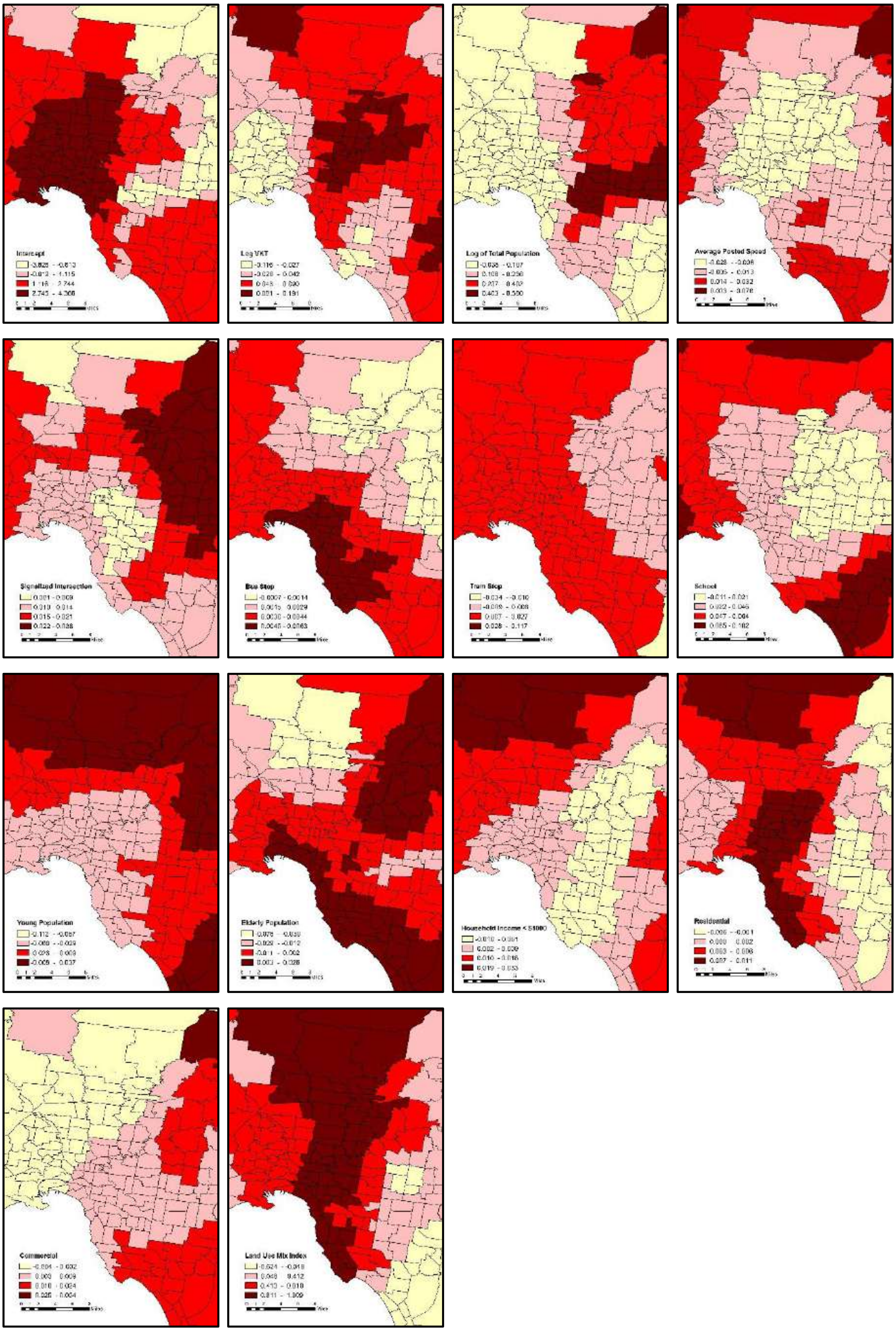


Fig. 3. Graphical representation of local coefficient estimates of variables in the total crash model

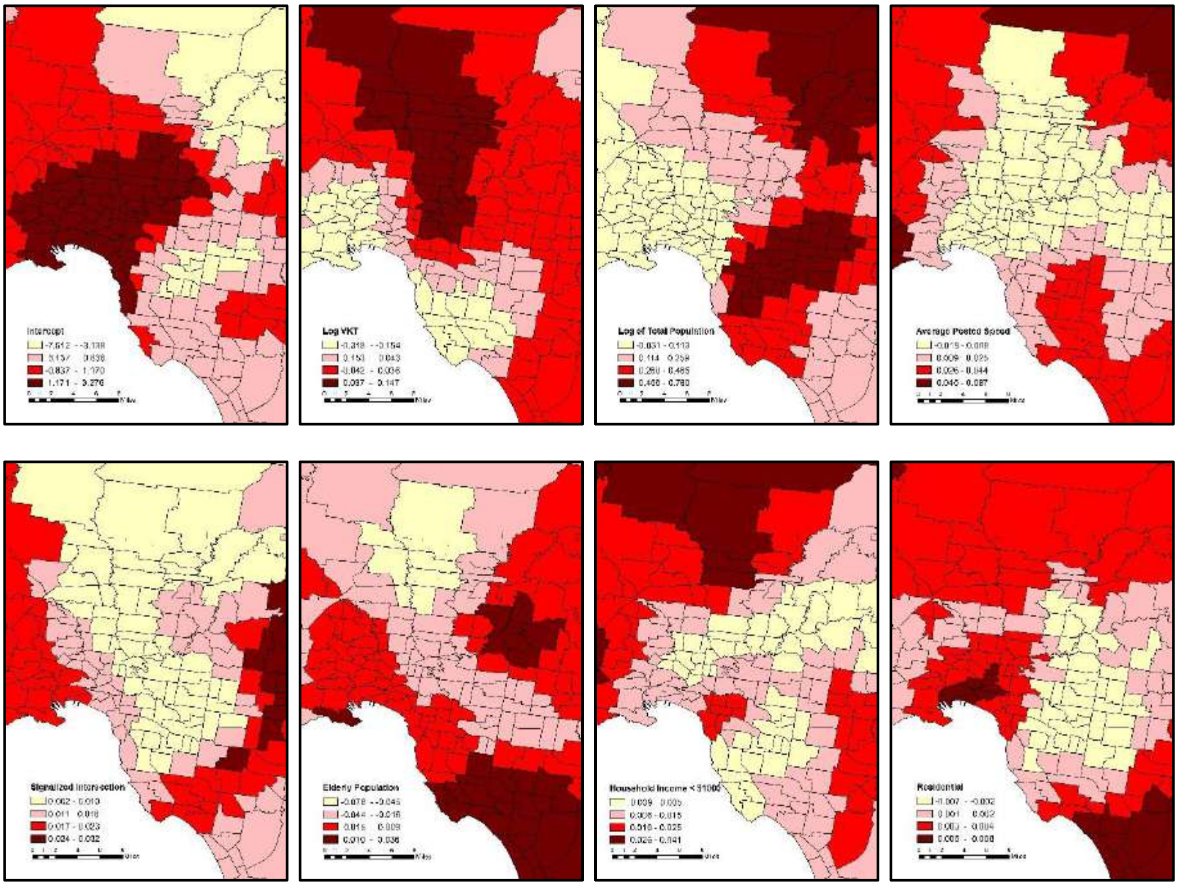


Fig. 4. Graphical representation of local coefficient estimates of variables in the serious injury crash model

Appendix D

Table 4. Models with total crashes as the dependent variable

	Total Crash Models								
	GLM (Global Model)		S-GWPR (Local Model)						
Variables	**Estimate**	**Std. Error**	**Mean**	**Minimum**	**Maximum**	**Lower**	**Median**	**Upper**	**SRP**
Intercept	1.543***	0.097	1.500	-3.825	4.366	0.577	1.700	2.434	√
Exposure									
Log of average VKT	0.078***	0.008	0.052	-0.116	0.191	0.023	0.061	0.094	√
Log of total population	0.112***	0.009	0.165	-0.038	0.590	0.056	0.087	0.260	√
Network									
Average posted speed	0.024***	0.001	0.010	-0.028	0.076	-0.004	0.011	0.022	√
No. of signalized intersections	0.012***	0.001	0.015	0.001	0.038	0.010	0.013	0.019	√
No. of bus stops	0.003***	0.000	0.003	-0.001	0.006	0.002	0.003	0.004	√
No. of tram stops	0.009***	0.001	0.006	-0.034	0.117	0.003	0.008	0.010	√
No. of primary and high schools	0.067***	0.003	0.047	-0.011	0.102	0.032	0.049	0.066	√
Socio-economic & Demography									
% of young pop (below 19 years) (YP)	-0.034***	0.002	-0.022	-0.112	0.038	-0.035	-0.021	-0.007	√
% of elderly pop (above 65 years) (OP)	-0.012***	0.002	-0.010	-0.076	0.026	-0.020	-0.007	0.003	√
Weekly household income < $1000 (HH1)	0.008***	0.001	0.009	-0.038	0.033	0.004	0.010	0.015	√
Land-use									
% of residential area (/sq.km) (RES)	0.002***	0.000	0.002	-0.006	0.011	-0.000	0.001	0.004	√
% of commercial area (/sq.km) (COM)	0.003***	0.001	0.006	-0.004	0.054	-0.000	0.004	0.010	√
Land use balance mix index (BAL)	0.319***	0.050	0.397	-0.624	1.309	0.032	0.412	0.784	√
Percent deviance explained	0.744		0.922						
BIC/MDL	2818.96		1977.76						

√ *Means Significant Random Parameter (SRP) (i.e. spatial (unobserved) heterogeneity is present)*
*** Explanatory variables which are statistically significant at 1% level
** Explanatory variables which are statistically significant at 5% level
* Explanatory variables which are statistically significant at 10% level

Table 5. Models with serious injury crashes as the dependent variable

	Serious Injury Crash Models								
	GLM (Global Model)		S-GWPR (Local Model)						
Variables	**Estimate**	**Std. Error**	**Mean**	**Minimum**	**Maximum**	**Lower**	**Median**	**Upper**	**SRP**
Intercept	0.300*	0.172	-0.607	-7.512	3.276	-1.707	-0.619	0.477	√
Exposure									
Log of average VKT	0.030**	0.013	-0.025	-0.318	0.147	-0.063	-0.003	0.025	√
Log of total population	0.119***	0.017	0.233	-0.031	0.780	0.091	0.175	0.319	√
Network									
Average posted speed	0.030***	0.002	0.022	-0.019	0.087	0.007	0.023	0.032	√
No. of signalized intersections	0.012***	0.001	0.015	0.002	0.032	0.010	0.014	0.018	√
No. of bus stops	0.002***	0.000	0.002						
No. of tram stops	0.007***	0.001	0.008						
No. of primary and high schools	0.074***	0.005	0.062						
Socio-economic & Demography									
% of young pop (below 19 years) (YP)	-0.036***	0.003	-0.024						
% of elderly pop (above 65 years) (OP)	-0.016***	0.003	-0.014	-0.078	0.036	-0.029	-0.013	0.001	√
Weekly household income < $1000 (HH1)	0.011***	0.002	0.013	-0.009	0.041	0.005	0.012	0.021	√
Land-use									
% of residential area (/sq.km) (RES)	0.001	0.001	0.002	-0.007	0.008	0.00	0.002	0.004	√
% of commercial area (/sq.km) (COM)	0.003**	0.001	0.002						
Land use balance mix index (BAL)	0.254***	0.088	0.486						
Percent deviance explained	0.672		0.899						
BIC/MDL	1079.86		979.89						

√ *Means Significant Random Parameter (SRP) (i.e. spatial (unobserved) heterogeneity is present)*
*** Explanatory variables which are statistically significant at 1% level
** Explanatory variables which are statistically significant at 5% level
* Explanatory variables which are statistically significant at 10% level

In-depth crash investigations in South Australia

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Centre for Automotive Safety Research

Abstract

The purpose of in-depth crash investigation is to produce holistic, high quality information on crashes that is not available from any other source, in order to understand the factors that contribute to crashes occurring, and to provide data necessary for countermeasure evaluation. This paper gives an overview of the method used for the Centre for Automotive Safety Research's (CASR) in-depth crash investigations and demonstrates the value of such data collection through examples of the research that it has enabled on a variety of topics, including: travel speed, alcohol, pedestrians, roadside safety, young drivers, and new vehicle technology.

Introduction

In-depth crash investigation is an essential ingredient of a region's crash investigation system (Monclus, Lowenadler, and Maier, 2006). The purpose of in-depth crash investigation is to produce holistic, high quality information on a sample of road crashes. In this way in-depth crash investigation complements other levels of crash investigation, such as routine police reports, that include a far greater proportion of all crashes that occur, but lack the detail needed to ascertain contributing factors.

In-depth crash investigations have been undertaken in South Australia through the University of Adelaide in various forms since 1963. At times these investigations have been focused on a particular road safety issue, such as speed or pedestrian crashes, but generally have been focused on general crash data collection to achieve the aforementioned purpose.

This paper will give a brief description of the current method and provide examples of the research it has enabled.

Method

Current in-depth crash investigations

The specifics of the investigation method have varied over the years since 1963. The current method is briefly described below.

CASR staff members are on call between 9am and 9pm Monday to Friday. Crashes occurring outside of these hours that have been attended by the Major Crash Investigation section of the South Australian Police are also investigated. CASR is notified of a crash seconds after the ambulance is dispatched, and the investigation team immediately travels to the crash scene, provided it is within 100 km of Adelaide and at least one participant is transported by ambulance.

On arrival at the crash scene, CASR staff talk to the emergency services, participants and witnesses; mark the physical evidence at the scene; photograph the scene, vehicles, and road infrastructure; collect data on the vehicles (including event data recorder download), road and crash circumstances; digitally map the road environment and evidence; and record participants' point-of- view videos.

After the initial scene visit, further data is obtained including: the police report, hospital and ambulance notes, driver and witnesses interviews, Coroners report (if fatal), alcohol and drug test results, crash and offence history of the driver, and location crash history. The speeds of the vehicles are also determined, if possible, using a computerised crash reconstruction.

Finally, a multidisciplinary panel reviews the crash, an agreed version of events is decided upon, factors that contributed to the crash having occurred are identified, and possible countermeasures identified.

Research output

The central output of CASR's crash investigation project is a database, site diagrams, photos and videos for use in CASR's research; it does not produce findings in and of itself. For this reason its value is chiefly in research output that has been enabled by the in-depth crash investigation data.

Results

The following are some key pieces of research that have been enabled by in-depth crash investigation data.

Historically, the data has been used to determine the relative risk curves for blood alcohol concentration (McLean and Holubowycz, 1981) and travelling speed (Kloeden *et al.*, 1997; Kloeden, Ponte and McLean, 2001; Kloeden, McLean, and Glonek, 2002), demonstrating a doubling of the relative risk of a road crash for every 5 km/h increase in travelling speed and 0.05 g/100mL increase in blood alcohol concentration, respectively. In-depth data was also used to determine the risk of pedestrian fatality relative to travelling speed and showed that a 10 km/h reduction in travelling speed could reduce pedestrian fatalities by 48% (Anderson *et al.*, 1995).

In more recent years the data has been used to show that:

- A medical condition was the main contributing factor in 13% of metropolitan area casualty crashes (Lindsay and Baldock, 2008);
- Barriers are a road departure countermeasure that could create a safe system, while traditional clear zones are not (Doecke & Woolley 2010; Doecke & Woolley, 2011; Doecke & Woolley 2013);
- A failure of the road transport system, rather than road user extreme behavior, is responsible for the majority of non-fatal (91-97%) and fatal (54%) crashes (Wundersitz, Baldock & Raftery, 2014);
- Young drivers are more likely to make driving errors, and their error types migrate from vehicle control errors to decision making errors as experience increases (Wundersitz, 2012);
- Autonomous emergency braking (AEB) could reduce fatal crashes by 20 to 25% and injury crashes by 25 to 35% (Anderson *et al.*, 2013) and that the main crash types for which it is an effective countermeasure are pedestrian, right turn, head on, rear end and hit fixed object crashes (Doecke *et al.*, 2012);
- Connected vehicles have the potential to provide substantial injury and fatal crash reductions (16-20% and 12-17% respectively) for a vehicle already equipped with AEB, as it is effective for certain crash types for which AEB is not (Doecke and Anderson, 2014; Doecke, Grant & Anderson, 2014).

Conclusion

In depth crash investigations conducted at the University of Adelaide provide a very detailed, holistic data set that has been used to conduct important research into factors that contribute to crashes occurring, and the evaluation of preventative and mitigating countermeasures.

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Should We Treat Fatal and Injury Crashes Differently for Road Safety Treatment Selection? The Evidence says Sometimes Yes Sometimes No

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Abstract

Two opposing views exist regarding use of fatal versus injury crashes to guide selection of road safety treatment: (1) fatal and injury crashes are equally important in guiding road engineering treatments: (2) fatal crashes should be assigned more weight than injury crashes in determining treatment priorities. Each view is adopted into policy in various countries and programs. To date the debate on which view is correct has been theoretical with proponents arguing that fatal and injury crashes do or do not differ systematically in ways relevant to road design and engineering. For example, it is argued that other factors such as age and frailty of the victims, or safety afforded by their vehicle may determine whether the crash is fatal or injury, not the specific details of the crash or the road. The critical issue is whether fatal crashes predict that other crashes (of the same type at the same location) are more severe than if no fatality has occurred (at that location and crash type). This paper empirically informs this critical debate by testing this the predictive power of fatal versus injury crashes at crash cluster locations in South Australia. Extraordinarily, each view is correct in certain crash circumstances: fatal crashes predict more severe injuries in some circumstances (e.g. sideswipe crashes in <50kmh zone) but not others (e.g. rear-end crashes in <50km/h zone, or right-angle crashes in 70-80kmh zone). These results can be applied to improve use of fatal crashes in selecting and prioritising treatments to improve safety benefits.

Introduction

Road safety resources are finite, and thus the targeting of these resources to best road safety effect is demanded by Government, public sector management, and road safety stakeholders. This paper examines the extent to which resources may or may not be better targeted by treating fatalities and serious injuries differentially in analyses designed to select future road safety interventions. It may appear to some that the answer is obvious and thus it may be surprising that this is an issue for investigation. However, clearly dichotomous views regarding the interpretation of deaths versus injuries currently dictate road safety treatment prioritizations for various programs.

View 1: Fatal and injury crashes should be prioritised equally

The first view acknowledges that fatality and injury are, of course, radically different outcomes for those involved and for the economy, but contends that fatal and injury crashes are equally important indicators of treatment selection or prioritization. This is based on the belief that whether crashes result in deaths or injuries is not systematically and consistently related to the nature or location of the crash. Rather, in otherwise similar crashes in terms of the type of crash and location of the crash, people die due to extraneous factors (e.g. physical frailty, older cars, emergency response time). Thus, there is little value in separating fatalities from serious injury crashes for predicting future crashes and outcomes.

In addition, it is argued that the severity of the crash may be largely related to behaviours known to influence the risk of death versus injury in the event of a crash, such as whether a helmet (WHO, 2006) or seat belt was worn (Cummings, Wells & Rivara, 2003; Evans, 1996), or speeding (for reviews see Job & Sakashita, 2016, Nilsson, 2004). These may be seen as largely independent of the engineering of the location and thus severity should not be considered in decisions about road engineering solutions (such as black spot treatments). Although this is not correct for speeding, which can be managed through road design (Job & Sakashita, 2016), it is largely correct for seat belt and helmet use.

Finally, proponents argue that a focus on fatalities may be counterproductive because it results in a concentration on crash locations based on relatively rare events and there are many more injuries than serious deaths. Combining deaths and serious injuries (or injuries generally) results in a larger sample of cases on which to base decisions.

These beliefs result in treating fatal crashes and injury crashes equally for the selection of road safety works. This view dictates decisions in, for example, Australia's Federal Blackspot Program, which allows that blackspots are selected on the basis of total casualties combined regardless of the severity of the injury (fatality or non-fatal injury).

View 2: Fatal crashes should be prioritised over injury crashes

The second view is that fatal and injury crashes are systematically different. This is based on the belief that fatal crashes are not only more severe and costly as an outcome, but also even for the same crash type and location, systematic differences exist in the crash which results in a death versus an injury. The factors which caused the greater severity of outcome may be systematically related to the location. For example, whether the crash results in a death versus an injury is determined by speed of impact based on evidence that speed of impact dramatically influence survivability (Nilsson, 2004; WHO, 2008), and the design of locations vary in the extent to which they encourage versus manage speeding. In addition, off road crashes will vary in severity of outcome based on the objects struck, which vary from location to location. Furthermore, behavioural factors may be systematically related to the crash location (e.g. speeding and non-use of seat belts are more common on more remote rural roads where enforcement is less likely: Raftery & Wundersitz, 2011). Thus locations with fatal crashes versus injury crashes are systematically different in terms of risk of severe crashes.

Under these beliefs, greater weighting is given to fatal than injury crashes in prioritising safety treatments. This view dictates decisions in, for example, blackspot selection in Sweden (SweRoads, 2001).

The Importance of examining which view is correct

These views are both currently applied in road safety practice. The influence of these views on road safety policy is substantial. As noted above the Australian federal blackspots programs adopts the first view while the blackspot program in Sweden as adopts the second view. In addition, the governments of different states and territories of Australia and other countries have adopted different views regarding how to select locations for speed cameras and for red light cameras. Some have prioritised fatalities over injuries in determining locations while others have based locations on total severe casualties (deaths and injuries combined). To the extent that one of these views is correct and the other view is presumed in policy decisions, sub-optimal prioritisation of road safety resources is occurring. Thus, determining which view is correct will allow more effective prioritisation to provide maximum benefits from limited road safety resources.

To date the debate regarding these issues has occurred at a theoretical level: with arguments presented for the contributions to deaths which are extraneous to the engineering and design of the location (such as frailty of the victim) versus factors which are related to the engineering and design of the location (such as object struck or speed of impact). This paper offers an empirical method for determining which view is correct and applies that method to data form South Australia. Results will inform future blackspot methodology and influence strategies for enforcement and related communication campaigns on whether to treat fatal and injury crashes similarly or differently.

To the best of our knowledge, no published studies have examined specifically whether crash sites with fatalities predict more severe injuries than comparable (i.e. controlling for predictors of crash severity including crash type, speed limit and road features) crash sites without fatalities. However, studies undertaken for other purposes provide hints as to the answer. For example, a large scale study by the NSW Centre for road Safety comparing crash severities on curves of different radii across many roads in NSW revealed relevant results (Job, 2010). The results (Figure 1) show that property damage only (two away) crashes peak in frequency at curves of radii around 150m, while injury crashes peak around 250m yet fatal crashes peak around 400m radius curves. These data suggest that there are systematic difference in the locations of fatal and injury crashes.

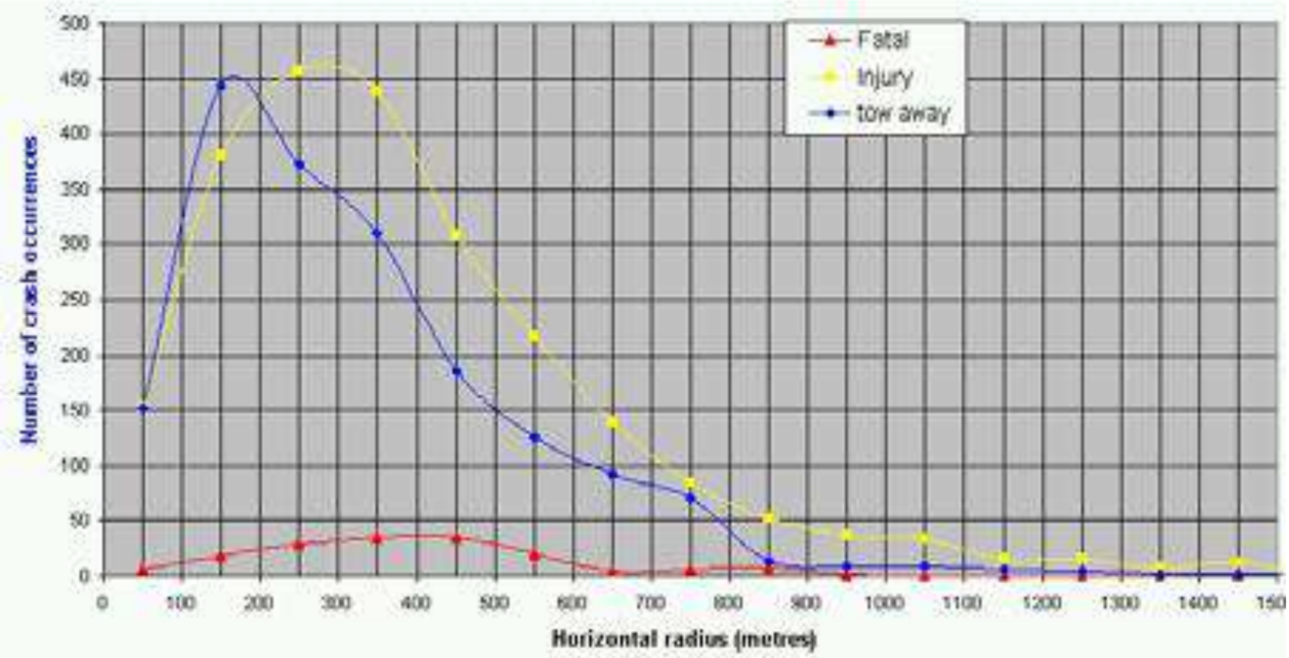

Figure 1: Frequencies of tow-away, injury and fatal crashes across curves of different radii (Job 2012)

Rationale for the Present Research

The dichotomous views on the treatment of fatalities and injuries in determining road safety interventions have been debated largely on the basis of the factors contributing to deaths in crashes (frailty versus location related factors, etc.) as described above. One way to empirically resolve this critical debate is to examine the extent to which fatal versus injury crashes differentially predict severity of other crashes (controlling for various additional factors). After all, this is the real issue determining how we should use fatal and injury crashes to select and prioritise road safety treatments: If the presence of fatal crashes predict more severe other crashes than the presence of injury crashes then fatal crashes should be given greater weighting in treatment prioritisation. On the other hand, if fatal and injury crashes are equal in predicting the severity of other crashes, then they should be employed equally in prioritising road safety treatments. Once seen this way, the debate can be addressed through the following specific research question: Do crash locations and crash types with fatalities have more severe injuries than otherwise similar crash locations and crash types where injuries but no fatalities have occurred? To take a concrete example, we can examine all instances of clusters of rear-end collisions at signalised intersections in 60km/h zones. We then classify the locations of all such crashes as being those where a fatal rear-end collision has occurred (called fatality-present locations) versus those where injury but not fatal crashes have occurred (called fatality-absent locations). We then compare the severity of injury crashes at these two sets of locations. The above described two views make explicit opposing predictions of the outcome. The view that fatal versus injury outcomes are determined by factors extraneous to the location (frailty, safety of the vehicle) predicts that the presence of a fatal crash versus only injury crashes makes no systematic difference in predicting the level of severity of other crashes at the relevant locations. The second view, that fatal versus injury outcomes are determined by factors related to the location (design, object near the road) predicts that fatal present location are likely to be higher risk and so injury crashes at these locations will be more severe.

Methods

Study 1: In order to answer this research question, the analyses were conducted employing crash and Compulsory Third Party (CTP) claims data from 1 January 2000 to 30 June 2013 in South Australia. Figure 2 presents a scheme of how the data were employed. Claims cost data (with discounts for at fault behaviour such as drink-driving reversed so that the claim cost is more reflective of injury) were employed as an admittedly imperfect measure of injury severity. Some limitations include: 1) claims costs vary with evolving medical treatments and their costs; 2) variability of schemes also means costs are not comparable across jurisdictions, rendering precise benchmarking and control comparisons for evaluation purposes impossible. However, a separate study using the same data sources has demonstrated validity of claims cost as a proxy measure for injury severity where claim costs were found to have increasing positive relationship with low, medium, and high injury severity injury (CDSU 2015a). Moreover, claim costs are influenced by all the factors of the crash which influence severity and the issue herein is whether within those factors there is a significant amount of variance attributable to factors predicted by fatal versus injury crash at comparable locations.

CTP claim amounts awarded per injury at intersections where a fatality had occurred were compared with the CTP claim amounts awarded per injury at intersections where no fatality had occurred, with intersections matched on crash type, speed zone, and traffic control. Study 1 was restricted to intersections to allow for clusters of crashes at comparable locations. Ratios of claim costs at fatality-present locations to claim costs of fatality-absent locations were computed. A ratio of 1 indicates that the costs of injuries at fatality-present and fatality-absent locations are the same, ratios above 1 indicate that injuries cost more at fatality-present locations and ratios below 1 indicate that injuries cost less at fatality-present locations. T-tests were also conducted to examine if the mean costs at fatality-present versus and fatality-absent locations were statistically significant (defined at p-value of 0.05).

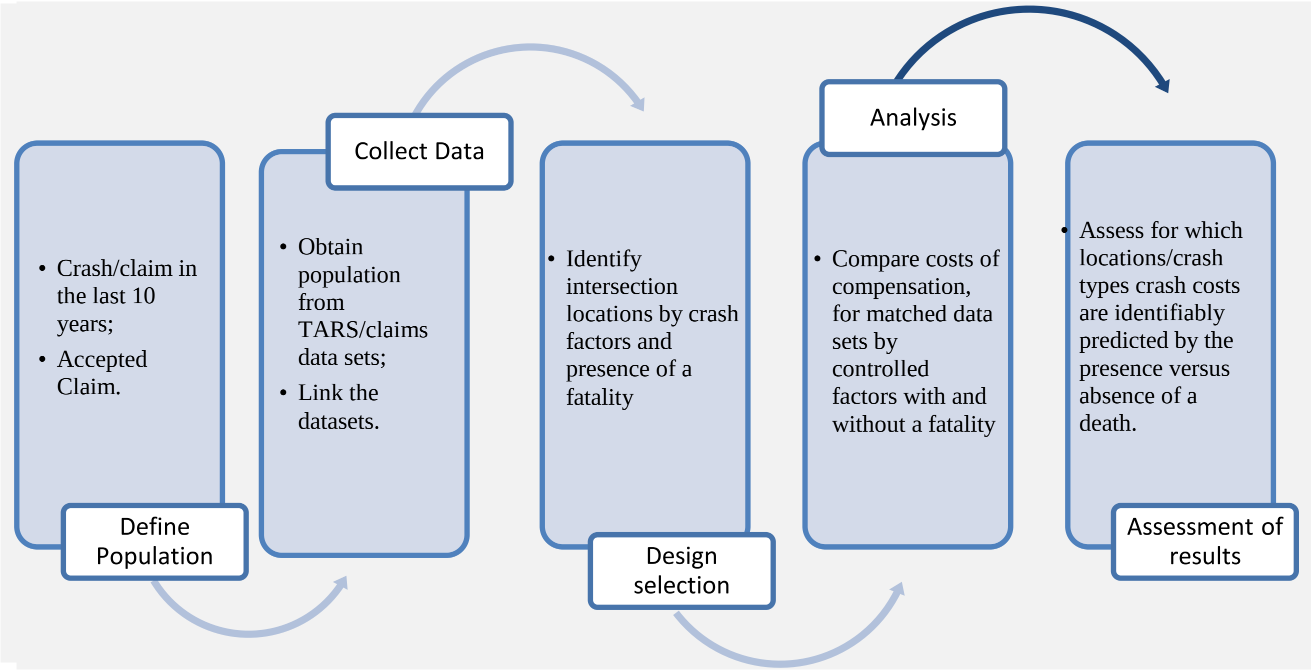

Figure 2: Schematic of injury data examination (CDSU 2015b)

In order to control other extraneous contributors to crash severity, crashes which involved especially severe vehicles or especially vulnerable vehicles were excluded Study 1: trucks and busses, motorcycles, bicycles, and pedestrians.

Study 1 control for crash type (6 types included, as presented in Table 1) intersection control (5 levels, as presented in Table 1) and speed limit (4 levels as in Table 1, with some limits excluded due to small sample size) means that this study may be interpreted as comprising 120 sub-studies (6 x 5 x 4) of parallel form. However, many of these comparisons contained too few cases, and results were not analysed, leaving 42 sub-studies with usable results.

Study 2: While pedestrian crashes were excluded from Study 1, because they occur particularly at intersections allowing sufficient data on these crashes, pedestrian crashes were treated separately, in Study 2. The rational and form of analysis were the same as in Study 1, except that there was only one crash type: pedestrian crash.

Results

Study 1 results controlling for factors of speed limit, intersection traffic control and crash type at once are provided in Table 1 including sample size for each comparison as well results. Study 2 results are reported in Table 2 (pedestrian crashes only).

For ease of scanning, fatality-present to fatality-absent ratios above 1.5 are in bold. Ratios between 0.95 and 1.05 are in italics. Ratios below 0.5 are in bold italics. Ratios above 1.5 suggest that injury costs at fatality-present locations are over 50% greater than injury costs at fatality-absent locations, which can be considered practically significant difference. Ratios between 0.95 and 1.05 suggest that injury costs at fatality-present versus fatality-absent locations differ within around 5%, which can be considered not to be a difference of little practical significance. Ratios below 0.5 suggest that injury costs at fatality-present locations are more than 50% less than injury costs at fatality-absent locations, which can be considered practically significant difference, though in an unexpected direction. All other ratios (i.e. above 1.05 and less than 1.5; greater than 0.5 and below 0.95) suggest that injury costs between fatality-present and fatality-absent locations are less than 50%. Further research for these crash circumstances may be required before making a judgement on the practical significance of these differences.

Statistical significance tests were performed on the ratios to further verify the differences. All of the ratios above 1.5 and below 0.5 were statistically significant, confirming their statistical reliability as well as practical significance. Two crash circumstances with a ratio between 0.95 and 1.05 were statistically significant (rear end and right turn crashes at traffic controlled intersections in 60km/h speed zone). However, the other two crash circumstances with ratios between 0.95 and 1.05 were statistically non-significant (right angle crashes at intersections with give way sign in 70-80km/h speed zone and right angle crashes at intersections with stop sign in 90-100km/h speed zone). Statistical significant is possible in cases of small practical impact when the sample size affords high statistical power.

Table 1. Study 1 summary results: comparisons of claims costs of injuries at fatality-present and fatality-absent locations controlling for speed limit, intersection controls, and crash type and statistical significance of the fatality-present to fatality-absent ratios

Speed limit	Traffic Control	Crash Type	Number of Claims (Fatality-absent locations)	Average Claim Cost (Fatality-absent locations)	Number of Claims (Fatality-present locations)	Average Claim Cost (Fatality-present locations)	Fatality-present to fatality-absent ratio	Significance of the difference between fatality present and fatality absent locations
50 km/h or below	Traffic Signals	Rear End	193	40,209	26	30,780	0.77	significant
50 km/h or below	No Control	Rear End	96	33,821	10	13,719	***0.41***	significant
50 km/h or below	Traffic Signals	Right Turn	105	36,270	17	24,293	0.67	significant
50 km/h or below	Traffic Signals	Right Angle	90	58,871	6	97,906	**1.66**	significant
50 km/h or below	Traffic Signals	Side Swipe	8	9,203	6	122,168	**13.27**	significant
60 km/h	Roundabout	Rear End	189	35,263	12	61,865	**1.75**	significant
60 km/h	Traffic Signals	Rear End	2,067	35,355	498	36,354	*1.03*	significant
60 km/h	Stop Sign	Rear End	178	27,029	12	45,809	**1.69**	significant
60 km/h	No Control	Rear End	1,115	42,325	42	24,850	0.59	significant
60 km/h	Traffic Signals	Right Turn	1,886	45,926	553	44,516	*0.97*	significant
60 km/h	Give Way Sign	Right Turn	68	27,724	9	60,194	**2.17**	significant

60 km/h	No Control	Right Turn	384	42,370	24	70,353	**1.66**	significant
60 km/h	Traffic Signals	Right Angle	764	48,735	138	52,147	1.07	significant
60 km/h	Stop Sign	Right Angle	489	41,817	44	78,503	**1.88**	significant
60 km/h	Give Way Sign	Right Angle	367	34,196	21	103,365	**3.02**	significant
60 km/h	No Control	Right Angle	969	43,883	41	123,689	**2.82**	significant
60 km/h	Roundabout	Side Swipe	16	23,246	6	102,246	**4.4**	significant
60 km/h	Traffic Signals	Side Swipe	66	38,479	25	50,947	1.32	significant
60 km/h	No Control	Side Swipe	44	45,030	7	179,964	**4.0**	significant
60 km/h	Traffic Signals	Head On	32	74,701	13	46,440	0.62	significant
60 km/h	No Control	Head On	53	47,450	6	62,470	1.32	significant
60 km/h	Traffic Signals	Hit Fixed Object	50	33,465	10	312,878	**9.35**	significant
60 km/h	Stop Sign	Hit Fixed Object	14	22,295	13	145,528	**6.53**	significant
60 km/h	No Control	Hit Fixed Object	45	91,031	18	153,617	**1.69**	significant
70-80 km/h	Traffic Signals	Rear End	383	38,790	107	46,854	1.21	significant
70-80 km/h	Stop Sign	Rear End	14	38,396	5	33,647	0.88	non-significant
70-80 km/h	No Control	Rear End	92	49,033	8	25,281	0.52	significant
70-80 km/h	Traffic Signals	Right Turn	257	70,003	87	44,497	0.64	significant
70-80 km/h	Stop Sign	Right Turn	7	40,985	9	113,957	**2.78**	significant
70-80 km/h	No Control	Right Turn	82	80,999	18	68,683	0.85	significant
70-80 km/h	Traffic Signals	Right Angle	133	49,642	29	63,293	1.27	significant
70-80 km/h	Stop Sign	Right Angle	89	54,247	23	77,626	1.43	significant
70-80 km/h	Give Way Sign	Right Angle	94	65,732	28	66,011	*1.0*	non-significant
70-80 km/h	No Control	Right Angle	173	45,869	27	96,079	**2.09**	significant

90-100 km/h	Traffic Signals	Rear End	7	16,640	12	95,062	**5.71**	significant
90-100 km/h	No Control	Rear End	31	39,059	10	42,752	1.09	non-significant
90-100 km/h	No Control	Right Turn	33	51,839	13	112,801	**2.18**	significant
90-100 km/h	Stop Sign	Right Angle	27	63,994	23	62,699	*0.98*	non-significant
90-100 km/h	Give Way Sign	Right Angle	46	49,919	44	88,160	**1.77**	significant

Note: Some combinations are missing because at least one of the cells for fatality-present or fatality-absent locations contained less than 5 cases, which is too few cases to provide reliable results; Ratios >1.5 are in bold; Ratios between 0.95 and 1.05 are in italics.

Table 2. Study 2 summary results: comparisons of claims costs of injuries at fatality-present and fatality-absent locations controlling for speed limit, intersection controls, and crash type and statistical significance of the fatality-present to fatality-absent ratios for Hit Pedestrian Crashes only

SPEED LIMIT	Traffic Controls	Number of Claims (Fatality-absent locations)	Average Claim Cost (Fatality-absent locations)	Number of Claims (Fatality-present locations)	Average Claim Cost (Fatality-present locations	Fatality-present to fatality-absent ratio	Significance of the difference between fatality present and fatality absent locations
50 km/h or below	No Control	33	88,312	5	72,256	0.82	non-significant
60 km/h	No Control	124	83,498	11	562,817	**6.74**	significant
60 km/h	Traffic Signals	211	75,718	37	65,698	0.87	significant

Note: Ratios >1.5 are in bold.

Discussion

The overall results of Study 1 present an extraordinary picture. Both views under consideration appear to be correct in particular circumstances. Of the 42 ratios computed, 27 were statistically significant and above 1. Of the 27 ratios above 1, 20 were above 1.5 and ranged between 1.66 and 13.27. That is, in 48% of the crash circumstances examined, injury costs at fatality-present locations were between 66% and 1327% greater than injury costs at fatality-absent locations, clearly supporting View 2, that fatal and injury crashes should be treated differently in prioritising safety treatments.

However, in four crash circumstances, the ratios were very close to 1 (including 0.98 and 1.00) and non-significant, indicating that there is no systematic difference in the severity of crashes at fatality-present versus fatality-absent locations. These ratios can be treated as indicating that the fatal crashes offer no practical prediction of severity of crashes beyond that offered by injury crashes. These cases support View 1.

Even more extraordinarily, there are clear and statistically significant circumstances where a fatal crash predicts the exact opposite. Of the 42 ratios computed, 10 were statistically significant and below 1. Of the 10 ratios below 1, only one ratio was below 0.5, at 0.41. This was for rear-end crashes at no traffic control intersection in 50km/h or below speed zone. In this crash circumstance, injury costs are almost 60% less at fatality-present locations than at fatality-absent locations. These cases support neither view, and the ratio of .42 is difficult to understand. (Speculative explanations are possible in terms of locations in high income areas, with safer cars, less dangerous behaviours but occasional fatalities due to older (retired) people living in wealthy area.)

Study 2 also produced mixed results even though sufficient sample size for statistical analysis only existed in 3 sub-studies. Unsurprising these were in urban speed zones. The significant result supported View 2, with injuries at fatality-present locations costing over 6.5 times injuries at fatality-absent locations. Study 2 may also be limited by the use of all pedestrian crashes due to available detail, whereas pedestrian crashes involve many types (walking from the opposite or near side of the road, emerging from behind a vehicle, walking along the road versus crossing, etc.).

The most obvious account of the broad range of results is simply that they represent random variation, due to the use of multiple tests or claim cost data which do not fully reflect injury severity. While the claim cost data are influenced by factors other than severity, injury severity is a major factor in cost. In addition, for a number of statistical reasons, random variation can be dismissed as an account. These effects are genuine, and in most instances of a size which is practically relevant. Thus, they demand explanation. Random variations may became statistically significant because many statistical tests were undertaken and .05 tests will be significant by chance. Of the 45 statistical test undertaken, at .05 probability we would expect 2 false positive results, whereas only 6 of the 45 tests over studies 1 and 2 were not significant. This is well beyond chance rate, indicating a legitimate though unexpected set of results. Finally, the results are not randomly distributed across crash types and speed zones. For example, rear end crashes and right turn crashes each have 4 instances of statistically significant results where fatalities predict lower claims costs, whereas hit fixed object and right angle crashes have none.

Conclusions

These results may be applied to identify which crashes should be assigned a higher weighting for fatal crash locations and for what crashes we should not in order to maximise the impacts of treatments. Based on this new evidence, there are some intersection types and crash types for which we should weight fatal crashes higher than injury crashes, and others for which there is no systematic difference and the crashes can be equally weighted, to increase the precisions of targeting of road safety engineering and behaviour changes interventions.

The present study may open the door to a range of additional investigations to comprehensively address this important issue of crash data usage. Extension of this work to non-intersection crashes and to a more comprehensive set of pedestrian crash types will be of value, to provide a more complete commentary on the circumstances in which fatalities should be and should not be given additional weighting.

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Regular linkage of crash and hospital data to inform the monitoring and evaluation of countermeasures on serious injury

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Abstract

New South Wales is targeting a 30 per cent reduction in serious injuries over the decade. This presentation outlines NSW's journey to develop and implement a serious injury reporting system which provides high quality data on all serious injuries from the hospital records, with details on the crash characteristics of those serious injuries that can be matched to a Police crash report.

This presentation also details the key results from the newly available data, how we are progressing on our target and how the availability of the data will impact on road safety policy and strategy in NSW.

Background

The NSW Road Safety Strategy 2012-2021, in line with the National Road Safety Strategy, has set a target of a 30 per cent reduction in serious injuries over the decade. It is therefore critical that serious injury data are available in order to influence the direction of the NSW Road Safety Strategy and the progress towards achieving its targets.

Method

In 2012 a commissioned study to identify serious injuries was undertaken using a data linkage process developed and conducted by Transport and Road Safety (TARS) Research, University of NSW. Following the success of this study, work began in 2013 on a project to refine the process and establish a regular data linkage between Police crash records and NSW hospital records.

The Centre for Road Safety has now established a quarterly process of matching crash data with hospital admissions for identification, monitoring and analysis of serious injuries. This provides high quality data on all serious injuries from the hospital records, and has details on the crash characteristics of those serious injuries that can be matched to a Police crash report.

Results

Data are now available for the ten-year period from 2005 to 2014. In 2014, just under 12,500 people were seriously injured on NSW roads.

The study found that some road-related serious injuries identified from hospital admission records were not reported to police or could not be linked to a police crash report. Overall, 61% of serious injuries identified in hospital admissions could be matched to police reports. Match rates varied considerably by road user type, from 22% for cyclists and 49% for motorcyclists, up to 86% for drivers. The reasons why some serious injuries could not be matched to police reports are under further research.

Over the ten-year period, annual serious injuries have increased by 11%, largely due to a 30% increase in serious injuries not matched to a police report. Serious injuries matched to a police report increased by 1% over the same period.

This presentation will outline some of the significant differences between the characteristics of fatalities and serious injuries. It will also discuss the costs of road trauma, the categorisation of non-fatal injuries according to severity and some work done to examine how jurisdictions around the world are addressing serious injury on our roads.

Discussion

The availability of serious injury data will enable us to better research and analyse road trauma and target road safety initiatives to reduce serious injuries, helping the Centre for Road Safety to fine tune infrastructure treatments, behavioural programs and other road safety initiatives.

Substance impaired driving education - a collaborative, systems approach to educating drivers to become responsible, informed, Safe Users

Anne Dowden[a] and Margaret Stevenson-Wright[b]

[a]Anne Dowdne REWA; [b] New Zealand Transport Agency

Abstract

The New Zealand Transport Agency led Substance Impaired Driving education project in New Zealand uses a collaborative systems approach to educating drivers to take personal responsibility and become Safe Users. Data shows that New Zealand drivers, their passengers and other road users are at far greater risk from substance impaired driving than previously thought. Current knowledge of substance impaired driving among drivers is low at a time when an increasing focus on health and safety requires responsible behaviour. The project reaches drivers through trusted influences (health professionals and others) using collaboratively developed education resources.

Project background and model

This project, led by NZ Transport Agency, is a collaborative partnership across Government Agencies and non-government organisations. This has enabled the project to formulate effective solutions, to access international and local evidence, and to reach and motivate stakeholders in a range of sectors so that they can educate drivers. Partners include Ministry of Transport, Ministry of Health, and New Zealand Police, Drug Foundation, Royal New Zealand College of GPs, Pharmaceutical Society, and Automobile Association.

New Zealand drivers, their passengers and other road users are at risk from substance impaired driving from drugs and medications used with or without alcohol. These risks include; death, serious injury, loss of reputation, criminal conviction, suspension or revocation of their drivers' licence(s) and loss of employment (where it is driving based or commuting becomes untenable).

The Substance Impaired Driving project engages with stakeholders as trusted influencers of drivers who can educate and inform drivers to take personal responsibility. The project worked with trusted influencers to develop education resources that are persuasive and motivate change in influencers' behaviour and the drivers that they influence.

The project model, in its entirety, contributes towards Safe Users who are educated at school as they become learner drivers, educated by their health professionals when they are prescribed potentially impairing medications, advised by their employers as it relates to health and safety (with an initial focus on the Heavy Transport sector), and informed by their local traffic Police whose roles include education, detection and enforcement.

The Substance Impaired Driving project in New Zealand initially focused on engaging health professionals to educate their clients/patients at risk of substance impaired driving.

Following the development of resources for health professionals and their clients/patients, piloting in health services showed that the resources would be used and can contribute to increased driver knowledge and responsible driver behaviours. The education of drivers uses an interactive resource that covers the law, their current medications, whether these can impair, signs of impairment, when and whether they can drive (or drink alcohol and drive) safely while taking their medications.

These education resources are being rolled out to the health sector with support of project partners, and further collaboration is underway with the Heavy Transport sector to develop fit for purpose education for this sector.

Key learnings

Key learnings of the Substance Impaired Driving project include:

- Collaboration has enabled access to a far stronger evidence base.
- New Zealand stakeholders highly value, and are motivated by, New Zealand evidence.
- Mining administrative datasets provides startling evidence for informing change across the Safe Road System.
- Collaboration enhances stakeholder ownership and enables relevant and effective solutions.
- The appearance of collaboration (through multiple endorsements of education resources, for example) strengthens the messages and motivates stakeholders to participate in the solution.
- Knowledge levels about this emergent topic are very low across most stakeholders groups, especially drivers, such that access to educative resources that promote personal responsibility may be a particularly effective, and cost effective, solution.

Let's CHAT about a whole school approach to road safety and health

Mick Jackson Pierce

School Drug Education and Road Aware (SDERA, Western Australia)

Background

Changing Health Acting Together (CHAT) is a School Drug Education and Road Aware (SDERA) initiative. SDERA is the Western Australian Government's primary drug and road safety education strategy for children and young people. To date, 103 primary and secondary, metropolitan and regional schools are involved in CHAT which includes in-school support guiding schools to develop a best practice whole-school approach to road safety, drug and resilience education, and to holistically examine student safety and wellbeing. Research clearly indicates that a whole-school approach to any safety/health related issue, where schools, parents and communities work together, can produce the best health outcomes.

Evaluation

In 2013 SDERA commissioned Edith Cowan University to conduct a process evaluation of the CHAT initiative. The purpose of the evaluation was to describe observed changes to whole school policies, practices and environments in schools participating in the CHAT initiative. Changes were observed and recorded by SDERA, school teams, staff, parents and students.

Presentation

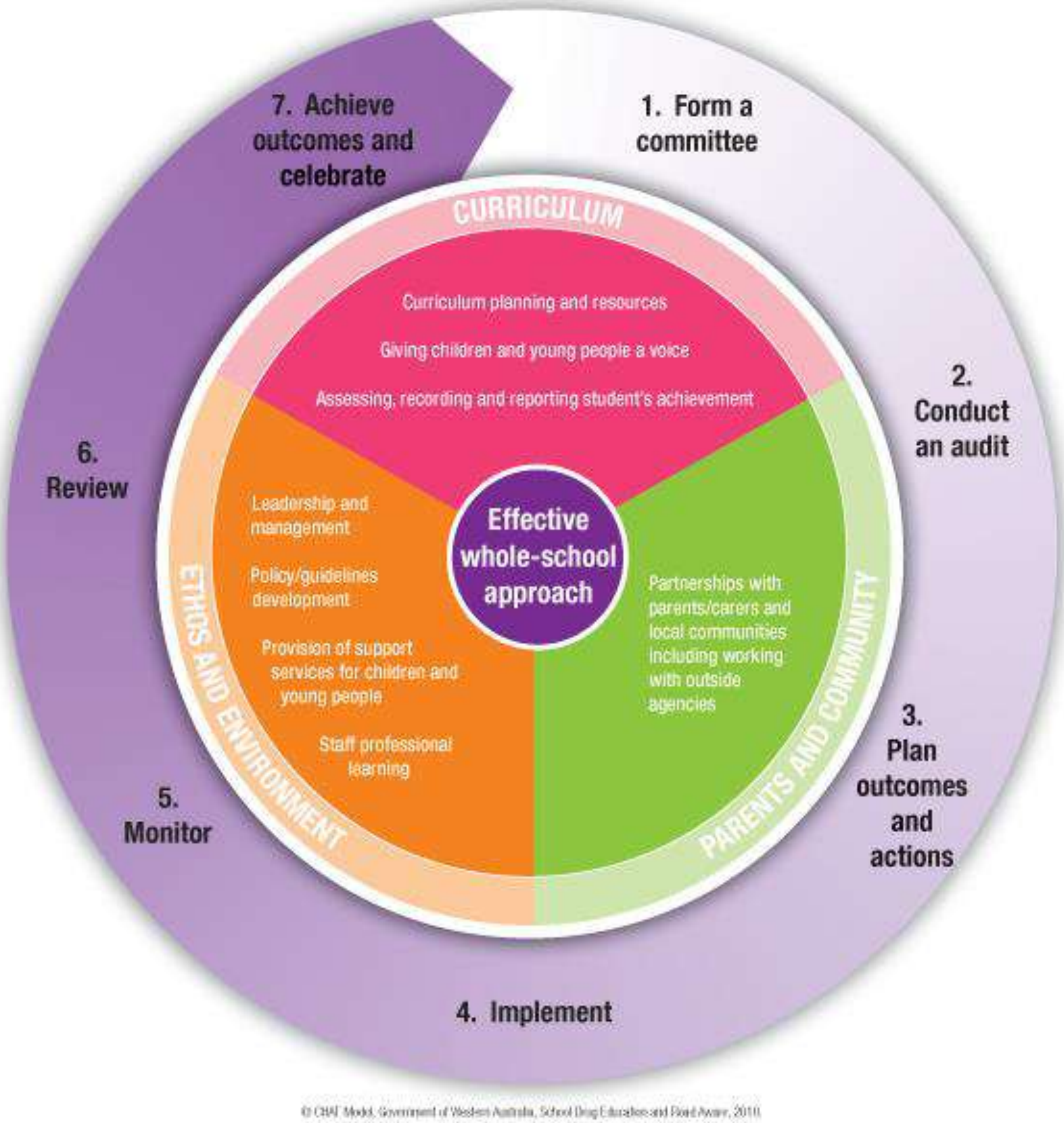
This presentation will describe the CHAT approach to whole school engagement; report on the key findings of the evaluation and explore how the findings impact on plans for developing a sustainable model for the implementation of a whole school approach to student health.

Benefits of the CHAT initiative

- development of policy and school guidelines for road safety, drug and resilience
- positive changes in the school culture
- improved student participation
- improved partnerships with parents
- a method for formalising processes and increasing collaboration with other schools and services
- opportunities for, and increased participation in, professional learning for teachers
- management principles that build human, organisational and social capital within the schools
- improvements to the social environment that can have a positive impact on students' safety and well being including their mental health, smoking and alcohol intake, and road safety practices.

The CHAT Model

The CHAT Model (below) demonstrates key elements of the Health Promoting School (HPS) framework that contribute to an effective whole school approach and how the model is used to assist schools to understand how their work can achieve best practice in the three HPS areas and clearly see the steps in the process they will work toward with guidance and support from SDERA staff.



CHAT Model ((Changing Health Acting Together Model), Government of Western Australia, School Drug Education and Road Aware (SDERA) 2010

Results

The majority of schools had implemented to a high standard, the first three steps of the CHAT seven step implementation process, with schools showing improvement at implementing steps 4-7 by the time they are working towards Gold. The majority of schools had implemented the first three steps comprised in the CHAT implementation process to high levels, with Gold schools having completed more fully the remaining steps than Bronze schools.

Most schools moderately agreed they had planned, implemented and monitored CHAT targets and activities across each of the three components of the CHAT Model, with higher agreement reported by Gold, compared to Bronze schools.

Qualitative evidence confirmed schools had used the CHAT implementation process to guide their implementation of activities to build resilience, drug and road safety education.

"It's just been a great model of how to do a whole-school approach effectively, because we've started from number one and we're still going around and around, because we're always reviewing and monitoring, it's been a really good process to refer to." [CHAT School]

The CHAT initiative has provided a process and guided framework for action in resilience, drug and road safety education through the establishment of leadership support and a school team to drive planning, implementation and evaluation.

"The main strengths of CHAT are the scaffolding. It actually has a complete structure but also it gives the schools flexibility within that structure." [CHAT School]

Likely sustainability of a child restraint program among Aboriginal and Torres Strait Islander children in 12 communities in NSW

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Abstract

Aboriginal and Torres Strait Islander children are over-represented in road related deaths and serious injury. *Buckle-Up Safely* was developed to work in partnership with twelve Aboriginal and Torres Strait Islander communities in New South Wales to promote correct use of appropriate restraints. An important element of a community-based program is to ensure that it is tailored to suit the needs of the community and that it is part of a long-term strategy. *Buckle-Up Safely* adheres to these aspects, ensuring that the program promotes strong community engagement and program ownership.

Background

In Australia, road related fatality rates for Aboriginal and Torres Strait Islander children aged 0-4 years are 4 times higher than for other Australian children the same age.(Henley G & Harrison JE, 2013) Children are less likely to be severely injured in a car crash if they are restrained in an age-appropriate car restraint, used correctly.(Brown & Bilston, 2006) Injury prevention programs have the ability to be more effective when they are: tailored to the needs of the community, part of a long-term strategy, led effectively, and part of a multi-agency collaboration.(Jamieson et al., 2012; Martiniuk, Ivers, Senserrick, Boufous, & Clapham, 2010) For this reason strong community engagement – Elders, local organisations and members of the community, linking in with existing services and resources has been an emphasis of the *Buckle-Up Safely* program.

Aim

The paper describes the program and its potential for sustainability.

Method

Buckle-Up Safely is a multi-faceted program providing various avenues of access to education and resources through the delivery of information and coordination of current Government funded and non-government services. Program elements include: parent and carer information sessions; preschool or childcare based professional development workshops; access to free restraint checks/fittings and, access to highly subsidised child restraints.

Program delivery is guided by the community and coordinated by a locally employed Community Worker recognising their local knowledge to tailor and adapt the program.

Based upon the Precaution, Adoption Process Model, program elements target key stages of the behaviour change model.(Neil D. Weinstein, Peter. M. Sandman, & Susan. J. Blalock,

2008) Information is first targeted to help parents become aware of the importance of and safety benefits associated with using child restraints, then focuses to help parents consider using restraints, leading to correctly using restraints with every car trip.

Governance and Sustainability

Buckle-Up Safely is overseen by a Steering Committee comprising representatives from local Aboriginal Community Controlled Organisations, key government and non-government organisations, providing an opportunity to develop ongoing relationships between those responsible for service delivery at the local level, policy makers and statewide service providers. A key strength of *Buckle-Up Safely* is that it brings together existing services and resources, paving the way for key program elements to extend beyond the project's funded life.

Conclusions

Buckle-Up Safely develops local capacity to enable delivery of a program for Aboriginal and Torres Strait Islander populations in communities throughout New South Wales. The program gains its strength and sustainability from the participation and input of local individuals within each of the sites. *Buckle-Up Safely* will be fully evaluated by December 2016.

Acknowledgements

The authors acknowledge the work and commitment of all the local Aboriginal Community Controlled Organisations involved in this project and the Aboriginal and Torres Strait Islander people who have worked as Research Assistants and Community Workers. This project is funded by NSW Health Aboriginal Injury Prevention Demonstration Grants Scheme and Transport for NSW. Dr Hunter is supported by a Post-doctoral Research Fellowship with The Poche Centre for Indigenous Health.

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Evaluation of Keys for Life Pre-driver Education

Deb Zines

School Drug Education and Road Aware (SDERA, Western Australia)

Abstract

Keys for Life is a School Drug Education and Road Aware (SDERA) initiative embedded in Western Australia's Licensing and School Graduation systems. A 2015 evaluation revealed over 60% of secondary schools are consistently implementing the 10-lesson program. Teachers, parents, students and stakeholders responded positively on a range of measures about program efficacy and about engaging in more than the legislated supervised driving hours. The program provides a best practice model by including, evidence-based curriculum, professional learning, assessment, parent initiatives and connections to Government policies.

Background

In 2015 SDERA commissioned Metrix Consulting to conduct an impact evaluation of the *Keys for Life* (K4L) pre-driver program to compare results with a 2008 evaluation, improve program uptake and meet funding requirements. The purpose was to determine how SDERA can make it easier for schools to engage with and deliver road safety education, with the intended outcome being to increase school and student participation, identify barriers to uptake and measure knowledge and intentions. The K4L program (described in part in figure 1) includes professional learning; support material and a policy framework to help schools implement and assess a 10-lesson road safety program and tailor it to local and student needs; student assessment; and a parent component. It is underpinned by the Health Promoting School framework and research about best practice in road safety education; and connected to the WA Curriculum and Licensing systems.

The evaluation aimed to measure and understand the number of schools implementing the program (2004 to 2015), how the program can be improved for schools and teachers to implement; and the impact of the program on student and parent knowledge and intentions about supervised driving.

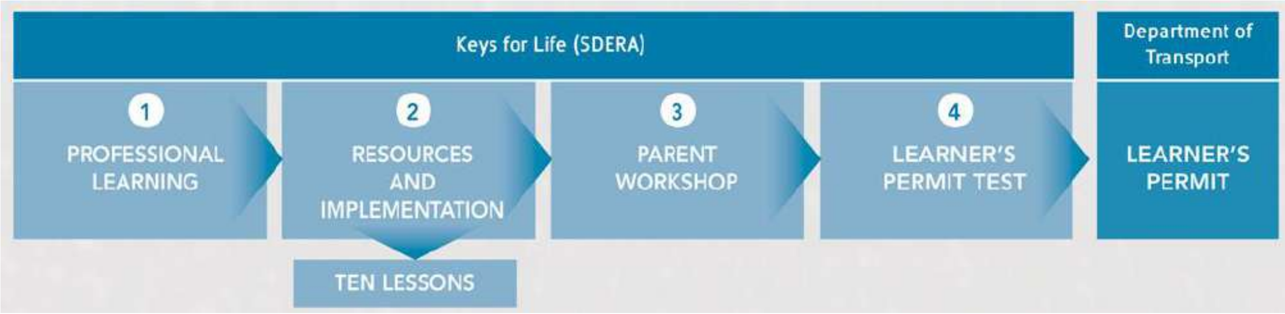

Figure 1. Keys for Life **Implementation Model**

Methodology

Participating teachers, parents and students were surveyed about knowledge, intentions and perceptions; principals, stakeholders and SDERA consultants were consulted about program optimisation; and 12-year implementation data was analysed. The feedback from parents and students also included measures about intended supervised driving hours.

Results

Overall the evaluation reflected positively on a range of measures including learning materials, student and parent knowledge and intentions about supervised driving, and the model of consultancy support. There was a reported high intention (80%) among lapsed and non-engaged schools to deliver the program; a very high intention (96%) among engaged schools to continue to deliver the program; a high level of road safety knowledge among teachers following proffesional learning; a high level of intention (84 to 89%) among students and parents regarding an increased commitment to extensive supervised driving for learner drivers; a high level of satisfaction with the program, resources, professional learning and its benefits; and a high level of satisfaction with service providers collaborating to offer complementary activities leading to a coordinated and best practice approach to road safety education in participating schools.

While 97% of teachers recommend the program highly and over 60% of schools implement annually, the greatest challenges are to engage more parents; sustain and increase school implementation; and regularly refine the learning materials and management information system.

Conclusions

The evaluation aimed to measure school and student participation in the Keys for Life program as well as a shift in student and parent knowledge and intentions relating to extensive driving practice and driving risks. The evaluation also aimed to measure the impact of various enablers and barriers effecting the uptake of the program in schools

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Telematics, a tool which is just another element in a safety management system

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Abstract

The use of telematics continues to grow throughout the Australian transportation industry as operators hope to take advantage of the operational and safety benefits of utilising these technologies.

This paper will explore how telematics should be treated as just another component in a safety management system and proper implementation is crucial in strengthening an organisations road safety culture. To do this, the National Road Safety Partnership Program (NRSPP) will apply a case study and consultative methodology with leading figures from the transport industry – including operators, drivers, insurers, technology providers and researchers.

NRSPP will explore the benefits of these technologies; requirements for effective implementation; and their place within an organisation's overall operations and safety management system.

Background

While the external environments facing light and heavy vehicle fleet operators differ, operational efficiency and organisational safety are two areas all operators can target to maintain a competitive edge and growth.

Rapid technological evolution has led to a diverse array of increasingly affordable telematics implementations marketed by a growing number of suppliers in Australia. The range of telematics available can include GPS tracking, accelerometers, connection to a vehicle computer to monitor seatbelt use, Electronic Stability Control (ESC) and other parameters, forward and in-cabin cameras, including in-cabin audio recording (IVCS), fatigue management compliance to name a few. With such a broad range of technological tools becoming available the operators can become concerned the focus is on 'big brother' and not improving safety. The attitude of operators is entirely dependent upon how the telematics systems are implemented and their supporting systems.

Method

The NRSPP conducted extensive consultation through 20 one-on-one interviews with a range leading figures from the transport industry. Those consulted included operators, insurers, technology providers and researchers. These interviews sought to take advantage of the different experiences and perspectives to develop a well rounded understanding of telematics on the ground in Australia and pathways for further use into the future. Of the 20 organisations interviewed, 10 expanded on case studies available on the NRSPP website and cited in Discussion Paper: In-Vehicle Monitoring Systems (IVMS): Safety through good practice telematics.

Results

All consulted spoke in positive terms regarding the potential for telematics to provide significant benefits to an organisation if properly implemented. There was consensus in the view that it should not be seen as a 'silver' bullet, but rather as an effective tool if well integrated into an organisation's operational and safety systems.

Key findings included:

- Bottom line benefits include increased fuel efficiency and reduced maintenance and incidents, resulting in lower insurance premiums and downtime costs. Productivity was also enhanced through efficient real-time resource allocation.
- Safety benefits were seen in improved driver compliance and behaviour, through tailored training and counselling possible through data collected by telematics.
- The provision of real time location of a vehicle information to customers regarding deliveries thereby taking the pressure of drivers being contacted directly for delivery status and the receiver can be prepared.
- Critical aspects of implementation include consultation of the workforce (in most cases, drivers) about program introduction, explanation of how telematics could improve safety and reduce workload and the provision of opportunities for feedback. All of this was crucial to avoid 'Big Brother' perceptions.
- In selecting telematics systems organisations must have a clear understanding of their objectives in order to select a system that will meet their needs. Providers can assist in this process.
- Effective management of the information collected is crucial. Accountability, consistency and regular review are hallmarks of effective information management.

Good Practice Implementation: Five key considerations

The importance of implementation was continually emphasised by those consulted. Synthesis of these consultations identified five key stages required to ensure the successful implementation of telematics. The implementation stages include:

1. Clearly defined goals – consider what is the problem to be solved? What are your expectations? What technology best fits the purpose?
2. Consider current and future needs when selecting the technology, especially its limitations.
3. Building employee acceptance – bridge the gap, drivers interact with the technology in the vehicle and with management. They need to be part of the journey and develop strategies that get their buy-in.
4. Real-time monitoring & feedback – explore the driver and operator side and how both can benefit
5. Management of feedback – consider how the data is going too managed, education opportunities and there must be accountability throughout the organisation for it. Importantly, complacency must not occur, drivers need feedback and coaching where applicable must be taken.

Benefits of good practice implementation

NRSPP engaged with operators of both light and heavy vehicle fleets for a first-hand account of their experiences with implementing telematics. Despite differences in fleet types and difficulties in quantifying exact benefits, where good practice implementation had occurred there were substantial crossovers in the benefits reported by operators.

Conclusions

Telematics can have an enormous safety benefits but should be treated as another tool which is part of an organisation's safety management system. It can be a powerful tool when properly implemented but it can also be a costly mistake if not properly integrated.

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European TeleFOT Project: Benefit-Cost Analysis SatNav and EcoDrive Technologies

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Abstract

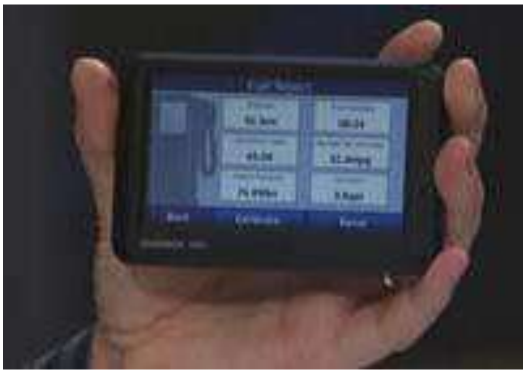
Calculation of benefit-cost-ratios (BCRs) is a commonly used methodology by governments in determining the need for future regulation. This study was undertaken as part of the European Commission's field trial TeleFOT program provided new findings on the likely benefit-cost safety and environmental outcomes for satellite navigation (SatNav) and (EcoDrive) technologies in Europe. The findings showed that for a range of scenarios, the best benefit-cost-ratio for SatNav was markedly above its economic cost (BCR>1). While a BCR for EcoDrive could not be calculated because of missing data, the fitment rates required to achieve a break-even outcome were quite achievable. The figures for the worst scenario outcomes were less impressive, generally failing to achieve break-even (BCRs less than one) or required higher fitment rates. BCRs for both technologies combined showed ratios between 3.16 and 2.78, assuming a 5% EcoDrive fitment rate.

Background

A major European Commission's Field Operational Trials research program (TeleFOT project) set out to assess the likely crash and environment benefits for a range of add-on technologies (devices used by drivers within their vehicle that come with their own mounting cradles). Two of these, the after-market Satellite Navigation devices (SatNav) and fuel and gas monitirs (EcoDriving) were of special interest. SatNav devices are becoming increasingly popular among all drivers; useful for finding a location in an unfamiliar area for all drivers. EcoDriving technology was shown to improve driver performance from increased vehicle efficiencies in fuel economy and reductions in CO2 emmissions in the TeleFOT trials.

The performance results of both these technologies were subjected to a benefit-cost-analysis (BCA) to show their likely benefits-to-cost ratios (BCRs) to identify the need for future regulatory action by governments. BCA is commonly used by governments and industries to show the likely safety and environmental reductions for new technologies in vehicles and is a necessary and important process in determining the need to introduce and mandate new technologies in today's vehicles.

Satellite Navigation (SatNav)



EcoDrive Technology

Method

TeleFOT (Field Operational Tests of Aftermarket and Nomadic Devices in Vehicles) project was a large scale collaborative project under the Seventh Framework Programme of the European Commission that run from 2008 to 2012. The project collect vehicle and driver on-road driving performance data comprising 100 man-years of travel data over 48 months, involving 3,000 drivers in seven European countries. From these data, assessments were made of the likely benefits of these two technologies, based on vehicle and mileage fleets, fitment rates of these devices, average distances used with these devices active, impact on distance travelled, and reductions in emissions. For both technologies, the BCRs were constrained to only passenger vehicles.

A number of assumptions based on field observations and published data were made in this analysis across all European countries for all passenger car vehicles. They included expected European annual mileage, SatNav usage rates, eco driving exposure, average trip length (km) saved per trip, costs per Km, CO_2 emission reductions, ecodrive fuel savings, monetary discount rates. Equipment costs were computed from a range of commercially available technologies, assuming a driver's likely willingness to pay for these devices.

Results

BCRs were only computed for SatNav as fitment rates could not be estimated for EcoDrive. In computing the potential BCRs for these two devices, the results were expressed in two ways; the best achievable outcome (BEST or most ambitious benefits) and the least or worst achievable outcome (WORST or minimal benefits), based on variations of the assumptions. Benefits for EcoDrive were expressed as the fitment rate required for break-even cost. The economic cost of SatNav was calculated to be €112.00 (A$174).

Table 1: BCRs for SatNav, and fitment Rates for EcoDrive to achieve break by discount rate

Discount Rates**	Satellite Navigation (SatNav)		EcoDrive*	
	Best Case	Worst Case	Best Case	Worst Case
3% discount	2.5	0.5	11.8%	23.7%
5% discount	2.34	0.47	12.6%	25.2%
7% discount	2.15	0.44	13.4%	26.9%

*Fitment rates were unknown for Eco Driving but figures show what a fitment rate for breakeven BCR would need be for EcoDrive
**Discount rates assume future money is valued less than current due to inflationary effects.

These figures show a Best Case BCR for SatNav of between 2.5 and 2.15 depending on what discount rate is adopted. A best case break-even rate for EcoDrive where benefit=cost would require a fitment rate for the technology of between 11.8% and 13.4%. If both technologies were combined, a best case BCR would be between 3.16 and 2.78, assuming a modest 5% fitment rate for EcoDrive, as shown in Table 2.

Table 2: BEST and WORST Scenarios for SatNav and EcoDrive combined

Estimated Outcome	Best Case	Worst Case
3% discount	3.16	0.73
5% discount	2.97	0.68
7% discount	2.78	0.64

Combined Benefit-Cost-Rates assume a 5% fitment rate and a 10% fuel saving for EcoDrive

Conclusions

This study undertaken as part of the TeleFOT project provided new findings on the potential cost effectiveness for SatNav and EcoDrive in Europe, used both independently and in combination. At **best**, SatNav showed a BCR greater than 2:1 (Benefit:Cost). While fitment rates could not be estimated from the data provided, anything greater that a 12% rate would be cost-beneficial for EcoDrive. Assuming a modest 5% fitment rate for EcoDrive, combinations of these two technologies at **best** would have a BCR around 3:1. The figures for the **worst** outcome were less impressive and generally failed to break-even (BCR less than one).

A number of additional indirect benefits were also identified that, if costed, would show even greater benefits than claimed here. Moreover, it is expected that if the fitment rates for these technologies were to increase, or the costs were to reduce with increases in their use, the likely BCRs would also substantially improve. While this study focussed only on passenger vehicles, given their greater use in buses and commercial heavy goods vehicles, these BCRs are likely to be quite conservative.

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An examination of the effectiveness and acceptability of mobile phone blocking technology among drivers of corporate fleet vehicles

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Abstract

There is technology available that can block mobile phones while driving. The aim of this research was to determine if mobile phone blocking technology is an effective and acceptable method for reducing driver distraction among drivers of corporate fleet vehicles. Two different technologies were assessed: one required software to be installed on mobile phones, while the other technology used software in addition to external Bluetooth hardware that paired with the phones. A sample of 104 study participants who regularly drove a corporate fleet vehicle were recruited through a major corporation in South Australia. Each participant experienced one of the two technologies, and their opinions on the technology and phone use while driving were assessed using pre- and post-trial questionnaires. A majority of participants reported that phone blocking was not reliable but a majority nonetheless considered the technology they trialed to be an effective way of preventing phone use while driving. Mobile phone blocking technologies may provide a useful method of changing mobile phone use behaviour while driving. However, product improvements are needed to reach higher ratings of user acceptance and approval.

Background

It is widely recognised by safety researchers that mobile phone use affects driving performance because it places considerable cognitive demands on the driver, drawing attentional resources away from the driving task. Indeed, there is evidence suggesting that mobile phone use while driving increases the risk of a crash (Dingus et al., 2016; Elvik, 2011; McEvoy et al., 2005). McEvoy et al. (2005), in one of the most notable Australian studies in this area, examined the mobile phone records of crash-involved drivers and found that a driver is four times more likely to have a crash resulting in injury when using a mobile phone, irrespective of the handset used. A more recent study by McEvoy et al. (2007) involved interviews with hospital-treated drivers in Western Australia and found that 30 percent of drivers were distracted prior to the crash, including two percent who were using a mobile phone. Elvik (2011) undertook a meta-analysis of studies examining crash risk and phone use. Elvik noted that methodological issues had resulted in heterogeneous results but nonetheless determined a point estimate of an increased risk of a crash when using a mobile phone of 2.9.

In a more recent study, Dingus et al. (2016) analysed 905 crashes in a naturalistic driving study in the US. They found an increased odds ratio for various forms of hand held phone use in crash incidents, including: browsing on a mobile phone, dialing a phone, reaching for a phone, sending a text, and speaking on a phone. The overall odds ratio for hand held phone use in the crashes was 3.6 (95% confidence limits of 2.9 to 4.5) (Dingus et al., 2016).

The most common response to this issue has been to ban phone use while driving and utilise enforcement of these laws to reduce its prevalence. An important question then becomes whether laws against using a phone while driving are effective at reducing phone use and associated crashes. In their review of this literature, Kircher, Pattern and Ahlstrom (2011) of VTI in Sweden concluded that bans on phone use while driving tend to produce compliance in the first year but that phone use frequency returns to baseline levels after that. The review of EU states by Janitzek, Brenck, Jamson, Carsten and Eksler (2010) also found that the severity of penalties had no effect on self-reported phone use rates while driving, and that self-reported use rates were also similar in countries with and without phone ban legislation. It is possible, however, that these findings all reflect insufficient enforcement.

Another interesting finding emerged from a naturalistic driving study of commercial truck drivers in the US (Hickman & Hanowski, 2010; Hickman, Hanowski, Camden & Alvarez, 2011). It was found that drivers' levels of mobile phone use while driving were consistent with fleet or company rules rather than with state legislation. This suggests that there is the capacity for fleet managers to influence drivers' mobile phone use more effectively than legislators. There are Australian corporations that have enacted or are considering enacting mobile phone bans for their vehicle fleet (Small, Bailey & Lydon, 2013), including the South Australian Department of Planning, Transport and Infrastructure. As occupational health and safety requirements are becomingly increasingly stringent, it is likely that preventing phone use by drivers of fleet vehicles can be accomplished using work health and safety (WHS) policies or regulations.

Given the equivocal findings of research into the outcomes of legislation prohibiting various forms of mobile phone use while driving, consideration needs to be given to alternative methods of controlling phone use. One option is to use technological means to restrict mobile phone operation when people are driving.

The *South Australian Road Safety Action Plan 2013-2016* has outlined a considerable number of key actions to help reduce serious casualties by at least 30 percent by 2020. One such action is to "Promote voluntary use of technology solutions that block incoming phone calls and messages while driving". The South Australian Motor Accident Commission (MAC) contracted the Centre for Automotive Safety Research to identify and evaluate a few of the more promising technologies.

Thirty-three products were briefly reviewed based on information available from publicity material on the Internet or details on 'app' (software application) stores. Around 21 products were claimed to be able to block incoming phone calls and messages. These were predominantly effective on Android based smart phones, while only a few products were claimed to be able to block incoming phone calls and messages on both iPhones and Android-based smart phones.

The aim of this study was to assess the performance of two phone blocking products in a field trial using a corporate vehicle fleet. With the assistance of MAC, a large South Australian corporation accepted an invitation to be involved in the study, permitting access to their staff as a potential source of volunteers to trial two different phone blocking technologies. Study participants were asked to report their attitudes and behaviour with regard to phone use while driving, and their impressions of the phone blocking technologies they experienced in the trial.

Method

Participants

Participants were recruited through a major corporation based in South Australia. The corporation assisted with promoting the project to its staff and organised information sessions at which CASR project team members described the study, explained how the various technologies worked, and invited staff to participate. Staff were reassured that their involvement in the study was voluntary and that they were free to withdraw at any time. Additionally, staff members were assured that if they participated they would remain anonymous, and that the corporation would not be informed who did or did not volunteer to participate. A total of 150 staff members registered an interest in being involved in the trial. Full participation in the study required a completed consent form and completion of both the pre- and post-trial surveys. Once those who did not meet these requirements were eliminated, the sample reduced to 104 (97 males, 7 females; age range 25-66, mean=48.9, *SD*=9.1). The sample included employees in a range of roles within the organisation, including corporate, technical, fieldwork, IT, and customer-focused. Each of the participants had work-issued and supported Apple iPhone 5C mobile phones operating on iOS 8 software or above. As one of the technologies being examined required a hardware device fitted to the vehicle, that technology was trialed on staff members with access to their own fleet vehicle. There were 28 participants who trialed the hardware technology, with the remaining 76 trialing the technology which was software-based only.

Materials

Phone blocking technologies

There were two technologies assessed in this trial, which will hereafter be referred to as Technology A and Technology B. Technology A was a proprietary software application ('app') that is downloaded onto a mobile phone. Once the software is activated, it relies on the phone's GPS as an internal 'trigger' to activate the software's phone blocking features (blocking calls, texts, app use). Blocking is triggered in this way when the phone is determined to be travelling above a threshold speed (approximately 20 km/h) for at least a minute.

Technology B also requires proprietary software downloaded onto the phone but uses a hardware trigger to activate the software's phone blocking features. This hardware, which was mounted to the windscreen of each participant's vehicle, communicates with the participant's phone via a forced Bluetooth connection. The hardware incorporates both an accelerometer and GPS to detect vehicle motion and once a speed threshold (approximately 20 km/h) is exceeded, it communicates to the phone and software via Bluetooth, activating blocking of the phone equipped with matching software and 'paired' with the device.

Both technologies work on iPhones (in addition to Android based phones), which was important for the project, as the work phones provided to participants by their organisation were all iPhones.

Technology A, when in blocking mode, silences phone calls and SMS texts (although vibration notifications still occur if not specifically disabled). Phone calls can be answered but this is reported as a violation in an associated web-based monitoring portal, and the user is given a written warning on the phone screen. The software thwarts (or 'blocks') phone use by returning the user to the mobile phone's lock screen (with an accompanied written warning on the screen) when any attempt at unlocking the phone occurs. All phone use attempts are reported as violations in the web-based monitoring portal. When in blocking mode, phone calls cannot be made, SMS texts cannot be sent, SMS texts can be received and can appear on the phone screen (if the phone is set to do so), but cannot be answered, and other apps cannot be used (except for permitted navigation software).

Hands free calls can be made using voice recognition ('Siri' on the iPhone). There is an emergency button, which can be used to dial '000'. As Technology A activates blocking on the basis of movement of the phone, it activates on public transport or on a bicycle, or as a passenger in a vehicle. There is a passenger override button that can be accessed and used to remove the blocking once it has commenced. When the phone ceases moving for more than a minute, blocking automatically ceases. This delay in blocking termination is set to avoid phone use during intermittent vehicle stops, such as at traffic lights or during congestion. However, an 'end of drive' button can be accessed to remove blocking immediately after cessation of driving.

If the software is deactivated at any time by 'swiping' if off, a single written warning is given to the phone user and the software remains inactive until it is activated again manually by the user or automatically (with an extended delay) through a function in the software. Software activity or inactivity is monitored by the web-portal on a central server, which attempts communication with the phone/software on a daily basis.

Technology B only operates when in the presence of a hardware device with which it has been paired. When the app is opened for the first time, it searches for a hardware device using Bluetooth and when it finds one, the person with the phone is asked to authorise pairing. After the initial pairing, the software forces Bluetooth and this cannot be deactivated on the phone unless the software is removed. When in blocking mode, Technology B prevents phone calls from being answered by intercepting incoming calls (sometimes after a one ring delay) and diverting them to message bank. Additionally, the driver receives an audio message on the phone's speaker indicating that a call from a particular number or person has been blocked. A software dispatched SMS text is also sent to the caller notifying them that the person they are calling is driving. In a similar manner to Technology A, Technology B blocks phone use by returning the user to the mobile phone's lock screen (with an accompanied written warning on the screen), when any attempt at unlocking the phone occurs. Hence, phone calls cannot be made, SMS texts can be received and may appear briefly on the phone screen (if the phone is set to do so), but SMS texts cannot be answered and texts cannot be sent.

Music and navigation apps still work but all apps can be blocked if required. There is a passenger override button. If a phone call is made while stationary, the technology also terminates any phone calls once the hardware device and paired phone begin moving in the vehicle. The phone continues to block for around 30 seconds after a drive has ended (again to avoid phone use during intermittent vehicle stops) but there is a 'fast release' button to end blocking immediately after the end of a trip. If the software is deactivated at anytime by 'swiping' if off, a persistent written warning is given to the phone user until the software is re-activated. Phone use attempts are also reported as violations on a web-based monitoring portal, in addition to other driver metrics. There were difficulties in obtaining sufficient Technology B hardware units for the study in a timely manner, so only 28 units were able to be trialed.

Neither app is required to be open and on-screen for their blocking functions to be active; they can run in the background. However, once in blocking mode, the app override features (such as passenger mode or end of trip) can only be accessed by forcing a block (tampering with the phone), and then swiping the warning message presented by the app. A phone power down may require the re-starting of the app.

Questionnaires

Two questionnaires were used for this study: one administered to participants before the phone blocking trial and one administered post-trial. The pre-trial questionnaire consisted of 28 items. The first four items consisted of demographics, items 5 to 13 were concerned with attitudes to use of a mobile phone while driving, items 14 to 21 were concerned with self-reported phone use while driving, and items 22 to 28 were concerned with perceptions regarding the use of phone blocking technology to prevent phone use while driving. All items were scored on a seven point Likert scale from 'Strongly disagree' to 'Strongly agree' (Q 5-13 and 22-28) or from 'Every time I drive' to 'Never' (Q14-21).

Items for attitudes to phone use while driving included references to hand-held and hands-free phone use, sending and reading text messages, and the person themselves versus a 'typical driver'. Sample items are: 'It would be dangerous for me to have a 'hands-freee' phone conversation on my mobile phone while driving' (Q5) and 'It is dangerous for a typical driver to send a text message while driving' (Q12). Items for self-reported phone use referred to making and answering calls, and sending and reading text messages, and made a distinction between the use of a work vehicle and the person's own vehicle. Sample items include: 'How often do you answer a phone call while driving a work vehicle?' (Q16) and 'How often do you receive and read a text message while driving your own vehicle for non-work purposes?' (Q21). Items concerned with phone blocking technology assessed beliefs about its effect on safety and its deleterious effects on work. Sample items include: 'I think mobile phone blocking technology would make me a safer driver' (Q23) and 'I think that not being able to communicate with others using my mobile phone while driving will make work more stressful' (Q25).

The post-trial questionnaire used a number of items from the pre-trial questionnaire. Items 1 to 13 remained the same (demographics and attitudes to phone use while driving). Items 14 to 21 (self-reported phone use while driving) remained the same but asked about behaviour during the phone blocking trial. A sample item is: 'How often during the trial did you answer a phone call while driving a work vehicle?' (Q16). Items 22 to 28 (beliefs about phone blocking technology) also remained but were reframed in terms of experiences of the technology during the trial. A sample item is: 'The phone blocking technology I experienced during the trial made me a safer driver' (Q23). Additional items asked about other aspects of the experience of the phone blocking technology. Examples included 'I was able to override the phone blocking technology when I needed to' (Q34), 'I was prevented from using my mobile phone by the technology when I should not have been' (Q36) and 'the phone blocking technology depleted my phone battery to a degree that caused me incovenience' (Q38). Finally, participants were invited to give the technology a rating on a scale of 0 (very poor) to excellent (10) and to make their own free text comments at the end about the technology they trialed.

Procedure

The organisation assisting us with the project set up recruitment sessions at their head office and metropolitan branches around Adelaide. A CASR project team member delivered a presentation about the trial and the two technologies. Those interested in being involved were provided with a consent form, information sheet and the pre-trial paper-based questionnaire and reply paid return envelope. Instructions were given on how to download and activate Technology A. Technology B required drivers with access to their own company car rather than a pool vehicle, and so specific staff members were invited to information sessions about Technology B. Those interested were given a hardware device, paired to their own phone, to install in their vehicle. Instructions were given for how to install the device.

During the recruitment sessions participants were told that the technologies would be operational 24 hours a day on weekdays only, and would not be operational on weekends. Also during these sessions, a discussion on what to expect from each of the blocking technologies was supplemented with example videos that demonstrated how the particular technology should work on their phones under different driving scenarios. This included what to expect with incoming call/text scenarios and attempts to make calls/texts while driving, and how to use passenger mode/end of trip mode. Additionally, information sheets re-iterating some of the presented information (including operating hours), and information sheets relating to the specific technologies from the technology providers were also distributed.

The trial lasted in each case for one month (November 2015). As the technologies were set only to block phones on weekdays, this gave a maximum of 22 days of blocking. Phones were blocked for the full 24 hours on these days. After the month long trial ended, invitations to complete an online (Survey Monkey) post-trial survey were sent to participants' email addresses. All participants who completed both the pre- and post-trial questionnaires were entered into a draw to win an iPad.

During the blocking trial it was noted within the web administration portal that a number of users of Technology A were de-activating the software (by swiping it off or tampering with various phone location service settings). Bulk e-mail and SMS text reminders were sent to those users on three occasions reminding participants to keep the software active and not swipe it off.

Analysis

Responses to the questionnaire were compared for the two groups of participants who experienced the two different technologies. For responses to individual items scored on Likert scales, comparisons were made using Chi-square tests. Responses to questions about attitudes to phone use while driving and the phone blocking technology, and self-reported phone use while driving were summed, and the resulting variables were compared using Repeated Measures Analysis of Variance, with Time (pre-and post-trial) treated as a Within-Subjects factor, and the Technology trialed treated as a Between-Subjects factor.

Results

Overall experiences

When asked if they had experienced phone blocking while driving, 53 participants trialing Technology A (69.7%) and all 28 participants trialing Technology B stated that they had. When asked if the technology had worked reliably, 15 participants (19.7%) stated that Technology A blocked the phone ‘every time’, compared to 47.8% for Technology B.

Table 1 shows that a minority of users of Technology A strongly agreed or agreed that it worked as it was supposed to, that they were able to override it when they should have been able to, that they were able to use their phone as a passenger, that it prevented phone use when it should not have, that they were satisfied with the technology’s performance, and that it depleted the phone’s battery. Chi square tests indicated that users of Technology B were significantly more likely to strongly agree or agree that the technology they trialed worked as it was supposed to, depleted the battery, and performed satisfactorily ($p<.001$).

Table 1. Participant experiences of the two phone blocking technologies

	Technology A (n=76)	**Technology B (n=28)**
	% Strongly Agree or Agree	
Worked as it was supposed to	33.3	78.6
Able to override	17.3	17.9
Able to use phone as a passenger	40.0	21.4
Prevented phone use when it should not have	42.7	22.2
Satisfied with performance of the technology	29.7	66.7
Depleted the phone battery	35.1	85.7

Similar proportions of participants reported frequently having trouble with accessing their phones at the end of the drive (19.7% for Technology A and 17.9% for Technology B). When asked if they would recommend the technology they trialed as a method of blocking phone use while driving, 60.5% of participants said ‘yes’ for Technology A and 64.3% of participants said ‘yes’ for Technology B.

When asked to rate the technology they trialed on a scale from 0 (very poor) to 10 (excellent), based on their overall experience with it, the average ratings were 5.5 (*SD*=2.7) for Technology A and 6.8 (*SD*=2.0) for Technology B. The difference in the two ratings was found to be statistically significant ($t_{(64.8)}$=2.57, p<.05).

Effects on attitudes and behaviour

Table 2 shows participant responses to items regarding attitudes to using a phone while driving and attitudes to phone blocking, before the trial and after having experienced the phone blocking technologies. Participants generally regarded sending and reading text messages and making hand held phone calls while driving as dangerous, while hands free phone calls were less likely to be regarded as dangerous. There appeared to be a tendency for participants to view phone use while driving as marginally more dangerous for the ‘typical driver’ than for themselves. Ratings of the danger of phone use while driving remained high after the trial. There was a reduction, as indicated by paired samples *t* tests performed on the entire sample, in the belief that phone blocking was a good idea for themselves ($t_{(103)}$=3.4, p<.01) or for the typical driver ($t_{(103)}$=3.9, p<.001).

Participants were unsure about the benefits of phone blocking before the trial but did not foresee a high likelihood of interference with necessary work tasks or communication. A minority thought it would make them a safer driver. After experiencing phone blocking, participants were more likely to indicate that phone blocking would have negative effects on their work (sum of the items referring to interference with work, tasks being more difficult, work being more stressful, and communication being prevented) ($F_{(1)}$ = 8.5, p<.01) and were less likely to think phone blocking would have positive effects (sum of items referring to improvements in safety and being worthy of consideration for their own vehicle) ($F_{(1)}$=19.4, p<.001). There were no differences in the extent to which attitudes changes for the two different technologies.

Table 3 shows self-reported phone use while driving among the participants. Participants reported low levels of phone use, and were especially unlikely to report sending text messages while driving. A repeated measures analysis of variance found that overall phone use while driving reduced during the trial phase compared to beforehand (F(1)=62.2, p<.001) but that there was no differential effect according to the type of phone blocking technology experienced.

Table 2. Participant attitudes in regard to phone use while driving and phone blocking technology

	Technology A (n=76)		**Technology B (n=28)**	
	% Strongly Agree or Agree			
	Pre-trial	Post-trial	Pre-trial	Post-trial
Dangerous for me to make hands free call when driving	33.3	30.3	28.6	28.6
Dangerous for me to make hand held call when driving	90.7	90.8	89.3	92.9
Dangerous for me to send a text when driving	97.3	98.7	100.0	100.0
Dangerous for me to read a text when driving	96.0	90.8	89.3	100.0
Good idea to use phone blocking when driving a work vehicle	57.9	43.2	53.6	57.1
Dangerous for typical driver to make hands free call when driving	45.3	50.0	39.3	50.0
Dangerous for typical driver to make hand held call when driving	94.7	96.1	88.9	100.0

Dangerous for typical driver to send a text when driving	100.0	98.7	100.0	100.0
Good idea for a typical driver to use phone blocking when driving	61.8	46.1	60.7	60.7
Phone blocking would interfere with work	15.8	32.9	10.7	21.4
Phone blocking would make you a safer driver in your work vehicle	39.5	21.1	42.9	32.1
Phone blocking would make work tasks more difficult	23.7	38.7	10.7	17.9
Phone blocking would makes work more stressful	9.2	22.7	7.1	7.1
Phone blocking would prevent important communication	19.7	28.0	14.3	32.1
Phone blocking would make you a safer driver in your personal vehicle	41.9	21.3	44.4	35.7
Would consider phone blocking in my own vehicle	32.4	20.0	40.7	35.7

Table 3. Participant self-reported behaviour in regard to phone use while driving

	Technology A (n=76)		**Technology B (n=28)**	
	% Never or Rarely			
Items	**Pre-trial**	**Post-trial**	**Pre-trial**	**Post-trial**
Frequency make phone call in work vehicle	76.3	88.0	53.6	89.3
Frequency make phone call in own vehicle	60.0	75.0	42.9	78.6
Frequency answering phone in work vehicle	70.7	82.9	42.9	89.3
Frequency answering phone in own vehicle	48.7	68.4	21.4	67.9
Frequency send text in work vehicle	97.4	100.0	89.3	92.9
Frequency send text in own vehicle	89.5	96.1	85.7	92.9
Frequency read text in work vehicle	88.2	96.0	75.0	89.3
Frequency read text in own vehicle	72.4	89.5	67.9	89.3

Discussion

The study of the performance of two phone blocking technologies using a sample of drivers of corporate vehicles produced mixed results, with reports of poor performance by the two technologies, no change in attitudes regarding the dangers of phone use while driving following the trial, but a statistically significant reduction in self-reported phone use during the trial.

Performance

Participants generally gave a negative appraisal of the two technologies, especially Technology A, which was the software only phone blocking product. Approximately 30 percent of participants reported not even experiencing phone blocking with Technology A, and only 20 percent said that it worked reliably every time. In some cases it is possible that the technologies were perceived not to have worked because participants did not actually have any calls made to them or texts sent to them by anyone. However, Technology A would occasionally cause the phone to vibrate and present an on-screen warning in the normal course of driving when the technology was active, regardless of whether a phone call/text being received.

Interestingly, despite its inability on many occasions to block the phone, over 40 percent of participants also agreed or strongly agreed that it prevented phone use when it should not have done. There were also problems with accessing the phone at the end of a drive. Not surprisingly, only 30 percent reported that they were satisfied with its performance.

Technology B, which involved software paired with a hardware device mounted in the vehicle, received a more favourable appraisal than Technology A but participants still reported that they had difficulties overriding it when required and that it sometimes prevented phone use when seated in the vehicle as a passenger. Significantly more participants reported experiencing issues with phone battery depletion with Technology B (85.7%) compared to those participants using Technology A (35.1%). Despite these problems, around two thirds of the participants were satisfied with the performance of Technology B and the rating they gave the technology on a scale from 0 to 10 was significantly higher than Technology A. Interestingly, they were not more likely to recommend it as a method for preventing phone use while driving than the participants asked about Technology A.

On the basis of the above, it appears that some improvement is needed in the reliability and usability of both products. However, negative opinions regarding the reliability of Technology A may have been influenced by the software not performing as was expected by the participants. That is, it didn't block when they expected it to and it did block when it was not expected. This may be because quite a few participants habitually 'swiped' off the software, possibly turned off location services (required for triggering) or turned off WiFi, possibly deleted the app, or due software glitches (blocking when not supposed to). This was despite our reminders to keep the software active (see the 'Limitations' section below). The perceived failure of the phone blocking occurring in these cases was therefore due to the software likely being inactive or due to genuine software failures. This was not such an issue with Technology B as the software itself provided persistent reminders to re-activate the software if a participant swiped it off and the software activation occurred through an external trigger.

The issue of battery depletion is difficult to address when the software requires constant monitoring of phone location (to determine phone speed to trigger blocking as required for Technology A). However, in the case of Technology B, 'location services' was not required to trigger phone blocking and was only used for collecting driver metrics, offered in this case as an additional service by the technology provider, so battery depletion may be easier to address for Technology B.

Based on the opinions of the participants, improvements to the technologies need to be made in terms of both blocking phones when they should and not blocking them when they should not. Aside from situations in which the software has been swiped off, blocking failures can occur for a number of reasons, including problems with the phone's internal GPS, problems with WiFi, software 'bugs', upgrades to the phone's operating system, and software incompatibility. Override functions also need to improve, especially in terms of usability.

Effects on attitudes

Participants generally held negative attitudes to phone use while driving before the trial, with a large proportion recognising the risks of hand held phone calls, and sending and reading text messages while driving. This might be due to their recruitment from a corporation with a strong safety culture, including a strong driving safety culture. A lower proportion of participants viewed hands free phone use as dangerous, which may be because use of hands-free is legal (under a full drivers licence). The technology trialed in this study permitted hands free phone use at the request of the corporation but only so people were aware when their phone was ringing, so that they could pull over and answer it. The corporation's phone policy does not permit hands free phone use while driving.

One outcome of this clear recognition of the dangers of phone use while driving was that it was difficult to detect any increase in the recognition of risk following the trial. The only items concerned with phone use attitudes which did demonstrate an effect were those related to phone blocking technology being a ‘good idea’: support for this idea dropped significantly following the trial, no doubt reflecting the negative experiences many participants had with the technologies.

In regard to other items enquiring about attitudes to phone blocking, there were indications that the trial had resulted in a more negative attitude to phone blocking technology as a viable method of reducing phone use while driving in an occupational setting. Following the trial, participants were more likely to indicate that phone blocking would negatively affect work and were less likely to think phone blocking would improve safety or be worth considering for their own vehicle. This was the case regardless of whether the participants had trialed Technology A or Technology B. Again, this demonstrates the effect of negative experiences with the phone blocking products assessed in the study.

Effects on behaviour

In keeping with the generally negative attitudes to phone use while driving, there were low levels of self-reported phone use even before the phone blocking trial had commenced. Around 90 percent of participants reported never or rarely sending a text message while driving. Despite the low baseline rate of phone use while driving, the phone blocking trial did result in reductions in this behaviour. There were increases during the phone blocking trial in the likelihood of participants ‘rarely’ or ‘never’ making or answering calls, or reading text messages. This was seen regardless of which technology was trialed. As those using Technology B would only get their phones blocked in work vehicles, it is interesting to note an apparent effect on behaviour also when driving their own vehicles, suggesting the possibility of a transferability of the effect on behaviour into other contexts.

It should be noted that, while the purpose of this study was to examine the effectiveness and acceptability of mobile phone blocking technology among drivers, the two technologies also allow the monitoring of an organisation’s mobile phone policy compliance through their respective web-portals. Organisations utilising either of these technologies can attempt to prevent mobile phone use by using the blocking capabilities of the technologies but can also monitor any non-compliance. Individuals can then be counseled if non-compliance is reported.

Limitations

The sample recruited for the study was based at an organisation with a strong safety culture in which phone use while driving was actively discouraged. Part-way through the project development phase, the organisation enacted a work health and safety directive banning all mobile phone use (including hand-free) while driving on company time or driving a company vehicle. This is likely to have contributed to most participants having negative attitudes to phone use while driving and only rarely engaging in such activities, even before the trial. This would have made it difficult in this trial to detect a positive effect of phone blocking technology. Nonetheless, statistically significant changes in self-reported behaviour were detected.

Also, difficulties with obtaining sufficient units of hardware for Technology B meant that only a small sample was available to assess that product. However, the sample for Technology B was of sufficient size to demonstrate statistically significant differences to Technology A on a number of measures.

Another limitation is that Technology B required participants with access to their own fleet vehicle, rather than using pool vehicles, meaning that the participant groups assessing the two technologies were likely to be different. However, patterns of responses on the pre-trial questionnaire were very similar.

Finally, it was easy to ‘swipe off’ or deactivate the software for Technology A and most participants did this at some stage during the trial. In fact, only one participant had phone blocking software operating for all 22 days of the trial. CASR staff were aware of who had deactivated the software from their phone and would contact participants to remind them to re-activate it. In total, only 22 participants had the software operating for 11 days or more, 40 people had the software operational for 1 to 10 days, and 14 people appear to have used Technology A for less than one day. This may partly explain why a large proportion of participants reported not even experiencing phone blocking with Technology A or that it did not worked reliably every time. Although this is problematic, it is also important to recognise that in a field trial such as this, one is interested in examining what people actually do, and it is apparent that many people will either deliberately or accidentally swipe off or deactivate the software and render it inactive.

Conclusions

The results of this trial suggest that phone blocking products may provide a useful method of changing mobile phone use behaviour while driving. However, the products, whether they be software only or software combined with hardware, need to improve to reach higher ratings of user acceptance and approval. A number of issues with the operation of the two technologies were identified in this trial which will need to be addressed in order to support a recommendation for wider implementation or promotion of phone blocking as a countermeasure for phone use while driving.

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Enhancing road safety with in-vehicle telematics

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Abstract

Telematics based insurance provides an opportunity to achieve further reductions in road trauma. In particular, it has the potential to reduce road trauma among young drivers, who are over-represented in crash statistics. This study investigates the largest collection of telematics data from Australian roads. We discuss the type of data that is available and show how driving behaviour differs between groups of drivers and changes in the early stages of licensing. Finally, we will discuss how this extensive database can be used in future research to significantly improve road safety in Australia.

Background

Studies and statistics consistently demonstrate that young drivers face higher than average risks of involvement in a transport-related crash, leading to higher injury and fatality rates (e.g., Australian Transport Safety Bureau (ATSB), 2004; Toroyan & Peden, 2007). Some initiatives have brought crash rates down, such as the successful introduction of the Graduated Licensing Systems (GLS) which targets drivers in the first six to twelve months of licensure when they are at highest risk (Russell, Vandermeer, & Hartling, 2011). Despite these initiatives, road trauma in Australia is still substantial (Bureau of Infrastructure, 2013) and young drivers remain over-represented in Australian crash statistics. To achieve further reductions in road trauma new strategies need to be developed and trialled (Stevenson & Thompson, 2014).

With changing technologies, new methods of influencing driving behaviour are emerging from the insurance industry in the form of telematics based incentives. For example, Bolderdijk, Knockaert, Steg, and Verhoef (2011) showed that Pay-As-You-Drive (PAYD) insurance incentives for young drivers significantly reduced speed limit violations. As the financial incentive offered by this PAYD insurance product is the largest for young drivers (e.g., 18 – 25 years), many PAYD customers belong to this age group. As part of an Australian car insurance product (Insurance Box Pty Ltd), in-vehicle telematics devices are now being fitted to vehicles that record usage data (i.e., location data transmitted via GPRS) for each customer, with this information stored in a large telematics database. Currently, this database contains data for over 5.5 million kilometres of driving and is the first of its kind in Australia. Hence, it provides a unique opportunity to understand driving patterns and model driving behaviour on Australian roads to find innovative solutions to reduce road trauma, especially for young drivers.

Method, Results & Discussion

In this study, the telematics database will be analysed using several mathematical techniques. The focus of this analysis will be to discover patterns in driving behaviour that are important with respect to road safety. First, we will look at the differences in driving behaviour between groups of young and older drivers. Furthermore, it will be investigated how quickly driving behaviour of young drivers converges to a stable level after gaining their provisional license. We also intend to investigate the relationship between behaviour stabilisation and the GLS. This will provide a better understanding of driving behaviour on Australian roads and will provide an indication of the time-frame and form of interventions to improve road safety.

Beyond this, we will use telematics data as part of a randomised controlled trial with our partner organisations Insurance Box Pty Ltd. and the Transport Accident Commission, where we will investigate the effects of driving performance feedback and financial incentives on safer driving behaviour. Data recorded by the in-vehicle telematics devices of participants will provide objective outcome measurements for understanding the effects of such an intervention.

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'MDT – Mobile Drug Testing': Using research to develop the first drug driving public education campaign in NSW

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Abstract

In December 2015, the first NSW public education campaign targeting illicit drug driving 'MDT – Mobile Drug Testing' was launched. The campaign is part of a co-ordinated approach to deterring drug driving by combining enhanced police enforcement with public education.

The campaign targets beliefs about enforcement, particularly the perceived likelihood of being caught drug driving. It was developed in partnership with the NSW Police Force and is based on insights from crash data and research exploring the behaviour, attitudes and beliefs of NSW drivers who use illicit drugs. Early post-campaign research suggests key messages have resonated with the target audience.

Background

In March 2015, the NSW Government announced a threefold increase in roadside drug testing in NSW by 2017. The policy was driven by Transport for NSW research identifying that 14% of fatalities on NSW roads over the period 2010-14 involved a driver or rider with at least one of three illicit drugs (cannabis, speed, ecstasy) in their system. To enhance the deterrence provided by increased testing, Transport for NSW developed a public education campaign in 2015.

Research insights and campaign development

Fatal crash analysis and insights from a survey exploring the behaviour, attitudes and beliefs of NSW drivers who self-reported illicit drug use (Taverner Research, 2015) were central to defining the communication approach.

The research highlighted that drug drivers in NSW are not yet convinced they will be caught. The reasons that drivers feel they were unlikely to be caught are based on perceptions about enforcement, including frequency, mobility and spread of drug testing. Many users also think their drug use does not impair their driving skills or elevate their crash risk (Taverner Research, 2015).

These insights highlighted challenges when communicating to this audience. First, illicit drug users may be resistant to communications focusing on the effect of drugs on driving skills, particularly if these are perceived to be inconsistent with personal beliefs. Campaign messages or concepts that could be perceived as condemning drug use rather than drug driving behaviour may also be rejected. Second, knowledge about how drug testing is conducted is uneven among users, with low levels of personal experience of testing.

Previous research established that increasing the perceived likelihood of detection by roadside breath testing (RBT) was initially critical to changing drink driving behaviour by NSW drivers (Job, Prabhakar & Lee, 1997). Due to the parallels between drug users' current attitudes and attitudes to drink driving in the early implementation of RBT, a campaign to support enforcement was identified as most likely to quickly shift behaviour. In the long term, there is also a need for communications to address some drivers' beliefs about crash risks and drug driving.

Campaign execution and success

The 'MDT – Mobile Drug Testing' campaign introduces a new acronym, MDT, to the road safety vernacular in NSW, highlights the increased scale and mobility of testing and features the roadside testing process. The campaign was developed in close partnership with the NSW Police Force to ensure a credible voice and realistic depiction.

The campaign includes a 30-second and a 15-second television advertisement featuring stationary roadside MDT and MDT conducted by a patrolling police vehicle. The executions directly challenge beliefs about how and when enforcement is conducted. Campaign imagery (***Figure 1***) leverages driver familiarity with RBT to connect MDT with high-visibility RBT operations, and illustrates the drug testing process. The advertisement is supported by radio, online material, and outdoor media. Where possible, campaign activity is scheduled around police operations to maximise deterrence.

Post-campaign research commenced in late January 2016. Results are pending but early indications suggest high levels of campaign recall, awareness and message take-out.

Figure 1 – MDT – Campaign imagery

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Development and Implementation of the NSW Mandatory Alcohol Interlock Program

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Abstract

The NSW Mandatory Alcohol Interlock Program (the Program) commenced on 1 February 2015. The Program helps repeat and serious offenders separate drinking from driving while enabling them to continue to access employment and essential services. This paper examines the road safety evidence and principles that guided the development of the Program, as well as the key policies, administrative features and support structures in place to ensure the Program operates as intended. The paper also explores key lessons learnt, including the importance of properly estimating costs and time for developing support systems and processes, and the need to monitor policy impact.

Background

When the Mandatory Alcohol Interlock Program was introduced, alcohol was a factor in around 20 per cent of fatalities in NSW. Nearly one in five drink-drive offenders were being convicted of a high-range first offence, and nearly one in six drink-drive offenders were being convicted of a subsequent drink-driving offence within five years. International evidence indicated that repeat drink drivers were more likely to be involved in a fatal drink-driving crash than other drivers (Hedlund & Fell, 1995).

NSW had a voluntary interlock program since 2003, however less than 5 per cent of eligible offenders entered the program annually. This limited program benefits in reducing re-offending and thereby improving road safety. Based on experience in other jurisdictions with a mandatory program (including Victoria, Queensland, Tasmania and South Australia), it was estimated that a mandatory program in NSW could reduce the re-offending rate of high-risk drink drivers from one in six to one in 12, equating to a reduction of around 500 offences per year.

Key policy considerations

The Program targets the highest risk drink-driver offenders – those who commit high-range offences and those who commit two or more drink-driving offences in five years. It is intended to be rehabilitative as well as punitive, drawing on best practice and evidence that a short time between when the offender commits the offence starts the learning process to separate drinking from driving is of greatest benefit.

Policy considerations to ensure the Program is effective, fair and focused on rehabilitation included:

- Striking the balance between judicial and administrative program features
- Developing features to encourage offenders to participate in the Program, including those in severe financial hardship
- Developing appropriate exemptions for offenders unable to participate due to a medical condition or not having access to a vehicle
- Developing performance monitoring features to address drink-driving behaviour and apply appropriate interventions

- Developing an appropriate market-driven approach to interlock service provision
- Developing partnerships across the Transport, Justice, Health and Community Services sectors to deliver operational solutions.

Implementation approach

The governance model for implementation comprises an inter-agency Steering Committee supported by a project team of subject matter experts, with ongoing consultation with partner agencies and organisations.

Key items progressed included:

- Participant database to enable performance management (including interface with Driver Licence Management System and provider database systems)
- Business rules and processes for program administration (including changes to licensing management systems)
- New provider accreditation and management framework including new Provider Agreements and technical and functional specifications for interlock devices
- Severe Financial Hardship scheme funded by NSW Government
- Communication materials to educate participants and the community.

Key learnings

Licensing data from Roads and Maritime Services show that, as at April 2016, over 4,000 mandatory interlock orders had been made by court and over 1,200 interlock licenses had been issued.

Key learnings from the implementation process include the importance of properly estimating costs and time involved in developing support systems and processes, and the need to monitor policy impact to respond to unintended consequences.

Phase One of the program evaluation entails a process evaluation and assessment of initial outcomes and is expected to be completed by July 2017. This evaluation will consider data collected from a survey of Program participants, survey and interview with exempted offenders, interviews with interlock service providers, and program and licensing data collected by Roads and Maritime Services.

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Not just the booze: Polysubstance use among fatally injured drivers

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Abstract

Alcohol is regarded as a significant cause of driver impairment. In more recent years however, concern has been growing over the use and abuse of illicit substances and prescription pharmaceuticals that can impair driving performance. The analysis of the toxicology records of N=1,375 drivers fatally injured in Western Australia 2000-2012 showed that over six in ten tested positive for either alcohol, illicit drugs and various pharmaceuticals alone or in combination. The identification of the presence of multiple, potentially impairing substances highlights the need to review current policies and practices in relation to the enforcement and management of substance impaired driving.

Background

Substance impaired driving is a dynamic road safety issue. Changes in the availability and pattern of use of potentially impairing substances, illegal or otherwise, requires regulators to continually monitor and counter an evolving landscape of impaired driving. Alcohol is foremost among the substances that can impair driving (Peck, Gebers, Voas, & Romano, 2008), followed by a number of highly prevalent illicit substances such as cannabis and methamphetamine (OECD, 2010; Palamara, Broughton, & Chambers, 2014). Certain 'legal' pharmaceuticals such as benzodiazepines are also associated with crash involvement (Meuleners et al., 2011) though these are more difficult to monitor and counter. This paper will report on the incidence over time of the above three groups of potentially impairing substances and the major characteristics of their presentation and co-use among drivers fatally injured on WA roads 2000-2012. Because of the known increased risk of impairment associated with the use of multiple substances, the paper will conclude with recommendations for regulators to be more vigilant of and responsive to the potential use and abuse of multiple substances by drivers.

Method

WA Police crash records of drivers and motorcycle riders fatally injured on WA roads 2000-2012 were linked with WA ChemCentre toxicology records to identify the presence and nature of illicit and non-illicit drugs and alcohol among drivers/riders. A total of N=1,375 linked records were extracted for analysis. For this paper each fatality was categorised in relation to the presence of alcohol (≥0.001gm%); the presence of one or more illicit substances (e.g., THC, methamphetamine, MDMA/Ecstacy), and the presence of legal pharmaceuticals (e.g., benzodiazepines). Univariate analyses were undertaken to describe the characteristics of the substance groups, their co-detection and their distribution over time (as a rate per 100,000 registered drivers).

Summary Results

Across the study period one or more substances were detected in around six in ten drivers. Alcohol (≥0.001gm%) was the most commonly detected substance (38.3% of fatally injured drivers) followed by legal pharmaceuticals such as opioids and benzodiazepines (23.8%) and illicit substances such as THC and methamphetamine (22.7%). The annual rate of fatally injured drivers testing positive for these substance groups was found not to have significantly changed over the period, though there is some evidence of a decline in the annual rate for each substance group post 2007 coinciding with the introduction of roadside oral fluid testing in WA (see Figure 1).

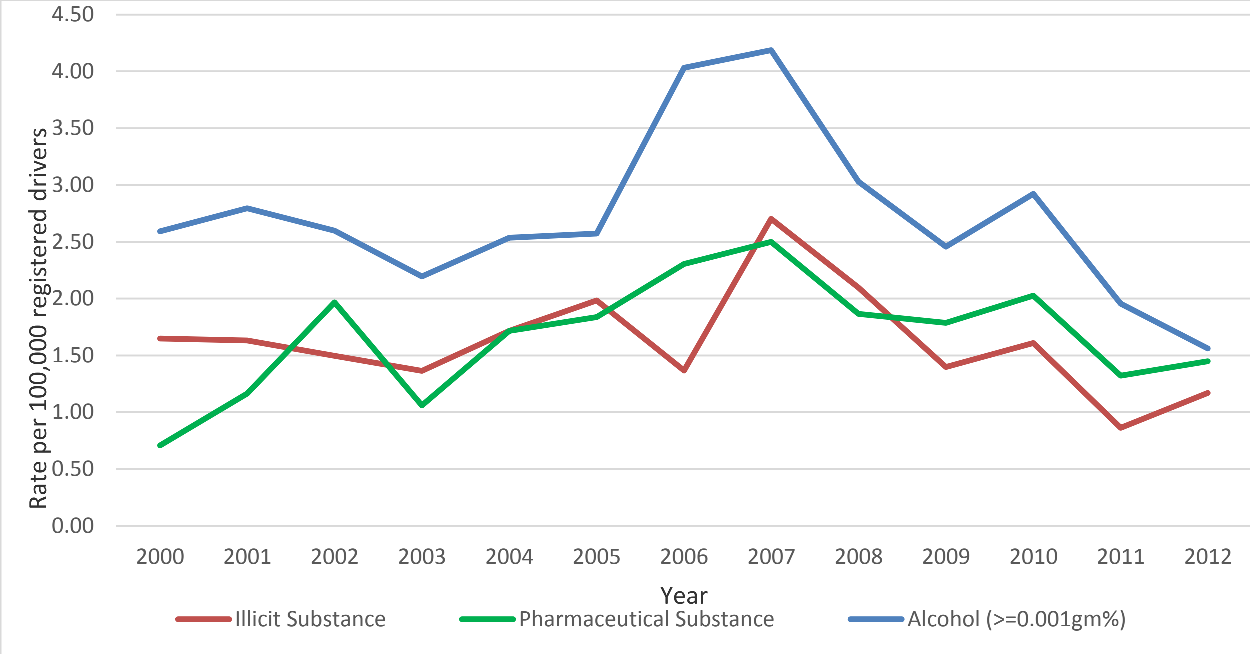

Figure 1: Annual rate of detection of illicit substances, pharmaceutical substances and alcohol (≥0.001gm%) in fatally injured drivers; Western Australia 2000-2012

Around a third of the n=863 fatally injured drivers who tested positive were found to be positive for *alcohol only*, with another third testing positive for two or more groups of substances (see Table 1). The most common substance combinations were (i) alcohol and one or more illicit substances (mostly THC) and (ii) alcohol and one or more pharmaceuticals (mostly opioids, benzodiazepines and anti-depressants).

Table 1. Detection of substances in fatally injured drivers; Western Australia 2000-2012

Substance Group	**N drivers**	**%**
Nil – no substances detected	512	37.2
Alcohol (BAC ≥0.001gm%) only	302	22.0
Pharmaceuticals only	180	13.1
Illicit substances only	106	7.7
Alcohol + Pharmaceuticals	69	5.1
Alcohol + Illicit substances	128	9.3
Illicit substances + Pharmaceuticals	50	3.6
Illicit substances + Alcohol + Pharmaceuticals	28	2.0
Total	**1,375**	**100**

Conclusions

This study shows that alcohol continues to present as the most common substance related risk factor for impairment among fatally injured drivers. For many of these drivers, any impairment associated with alcohol may have been exacerbated by the identified co-use of illicit and legal pharmaceuticals such as THC, methamphetamine, benzodiazepines and opioids that are also known to impair driving performance. The increased risk of impairment associated with the combined use of alcohol and other impairing substances has been acknowledged in Victoria with the newly introduced combined drug and alcohol offence. This development should similarly be adopted elsewhere in Australia and thought given to how the policy might be extended to include other commonly prescribed and potentially impairing pharmaceuticals such as benzodiazepines.

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You don't have to be speeding to be driving too fast on country roads. NSW/ACT 'drive to conditions' awareness campaign.

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Abstract

This NSW/ACT cross border education campaign focuses on motorist's behaviour and their awareness of conditions on country roads. Campaign messages (delivered via social media, radio and corporate advocates) address appropriate speed selection; highlight potential hazards; and urge motorists to slow down and drive to conditions. Combining three road safety elements -Education, Enforcement and Engineering, the campaign brings road safety stakeholders together from a variety of sectors including Councils, NSW and ACT Government, Police, philanthropic and corporate organisations. After a 2014/15 pilot run in the Yass Valley, a 2016 campaign has been run across a total of nine local government areas.

Background

First developed and delivered as a pilot within Yass Valley the campaign has now been delivered across nine Councils by Road Safety Officers (RSOs) employed via the NSW Local Government Road Safety Program. The campaign was funded by the NRMA ACT Road Safety Trust. Participating Councils include: Yass Valley, Queanbeyan, Palerang, Goulburn Mulwaree, Eurobodalla, Snowy River, Tumut, Gundagai and Tumbarumba. The 2016 campaign was timed to run over the Easter break and NSW/ACT April school holidays.

Supporting Research

The ARRB Group report *Updating crashes involving ACT vehicles and controllers in NSW: 2006 to 2010* highlighted that crashes involving ACT motorists on rural roads featured more heavily in statistics than expected. Roads and Maritime Services (RMS) crash data (2010 to 2014) shows that 13.5% of crashes in participating LGA's are ACT licenced motorists, this is as high as 28% in Palerang and 22% in Queanbeyan. This RMS data also shows that NSW motorists crashing on NSW country roads are most prevalent, particularly motorists crashing in LGA's other than where they reside.

Up to 50% of these country road crashes are 'off road' type crashes suggesting motorists may be selecting inappropriate speeds while driving on lower standard roads and may be unfamiliar with more varied road environments.

The *NSW Road Safety Strategy 2012 -21* states that 'while only one third of the NSW population resides in areas, two thirds of all fatalities occur there'. In summary, a campaign that reached both NSW and ACT motorists was needed.

The ACT NRMA Road Safety Trust also funded an ARRB Group research project in 2014/15, investigating *ACT drivers' and riders' perceived risk of driving or riding in NSW*. Results of this study also informed the methodology of and message content included in the Country Roads campaign.

Working Together

One of the highlights of the campaign has been the stakeholder engagement achieved and collaborative work between Councils, NSW and ACT Police and both private and Government road safety stakeholders.

This collaboration greatly increased the reach and impact of the campaign well beyond the means of its advertising budget. Maintaining regional delivery, through the established RSO network meant that local issues were highlighted and intelligence was shared between Councils and local Police, facilitating informed and targeted enforcement.

Both ACT and NSW Police supported the campaign offering enforcement and social media support. Police increased their presence on country roads with all 11 NSW Southern Region Local Area Commands briefed about the campaign via their Superintendent Commander.

Education

The scheduled Facebook campaign received 1.5 milllion views via a dedicated campaign Facebook page. Messages were simple, directly relevant to country road conditions and offered both cautionary and advisory content. Posts were shared by the NSW Traffic and Highway Patrol command and the ACT Policing Facebook pages. The 2500 page likes achieved included Council Facebook pages, Police Local Area Commands, Fire and Rescue, Rural Fire Brigades, car dealerships, training organisations, driving schools, sporting groups and transport companies as well as individuals.

Over 2600 scheduled radio announcements (asking motorists to slow down on country roads) were aired across 12 ACT and regional radio stations spanning a large geographical area incorporating; Queanbeyan, Yass and Bungedore, Southern and South Western regional NSW (Goulburn, Upper Lachlan, Snowy, Tumbarrumba and reaching Wagga Wagga), and the NSW South Coast (Braidwood, Bateman’s Bay, Ulladulla and beyond Eden).

The campaign post card, branded car air freshener and posters (with five primary safety messages) were distributed via 11 NRMA branches, through regional tourist information centres, libraries, Driver Reviver and Council offices. Variable Message Signs and bridge banners were also used on key roads during the Easter break and April School holidays – with ’drive to conditions’ messaging.

Engineering

The campaign also worked to increase focus on road safety engineering on country roads. The campaign promoted intelligence sharing between Police and Council and prompted community comment. This has resulted in the reporting of hazards, identification of hot spots and prioritisation of road safety checks by Councils. Examples of road safety engineering highlighted or completed as a result of the campaign include: road side clearing (enhancement of clear zones); increased guide post frequency; installation of additional curve advisory signage; installation of advance warning signage for rural bus stops, placement of warning signage re wildlife, initiation of speed zone reviews and line marking (maintenance and installation).

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Cycling Safety in NSW: Attitudes and Behaviours

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Abstract

The number of people cycling in NSW has increased in recent years. Over the last decade, an average of 11 cyclists have been killed each year in NSW, and from 2009-2013, 7,669 were seriously injured. The main objective of this research was to explore the attitudes, behaviours and beliefs of cyclists and drivers in relation to cycling safety. It comprised focus groups and a survey undertaken with cyclists and drivers in late 2015. The findings contribute towards a deeper understanding of the factors that may influence bicycle crashes, and points to potential avenues for action to improve cycling safety.

Context

In 2014, 11 cyclists were killed and, in 2013, the most recent reporting year, 1,800 were seriously injured in hospital-reported crashes. While this represents a comparatively small proportion of total annual casualties on NSW roads, cyclists are a vulnerable road user group, and are more susceptible to serious injury than more protected vehicle occupants. Prior research conducted by Transport for NSW indicates that safety is a key barrier to adopting cycling for transport.

This research was commissioned by the NSW Centre for Road Safety to better understand the attitudes and behaviours of NSW drivers and cyclists around cycling safety.

Methodology

The research program commenced with a qualitative phase comprising 11 focus groups with cyclists and motorists, designed to inform the subsequent quantitative phase. The quantitative research comprised an online survey of 2,064 road users. This included n=1,040 drivers and n=1,024 cyclists. All fieldwork was conducted between August and November 2015. The research canvassed a range of areas relating to cycling safety, awareness and perceptions of cycling related road-rules, and driver and cyclist behaviour.

Research findings

Key findings from the research include:

- *There is some recognition of shared responsibility.* The quantitative findings supported the common perception in the qualitative research that no one group is always at fault in collisions, and that a combination of factors arising out of the behaviour of both parties is usually to blame.
- *Opinions diverge about what is common sense or appropriate cyclist behaviour.* In the qualitative research, views differed greatly between individuals and ranged from it being most appropriate for cyclists to act like motor vehicles (not being allowed on footpaths and obeying traffic lights), to it being appropriate for cyclists to essentially behave like pedestrians.

- *Rule-breaking by cyclists is sometimes seen as socially acceptable.* Perceived social acceptability of cyclist rule-breaking varied considerably depending on the road rule in question.

- *Understanding of road rules is limited.* Both the qualitative and quantitative findings indicate limited understanding of, and little thought given to, the road rules relating to cyclists among either cyclists or motorists.

- *Rule breaking by cyclists is relatively common.* Nearly one in three cyclists (29%) reported knowingly breaking the road rules at least sometimes. As compliance decreases, perception of the social acceptability of breaking road rules increases, suggesting either the role of perceived social norms in guiding behaviour or the post-rationalisation of poor behaviour. Rule-breaking also appears at least in part fuelled by a lack of knowledge of the illegality of the behaviour.

- *Some motorists are not routinely checking for cyclists.* The most common motorist behaviours that may put cyclists at risk relate to a failure to specifically check for cyclists on the road.

Conclusions

The research points to several potential avenues to improve cycling safety in NSW. The research will be used to help implement *Transport for NSW's Cycling Safety Action Plan 2014–2016* and guide future Action Plans, to reduce the risky behaviour of both cyclists and drivers and improve the safety of cyclists using the Safe Systems approach.

Preparing New Zealanders for transport cycling: a competency model

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Abstract

For many New Zealanders, learning to ride a bike is a life milestone; however, having the skills and desire to cycle for transport is limited to a small percentage of Kiwis. As part of a wider programme to make cycling a safer and more attractive transport mode, this research project re-examined the goals and effectiveness of cycle skills training. Through a literature review and qualitative methods a 'cycling competency model' was developed . This model and accompanying recommendations provide a systematic way to prepare New Zealanders to ride on the network, while maximising the impact on safety and cycling participation.

Background

New Zealand is currently implementing a multi-faceted programme to make cycling a safer and more attractive transport mode in order to increase the number of people travelling by bike. As well as investment in cycling infrastructure, this programme focuses on behaviour change approaches, such as cycle skills training. Quantifying the effect of cycle training is difficult and there is a lack of evidence linking cycle training with reduced injury risk (Richmond, Zang, Stover, Howard, MacArthur, 2014) and cycling participation (Goodman, van Sluijs, Ogilvie, 2015). The NZ Cycling Safety Panel also recognised the need to improve the consistency of and overall approach to cycle training in New Zealand (Cycling Safety Panel, 2014).

The objective was to examine the competencies cyclists need to ride on the network safely and identify the strategies that will enable the development of these competencies over the life course, whilst maximising safe road use and trips by bike.

Method

A literature review was undertaken covering: the skills, knowledge and attitudes children and adults need to ride on the road; the effect of cycle training on safety and cycling participation; and the current reach and approach to cycle training in New Zealand.

A qualitative research process involved semi-structured interviews with 15 stakeholders (cycle training providers, road safety professionals and school representatives), focus groups (3) with parents and students and an online survey for people who cycle or want to cycle (n = 262).
Qualitative data was coded and analysed for themes and integrated with learnings from the literature review to form the Cycling Competency Model (Figure 1).

Results

Cycling on the road network requires the application of motor skills, cognitive skills and perceptual skills in different environments (Ellis, 2014). These skills, combined with positive attitudes to safety, perceptions of the road as a shared space, and the valuing of cycling as a transport mode – represent a broader view of cycling competency. The Cycling Competency Model (Figure 1) describes how traditional training can be combined with other formal and informal approaches to facilitate the cumulative development of this cycling competency over time. The model demonstrates the importance of parents and peers in supporting others to cycle, facilitating practice and experience and reducing the sole reliance on external support. The model also presents how cycling infrastructure, cycling promotion, spaces to ride and community perceptions of cycling can combine with training initiatives to maximise the impact on safe road use and cycling participation.

There are good examples of established cycle training programmes in NZ, as well as innovative approaches to skill development and cycling promotion; however, the need for consistent and coordinated approaches, the involvement of families and the opportunity to ride from a young age are examples of critical gaps.

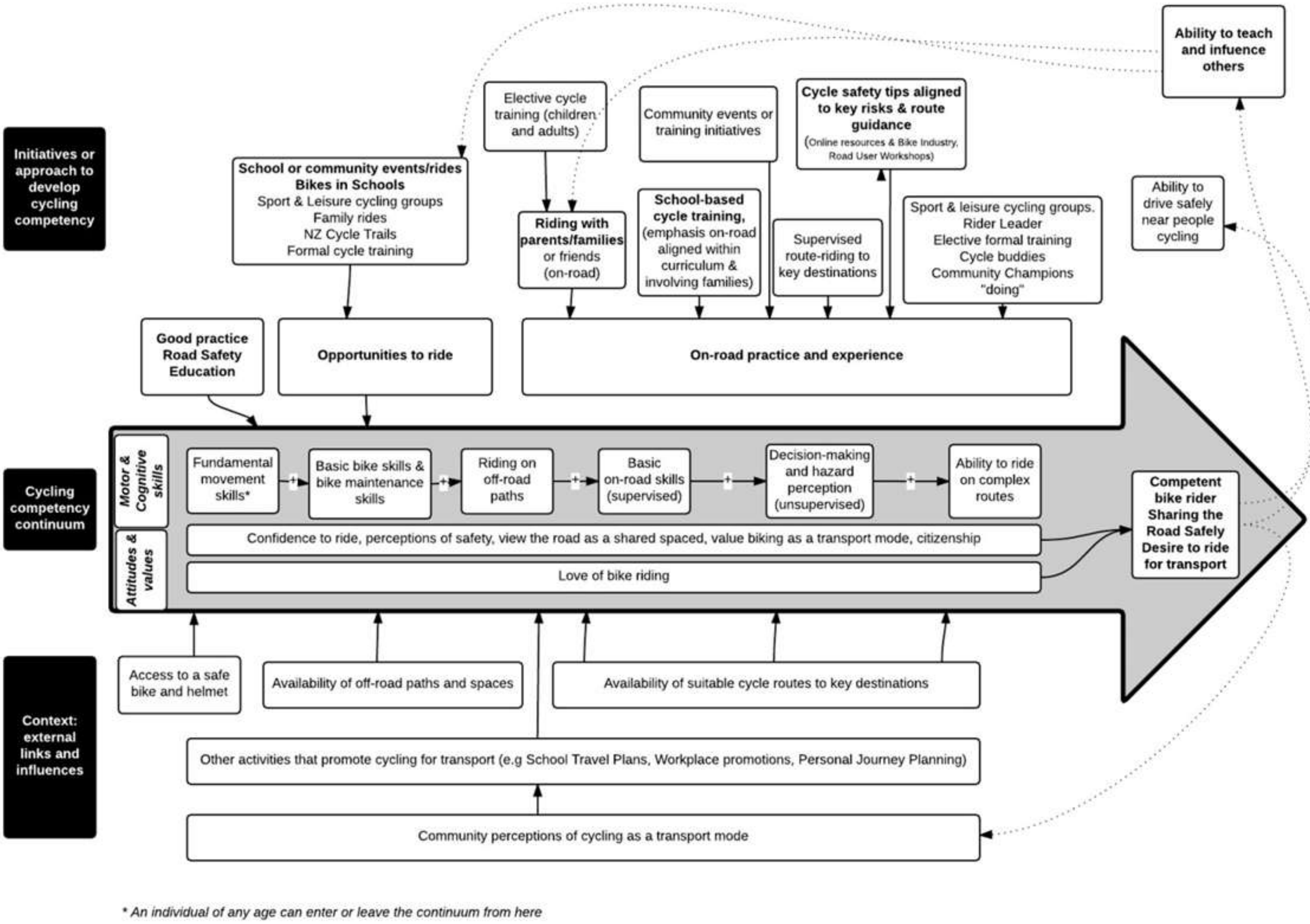

Figure 1. Cycling competency model for New Zealand

Conclusions

Developing the competencies required to ride for transport are cumulative, requiring practice and experience. In order to maximise outcomes of safe road use and cycling participation, multiple touch points of informal and formal training need to be facilitated over the life course. These initiatives also need to be coordinated with other activities that support cycling and with the environmental context of the individual.

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The safety of child passengers of adult cyclists

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Abstract

There is a global lack of knowledge regarding the safety of children transported as the passenger on a bicycle. To address this gap a survey was conducted with cyclists who transport their children by bicycle. This paper examines the causes and circumstances leading to the injury of child passengers, including characteristics of the types of carriers used, bicycles, and cyclists involved. This research is the first of its kind to explore the safety of child passengers in great detail and has the potential to improve the safety for these children.

Introduction

In Australia, the increasing popularity of new bicycle child carriers such as front-mounted seats, cargo bikes, and trailers has produced an interest in the safety of child bike carriers (Carroll, 2014). While much research has addressed the safety of adult cyclists very little is known about the safety implications associated with the transportation of children as passengers on a bicycle. There is a need for research in this area.

In order to address this significant gap the Centre for Automotive Safety Research, in conjunction with the Monash University Accident Research Centre, undertook a study examining the safety of different transportation options for child passengers on bicycles through an investigation of the occurrence of incidents and injuries associated with each. This larger research project involved the analysis of hospital injury data, surveys of parent cyclists, and discussions with key stakeholders. This paper reports findings from the parent survey component which examined the causes and circumstances leading to any incidents involving child bicycle passengers.

Method

Data was collected by means of an on-line self-report survey. Cyclists who were parents of children aged five years or younger, reside in Australia, and transported at least one child by bike were eligible for the study. A total of 94 participants (76% male) aged 24-58 (M=39.59, SD=6.36) completed the survey. In the 12 months preceding the survey 74% reported riding “3-4 times per week” or more and 73% reported transporting child passengers “once or twice a week” or more often. The number of children transported per trip ranged from 1-6 with the majority transporting one (69%) or two (29%) children.

As there is limited information about either parents who transport child passengers, crash or non-crash incidents involving child passengers, or injuries to child passengers, an on-line self-report survey was used to collect data about a range of factors including experience transporting children, crash and non-crash incidents, and injury mechanisms and outcomes.

Results

Twelve cases of a crash involving a child passenger were identified; no injuries to child passengers were reported. Eight children were injured in non-crash incidents, half of which were due to a bike tipping over when stationary or nearly stopped (n=4). The non-crash incident was unknown in three cases due to missing data. In all cases the child passenger received minor injuries (bruise n=4, scratches n=1) the treatment for which was most commonly administered at home and involved observation of the child (n=3), pain management (n=1), or cleaning and dressing a wound (n=1).

Discussion

This study is the first of its kind to explore the causes and circumstances leading to the injury of child bicycle passengers. A survey of 94 parent-cyclists found that no child passenger was injured due to a crash event and very few were injured in non-crash events. In order to better understand child passenger safety the findings will be discussed with reference to the mechanisms of the event and the characteristics of the carrier and cyclists involved. This research addresses an important gap in current knowledge and has the potential to further improve the safety of child passengers.

Acknowledgements

This research was funded by a research grant from the NRMA-ACT Road Safety Trust.

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Estimating the safety benefits of separated cycling infrastructure: Does modelling the mechanism matter?

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Abstract

Separated cycling infrastructure that removes interaction between cars and cyclists is assumed to reduce risk of collision. However, the potential for separated infrastructure to act against other mechanisms also assumed to contribute to cyclist safety has not been empirically explored. We constructed an agent-based model to investigate the potential effects of introducing separated cycling infrastructure to a transportation network. Results suggest that in transportation networks where behavioural adaptation among drivers is assumed to be active, low levels of separated infrastructure that reduces exposure of drivers to cyclists while providing incomplete origin-destination coverage may provide little or no overall safety benefit.

Background

At face value, the addition of safe cycling infrastructure that separates cyclists from motorised vehicles appears to be a logical step in efforts to reduce risk exposure for vulnerable road users, and therefore, deaths and injuries associated with car vs cyclist collisions. However, the safety benefits of separated cycling infrastructure, and the extent to which it contributes to reductions in car vs bicycle collisions remains a contested issue. Beyond the 'activist' position taken by some that cyclists should attract equal weighting as motor vehicles on public roads (Furness, 2007), aspects of the safety benefits assumed to underlie separated cycling infrastructure may run counter to popular understanding of how population-level cyclist safety is achieved through other means.

For example, the Safety in Numbers (SiN) theory suggests that cyclist vs car collisions reduce in a non-linear fashion with increasing numbers of cyclists in a transport system. Although the mechanisms underlying SiN remain contested (Bhatia & Wier, 2011; Christie & Pike, 2015), various authors have suggested it may be influenced by behavioural adaptation among drivers (Jacobsen, Ragland, & Komanoff, 2015), cyclist density (Thompson, Savino, & Stevenson, 2015), or separated infrastructure (Christie & Pike, 2015; Pucher, 2001).

There may be truth to each of these candidate mechanisms, which have usually been studied in isolation. It is unclear, however, whether each works in concert to produce an overall safety effect, or whether, under the right (or wrong) circumstances, these individual mechanisms may act against one another to increase risk. For example, if behavioural adaptation by drivers works through increasing exposure of drivers to cyclists, this poses potential issues for the the role of separated infrastructure, which by default, *reduces* exposure to cyclists by removing them from the road.

Method, Results & Discussion

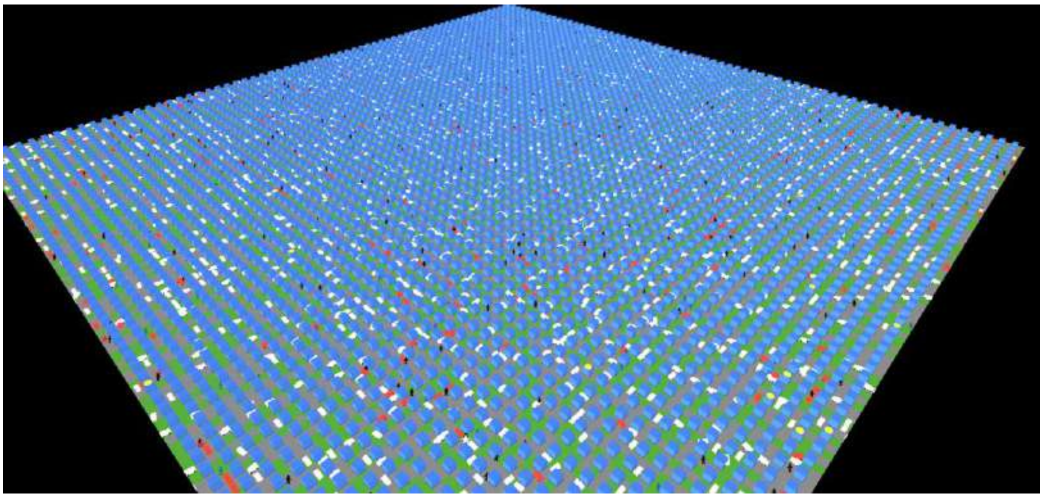

Figure 1. Birds-eye view of the simulated transport system

In the absence of in-situ laboratories, Agent-Based Models (ABMs) offer an efficient means of exploring proposed mechanisms underlying cycling safety to determine whether their effects can be replicated in simulated environments.

We constructed a simulated transport network using an ABM consisting of 2000 cars and 400 cyclists (see Figure 1). Among a population of simulated drivers who displayed behavioural adaptation in response to exposure to cyclists consistent with the proposed mechanisms underlying the SiN theory, we then altered road infrastructure throughout the network to include increasing saturation of separated cycle-pathways.

Preliminary results showed that under circumstances where behavioural adaptation operated among simulated drivers, low levels of separated cycling infrastructure (<25%) led to little or no change in car vs bicycle collisions to consequent reductions in behavioural adaptation by drivers. However, as separated cycling infrastructure reached peak saturation across the network, significant reductions in collisions were observed.

This study demonstrates the importance of modelling potential psychological and behavioural mechanisms associated with cyclist and vehicle interaction when estimating the safety benefits of new urban infrastructure. Practically, it suggests that critical levels of separated cycling infrastructure, beyond those currently present in many western cities, may be required to off-set reductions in behavioural adaptation among drivers before reductions in deaths and injuries might be expected.

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What do people think of road safety advertising campaigns?

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Abstract

Audience reaction to New Zealand's drink-driving, speed drugged-driving and fatigue advertising messages is monitored through a continuous survey of audiences' reactions to the advertising messages. The paper discusses some of the changes which have been measured in people's perceptions and attitudes from campaigns targeting speeding, drink-driving, fatigue and drugged driving. In addition, the surveys provide a monitor of public interest and concerns with the significant road safety issues of the day.

Background

Critical to New Zealand's road safety advertising programme is the continuous monitoring of audience reactions to the advertising messages. A weekly survey since 1997 provides information about the advertisements themselves, such as relevance, takeout, level of conversation, and likelihood to change attitudes. Perceptions and attitudes about road safety issues are included in the survey, using a stratified sample to provide sufficient data for youth, rural and Maori audiences. The findings are used on a weekly, monthly, quarterly and annual basis, but have rarely been used outside the advertising programme.

The survey programme allows the advertising campaigns to adapt and react rapidly to changes in public attitudes and behaviours, with new material, new media strategies or new target audiences. Although designed to support advertising, the information collected can be used more widely to inform road safety strategies and policies. This paper discusses the use of the survey in three of New Zealand's campaigns.

Campaign tracking

Over the years, the drink-driving campaign has seen substantial success among rural and young drivers. The advertising component is designed to support enforcement and to encourage lower levels of drinking if driving. Between 1998 and 2003, survey respondents' perceived likelihood of encountering a Police checkpoint increased steadily from 20% to 35%, with pronounced seasonal increases each December. Advertising messages subsequently promoted the social unacceptability of drink-driving, giving a small decrease in the perception of enforcement to 30% by 2007, but an increased perception that four or five drinks was a road safety problem. In 2014 the driver alcohol limit was lowered to 50 mg/100ml. The campaign now targets young males through influencers he might listen to, such as his close mates, his family and his colleagues, friends, teammates and even local bystanders. Those in the survey who say they would drive after more than two drinks have since decreased from 9% to 6%.

Speeding has proved a difficult behaviour to shift. While the advertising continues to support the efforts of Police, it has had a subtle change of emphasis in recent years, to bring the principles of a safe system into the public arena. In particular, people's vulnerability and fallibility have featured heavily in recent advertising messages. Behaviour changes are measured through regular surveys of vehicle speeds. Attitudinal changes are also monitored from levels of support for the enforcement programme, perceptions of others' speeds, attitudes towards speed, and beliefs about the relationship with injury and the likelihood of being ticketed. Respondents who believe they will are likely to be ticketed at speeds over 110km/h has increased from 63% to 72%.

The fatigue campaign has in some ways had the most difficult task, without an enforcement aspect to be reinforced by advertising, and no straightforward behaviour measure to show safety gains. The advertising tracking survey instead monitors a set of self-reported behaviours, which are typically slow to change; only one (the percentage of respondents who say they would get a good night's sleep before driving long distances) has shown a significant improvement from 70% to 82% in the past 8 years.

In addition, the surveys have provided a monitor of public interest and concerns with the significant road safety issues of the day. These perceptions can change in response to high profile incidents, bursts of media interest in particular issues, as well as the advertising campaigns themselves. The regular topics (alcohol, speed, road conditions and mobile phones) are always highlighted, but some important issues (such as fatigue) remain low on the list.

Framing road risks: Why road crash messages don't put people in the driver's seat

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Abstract

Road safety advertising in Australia is largely based on the assumption that more fear results in greater persuasion. As such, the portrayal of violent road crashes remains the status quo. The current research aimed to investigate if individuals perceive they can influence such outcomes, as theory suggests that efficacy perceptions are central to fear appeal success. Results from two studies demonstrated that participants believed their behaviours would influence financial and point penalty outcomes but not the occurrence of road crashes. This research demonstrates why the portrayal of car crash outcomes in road safety messages needs to be reconsidered.

Background

At their most basic, fear appeals are communication attempts that present the negative consequences of engaging in risky behaviours. The message aims to elicit fear by presenting a threat, in an attempt to encourage motivation for the performance of protective behaviours (Ruiter, Abraham, & Kok, 2001). In Australia, road safety advertising frequently employs the use of fear appeals that demonstrate severe consequences of risky driving in graphic ways (Donovan & Henley, 2003; Lewis, Watson, & White, 2008; O'Rourke, 2000). The consequences portrayed often involve horrifying pictures of mangled cars, bloodied victims and even the death of children (Algie & Rossiter, 2010). While some advertisements have focused on legal sanctions such as fines and demerit points (Donovan, Jalleh, & Henley, 1999) and others have appealed to perceptions of social acceptability (see the 'Pinkie' campaign, New South Wales Government, n.d.), outcomes portraying crashes, injury and death certainly remain the status quo (Algie & Rossiter, 2010; Carey, McDermott, & Sarma, 2013; Lewis, Watson, & White, 2013). It seems that Australia is not alone in this endeavour, with countries such as New Zealand, the USA and UK also favouring this approach. This is decidedly different to countries like The Netherlands who have a long history of employing tactics such as humour in this field (Hoekstra & Wegman, 2011).

The use of fear appeals in Australian road safety advertising became particularly popular in the 1990s. At this time, the Victorian Transport Accident Commission (TAC) had employed a series of hard hitting advertisements that demonstrated graphic scenes of road carnage, accompanied by depictions of the physical and emotional consequences (Donovan et al., 1999; Lewis, Watson, Tay, & White, 2007). These advertisements were expensive to create with estimated costs between $AUD 250,000 and 450,000 per advertisement. The TAC won international recognition for these advertisements and their approach was swiftly adopted by several other Australian jurisdictions (Donovan et al., 1999).

While experts have recommended that theoretical foundations and prior research are necessary to create successful road safety campaigns (Delaney, Lough, Whelan, & Cameron, 2004; Delhomme et al., 2009; Woolley, 2001), in practice this rarely occurs (Elliott, 2011; Wundersitz, Hutchinson, & Woolley, 2010). This is despite the potential pitfalls of fear appeals as a method of risk communication in road safety being emphasised for some time. Employing learning theory principles, Job (1990) highlighted how embedding fear as a punishment procedure in road safety messages is likely to be ineffective. Henley and Donovan (1999) noted the frequent use of death threats in Australian threat appeals generally. They maintain that death is a qualitatively different outcome in comparison to non-death outcomes in threat appeals. With non-death outcomes, it might be possible to offer solutions or behaviours that affect the outcome. However, it is much more difficult to reassure individuals that their behaviours will prevent death (Henley & Donovan, 1999). This is especially important to consider in a road safety domain because death is a consistently portrayed outcome in risk communication attempts. Similar concerns regarding the suitability of fear campaigns in road safety advertising have continued to be conveyed (Castillo-Manzano, Castro-Nuño, & Pedregal, 2012; Elliott, 2003, 2005; Hoekstra & Wegman, 2011; Wundersitz & Hutchinson, 2011).

Even though evidence for the use of fear appeals in road safety is scarce, fear campaigns continue to be used as a method of road safety advertising. It has been suggested that change is unlikely and the state of affairs will need to be tolerated for years to come. That is, decisions regarding the content of road safety advertising will continue to be made without thorough evaluation or scientific evidence (Wundersitz et al., 2010). Consequently understanding the factors that influence the relationship between fear and persuasion may be more valuable to investigate (Lewis et al., 2007). Proponents of this view have employed fear appeal theory – in particular the Extended Parallel Process Model (EPPM; Witte, 1992) as a theoretical foundation upon which to base research (Lewis, Watson, & White, 2010; Lewis et al., 2013). Inherent to this model is the idea that the perception of threat is needed to generate fear which, in turn, motivates processing of a message. However, it is coping appraisal which determines whether the message is accepted or rejected (Lewis et al., 2007; Maloney, Lapinski, & Witte, 2011). The coping appraisal component of the EPPM concerns evaluations of self efficacy and response efficacy. Self efficacy can be defined as a person's belief or confidence in performing a behaviour while response efficacy refers to a person's belief that the behaviour will be effective in preventing the threat (Boer & Seydel, 1996; Maloney et al., 2011). The relationship between threat perception and coping appraisal hypothesised by the EPPM is an interactive one. That is, threatening information will only result in adaptive behaviour (message acceptance) if there are positive coping appraisals (Ruiter, Verplanken, Kok, & Werrij, 2003).

Empirical evidence for the proposed theoretical relationship has been inconsistent. Meta analyses from the broader health literature have demonstrated main effects of threat and efficacy but have provided no evidence for the proposed interaction between these variables (de Hoog, Stroebe, & de Wit, 2007; Witte & Allen, 2000). These findings indicate that higher threat alone can facilitate message acceptance. Peters, Ruiter, and Kok (2012) hypothesised that the inconsistent evidence could be due to poor selection of the target audience, as audience profiles on threat and efficacy are not considered prior to receiving a threatening message. Thus, a review of empirical evidence by these authors included only studies that manipulated both variables. Results demonstrated an interaction effect between threat and efficacy whereby threat only had an effect on adaptive behaviour when efficacy was high. Likewise, the effect of efficacy was only significant when threat was high. This research suggests that unless efficacy perceptions are high at baseline (or effectively enhanced via an intervention), threatening communications can be ineffective at influencing adaptive behaviour (Peters et al., 2012).

The implications of this work are important to consider when discussing road safety outcomes. As noted by Pedruzzi, Swinbourne, and Quirk (2012) a negative road outcome can be perceived, correctly, as a function of other people's behaviour. Therefore individuals may feel they have limited ability to influence outcomes. Road outcomes fall into two broad categories. Those an individual has control over (e.g. their own speeding behaviour) and those an individual has no control over (e.g. a speeding driver in another car). Road campaigns tend to target the former by demonstrating how the viewer's driving behaviour can result in negative outcomes. The work of Peters et al. (2012) suggests that the effectiveness of these messages may depend upon pre-existing perceptions of driving behaviours to influence negative outcomes. However, the EPPM will have different predictions depending upon the target outcome. Individuals may have control over their own road behaviour but negative road outcomes can still occur in the presence of this behaviour. Such a situation will likely affect efficacy appraisals. It therefore makes sense to evaluate individuals' belief in their ability to influence road outcomes. This is important because real world applications of road safety risk communication generally fail to include or address efficacy components. Understanding efficacy appraisals could provide valuable insight into audience beliefs about road risks, and, the most appropriate outcomes to target in road safety research and advertising employing threat as a stimulus.

The current research thus aimed to investigate if belief in one's ability to perform a set of road behaviours is in fact related to beliefs in influencing the occurrence of negative road outcomes. In order to do this participants were asked to estimate control perceptions, specifically their confidence in their ability to control or influence a set of road behaviours and outcomes. Numerous road safety advertisements focus on crash or fine outcomes, therefore these outcomes were the subject of this investigation. As the occurrence of fine penalties are ultimately due to individual behaviour, it was hypothesised that perceived control over road risk behaviour and perceived control over the occurrence of fines would be similarly high, and related to each other. In contrast, it was hypothesised that perceived control over the occurrence of crash outcomes would be relatively low and have weak or no relationship with perceived control over road risk behaviours.

Study 1

Method

Participants

A sample of 236 participants was recruited from the Townsville region in North Queensland via the advertisement of an online survey. The survey link was largely advertised on online social networks, university newsletters, and community events pages. Participants could click on the advertised link to proceed to the survey. Of this sample, 31 participants requested to fill out a paper questionnaire. The majority (85%) of the sample were Queensland residents while 25 participants reported living elsewhere in Australia. There were 3 participants who reported living overseas while 4 individuals did not give any information about their place of residence.

The sample consisted of 156 females and 76 males (4 participants did not indicate their gender) ranging in age from 18 to 73 years (M = 38.97, SD = 13.89). Eight percent of the respondents reported their highest level of education was year 10 in secondary school. A further 22% reported completing year 12. Almost 33% had completed an undergraduate degree. About 8% of the sample reported having a trade qualification while the remaining 27% reported completing some other form of education. Cases were examined for missing values. A total of 29 participants were missing data on one or more of the variables of interest and were excluded. These participants were older than those without missing data ($t_{(233)} = -2.01$, $p = .05$). However the distribution of gender did not differ between groups (χ^2 (1, N = 232) = 2.19, $p = .15$). Six participants with missing data had been involved in a car crash compared to fifty participants without missing data. These proportions were not significantly different (χ^2 (1, N=235) = .10, $p = .75$). Missing data was dealt with using list wise deletion thus resulting in a final sample of 207 participants.

Measures

This study was embedded within a broader project, and only the behaviours and outcomes specific to this report are grouped and listed below. Specifically, three target variables were examined. These were control over road behaviours, and control over fine and crash outcomes.

Control over road behaviours

Participants were presented with a number of road behaviours. These behaviours included 'driving without talking on a mobile phone,' 'driving without texting,' 'driving over the speed limit,' and 'driving with a blood alcohol level over the legal limit.' Participants were asked to consider each behaviour happening to them, and indicate their confidence in their ability to control or influence each one. Participants responded on a 7 point Likert scale (1 = no confidence, 7 = complete confidence).

Control over fine and crash outcomes

A number of road related outcomes pertaining to fines were presented to the participants. These outcomes included 'being booked for speeding,' 'being booked for drink driving,' 'being booked for talking on a mobile phone while driving,' and 'being booked for texting while driving.' One item 'being involved in a car crash' assessed control over a crash outcome. Participants were asked to think about the outcomes happening to them and indicate their confidence in their ability to control or influence each one. Participants responded on a 7 point Likert scale (1=no confidence, 7 = complete confidence). Participants were also asked to indicate whether or not the event had happened to them.

Procedure

Ethics approval was obtained through the James Cook University Ethics Committee (H4576). Participants were directed to an online version of the survey which was hosted at Survey Gizmo. Participants were asked to think about the behaviours and outcomes described as actually happening to them before indicating their confidence in their ability to control or influence each one.

Results

Statistical methods & data preparation

Data was analysed using both SPSS and AMOS (version 22). In order to test the effects of behavioural control on fine and crash outcomes, Structural Equation Modelling (SEM) with AMOS was used. The strength of this approach, in comparison to creating composite variables, is that latent variables can be tested and a Confirmatory Factor Analysis (CFA) can be performed simultaneously. Furthermore, SEM can provide more accurate estimates of relationships as it models the error variance specific to each variable. The overall models were tested with Maximum Likelihood Estimation using the covariance matrix. Univariate and multivariate non normality were assessed by examining normality statistics in AMOS (see Byrne, 2010). To adjust for inflated standard errors when data was identified as multivariate non normal, Bollen-Stine bootstrapping procedures were performed with 2000 bootstrapped samples at 95% confidence intervals (Bollen & Stine, 1992). Sample size considerations for SEM require at least 10 participants per estimated parameter as less than this can result in power and model stability issues (Kline, 2011). In consideration of this, no more than 20 estimated parameters were modelled with the current sample.

Model fit was assessed with chi square indices, Bentler's Comparative Fit Index (CFI; Bentler, 1990), the Adjusted Goodness of Fit Index (AGFI), the Root Means Square Error of Approximation (RMSEA) and the Standardised Root Mean Square Residual (SRMR). A non-significant chi square is indicative of good model fit. The post hoc adjustment made by the Bollen –Stine bootstrap also yields a non-significant p value to indicate good model fit. For CFI, values obtained should be greater than .95 (.90 at minimum) AGFI should be above .90, RMSEA less than .06 and SRMR less than .05 (Byrne, 2010). Latent variables were created for 'control over behaviours', and 'control over fine outcomes'. CFA was performed to evaluate the validity of the latent variables used in the structural model.

Control appraisals

Participants' average ratings of control for the behaviours and both fine and crash outcomes are presented in Table 1. The table also includes the average ratings for each item. Internal consistencies are presented for the latent variable measures.

Table 1. Means, standard deviations and internal consistencies for each item and measure

Control appraisals	**Mean (*SD*)**	**α**
Driving without phone	5.97 (1.50)	
Driving without texting	6.27 (1.33)	
Speeding	5.76 (1.34)	
Drink driving	6.26 (1.56)	
Control over behaviours	6.06 (1.05)	.71
Booked for phoning	5.95 (1.57)	
Booked for texting	6.03 (1.60)	
Booked for speeding	5.68 (1.45)	
Booked for drink driving	6.45 (1.14)	
Control over fine outcomes	6.03 (1.19)	.84
Control over a car crash	3.66 (1.51)	

Tests of the hypothesised model

Normality testing demonstrated significant evidence of multivariate non normality. Mardia's multivariate kurtosis index was 82.33 (C.R. = 42.09). As such Bollen-Stine bootstrap was employed to adjust for the lack of multivariate normality. The hypothesised model and pathways are illustrated in Figure 1 along with their standardised coefficients. Only the direct relationships between variables were tested. No mediation was tested nor was it expected to occur for the following reasons. Fine outcomes are not necessarily indicators of risk for road outcomes such as crashes. Furthermore, in an applied context fine outcomes are not portrayed as leading to crash outcomes.

The direct pathway between the latent variables 'control over behaviours' and 'control over fine outcomes' was significant (p < .001). This relationship indicates that as perceived control over road behaviours increases, perceived control over fine outcomes tends to increase as well. The pathway between 'control over fine outcomes' and control over 'being involved in a car crash' was not significant (p = .23). The relationship between 'control over behaviours' and control over 'being involved in a car crash' was also not significant (p = .79). The factor loadings for each item onto the respective latent factors were all significant (p < .001). The item reliabilities are reported in Table 2. In particular, control over speeding and control over drink driving seem to be poor measures of the 'behaviours' construct. Likewise, control over being booked for speeding and control over being booked for drink driving are also weak measures of the 'control over fine outcomes' construct. These items require further investigation. Model fit statistics indicated a poor fitting model with χ^2 (25) = 177.68, p = .00; CFI = .84; AGFI = .72; RMSEA = .17 (90% CI = .15;

.20); SRMR = .12. Bollen-Stine bootstrap produced an adjusted p value < .001 further supporting poor model fit.

The zero order correlations between the behavioural control and fine outcome control items were further investigated. These correlations (using Spearman's rho) are presented in Table 3. These relationships were investigated due to the poor model fit, and poor item reliability of the speeding and drink driving items for both the behaviours and fine outcome constructs. Of importance here is that the behavioural items correlated significantly with their respective fine outcomes. For example, perceived control over speeding and perceived control over being booked for speeding was significantly and positively correlated. All behavioural items were significantly and positively correlated with their corresponding fine items. The model output suggests that the items assessing use of a phone while driving or being booked for using a phone while driving account for most of the variance in the control over behaviours and fine outcomes factors. The correlation between control over 'driving without talking on a mobile phone,' and control over 'driving without texting' was significant, positive and particularly strong, suggesting the items assessed similar behaviours. In addition, the significant positive correlation between control over 'being booked for talking on a mobile phone while driving,' and control over 'being booked for texting while driving' is suggestive of a similar situation. There were significant positive correlations between the remaining road behaviours. Specifically, as control over one road behaviour increased, control over another road behaviour tended to increase as well.

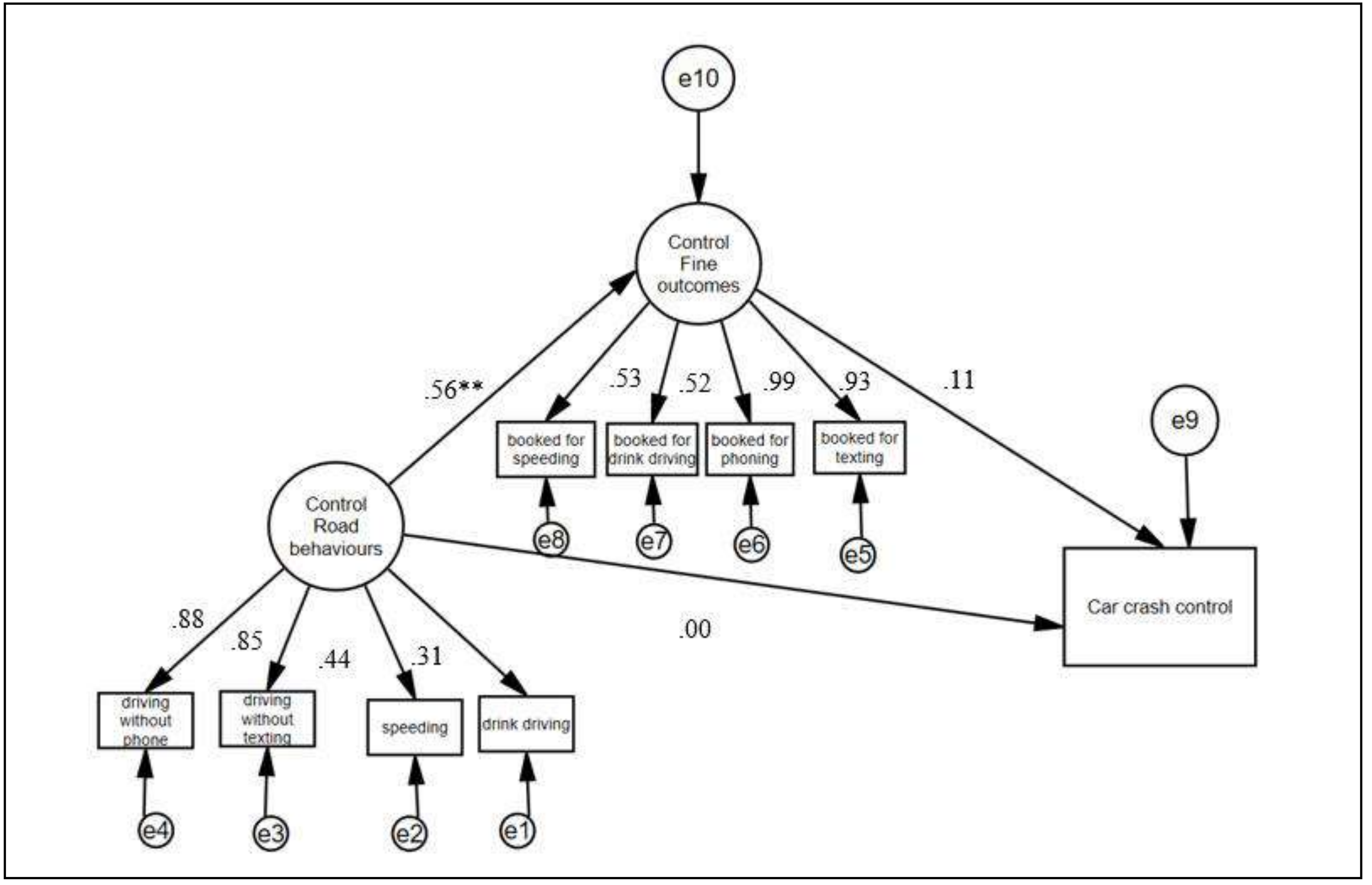

Figure 1. Road model including standardised coefficients for structural pathways and measurement model

**p < .001

Table 2. Item reliabilities for items in the measurement model

Item	**Estimate**
Driving without talking on a mobile phone	.78
Driving without texting	.72
Driving over the speed limit	.20
Driving with a blood alcohol level over the legal limit	.10
Being booked for speeding	.28
Being booked for drink driving	.27
Being booked for talking on a mobile phone while driving	.97
Being booked for texting while driving	.87

Table 3. Correlations between items in the measurement model

Item	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1. Speeding	1							
2. Driving without phone	.43	1						
3. Driving without texting	.40	.75	1					
4. Drink driving	.38	.26	.33	1				
5. Booked for speeding	.55	.33	.31	.28	1			
6. Booked for drink driving	.31	.26	.26	.46	.48	1		
7. Booked for phoning	.34	.55	.52	.33	.48	.47	1	
8. Booked for texting	.33	.47	.57	.34	.41	.43	.89	1

Note. All correlations are significant at the 0.01 level

Discussion

The aim of the current study was to investigate relationships between behavioural control and negative road outcomes frequently communicated in road safety advertising. This was conducted in order to understand if an individual's perceived ability to perform road behaviours was in fact able to influence the occurrence of negative road outcomes. Understanding these relationships would provide insight into the best outcomes to model in road safety advertising. It was found that ratings for perceived control over behaviours and perceived control over fine outcomes were, on average, quite high. This result was not unexpected. The road behaviours employed in this study are enforced by compliance frameworks which will affect motivation to carry out such behaviours. Likewise, being booked for speeding or drink driving cannot occur unless an individual performs the risky behaviour. Specifically, as beliefs in the ability to control road behaviours increased, so did beliefs in the ability to control fine outcomes. This is in contrast to a situation where the individual did not wholly determine outcomes. For example, control over being involved in a car crash was comparatively low, and not related to control over behaviours. This could be because a car crash outcome can occur in the presence of a risk mitigation behaviour due to the behaviour of other drivers on the road.

The implications of these findings are straightforward and impact upon theory and practice. The first consideration involves control perceptions, efficacy and the hypotheses of the EPPM. Perceived control over an outcome or situation is a function of one's perceived ability to enact a set of behaviours, and the belief that the behaviour will be effective in influencing the outcome. These beliefs are reflected in self-efficacy and response efficacy respectively (Boer & Seydel, 1996; Maloney et al., 2011). These components are extremely important to fear appeal theory which hypothesises that without high efficacy, message acceptance is unlikely, rendering the fear appeal ineffective (Witte, 1992, 1996). The investigation of different control targets in this study, allowed for the identification of a negative outcome characterised by high perceived control, specifically, a fine outcome. However, of particular importance here is understanding whether self-efficacy for performing a behaviour is in fact related to bringing about an outcome. These appraisals may determine the effectiveness of threatening road safety messages. Results from the current study suggest that messages focusing on outcomes such as road crashes would be ill informed as such outcomes have no relationship with perceived control over behaviours. Rather, there was a strong relationship between control over road behaviours and fine outcomes demonstrated here. It would therefore seem that in order to best influence behaviour, outcomes related to graphic crashes and deaths should instead be replaced with outcomes related to financial and point penalties. Further, the correlations between the behavioural items indicates that the perceived ability to control a risky or protective road behaviour allows an individual to influence other road related behaviours. Interventions targeting at least one risk behaviour may therefore have some benefit in reducing other behaviours.

While this study has important implications for the focus of road safety campaigns, there are some limitations. First, the item assessing control over a car crash allowed for the perception that another person can cause a crash. Future work should employ items that exclude this possibility. If the relationship between behavioural control and occurrence of a car crash changes when perceiving fault, it has direct implications for interventions. The finding would suggest that making fault salient could result in more effective campaigns. This was addressed in Study 2. Further, some of the items used in the model were not reliable indicators of the latent variables. For example, the items related to speeding and drink driving were poor indicators of their constructs. This may be a consequence of the phone offence items used for each construct. These items were very similar, highly correlated, and as such accounted for most of the variance in both the behaviour and fine variables. Additionally, the behavioural items were not framed consistently. Two items were framed as protective behaviours while the remaining two were framed as risk behaviours. It could be that the poor reliability of the items may be an effect of frame. These issues were also addressed in Study 2.

Study 2

Study 2 aimed to retest the structural model developed in Study 1 with a new sample. Study 1 allowed individuals to perceive that a car crash outcome could be due to the fault of another person. Study 2 corrected for this assumption by making fault salient. The item reliability issues from Study 1 were also addressed. It was hypothesised that behavioural control would have a strong and positive relationship with control over fine outcomes as previously demonstrated. No other significant relationships were expected to occur in the structural model.

Method

Participants

Participants were recruited mainly from the North Queensland region in Australia. Recruitment occurred largely via advertisements on local radio and news channels, online forums, newsletters and local car enthusiast websites and Facebook pages. Advertisements were also put up around the University and psychology students could participate for credit points. As the survey was conducted as an online survey, advertisements included the address of the online URL. Initially, 339 participants chose to participate by clicking the start button. Of these, 43 participants did not provide any further information. Another 24 of the participants indicated they lived outside of Australia and were thus removed from the analysis. A further 44 participants did not have scores on the variables of interest and were also excluded, resulting in a final sample size of 228 participants. There were 77 males and 133 females in the sample (18 people did not give information about gender). Participants ranged in age from 17 years to 71 years (M = 34.89, SD= 15.17) and approximately 30% of participants indicated their highest level of education was an undergraduate degree.

Measures

This study was embedded within a broader project, and only the variables specific to this report are described. To assess perceived control over road behaviours, 7 items were used employing different frames. Four items were framed as protective behaviours and three items were framed as risk behaviours. Examples of protective items included ‘driving to the speed limit,’ and ‘driving without using a mobile phone.’ Examples of risk items included ‘driving over the speed limit’ and ‘being distracted by a mobile phone whilst driving.’ Three items assessed perceived control over fine outcomes. These were ‘being booked for speeding,’ ‘being booked for using a mobile phone while driving’ and ‘being booked for drink driving.’ One item ‘having a crash as the driver at fault’ assessed perceived control over a crash outcome. Participants responded on a 7 point Likert scale (1 = no confidence, 7 = complete confidence). Participants were also asked questions about their driving history.

Procedure

Ethics approval was obtained through the James Cook University Ethics Committee (H5043). The survey was hosted at Survey Monkey and participants were directed to an online link ‘Road threats: Feelings, thoughts and behaviours’ which first described the study. As per Study 1, participants were asked to think about the behaviours and outcomes happening to them before indicating their ability to control or influence each one.

Results

Statistical methods

Data was analysed using SPSS and AMOS (versions 22). For the analyses employing SEM techniques latent variables were created for 'control over behaviours' and 'control over fine outcomes'. For control over behaviours, protective items were grouped separately to risk items. Therefore, any effects of frame could be included and accounted for. Model fit was assessed using the same indices described in Study 1.

Sample characteristics

About 90% of the sample reported having access to a car for their own personal use. Approximately 10% reported having access to a motorbike while 4 participants reported access to a scooter. Participants reported being licenced for .5 to 59 years (M = 17.04, SD = 15.00) and also reported high amounts of driving activity. On average participants spent over 9 hours driving as a driver per week (SD = 9.26). Approximately 60% of respondents reported they had been booked for a traffic offence. The most frequently reported offence was speeding. While 40% of respondents indicated they had never been in an accident as a driver, the remainder had been in at least one accident as a driver. When asked to think about the most severe accident they had been involved in, 66% of respondents reported being the driver. Almost half (48%) of these individuals reported they were at fault. About 18% of respondents reported having an insurance claim made against them in the past and 10% reported losing their licence at some stage.

Retest of the measurement model and structural pathways

In a similar manner to study 1, control over road behaviours and control over fine outcomes were modelled as latent variables. However, in this study the road behaviour items were grouped by the frame employed. This resulted in two separate latent variables, 'control over risk behaviours,' and 'control over protective behaviours.' Participants' average ratings of control for each item and their corresponding latent variables are presented in Table 4. Internal consistencies are also presented for the latent variables.

CFA was performed in AMOS to again evaluate the validity of the latent variables used in the structural model. The latent variable 'control over risk behaviours' was chosen in this analysis. This measure had a greater estimate of reliability (Table 4), but most importantly control over risk behaviours is more appropriate to use due to the risk frame largely employed in road campaigns[1]. Normality statistics in AMOS demonstrated evidence of multivariate non normality – specifically positive kurtosis (Mardias coefficient = 32.02, C.R. = 21.54). As such Bollen-Stine bootstrapping procedures were performed with 2000 bootstrapped samples at 95% confidence intervals (Bollen & Stine, 1992). The final model consisted of 19 estimated parameters. The measurement model and pathways under investigation are presented in Figure 2. The standardized coefficients for the structural pathways are included in the figure. There was no relationship between control over risk behaviours and control over having a car crash as the driver at fault. The direct pathway between control over risk behaviours and control over fine outcomes was significant. This relationship indicated that as perceived control over risk behaviours increased, so did control over fine outcomes. This accounted for 45% of the variance in control over a fine outcome (R^2 = .45). There was a significant and positive relationship between control over fine outcomes and control over

[1]For interest the hypothesised model employing 'control over protective behaviours' has been included as an appendix. Standardized coefficients for the structural pathways and factor loadings for the measurement model have been provided along with indices of model fit. Item reliabilities for items in the measurement model are also provided (See Appendix A).

having a crash as the driver at fault. This relationship indicated that as control over fine outcomes increases, control over a car crash at one's own fault tends to increase as well.

The factor loadings for each item onto their respective latent variable are displayed in Table 5. All loadings were significant ($p<.001$). Item reliabilities are reported in Table 6. Modification Indices were examined to assess any source of model mis-specification. These indices give an indication of the residual covariance, and represent the decrease in the value of the chi-square that would result if the parameter was freed. An examination of the modification indices suggested to co-vary the error terms as specified in Figure 2. The highest cross loading was between e3 and e6 (coeff = .31). Model fit statistics indicate good model fit with χ^2 (9) = 17.19, p = .05; CFI = .99; AGFI = .94; RMSEA = .06 (90% CI = .01; .11); SRMR = .03. The Bollen-Stine bootstrap procedure to correct for non normality produced an adjusted p value of .27, thus also suggestive of adequate model fit. The entire model accounted for 29% of the variance in control over a road crash outcome (R^2 = .29).

Table 4. Means, standard deviations and internal consistencies for each item and measure

Measures	**Mean *(SD)***	**α**
Driving over the speed limit	5.46 (1.55)	
Being distracted by a mobile phone whilst driving	5.21 (1.76)	
Driving with a blood alcohol content (BAC) over legal limit	4.86 (2.55)	
Control over risk behaviours	5.18 (1.60)	.72
Driving to the speed limit	6.11 (1.18)	
Driving without using a mobile phone	6.03 (1.41)	
Refraining from drinking and driving	6.64 (.99)	
Ensuring you are not tired when driving	5.30 (1.36)	
Control over protective behaviours	6.02 (.86)	.64
Control over fine outcomes	5.80 (1.36)	.81
Control over having a crash as the driver at fault	4.86 (1.57)	

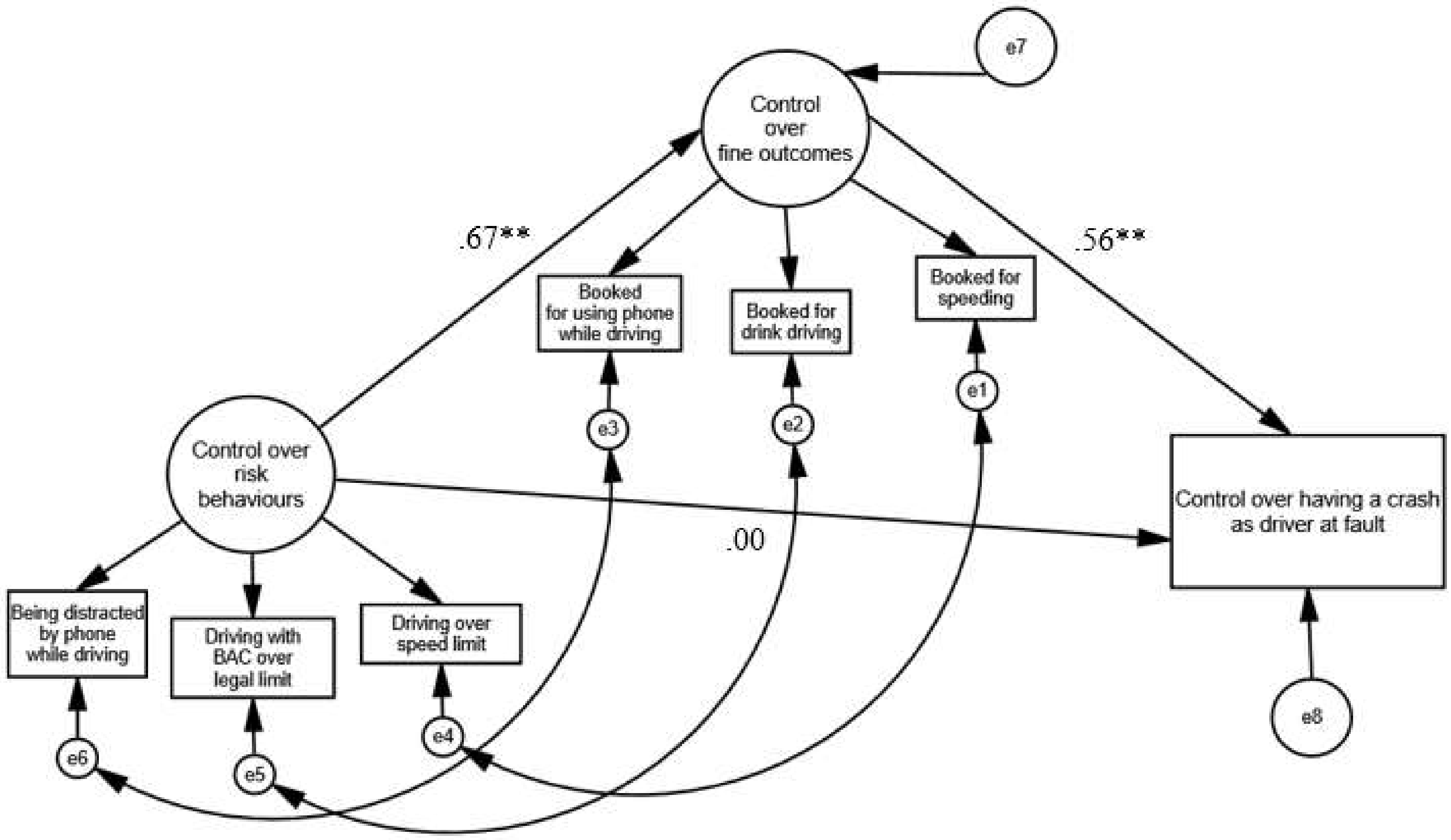

Figure 2. Measurement model and structural pathways tested for hypothesised model of road control

**p <.001

Table 5. Factor loadings for each item onto their respective latent variables

Control over risk behaviours	**Factor loading**
Driving over the speed limit	.71
Being distracted by a mobile phone whilst driving	.82
Driving with a blood alcohol level over the legal limit	.62
Control over fine outcomes	
Being booked for speeding	.63
Being booked for using a mobile phone while driving	.87
Being booked for drink driving	.81

Table 6. Item reliabilities for items in the measurement model

Item	**Estimate**
Control over driving over the speed limit	.50
Control over being distracted by a mobile phone whilst driving	.67
Control over driving with a blood alcohol level over the legal limit	.39
Control over being booked for speeding	.40
Control over being booked for using a mobile phone while driving	.75
Control over being booked for drink driving	.65

Discussion

A retest of the measurement model and structural pathways demonstrated results that were for the most part as hypothesized. The relationship between perceived control over risk behaviours and perceived control over fine outcomes was particularly strong, accounting for 45% of the variance in perceived control over being fined. This finding suggests as belief in the ability to control risky road behaviours increases, so does belief in the ability to control fine outcomes. Specifically, being able to control the performance of risky road behaviours such as speeding, distraction, and drink driving, was generally perceived as being effective in controlling whether or not an individual is fined for such behaviour. In contrast no relationship between perceived control over risk behaviours and perceived control over a crash outcome was detected. This relationship was not evident even though this study rectified the limitation of Study 1. The crash outcome was clearly framed as the respondent's fault, that is, as a consequence of the respondent's behaviour. These findings should provide a warning against the consistent use of crashes in Australian road safety campaigns.

The significant and positive relationship between perceived control over fine outcomes and perceived control over crashing at fault was unexpected. This relationship indicated that increases in the perceived ability to control fine outcomes were related to increases in the perceived ability to control crashing as the driver at fault. In order to explain this relationship, it is helpful to consider the hypotheses proposed by the EPPM (Witte, 1992). Specifically, if an individual perceives risk of a fine, s/he will be motivated to act to decrease their fear. However, this action could include carrying out a behaviour that alleviates the threat but does not comply with driving laws. For example, if the location of a speed camera is known, an individual may speed but take an alternate route to avoid a fine. The avoidance of fine outcomes may lead to beliefs of superior driving ability. If an individual overestimates their driving ability, crashing at fault would be perceived as an unlikely occurrence. This hypothesis may explain the unexpected relationship between the fine and crash outcome variables. Additionally, overestimations of driving ability have been found to be quite common in motorists (Harré, Foster, & O'Neill, 2005; Job, 1990; Pedruzzi & Swinbourne, 2009). If motorists perceive that they are unlikely to crash at fault, it also gives rise to the possibility that the model employed in this study was unable to adequately capture the hypothesised relationship between behavioural control and control over crashing at fault. Future work should aim to understand if overestimations of driving ability affect this pathway.

The increased reliability of the measurement model, compared to Study 1, could be a result of the consistent frame employed for the items in this study. In Study 1 the behavioural control variable consisted of behaviours framed in both positive and negative ways. The model employed in this study used items that were framed consistently as risk behaviours. Additionally, some of the item reliability issues were addressed in the current study. For example, two separate (and highly correlated) items were used in Study 1 to assess perceived control over talking or texting while driving. The current study instead replaced these items with one item assessing perceived control over mobile phone related behaviours. The current study freed pathways between the respective behaviour and fine outcomes as suggested by the modification indices. This was not performed in Study 1 due to sample size considerations. This likely contributed to the better model fit in the current study. Correlated error terms in a measurement model indicate overlap in the unique variance of items, therefore the approach is usually reserved for error terms within latent factors. In this situation, it makes sense that residual error would be shared by the items specified in the model. For example, perceived control over speeding behaviour allows an individual to control the occurrence of being booked specifically for speeding. However, the relationship between each factor and control over crashing at fault demonstrates that they are qualitatively different measures. It is also possible that the better reliability of the measurement model is due to the change in sample.

The main limitation of this work regards the selection of the sample. While research examining road safety behaviour in regional samples has been called for (Veitch, Sheehan, Turner, Siskind, & Pashen, 2005) it might be hasty to draw conclusions to large metropolitan areas. The environment in North Queensland requires drivers to switch driving strategies more often than metropolitan drivers. Specifically, the region consists of smaller urban areas connected by long stretches of highway driving. These roads have considerably less traffic and fewer lanes, however more random road risks are prevalent. For example, highways can be crossed by wildlife at any time of the day thus impacting on driving conditions without warning. Poorly designed roads are often damaged or inaccessible as a result of severe weather events such as storms and cyclones. These events contribute to a high risk environment that can be more unpredictable than some metropolitan areas. Consequently, these experiences may have contributed to the perception that road behaviours were not able to influence the occurrence of crashes. Future work should be carried out in an urban environment to ensure the validity of the framework across diverse driving environments and thus samples.

Finally, the framework employed in the current body of research allows inferences to be made regarding the selection of outcomes for the development of effective road messages. This framework could also be used to predict message acceptance outcomes frequently employed in the literature. Most research using models such as the EPPM (Witte, 1992) sums the components of self-efficacy and response efficacy in order to test the relationship between efficacy and message acceptance or message rejection. The current research demonstrates how this could be problematic in a road context. Ensuring the relationship between self-efficacy for performing a behaviour is in fact related to controlling an outcome is necessary for adaptive behaviour. This research demonstrates that the predictions of the EPPM will be different depending upon the road outcome targeted. This insight could be lost, and potentially result in inconsistent evidence, if efficacy components are simply combined. Instead, the relationships between the components need to be defined in the model. In this study individuals believed that performing a preventative or risk behaviour on the road had no relationship with the occurrence of a road crash outcome. Beliefs such as these prior to receiving a message might, therefore, act as potential barriers to acceptance of threatening road messages. The identification of appropriate control targets may consequently need consideration to enhance the predictive power of the EPPM. Future work should consider this possibility both within and outside of the road safety field.

Concluding remarks

This study demonstrates that the portrayal of crash outcomes in road safety advertising is counterintuitive because even high perceptions of self-efficacy for road behaviours are perceived to have little bearing on crash outcomes. Participants tended not to consider that crashes were in their control, or that engaging in risk mitigation behaviours such as driving within the speed limit would have any benefit in terms of preventing crashes – even when the crash was framed as the fault of the individual. These findings are quite surprising and somewhat alarming. This research suggests that campaign designers should concentrate their efforts on increasing the perception that people will be penalized with financial and point penalties for risky road behaviours. As these outcomes are largely appraised as controllable by individuals, risk mitigation behaviours should increase in an effort to avoid fine outcomes. Engaging in these behaviours will consequently reduce the number of road crashes.

Additionally, it is suggested that such messages should remind audiences that they are responsible for the occurrence of fine outcomes, by providing clear and controllable behavioural directives to prevent such outcomes. Factors in the environment may activate beliefs that interfere with pre-existing control perceptions. For example, there are groups in the community that actively seek out concealed speed cameras and warn others of their whereabouts ("Masked protesters," 2014). Likewise, social media campaigns exist to block fine efforts by the police (O'Rourke, 2015). Radar scrambling devices can be easily purchased which stop traffic cameras from detecting speeding cars. Anecdotal evidence suggests that many motorists perform these behaviours because they believe that hidden traffic cameras exist for 'revenue raising.' It could be suggested that groups such as these are less likely to believe that fines are appropriate enforcement activities. As such, advertising efforts should remind people that these outcomes are under their own personal control. The implementation of such efforts may involve roadside billboards, messages, and increased policing efforts. For example, the use of speed monitoring devices on the road are an instant cue to slow down. This feedback method may also act to remind people that they will be caught if they continue to speed. The execution of these methods will need to constantly evolve in order to be ahead of motorists performing behaviours to escape negative consequences (Job & Sakashita, 2009).

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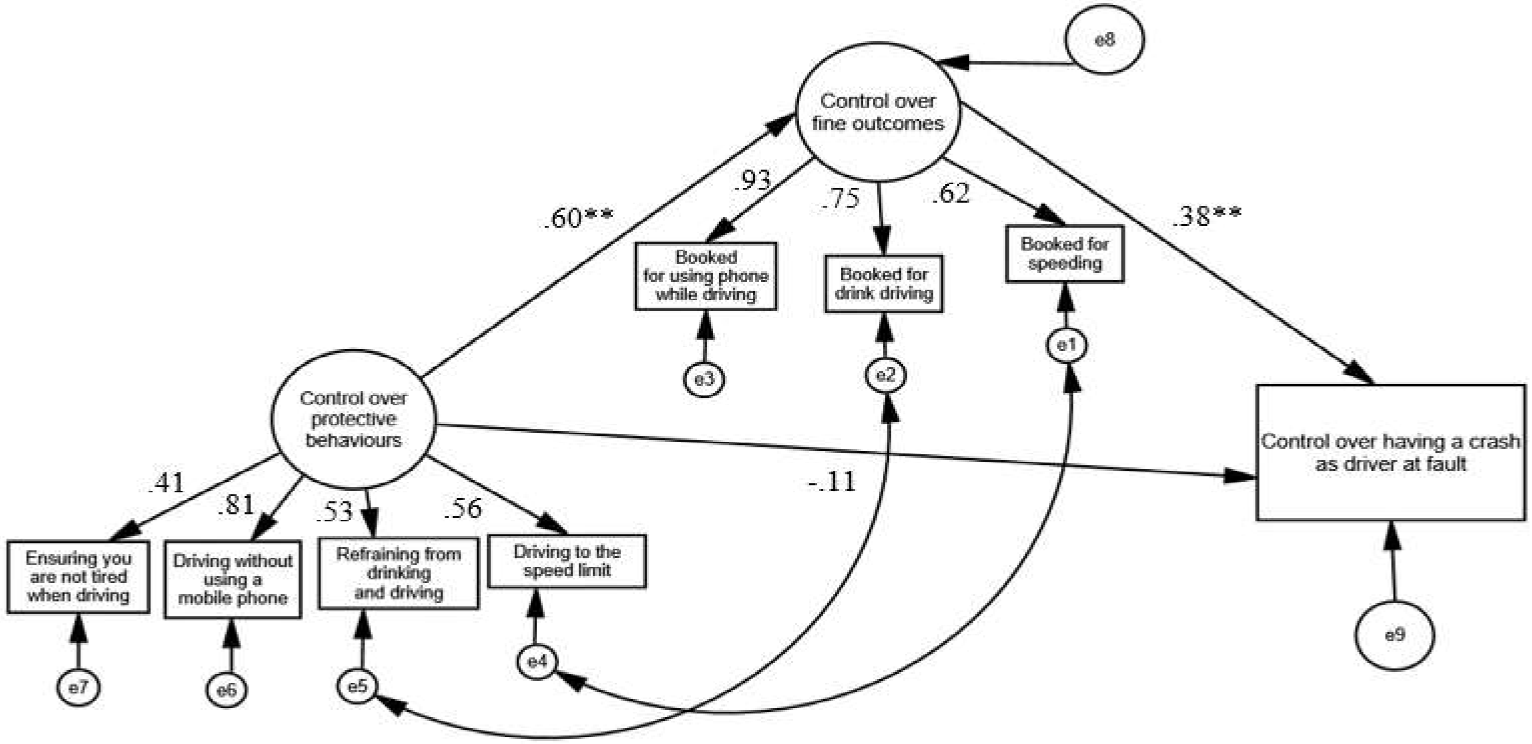
Appendix A



***Factor loadings and structural pathways for model employing control over protective (safe) behaviours*[2]**

**p < .001

[2] All factor loadings were significant (p <.001). Model fit statistics indicate poor model fit with χ^2 (16) = 38.77, p < .001; CFI = .96; AGFI = .90; RMSEA = .08 (90% CI = .05; .11); SRMR = .05. A Bollen-Stine bootstrap procedure to correct for non normality produced an adjusted p value of .04, also suggestive of poor model fit.

An accident is a crash is a collision – or is it?

Sonia Roberts

NSW Police Force Media Unit

Abstract

An accident is a crash is a collision. Semantics, most certainly, but is the use of the “A” word hurting road safety?

In terms of road trauma, the majority of crashes where people are killed or injured can be attributed to human factors such as speeding, impairment by either drugs and/or alcohol, non-use of occupant restraints or helmets, and tiredness. Mechanical factors can also be a consideration.

The presentation will examine the perceptions and definition of the terms and how this might impact on community understanding of road trauma and telling the road safety story across all media platforms.

Background

Accident, when used as a noun, is defined as ”an unfortunate incident that happens unexpectedly and unintentionally, typically resulting in damage or injury”.

A collision, when used as a noun, is defined as ”an instance of one moving object or person striking violently against another. Yet, under each definition, each word is used as a synonym for the other”.

The work of Haddon, between 1963 and 1972, in rejecting the term accident and redefining causational factors to take in elements such as engineering, the environment and education, has also been considered. Haddon’s research also defines the major stages of an injurious event.

This abstract and presentation will provide advice to NSW Police Force Media Unit recruits in obtaining a functional understanding of road trauma and the use/application of related terminology.

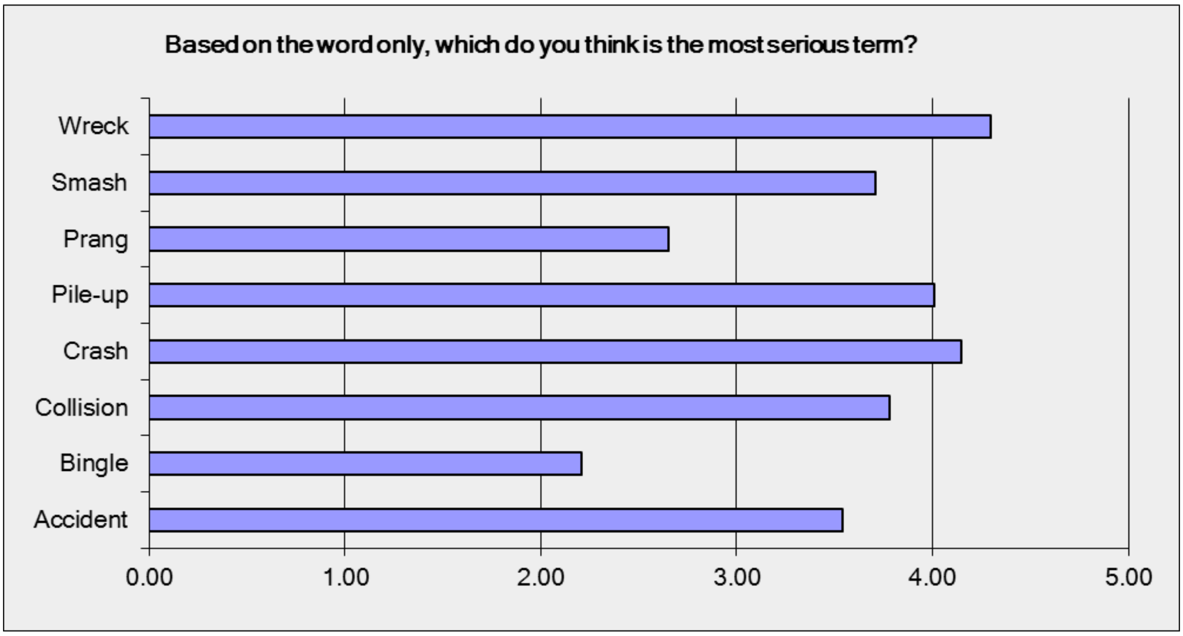
Why then are some sectors of the road safety world and the media using the term accident?

An online survey was conducted via Survey Monkey for two months. There were 132 respondents with over half falling into the 30-60 year age groups. Occupationally, the majority of respondents were in law enformcment, media and office/administration roles.

When asked how often they dealt with road trauma related issues, more than half of the respondents indicated they did not encounter these issues that often.

A number of potential synonyms for road trauma were listed in alphabetical order. From this list and based on perception of the word only, respondents were asked to rank them in terms of seriousness.

Just over half of the remaining respondents (64) rated the term “wreck” as extremely serious followed by “pile-up” (44) and “crash” (32). Only nine respondents considered the term accident” to be extremely serious. Only four of the 132 respondents skipped the question.



Source: Survey – An accident is a crash is a collision – bacall_au. www.surveymonkey.com)

Figure 1. Overall survey results regarding perception of road trauma synonyms

At the Bathurst 1000 in 2015, Chaz Mostert lost control of his car during a qualifying session, hit the track wall and was seriously injured. Speed was widely recognised as being the cause. Media coverage focussed on calling it a crash, smash or a collision. However, those in the commentary box including former drivers often used the term accident.

Sydney television and radio identity Glenn Wheeler was hit by a van while riding his motor scooter at Woolooware in 2015. The female driver was convicted of driving under the influence of cannabis and negligent driving causing grievous bodily harm. His fellow broadcasters described the incident as a tragic accident.

Dr Brian Owler, referenced "terrible avoidable accidents" in his address to the 2015 Australasian Road Safety Conference.

Does the attribution of blame play a part in what word has been used to describe the event that has led to a person being killed or injured?

In line with the conference theme it is important when discussing road trauma that we are innovative in our choice of words and not reach for obvious terminology, when other terms would have greater impact.

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Driving Change: Process Evaluation of a Multi-Site Community Licensing Support Program

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Abstract

Driving Change is a NSW community-based Aboriginal licensing program that was implemented in 12 communities. This process evaluation triangulates interviews (n=22), focus groups (n=18) and participant data (n=820) to explore barriers and facilitators to implementation and impact.

Driving Change is reaching the target population, facilitating licensing access and is highly responsive to community and client need. While interviewees reported strong support for the program, challenges to implementation included supporting field staff to broker collaborative stakeholder relationships and maintain community engagement. This evaluation highlights the value of stakeholders working collaboratively to overcome implementation challenges, build capacity and positively impact Aboriginal communities.

Background

Aboriginal people are estimated to be significantly under-represented among licence holders in NSW comprising 2% of the eligible driver population but only 0.5% of all licence holders (Transport for NSW, 2014). Low levels of licence participation in Aboriginal communties is a significant contributor to higher rates of transport-related injury, infringements, incarceration and transport disadvantage (Styles & Edmonston, 2006). The NSW government has committed to supporting evidence-based initiatives to reduce transport injury and increase legal and safe driving in Aboriginal communities (Transport for NSW, 2014). Integral to achieving this is assisting Aboriginal people to access the licensing system.

The Driving Change program was implemented to address barriers to licensing in 12 Aboriginal communities across NSW. The program targets young people aged 16-24 years and includes facilitating access to local services, intensive case management and providing mentoring through the licensing system. While there is an identified need for licensing support for Aboriginal communities, few licensing support programs have been evaluated. Thus, little is known about the effectiveness and acceptability of such programs to Aboriginal communities. The Driving Change process evaluation documented program implementation, explored the impact on the target communities and provided valuable insight into best practice for developing and implementing sustainable community-based driver licensing programs.

Methods

Mixed methodology combined framework analysis of stakeholder interviews (n=22) and community focus groups (n=18) with descriptive analysis of participant data (n=820) collected April 2013 to February 2016. Triangulation of data provided a rich understanding of fidelity, dosage and the program context including barriers and facilitators to implementation. Community engagement and acceptability were explored to determine the program's responsiveness to community and cultural needs.

Results

The target population is being reached with the majority of clients aged 16-24 years (72%), unemployed (88%) and with multiple barriers to licensing (67%). Licensing outcomes were achieved at all sites with 33% of learner drivers attaining a provisional licence. Interviewees conveyed strong support for the program, reporting that it was highly acceptable and particularly responsive to clients with complex needs. Recruiting volunteer mentors and maintaining long-term community engagement were significant implementation challenges. Further, it emerged that consistent and active support from local stakeholders was integral to field staff capacity to assist clients and deliver licensing outcomes. Consequently, the program intensified support for field staff to broker collaborative relationships with communities. Overall, a high level of collaboration between community and field staff facilitated implementation and built ongoing capacity to promote sustainability of the program.

Discussion

Driving Change has assisted young Aboriginal people to access licensing services in NSW. The program is reaching the target population and delivers a sufficiently flexible program that is responsive to community and client identified need. This process evaluation highlights the value of involving community and government stakeholders to foster capacity building and ensure a culturally acceptable approach to reducing injury, promoting safety and positively impacting Aboriginal communities. Beyond feeding directly into program delivery, process evaluations assist ongoing innovation of the program, promote program sustainability and ensure that the intervention is being delivered as intended with a high level of impact.

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‘It’s exactly what we needed’: A process evaluation of the DriveSafe NT Remote driver licensing program

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Abstract

DriveSafe Northern Territory (NT) Remote was implemented by the NT government to increase driver licensing in underserviced remote communities. This process evaluation triangulates informant interviews, program observation, program data and de-identified licensing data.

DriveSafe is accepted by remote NT communities, and impacting driver licensing rates in these settings. There was a greater increase in licences at intervention sites compared with other remote areas. A dose-response relationship showed greater licence outcomes at communities that received higher levels of program delivery. Interviewees regarded DriveSafe as highly engaging and flexible. DriveSafe’s culturally responsive and innovative approach should lead to further positive licensing outcomes.

Background

The Northern Territory (NT) has the highest rate of road transport-related injury of any jurisdiction in Australia, and the Aboriginal people in the NT have a fatality rate due to road transportation more than double the rest of the NT population (Australian Institute of Health and Welfare, 2012, p. 24). This has been attributed to known risk factors for transport-related injury in Aboriginal communities: remoteness, non-use of seatbelts, alcohol use and vehicle overcrowding (Clapham, Senserrick, Ivers, Lyford, Stevenson, 2008; Henley & Harrison, 2013). Unlicenced driving is also common due to the vastness of the region and the complex range of barriers to licesning in remote Aboriginal communities (Elliot & Shananhan Research, 2008; Helps et al., 2008; Job & Bin-Sallik, 2013). The *DriveSafe NT Remote* program was implemented in 2012 by the NT Government to address barriers to licensing faced by remote NT communities. DriveSafe faciltate proof of identifcation, deliver road safety education, professional driving lessons and administer the Learner and Provisional tests. Similar programs have been developed and implemented previously yet many have proved unsustainable due to inadequate funding and an inability to demonstrate outcomes. Further, licensing support programs are under-evaluated and there is limited evidence to establish best practice for program development. This process evaluation reviews program implementation and explores whether DriveSafe is addressing the needs of the target communities.

Methods

A mixed-methods approach triangulated NT licensing data, program data, program observation and informant interviews (n=30). Interviews were audio recorded and professionally transcribed; a general inductive approach to the analysis was employed. Program data (April 2012 to June 2014) and de-identified licensing data from the NT Motor Vehicle Registry were analysed for trends in service delivery and licensing rates pre and post-program.

Results

Interviewees reported strong support for the program, and regarded the program as highly engaging and acceptable. Adaptations to program delivery in response to implementation challenges have prioritised community capacity building and the sustainability of the program. There was a dose response relationship with greater licence outcomes at communities that received higher levels of program delivery. Trends in licences showed a greater increase in new licences at intervention sites (Learner 24% and Open licence 18%) compared with other remote areas (Learner licence 13% and Open licence 8%).

Discussion

The DriveSafe program is achieving licensing outcomes and has demonstrated capacity for a flexible approach that is responsive to remote communities. Variation in program delivery across regions predominately reflects flexible service provision adapted to meet community needs. The variation in delivery is also indicative of community capacity and engagement with the program. Notably there was a positive association between areas that received a high dose of the program and communities that had increased licensing outcomes post program delivery. This relationship was reinforced by staff reports that program delivery is strengthened in communities that actively engage with the program. DriveSafe's innovative delivery and culturally responsive approach should lead to further positive licensing outcomes. Process evaluations of multi-site community programs provide a valuable and pragmatic approach to ensuring the intervention is being implemented as intended to impact the target population.

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A transport crash injury return-on-investment calculator

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Abstract

While the benefits of a whole-of-system approach to the prevention and management of trauma are widely acknowledged, operationalizing the systemic concept is difficult. As a result, the whole system is rarely visualized or evaluated in its entirety. In this paper we report the results of a policy simulation experiment that tested the relative benefits of a range of possible policies addressing different parts of the trauma care system. The specific aim of the study was to identify which of the investment options optimize the population satisfaction with the trauma system performance.

Background

Traffic crash injury was chosen as an indicator injury type for evaluation of a comprehensive trauma system because it is a leading cause of injury related death and disability, has well-documented risks and frequencies measured at all points of the continuum, and has mature institutional and financial responses within the social environment to respond to these systemic risks.

Methods, Results & Discussion

The methods used to address the study aim were conducted in a series of steps in accordance with the conventional system dynamics approach; i.e. i) development of the qualitative model, ii) specification of the dynamic hypotheses, iii) mathematical representation of the qualitative model, iv) specification of a base model, v) a set of simulation experiments.

The conceptual model of the causal factors for road crash serious injury and death was developed over a 12-month period on the basis of a systematic review of the literature and a series of workshops with road safety researchers, policymakers, and practitioners from across the world. The population health module was based on the definitions of epidemiology. The acute care module was based on the HHS/American College of Surgeons/American trauma society specification an optimally functioning acute care response, and the rehabilitation module was developed over a 12-month period on the basis of a series of workshops with rehabilitations researchers, policymakers, and practitioners in Victoria.

There were seven policy leavers included in the overall model. Three related to the crash module, one for the acute care module, and three for the rehabilitation module. These policy levers test whether i) road traffic crashes could be reduced by investment in protective infrastructure for vulnerable road users (bicyclists and pedestrians), ii) overall crashes could be reduced by investing in active safety interventions (ie crash avoidance and road user behavior measures), iii) injuries and severity of injury given a crash could be reduced by measures that increased occupant protection, iv) the distribution of outcomes from trauma care (death, needing rehabilitation, and discharged home) could be positively shifted by implementing ACS accredited protocols, and v). improved rehabilitation outcomes could be achieved by increasing availability of services, implementation of optimal service, and optimally managed compensation/litigation procedures.

The dynamic hypotheses were operationalized using two units of measurement. The first was Australian Dollars, for charges to the population in Victoria for vehicle insurance premiums and insurance scheme costs required to cover medical and rehabilitation care of Traffic Crash Injury. The second unit of measurement was a measure of citizen satisfaction in relation to motor vehicle insurance premiums paid and client satisfaction in relation to post injury services received.

Two sets of results will be presented, relating to the two main hypotheses examined by the simulation. Findings of the study demonstrate the value of this methodology for use as efficient decision support for the formulation of effective policies to minimise road traffic injury related harm.

Maximising the Impact of Evaluation in Road Safety

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Abstract

Evaluation should be a key input to road safety policy-making, and developing and improving countermeasures. There is broad consensus on this, but evaluation utilisation is by no means universal. This paper presents the perspective of a road safety agency on its practice of evaluation. It draws on nine interviews with a range of agency staff, and lessons learnt through experience. It discusses the most common barriers to evaluation utilisation, and explores practices that maximise the chance of evaluation findings being translated into policy decisions and practice. Key findings include scope, focus and reporting.

Background and method

At the NSW Centre for Road Safety (CRS), evaluation is viewed as a key tool to inform policy and program development and implementation. Good evaluation not only answers the question whether or not an initiative works, but also *why* it does or does not work. Understanding the facilitators and barriers to evaluation use is essential for maximising evaluation impact and for achieving the best return on countermeasure and evaluation investment.

This work draws on two fields of literature – the work of Rune Elvik and others on evaluation in road safety specifically, and the work of Michael Quinn Patton on the utilisation of evaluation more generally.

However, this piece of work is ultimately pragmatic – it reports on 360 degree feedback interviews, undertaken with nine staff representing each of the key functions within CRS, and on lessons learnt through practice. From the perspective of evaluation users, it answers the question "What has evaluation ever done for us?"

Key findings

Practices that facilitate or hinder evaluation impact span the planning, commissioning and implementation stages of evaluation – and are the collective responsibility of both internal staff and the external evaluators.

The scoping of the evaluation is a key factor in evaluation success and is primarily the responsibility of the commissioning agency. Evaluations need to focus clearly on answering evaluative questions, such as the effectiveness and efficiency of the initiative, not broader research questions. It is difficult but critical to obtain early and proactive engagement of key stakeholders, particularly senior stakeholders, and to challenge ideas about appropriate and achievable scope. It is important that evaluations do not try to do too much – our experience leads us to recommend a more narrowly focused piece of work which clearly answers the mutually agreed questions. Commissioning staff and evaluators need to work together to clarify where a commissioned evaluation starts and ends and where the internal policy analysis task starts and ends.

Evaluation design, data collection, analysis and reporting are the bread and butter tasks of the evaluators. While standards are high on average, there are instances where primary data collection design is compromised and where the reporting is too detailed without clear messages. Reports need to tell a clear story, focused on answering the key evaluation questions. A collaborative discussion prior to the analysis and write up can be beneficial for reaching a common understanding of key focus areas, what information is already known, and the most useful report structure and format. Typically a report structured by evaluation question is most useful. Consideration should also be given to the presentation of recommendations and whether there is value in workshopping next steps.

Conclusions

The interview process uncovered a good news story for evaluation. It reveals that evaluation is often informing improvements to program delivery and process. However, there are some reasonably straightforward things that commissioners and practitioners can be doing to improve the impact of evaluation, including focusing evaluation, setting a realistic scope and working together collaboratively to obtain robust answers to the key evaluation questions.

A Preventative Approach to Heavy Vehicle Road Safety – Reforming Australia's Heavy Vehicle Chain of Responsibility Laws.

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Abstract

This presentation considers how reforms to Australia's heavy vehicle chain of responsibility laws are likely to help reduce the rate of heavy vehicle road crash fatalities by considering the impact of similar reforms to other safety laws, both in Australia and overseas.

Context

Despite reductions in the number of heavy vehicles involved in road crash fatalities, heavy vehicles still accounted for almost 20% of all road deaths in 2012 (BITRE 2015). In addition, although road freight workers comprise only a quarter of all transport, postal and wherehousing workers, in 2012 road freight workers accounted for 71% of deaths (Safe Work Australia). This number is 15 times the national all industries rate and is two and a half times the rate for the transport, postal and wherehousing industry as a whole (Safe Work Australia).

Australia's heavy vehicle sector is expected to double between 2006 and 2020, and triple by 2050 (BITRE 2014), with interstate trucking expected to generate a significant portion of this growth (IPA 2009).

Accordingly, and unless something more is done, road deaths involving heavy vehicles will continue to be a safety issue for the foreseeable future.

Chain of Responsibility Reforms

Unlike many parts of the world, Australia does not use operator licencing to regulate its heavy vehicle sector. Instead, and for almost 20 years, Australia's heavy vehicle laws have relied on the concept of chain of responsibility (CoR).

CoR is designed to ensure that any party in a position to control and influence on-road behaviour is identified and held accountable. In simple terms, CoR recognises the on-road effects of the actions, inactions and demands of off-road parties in the transport and supply chain, and provides a mechanism for holding these parties accountable. The CoR provisions apply to operators, prime contractors, employers, schedulers, consignors and consignees, loading managers, loaders, packers and unpackers.

In early 2016 Australia's transport ministers approved reforms to the Heavy Vehicle National Law (HVNL) to provide a more outcomes based approach to CoR. These reforms are intended to promote a more proactive culture of safety and enforcement, and to better align with Australia's other national safety laws.

Key features include:

- reformulating the existing CoR obligations as a primary duty of care to ensure the safety of road transport operations;

- adopting ‘so far as reasonably practicable’ as the standard of care, to align with the standard applied in other national safety laws;

- aligning penalties with the penalties for breach of the primary duty of care as set out in other national safety laws; and

- applying the primary duty to executive officers through reformulating existing executive officer liability CoR offences as a positive due diligence obligation.

Amending legislation is expected to be introduced to Queensland parliament as the host jurisdiction for the HVNL later this year.

Reducing the Rate of Road Crash Fatalities

The focus of this conference presentation is to explain these reforms and explore how they are likely to help reduce the rate of heavy vehicle road crash fatalities. This presentation will include considering the impact of similar reforms to other safety laws, both in Australia and overseas.

Conclusions will then be drawn as to the likely impact of these reforms.

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Proposed Australian/New Zealand AS/NZS 3845.2 Standard for Truck Underrun Barriers: Design, Testing and Performance Requirements

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Abstract

Each year around twelve fatalities occur as a result of truck rear underruns in Australasia. The injuries are usually horrific. Given Australia has adopted a 'Safe System Approach' road safety strategy, all such foreseen fatalities need to be addressed if a design countermeasure can be implemented. This paper presents details of practical test requirements set out in the draft Australian New Zealand standard AS/NZS 3845.2: Road Safety Barrier Systems and Devices which is now out for public comment. Brief details of the crash test matrix and the basis on which requirements were established is presented.

Background

Rear underrun car crashes into heavy vehicles with rear overhangs where the truck structure intrudes into the impacting vehicle's occupant compartment represents the most extreme example of system incompatibility between heavy vehicles and passenger cars. Figure 1 (a) shows some real world crashes where people have died as a result of such horrific crashes in Australia (Rechnitzer & Foong, 1991). Any car impact protection devices such as crumple zones, frontal airbags, or pre-tensioning belts are completely negated by the obvious mismatch between the truck's rear and car's crashworthiness systems as shown in Figure 1 (b) (Rechnitzer & Grzebieta, 1991, Grzebieta & Rechnitzer, 2001). This type of crash often causes severe or fatal injuries to car occupants due to the mismatch in mass ratio, stiffness ratios, compartment intrusion, and importantly interface geometry (Rechnitzer & Grzebieta, 2001, Grzebieta & Rechnitzer, 2001).

Haworth and Symmonds (2003) estimated that rear underrun crashes in Australia account for some 10 or so fatalities and around 150 serious injuries every year. Despite this, there currently is no legislation or Australian Design Rule (ADR) requiring crash testing of underrun barriers. The US Insurance institute of Highway Safety has also identified that truck underrun fatalities and serious injuries are occurring as a result of inadequate truck underrun barriers and the lack of a crash performance test standard (IIHS, 2014).

Truck Underrun Barriers (TUB's) can be thought of as a barrier or a crash cushion that prevents the vehicle from underrunning the truck, and hence injuries, as shown in Figure 1 (c) & (d). TUBs are permanently fixed to the rear of any truck or trailer. A considerable amount of research work has been completed into establishing what is a suitably crashworthy TUB (Rechnitzer, Powell & Sayer, 2001, Zou, Rechnitzer & Grzebieta, 2001, Rechnitzer, 2003). Readers are referred to that material because of the word restriction in this Extended Abstract.

Proposed Standard

To address this shortcoming in the ADR, a new Australian Standard AS/NZS 3845.2: Road Safety Barrier Systems and Devices (Standards Australia, 2016) now specifies an underride crash test based on US MASH crash testing protocols for Australia and New Zealand for regulators and operators who wish to have crashworthy TUBs fitted to trucks that operate within or deliver materials to a road works/maintenance site. These performance criteria can be equally applied to any truck or trailer of an articulated truck that operates on any public road and are used to protect the occupants in a vehicle that runs into the back of the truck or trailer.

Table 1 shows the crash test matrix that underrun devices are required to comply with. Tests are based on the United States (US) Manual for Assessing Safety Hardware (MASH) protocols where a 1500 kg sedan car (1500A) and then a large 2270 kg sports utiliity vehicle (2270P) are impacted into the truck underrun barrier at a speed of 70 km/h in a centred and a 30% offset configuration. The barrier must meet certain crashworthiness criteria (C, D, F) detailed in MASH. The research work by the Authors referred to above have established that all criteria can be readily met by well designed TUB. This would be elaborated on in the presentation and in an expanded 10 page paper.

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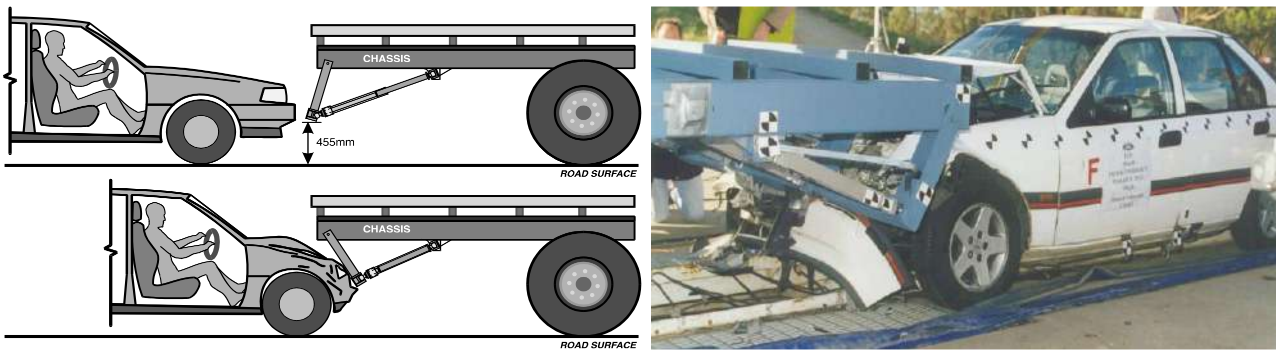
(a) real world fatalities *(after Rechnitzer & Fong, 1991)*

(b) underrun mechanism *(after Rechnitzer & Grzebieta, 2001)*

(c) rigid barrier design *(after Rechnitzer, Powell & Sayer, 2001)*



(d) energy dissipating barrier design *(after Rechnitzer, Powell & Sayer, 2001)*

Figure 1: Underrun crashes and barrier crashworthiness

Table 1. Test Matrix for Truck Underrun Barriers from AS/NZS 3845.2: Road safety barrier systems and devices bashed on MASH crash test protocols.

Test Level	Feature	Test designation	Impact conditions			Impact point	Evaluation Criteria (see Table 5.1 of MASH)[c]
			Vehicle	Nominal Speed[a] (km/h)	Nominal Angle[a] θ deg.		
2	Truck Underrun Barrier	2-51	2270P	70	0	(b)	C,D,F
		2-52	2270P	70	0	(b)	C,D,F
		2-54	1500A	70	0	(b)	C,D,F
		2-55	1500A	70	0	(b)	C,D,F

Timing of drowsiness events in heavy vehicle fleets

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Abstract

Data collected from long-haul trucking fleets were analysed to examine the timing of drowsiness events while driving. Drowsiness event data were collected over a two-month period from 49 trucks. Events were recorded by a commercially available camera-based system mounted on the dashboard that measures head and eyelid metrics to assess drowsiness. By the 90th minute of driving, 75% of drivers who commenced their trip between 6pm-12pm had experienced a fatigue event. Future work will incorporate measures to account for the total trip duration to more fully assess the impact of time of day and trip start time on event rates.

Background

Driver drowsiness is implicated to be a casual factor in up to 20% of road traffic crashes (Conner et al., 2002; Horne & Reyner, 1995). While crash-based studies employ various criteria to identify fatigue, researchers generally acknowledge derived values to be likely underestimates and lacking the desired levels of accuracy with regard to identifying a definite involvement of drowsiness (Armstrong et al., 2013: Williamson et al., 2011). Most existing data are based on observational, survey, naturalistic and crash-based approaches where surrogate indicators of fatigue are used including time of day. This study analyses a large existing database of real-time drowsiness events collected from long-haul trucking fleets to examine the prevalence of drowsiness events while driving.

Method

Data for the analysis were collected from 49 trucks across three medium-sized long haul transport companies in South Africa over a two-month period in 2015. A camera-based driver monitoring system was mounted on the dashboard and measured the position and orientation of the head in three dimensions, as well as the extent of eyelid opening, to make assessments of driver drowsiness. Data are drawn from the baseline period where the system logged data but did not alert the driver. The time-to-first drowsiness event and duration (seconds) of the first drowsiness event by time of trip commencement were analysed (Hosmer et al., 2008).

Results

The mean time to the first drowsiness event being detected was 63 minutes, with observed differences by time of trip commencement not being statistically significant (Table 1). The median indicates that 50% of the sample experienced their first drowsiness event by 45 minutes into the trip, and the mean duration of the detected event was as long as 3.8 seconds on average for drivers commencing their trip in the evening.

Table 1. Summary statistics of time-to-first drowsiness event (minutes) and duration (seconds) of the first drowsiness event, by time of trip commencement

	Time of trip commencement				
	12.00 am - 5:59 am	**6.00 am - 11:59am**	**12:00 pm – 5.59pm**	**6.00 pm – 11.59pm**	**Entire day**
Time to first drowsiness event					
Mean (SD)	67.7 (64.3)	57.5 (46.3)	61.6 (55.8)	64.0 (53.7)	63.0 (56.7)
95th% CI	55.0-80.4	45.4-69.6	44.9-78.3	50.6-77.4	56.7-70.5
Median	44	42	48	50	45
Duration of first drowsiness event					
Mean (SD)	2.7 (3.4)	2.7 (2.1)	3.2 (4.1)	3.8 (4.9)	3.1 (3.7)
95th% CI	2.2-3.4	1.3-2.8	2.2-4.2	2.9-5.0	2.6-3.5
Median	1.85	1.85	1.82	2.06	1.87
Number trips	99	56	43	62	260

The point at which 50% of drivers experience their first drowsiness event can be seen to be range from 42 to 50 minutes (Figure 1). By way of example, the 90th minute of driving, 75% of drivers who commenced their trip between 6pm-12pm had experienced a drowsiness event. This is a standard way to present Kaplan-Meyer curves. While there is no statistical difference, it is an interesting observation that drivers who commenced their trip between 12am-5:59am either experienced an event quickly (i.e., nearly 40% within 30 minutes), or took longer to experience their first event; this difference is apparent from 90 minutes onwards compared to the other driver commencement time groups.

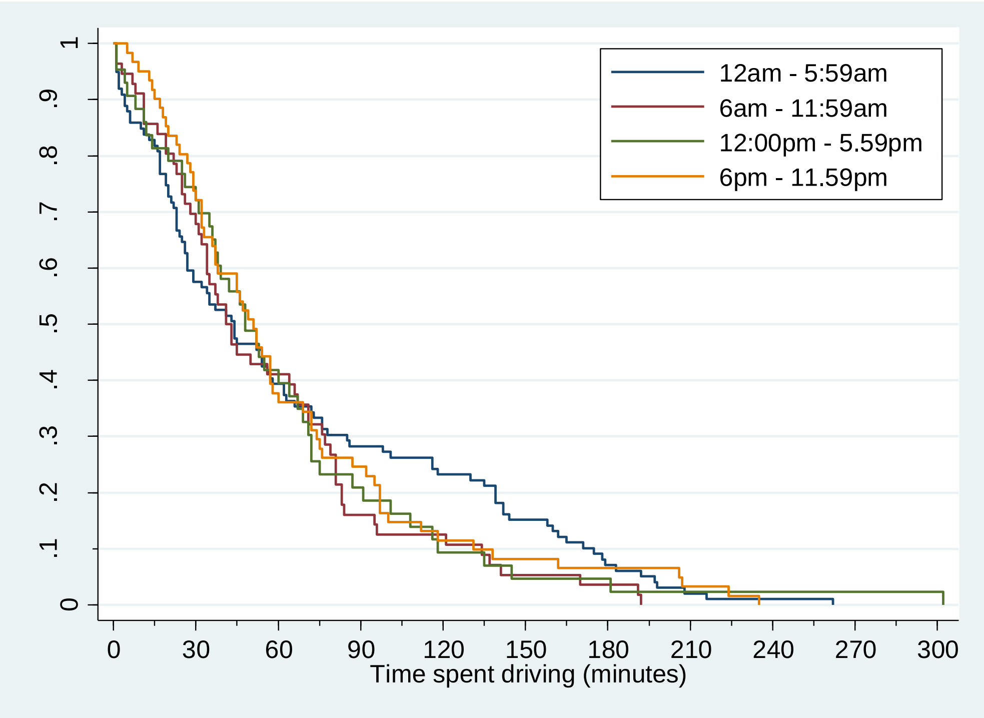

Figure 1. Probability of remaining drowsiness event free by time spent driving, given trip commencement time

Conclusion

Half of the drivers experienced a drowsiness event within their first 45 minutes of driving, and these events were on average 3.1 seconds in duration. At high speeds of travel (average speed: 77 km/h), the distance covered by these trucks within these drowsiness events was 66 metres on average. Importantly, these drivers experienced multiple drowsiness events across their trip. Future work will incorporate measures to account for the total trip duration to assess whether the total number of drowsiness events experienced by drivers differs firstly across the day, but also based on the time they commenced the trip.

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Heavy Vehicle Safety Chain of Responsibility Implications

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Abstract

Much has been discussed and enacted in regard chain of responsibility involving the loading, operation, scheduling, driver behaviour, driver fatigue and maintenance practices of heavy vehicles and road trauma. In comparison, hitherto, minimal attention has been devoted to chain of responsibility implications associated with heavy vehicle design, specification and detailing aspects and road trauma. This interaction is intensified due to the general adverse infrastructure standard (both sealed and unsealed), long haulage distances, the commonplace haulage of high centre of gravity loads and significant productivity pressure. Furthermore even greater attention must be devoted to correct specification and detailing should the vehicle be hauling combustible loads, stock grates, comprise a 'new generation' high productivity combination or be hauled by a short wheel base prime mover. In addition the alarming continual increase in road trauma generated by heavy rigid vehicles suggests chain of responsibility implications be applied to the widest extent possible.

One paramount componentry requiring careful specification, applicable to both rigid and articulated heavy vehicles, is the drive air suspension. In particular, the suspension must exhibit consistent, reliable behaviour, exhibit optimal traction and braking, optimal in service roll resistance and minimal frame rise and droop. In addition, the installed air suspension should generate minimal loading to the vehicle's chassis and drive line componentry and minimal vehicle vibrations and pitching. It is also desirable the drive suspension inflict minimal infrastructure damage. Fortunately simple relatively low cost, easily retrofitted modifications can be effected to convert existing adverse static load sharing suspensions to optimal dynamic inherently damped mean ride height single valve controlled air suspensions. An immediate advantage of the latter optimal air suspensions is that their damping characteristics are relatively invariant of the state of repair of the mechanical shock absorbers. The same strategically allays the findings of past RTA testing which revealed 60% of vehicle axles operate with mechanical shock absorbers out of specification.

To highlight the system advantages test results will be presented highlighting the traction and braking advantages exhibited by typical in service dynamic load sharing air suspensions on typical pavements both dry and wet.

Opportunity will also be taken to declare paramount vehicle operator feedback relating to the application of ABS, EBS, electronic stability control (ESC) and electronic roll protection (ERP) systems and software. Special note will be made to operator experience hauling on poor quality roads and for vehicles hauling high centre of gravity loads. This feedback unfortunately reveals these technologies are not the assumed convenient panacea for reducing heavy vehicle road trauma. In fact, the concoction of problems exhibited confirms the necessity to first correct the operational characteristics of standard air suspensions. So much so that the successful application and operation of the stated complex software based technology systems demands the drive suspension be upgraded to the state-of-the-art reliable analogue hardware based dynamic load sharing system.

Brief discussion will also be devoted to cabin thermal loading and other vehicle detail differences generated by operating essentially 'converted left hand' drive vehicles on local roads. Here it will be stressed the local heavy vehicle market is not sufficient in quantity to justify purpose supplied vehicle componentry for local RH drive operation. Purpose supplied componentry and engine component arrangements (in particular the exhaust manifold and exhaust duct routing (and

meticulous design, detailing and maintenance of same in combination with the cabin air conditioner) will yield paramount improvements to reducing (both thermal and vibration induced) driver fatigue. The significant reduction in driver fatigue will, in turn, reduce heavy vehicle road trauma.

The Use of a Safety Platform at an Intersection to Align Approach Speeds with Safe System-an Australian-first Innovative Trial

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Abstract

An innovative trial was introduced at a signalised intersection in Victoria with the intention of aligning approach speeds to Safe System speeds. Trial results from the combined treatment of signals, reduced speed limits and a Safety Platform indicate lower speeds at the trial site when compared to control intersections. Due to the combination of treatment, the direct effect of the Safety Platform on the lowered speed is not as clear, and will need to be investigated at the next stage of trial.

Introduction

VicRoads introduced an Australian-first innovative treatment at the signalised intersection of Surf Coast Hw/Kidman Avenue, Belmont to contain vehicle speeds to Safe System speeds (Tingvall and Haworth 1999, Candappa, Logan et al. 2015). This T-intersection has a higher than average crash rate due to high traffic volume on Surf Coast Highway and its 70km/h speed limit. Key crash types involved right-turning vehicles from Kidman Ave and through vehicles travelling on Surf Coast Highway. The treatment, known as a "Safety Platform (SP) or Raised Stop Bar - a gradual crest just after the stopline - was introduced in October 2015. SPs, were first trialled in the Netherlands. The final trial design, designed to maximise likelihood of reduced approach speed while minimising undue occupant discomfort, and risk of heavy braking - comprised a combined treatment of traffic signals, speed limit reduction and the Safety Platform.

Methods

Pneumatic tubes were used to measure speeds on approach to the intersection, and video footage of the intersection taken over a 2-week period. Three control locations were used in the study. Stopping locations and location of brake initiation were noted using video footage. The trial was evaluated by MUARC.

Results and Discussion

Results indicate reduced travel speeds through the intersection, with mean and 85% travel speeds at Kidman Av/Surf Coast Hwy 12.3 km/h and 12.6 km/h less than those measured at the signalised intersection at control 1, and 20.5 km/h and 15.2 km/h less than the non-signalised intersection of Control 2. Study findings suggest that as a result of the reduced speeds, crash kinetic energy (KE) levels are far more aligned with Safe System ideals; instead of KE levels of around 190 KJ, KE levels were estimated to be just above Safe System recommendations of 96.5 kJ. In contrast, when considering the 85% speeds, KE levels at both the Control 1 and 2, in the post-treatment period were closer to double (189 kJ) the tolerable levels, (Tingvall and Haworth 1999, Candappa, Logan et al. 2015). This implies reductions in serious injury crashes at Kidman Av/Surf Coast Hwy intersection post treatment.

About 20% of the drivers encroached the stop line when stop at red signals, suggesting some driver confusion and uncertainty as to where they are required to stop. It is possible that a mixed message is being provided to the driver, the expectation of needing to stop at the signal pedestals conflicting with the requirement to stop prior to the SP. While this needs to be considered further, particularly if the design will be introduced at locations where pedestrian crossings can be incorporated on the SP, there were no notable conflict with pedestrian at the present site. Some drivers braked well before necessary, suggesting some uncertainty and hesitation.

Due to the combination of treatment, the direct effect of the Safety Platform on the lowered speed is not as clear, sand will need to be investigated at the next stage of trial.

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Safety of raised platforms on urban roads

Tariro Makwasha and Blair Turner

ARRB Group Ltd

Abstract

A recently concluded Austroads study identified effective countermeasures for improving safety outcomes on urban arterial roads. Included in the study were raised platforms at intersections (raised intersections), midblock and pedestrian crossings (wombat crossings). While these treatments have been widely applied overseas and to an extent, across Australia and New Zealand (especially wombat crossings and at midblock sections on local and collector roads), a measure of effectiveness in mixed use and high volume environments in an Australian context was required. To determine the effectiveness of these measures in terms of crash frequency and severity as well as vehicle speeds, a retrospective matched control analysis was conducted. This paper presents the estimated crash and speed effects of raised platforms.

Background

Urban arterial roads are characterised by a high number of crashes, including those that result in fatalities and serious injuries. At particular risk on these roads are vulnerable road users (pedestrians, cyclists and other non-motorised road users). Intersections are also typically high risk locations on the urban road networks. Raised platforms were identified as a potential measure for managing speeds and crashes on urban arterials for different road environments, functions and road users while maintaining efficiency. The key aim of this evaluation was to determine the safety effectiveness of this treatment.

Raised intersections

Raised intersections are a speed management and safety device generally used on local roads, with some examples on arterials through activity centres. The entire intersection acts as a form of speed hump aimed at reducing vehicle speeds to 50 km/h or less (Austroads 2010). Alternatively, raised stop lines can be used in advance of the intersection. The height of the intersection is often equal to that of the surrounding pavement, which can facilitate pedestrian crossing movement. They can be painted or paved to raise driver awareness of the intersection as illustrated in Figure 1. An extensive review of existing literature indicated that raised intersections are most common in Europe, especially the Netherlands. Trials have also been completed in the United States and on local and collector roads in Australia and New Zealand.

Surf Coast Shire, Victoria

Source: VicRoads.

Figure 1. Raised platform at intersection

Raised platforms at midblock and wombat crossings

Raised platforms at miblock sections are typically used to maintain lower speeds along a route. In high pedestrian activity areas, raised platforms at midblock generally include pedestrian crossing facilities. The raised pedestrian crossings, typically termed wombat crossings in Australia, have a similar profile and speed reduction effect as flat top speed humps but they differ in that they give priority to pedestrians rather than motorists (Austroads 2016a). When designed with appropriate signs, markings and lighting, this adds a pedestrian mobility and safety element to the speed management objectives as Figure 2 shows.

Brisbane Airport, Queensland **City of Gold Coast, Queensland**

Source: Austroads (2016a).

Figure 2. Raised platform at midblock and wombat crossing

Method

A quasi-experimental retrospective matched-comparison approach was used in this evaluation. To determine whether changes in crashes at treatment sites were significantly different from those at comparison sites, Poisson regression with a log-link function was applied. The assumption was that crashes follow a Poisson distribution:

$$\Pr(y|\mu)=e^{-\lambda}\lambda^{y}/y!$$

where y is the number of crashes and λ the average of the distribution.

To control for violations in distribution assumptions of equal variance and mean, robust standard errors were used in the estimation. Tests for the most appropriate distribution were also conducted. This involved fitting both Poisson and Negative Binomial distributed models and comparing the Akaike Information Criteria (AIC) and the log-likelihood to determine the most parsimonious distribution.

Each treatment site was matched to untreated similar sites (comparison), matched on criteria outlined below. The comparison sites accounted for the effect of the underlying traffic, socio-economic conditions and other road safety initiatives excluding any effects from the treatments under consideration. The treatment effects were measured by comparing before and after crashes at treatment sites and within the treatment group while accounting for the underlying trends.

Where limited sites were available, the evaluation results were combined with those in leading international literature to provide a recommended value.

Site Data

While the key gap in knowledge and the focus of this study was on urban arterial roads, it was evident that most of raised platforms were not widely applied on arterial roads. The site selection therefore included treatments on higher volume collector roads with a traffic mix and function approaching that on arterial roads. The selection of all sites depended on the surrounding land use, the traffic volumes prior to installation and road function.

The different sites were categorised into three broad categories depending on location and function. These were raised intersections (sites in this study were raised intersections only, and did not include raised approaches or stop lines at intersections), wombat crossings (i.e. platforms with pedestrian crossing facilities); and raised platforms at midblock locations. Overall, there were 10 raised intersection 26 raised midblock sites and 14 wombat crossings. All sites that were installed from 2013 onwards were excluded from the current evaluation as the after period was not long enough for an informative crash analysis. However, these sites have been reserved for future evaluations.

The comparison group included sites from the treatment LGAs with similar attributes to the treatment sites in terms of speed limit, surrounding land use and geometric design. Where similar sites were not available in the same LGA, comparison sites were obtained from a neighbouring LGA. While effort was made to ensure the comparison group was as similar as possible to treatment sites, the use of a comparison group does not require an identical match. This approach uses a number of sites to improve the accuracy of the comparison sites. Care was taken in the selection of comparison sites to ensure that they did not receive the same treatment during the evaluation period.

The selection of the comparison group ensured that:

- the before and after periods for the treatment and comparison groups were the same in order to avoid temporal bias
- the crashes in the before period were similar at both treatment and comparison groups
- the speed limit at the treatment and comparison groups was similar
- similar geometry at the treatment and comparison sites
- where possible, the traffic volumes at the treatment and comparison sites were matched as closely as possible, however, where traffic volumes were not available, the match was based on road function and the surrounding land use
- intersection layout was similar to the treatment site (for raised intersections)
- similar traffic control to match downstream and upstream of platform
- comparable section length considered where platforms were a route treatment.

Crash Data

Crash data for the treatment and comparison sites for each of the countermeasures was obtained from the respective jurisdictions. For Victoria sites, crash data was obtained from Crashstats while data for Queensland and New South Wales was obtained from the Austroads crash dataset and the LGAs in the study.

The crash data covered five years before and after the treatment was installed. The five year period was selected as it is long enough to take into account maturation while being short enough to ensure any technological advances, traffic mix and other socio-economic trends remain as similar as possible in the before and after periods. While the aim was to have a uniform dataset with equal before and after periods, some of the treatments were in place for shorter periods. This issue was addressed in the selection of comparison sites. Crashes at the comparison sites were classified into the before and after periods using the installation dates at the treatment sites. This therefore meant both treatment and comparison groups had similar data. The use of a comparison group meant there was sufficient data for the evaluation.

Before and After Period

The before period was defined as five years prior to the installation date, up to a month before the installation date and the after period was defined as the period a month after the installation date onwards. Therefore, the installation period covered three months, a month before and after the installation date as well as the installation month. This period was designed to account for changed traffic conditions before, during and after installation while allowing for an adjustment period following the installation.

For each of the treatment sites, three similar sites were selected as the comparison group. In order to form a consistent baseline measure, crashes in the before period at the comparison sites were closely matched to those at the treatment site. The analyses was based on casualty crashes only (i.e. did not include non-injury crashes).

Statistical Analysis

The Poisson log-linear analysis was conducted to test the significance of differences in casualty and FSI crash changes as well as pedestrian crash changes at treatment and comparison sites. The model for each individual treatment type was specified as outlined in Equation 1.

$$ln(y_{pgs})=\alpha+\beta_{ps}+\gamma_{pg}+\delta_{pgs}+\varepsilon_{pgs} \qquad 1$$

where

y_{pgs}	=	Cell casualty crash count (or FSI crash count)
$\alpha, \beta, \gamma, \delta$	=	Model parameters to be estimated
ε	=	Error term
p	=	Before or after period index
s	=	Site number or jurisdiction
g	=	Treatment or comparison group index

The interaction term was modified to estimate the average crash effects across all sites within the treatment and comparison groups and to estimate the crash effects within each site, time period and treatment group combination.

The overall crash effectiveness of the different treatments accounting for comparison site crashes is defined as

Percentage crash change=100×(1-exp(δ_{111}))

where δ_{111} is the parameter for the after installation period at treatment site 1.

Results

Overall effect

The evaluation showed a statistically significant casualty crash reduction of 53% for all sites regardless of platform type. There was a net reduction of 47% in casualty crashes at raised platforms at midblock and 63% at wombat crossings as shown in Table 2. These reductions were statistically significant. However, the casualty crash changes were not statistically significant for raised intersection. This is attributable to the small sample size and the number of crashes at both treatment and comparison sites.

Table 2. Estimated casualty crash changes

Raised platform treatment	Before	After	Estimated casualty crash reduction (%)	Significance	Lower 95% confidence level (%)	Upper 95% Confidence limit (%)
Intersection	13	7	55.4	0.1059	-18.7	83.2
Midblock	91	49	46.9	0.0011	22.1	63.8
Wombat	42	18	62.6	0.0012	32.5	79.3
Overall	146	74	52.6	0.0000	35.7	65.1

While the crash reductions at wombat crossings were statistically significant, the relatively small number of crashes at the treatment sites required further review of the treatment's effectiveness. The casualty crash reduction at wombat crossings and raised intersections were regarded as indicative and combined with leading international literature to determine the likely effectiveness. These findings are outlined in Turner et al. (2016) and Austroads (2016b).

Treatment level effect

Further analysis by crash severity showed statistically significant reductions in both FSI and non-FSI crashes for all platform types of 49% and 54% respectively. The analysis also showed statistically significant reductions in both FSI and non-FSI crashes at wombat crossings and statistically significant reduction in non-FSI crashes at midblock locations as shown in Table 3.

Table 3. Estimated crash changes by severity

Raised platform	Severity	Before	After	Estimated casualty crash reduction (%)	Significance	Lower 95% confidence level (%)	Upper 95% Confidence limit (%)
Midblock	**FSI**	23	14	38.1	0.1764	-24.1	69.1
	Non-FSI	68	35	49.9	0.0016	23.0	67.4
Wombat	**FSI**	16	5	66.6	0.0438	3.0	88.5
	Non-FSI	26	13	61.2	0.0099	20.3	81.1
Overall	**FSI**	40	20	48.9	0.0195	10.2	70.9
	Non-FSI	106	54	53.5	0.0000	34.1	67.2

Raised intersections

As indicated earlier, the low number of sites and crashes at raised intersections most likely led to non-significant crash reductions. In order to provide an indication of the changes in crashes by severity, a simple comparison of crashes by severity before and after installation was conducted. The analysis showed reduction in non-FSI crashes as outlined in Figure 3.

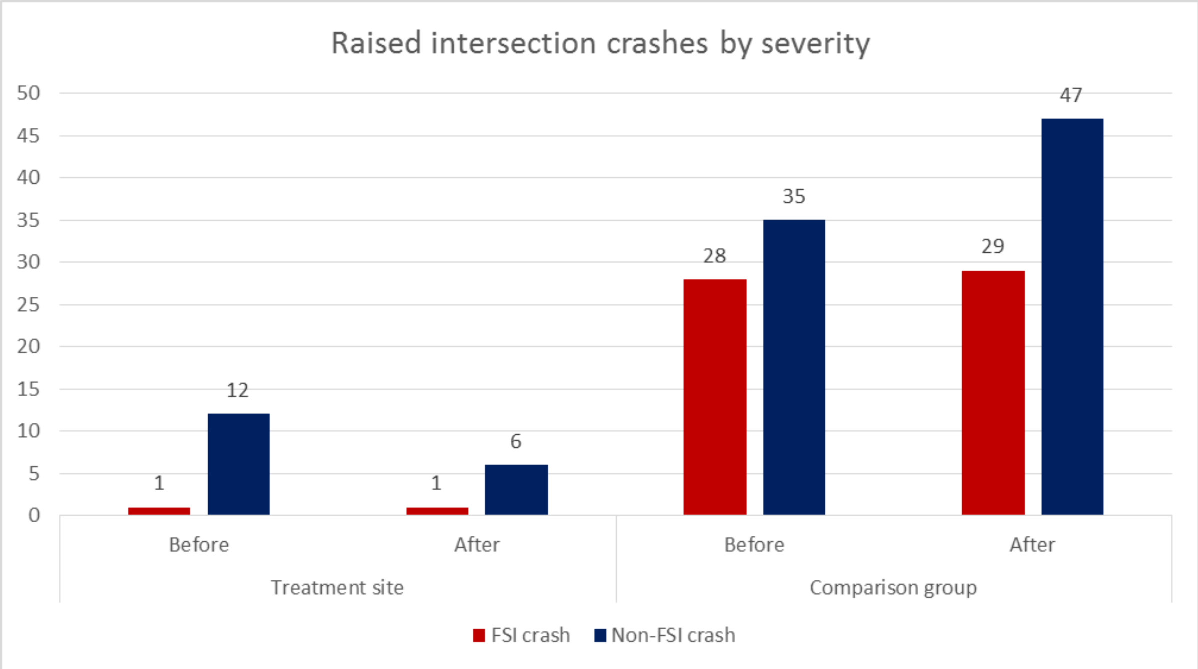

Figure 3. Change in crashes by severity at raised intersections

An analysis of the crash types at the treatment and comparison sites showed that most of the crashes prior to treatment installation at treatment sites were pedestrian crashes. There was a net reduction of 52% in pedestrian crashes, 62% for rear-end crashes and 61% for cross traffic.

Raised platforms at midblock

Similar analyses were conducted for raised platforms at midblock sections. The analysis was also conducted at a jurisdictional level. The analysis showed higher reductions in casualty crashes for raised midblock treatment sites in New South Wales compared to Victorian sites (62% relative to 41%). However, the number of crashes at the New South Wales treatment sites was lower than for Victoria. Due to the limited number of sites for Queensland, only the results for New South Wales and Victorian sites are outlined in Table 4.

Table 4. Estimated crash changes by speed zone – raised platforms at midblock

	No. sites	Before	After	Estimated casualty crash reduction (%)	Significance	Lower 95% confidence level (%)	Upper 95% Confidence limit (%)
New South Wales	5	25	9	61.9	0.026	10.8	83.7
Victoria	19	61	40	40.5	0.021	7.7	61.7
Overall	26	91	49	52.6	0.000	35.7	65.1

Further analysis by crash severity showed a net reduction of 38% in FSI crashes and a statistically significant 50% reduction in non-FSI crashes.

Further analysis of crashes by speed zone was conducted. The analysis indicated overall reductions in both FSI and non-FSI crashes for both 50 km/h and 60 km/h zones. The reduction in non-FSI crashes at 50 km/h sites was statistically significant. The analysis also showed that the crash reductions at 60 km/h sites were not statistically significant as shown in Table 4.

Table 4. Estimated crash changes by jurisdiction – raised platform at midblock

Speed zone	Crash severity	Before	After	Estimated casualty crash reduction (%)	Significance	Lower 95% confidence level (%)	Upper 95% Confidence limit (%)
50 km/h sites	**FSI**	11	6	40.5	0.3442	-74.4	79.7
	Non-FSI	42	15	65.0	0.0015	33.0	81.7
	Total	53	21	59.8	0.0012	30.2	76.9
60 km/h sites	**FSI**	12	8	37.7	0.3474	-67.1	76.8
	Non-FSI	26	20	25.4	0.3746	-42.5	60.9
	Total	38	28	29.4	0.2077	-21.3	58.9

Due to limited crash data, the evaluation of wombat crossings was based on Victorian sites only. The analysis showed statistically significant reductions in casualty crashes of 67%. Additionally, there were reductions of 66% and 61% in FSI and non-FSI crashes respectively. Further analysis by crash type showed reductions in pedestrian crashes (73%), intersection crashes (68%) and rear-end crashes (69%).

Discussion

The overall casualty crash analyses at raised midblock platforms and wombat crossings indicated statistically significant reductions in crashes, with CMFs of 0.53 and 0.37 respectively.

Literature on crash analyses at wombat crossings on urban and suburban roads show a CMF ranging from 0.35 to 0.60 (e.g. Elvik & Vaa 2009 and Haleem & Abty 2011). The crash analysis in this study falls within this range (0.37). However, given the limited number of crashes at the treatment sites, an overall conservative reduction of 40% in casualty crashes was adopted. The findings for the different crash types were also comparable with existing literature. Similarly, the speed and traffic volume changes (reductions) at wombat crossings were also similar to those in existing literature. Existing research showed reductions in 85th percentile speeds of between 5 km/h and 9.4 km/h while this analysis indicated reductions of between 4 km/h and 11 km/h, with an average reduction of 4 km/h at 40 km/h sites and 6.8 km/h for 50 km/h sites. Most of the wombats were located at high pedestrian volume sites with traffic volumes of between 3500 and 5000.

On the other hand, existing literature on raised platforms at midblock mainly focuses on operational impacts, i.e. impacts on speed and traffic volumes. This analysis however, did not have sufficient after data for an analysis of traffic volumes. The literature reviewed in this study reported speed reductions at raised midblock platforms of similar to those in this evaluation. The reductions in 85th percentile speeds were between 5 km/h and 17 km/h on approach and 20 km/h to 25 km/h at the platform (Marek & Walgren 2000). This analysis found reductions of between 3 km/h and 13 km/h on approach. The traffic volumes at the treated sites (in the before period) ranged from 1000 to 7550, with most of the sites falling between 2500 and 4500. Further research into traffic volume changes is required in order to determine the impact of raised midblock platforms on traffic volumes.

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Evaluation of Red Motorcycle Box to the Traffic Flow, Occupancy Rate and Stop Line Violation at Signalized Intersection in Bogor

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Abstract

Aim of this paper to evaluate of red motorcycle box to the traffic flow, occupancy rate and traffic violation. The traffic flow analysis method used Indonesia road capacity manual while the occupancy rate and traffic violation method used the guideline of red box monitoring. Analysis result show that after implemented the red box, the traffic flow are increased 15.64%. The occupancy from 20% to 34% due to access blocking to the red box by non-motorcycle vehicles while the red box has occupied by motorcycle only from 33% to 68%. The number of stop line violation has decreased up to 89.88%.

Background

The number of motorcycle's population until the end of 2013 was reach the peak around 85.45 million units and the sales was reach 7.22 million units. The accumulation of motorcycle disorderly movement at signalized intersection during waiting at the red light is a negative impact due to high motorcycle population. The red box is an alternative solution to increase signalized intersection performance

Red motorcycle box at signalized intersection basically developed from the concept of Advance Stop Lanes (ASLs) for bicycle. An ASLs, also called advanced stop box or bike box, are road markings at signalized road intersection allowing certain types of vehicles to head start when the traffic signal changes from red to green. Advanced stop lines for bicycle are implemented widely in the United Kingdom, the Netherlands, Denmark, and other European countries. Therefore, this concept is try to implement for motorcycles.. Red motorcycle box which is developed to split queue between motorcycle and other types vehicles when waiting at red light (Idris, 2007).

Separation of motorcycles from other types of vehicle is expected improve performance of signalized intersections to be more orderly, safely, and smoothly. The trial implementation of the red box at Pajajaran-Pangrango in Bogor City is shown in Figure 1.

Figure 1. Implementation of Red Box for Motorcyle in Bogor

Method

Research methodology is divided into traffic survey method and analysis method. Traffic data surveyed is the volume of all types of vehicle at three time segments, in the morning, afternoon and evening, where each session is equal to 10 red light phase. Furthermore the data analysis, to evaluate the performance of red box implementation requires method of analysis which include traffic flow, occupancy rate and stop line violation. Analysis method of Traffic Flow data was collected per 6 seconds to analysis the number of traffic flow at green light. Analysis Method of Occupancy Rate can be counted by the occupancy to the capacity of the red box during the red light. The stop line violation rate can be counted by the number of motorcycles that violate the stop line.

Results

Data collection of traffic volume was conducted from before to after implementation of red motorcycle box. Analysis result show that after implemented the red box, the traffic flow are increased up to 15.64%. The occupancy rate to the capacity of the red box show the low rate from 20% to 34% due to access blocking to the red box by non-motorcycle vehicles. Meanwhile, the red box has occupied by motorcycle only show the moderate rate from 33% to 68%. It means there are still non-motorcycle vehicles has occupied the red box due to lack of discipline and rules awareness. In addition, the number of stop line violation has decreased up to 89.88%.

Conclusions

Evaluation of the red motorcycle box showed a significant result. The traffic flow increased, the number of stop line violation decreased. On the other hand, the occupancy rate show the moderate rate. The important point is the red box is quite effective to make the intersection more orderly, safely and smoothly

Citations:

- Motorcycle's population until the end of 2013 was reach the peak around 85.45 million units and the sales was reach 7.22 million units. (AISI, 2014).
- Separation of motorcycles from other types of vehicle is expected improve performance of signalized intersections to be more orderly, safely, and smoothly. (Idris, 2007).

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Bicycle rest stops in mountainous terrain to improve road safety for cyclists

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Abstract

To improve safety for on-road cyclists in mountainous terrain, a concept for a bicycle rest stop has been developed. The intent of the rest stop is to provide a safe space for cyclists to temporarily stop (to conduct repairs or rest) on roads where the left side of the road has numerous steep drop-offs, narrow lane widths and no shoulder. Design considerations include location, constructability, maintenance and costs. It is hoped that this concept design can be trialled in the near future to determine the effectiveness of such a treatment on improving road safety for cyclists.

Background

A winding mountainous road in the Gold Coast hinterland, popular with cyclists, presented an opportunity to develop an innovative engineering solution. Through a road safety audit, it was identified that the steep grade, narrow lanes, no shoulders and frequent unprotected drop-offs posed a risk to slow-moving cyclists. In particular, if cyclists needed to stop to rest, make repairs or wait for other cyclists there was limited safe space to do as the left lane was adjacent to numerous steep drop-offs. Figure 1 provides examples of road cross sections where this treatment may be appropriate while Figure 2 depicts the high level of cycle activity in the area by both recreational and training cyclists.

Figure 1. Example of limited road space for cyclist stopping

Figure 2. Strava Heat Map

Investigation

During concept design development, a variety of issues were investigated to ensure that it was a reasonable and practicable solution. This treatment may be effective to improve safety in other mountainous roads where cycling is popular and road widening is not a feasible option.

Location

Selection of appropriate sites require consideration of road cross-section types, vehicle volumes, cyclist volumes and speeds. A rest stop style treatment is suitable on routes that are frequented by high numbers of cyclists and have narrow lanes, no shoulders and unprotected drop-offs (generally mountainous terrain with steep winding roads).

Infrastructure

The design of the rest area had to incorporate infrastructure elements that reflected the needs of the user (i.e. cyclist) and was compatible with the terrain while not introducing additional hazards into the road environment. Hold rails were recommended to allow cyclists to prop comfortably while also serving a dual purpose in providing protection from drop-offs. Surface treatments had to be durable to ensure limited maintenance while providing adequate drainage and slip resistance in wet weather. Amenity was also considered to ensure that visually the rest stop did not detract from the natural environment.

Constructability and Costs

The constructability of the concept is challenging due to the nature of the road type (i.e. narrow and winding) which introduces risk and inconvenience during installation and maintenance. Ideally the rest stop would be prefabricated to allow installation within a short timeframe with limited requirements for traffic management. However, footings would have to be site-specific designs given that each site would have different geometry and varying sub-soil conditions. Ease of maintenance is also essential to again limit the road safety risk of working roadside in these environments.

Next Steps

It is intended that a concept design will be finalized to sufficiently prepare a project proposal for a trial of the treatment. Further refinement of the design will be required to include safety in design considerations, fabrication costs and compliance with existing design standards. The scope of the trial treatment investigation will need to consider duration of the trial, appropriateness of a location and methodologies for determining quantitative and qualitative measures of effectiveness and perceptions by cyclists and other road users.

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Not all Roads are Created Equal: A Framework to Align Travel Speeds with Road Function, Design, Safety and Use

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Abstract

The newly developed Speed Management Framework, introduced as part of New Zealand Transport Agency's Speed Management Guide, provides a single assessment method for determining safe and appropriate speeds at a network level. The framework aims to better align travelling speeds with road function, design, safety and use, while linking into wider planning and investment programmes. This paper presents the findings of applying the framework to the Waikato region, including analysis of the assignment and prioritisation of intervention strategies to road sections where speed management interventions have high benefit safety and efficiency opportunities. This paper will be of interest to all those involved in network management and those interested in understanding the potential safety benefits of speed management interventions.

Introduction

In September 2015, the New Zealand Transport Agency (the Agency) published the draft Speed Management Guide, which is an Agency responsibility under the second Safer Journeys Action Plan (2013-15). In order to progress the guide to final status, the Agency initiated a Speed Demonstration Project in the Waikato Region to demonstrate the guide and inform the refinements to the newly developed speed management framework published in the draft guide. The Waikato is one of the worst performing regions for road safety outcomes in New Zealand and has been subject to considerable focus for improving safety outcomes in recent years. The demonstration therefore also provided technical support to the Waikato Regional Council and local Road Controlling Authorities (RCAs) which had been progressing a speed management project for some time. The Waikato Speed Demonstration Project is an essential element in proving the robustness of the assessment framework and building confidence in the process, both in the Waikato Region and also for other regions observing the demonstration.

Speed Management Guide

The fundamental premise of the Speed Management Guide is to reduce deaths and serious injuries by determining vehicle speeds that are safe and appropriate for the function, design, safety and use of each road. It is designed to contribute to the 'Safe Speeds' pillar of the Safe System approach to road safety and to network efficiency where that is appropriate according to the road classification. It is important to acknowledge that the safe and appropriate speeds identified in this Guide are not fully safe system compliant speeds. Whilst they represent a strong move in the right direction towards safer speeds, there will still be many roads without directional separation that are assigned travel speeds in excess of 70km/h.

The stated objectives of the Speed Management Guide are to:

- *Ensure a consistent sector-wide approach is adopted to manage speeds so they are appropriate for road function, design, safety, use and the surrounding environment; and*
- *Help RCAs and other system designers identify and prioritise the parts of their networks where better speed management will contribute most to reducing deaths and serious injuries, while supporting overall economic productivity.*

- *Support a new conversation on speed by demonstrating that not all roads are equal*

The Speed Management Guide contains a step by step Speed Management Framework to help RCAs plan, invest in and operate an effective speed management plan. It outlines how speed management can achieve both safety and efficiency, and enable RCAs to effectively engage with their communities to build support for an evidence-based, network-wide strategic approach to achieve these twin outcomes.

Speed Management Framework

The Speed Management Framework is primarily governed by the One Network Road Classification (ONRC). The ONRC involves categorising roads based on the functions they perform as part of an integrated national network. The classification helps RCAs and the Agency to plan, invest in, maintain and operate the road network in a more strategic, nationally consistent and efficient way.

The safe and appropriate speed matrix shown in Figure 1 has been approved by the National Road Safety Committee[1]. It is based on the ONRC, a simplified horizontal alignment classification (straight, curved, winding/tortuous) and generalised land use category. The matrix is the fundamental building block upon which the Speed Management Framework has been developed.

<table>
<tr><th>Classification</th><th>Straight open road /urban motorways</th><th>Curved open road</th><th>Winding open road</th><th>Urban (not motorway)</th></tr>
<tr><td>Class 1
High volume national</td><td>100–110km/h[7] *

Depends on design and safety risk (e.g. divided 4-5 star, grade separated intersections, safety barriers) and factoring in enforcement thresholds</td><td></td><td rowspan="3">60-80km/h</td><td></td></tr>
<tr><td>Class 2
National, Regional, Arterial</td><td colspan="2" rowspan="2">80-100km/h
Depends on safety risk and whether volumes justify investment to bring the road up to 3 star equivalent, also enforcement thresholds</td><td>50km/h

60-80km/h where safety risk allows, e.g. fewer intersections, mode separation for active users</td></tr>
<tr><td>Class 3 Primary and secondary collector</td><td rowspan="2">30-50km/h

30km/h if high volumes of cyclists/pedestrians
Recognise access and place

10km/h for Shared Spaces</td></tr>
<tr><td>Class 4
Access and low-volume access
All winding/tortuous</td><td colspan="3">60-80km/h
Depending on roadside development, pedestrian and cyclist volumes, whether sealed or not</td></tr>
</table>

Figure 1. Recommended Safe and Appropriate Speed Ranges for Road Classes (NZTA, 2015)

[1] The National Road Safety Committee (NRSC) is a group of government agencies with responsibilities for road safety. The NRSC developed and is responsible for implementing the Safer Journeys strategy and Safer Journeys action plans. The NRSC members include the Ministry of Transport, NZ Transport Agency, Police and the Accident Compensation Corporation. NRSC associate members include Local Government NZ, the Energy Efficiency and Conservation Authority, the Ministries of Justice, Health, Education and the Ministry of Business, Innovation and Employment (Department of Labour).

* It should be noted that 110km/h is not yet a legal speed limit in New Zealand. However, processes are in motion to modify legislation to enable the introduction of this higher speed limit.

The Speed Management Framework sets criteria for a range of safe and appropriate speeds in urban and rural environments. The Speed Management Guide defines safe and appropriate speeds as travel speeds that are appropriate for the road function, design, safety and use.

The key factors in the Speed Management Framework that are used to derive the safe and appropriate speed for any given section of road are:

- **ONRC**, which represents the function of the road within the whole network.

  The ONRC factor provides the overarching basis for aligning travelling speeds with road function, design, safety and use, as it takes traffic volumes, freight networks and place functions into account. The ONRC factor provides the essential network efficiency component into the analysis, ensuring the results are both safe and appropriate for the network function.

- **Road safety risk metrics**, primarily Personal Risk, which is a measure of the actual safety performance of a road for individual road users based on historic crash data.

  The Personal Risk of a road is calculated using the formula:

$$Corridor\ Personal\ Risk = \frac{(Corridor\ Collective\ Risk\ x\ 10^8)}{Qcorridor\ x\ 5\ years\ x\ 365\ days}$$

  Where:

  Collective Risk is calculated by applying death and serious injury severity indices to all injury crashes along a road and dividing the summed severity index by the length of the road in kilometres.

  Qcorridor is the weighted average daily traffic volume along a corridor. (Brodie et al).

- **Infrastructure Risk Rating (IRR)**, which is a road assessment methodology designed to assess road safety risk based on design features, operational characteristics and interactions with adjacent land use, independent of crash history. IRR is designed for assessing risk on roads where Personal Risk can be an unreliable indicator of safety risk because of low traffic volumes. Full details of the IRR assessment methodology, application and results are presented in 'An Automated Process of Identifying High-Risk Roads for Speed Management Intervention' (Zia et al.).

Incorporating the reactive Personal Risk metric and the proactive IRR metric into the safe and appropriate speed assessment acknowledges the intrinsic link between travel speeds and safety outcomes.

The criteria associated with all safe and appropriate speed outcomes for urban roads is shown in Table 1. A road section needs to satisfy the criteria in each of the 'Function / Feature', 'Road Safety Performance' and 'Infrastructure Risk Rating' assessment categories to justify the safe and appropriate speed.

The safe and appropriate speed for each road section is then compared to the existing speed limit. If the safe and appropriate speed and speed limit are the same, the road section is deemed to be 'in alignment' with the Speed Management Framework. Equally, where the safe and appropriate speed and speed limit are different, the road section is deemed to be 'not in alignment'.

A key purpose of the comparison between the safe and appropriate speed and the speed limit is as an initial filter to reduce the number of road sections taken through for subsequent assessment, classification and prioritisation. It is not a confirmation that a lower or higher speed limit is justified. The overarching aim of the framework is to achieve regionally and nationally consistent outcomes and enable road controlling authorities to prioritise speed management efforts and available resources to risk.

Table 1. Proposed Safe and Appropriate Speed Criteria – Urban Roads

Function / Feature	**Personal Risk**	**Infrastructure Risk Rating**	**Safe and Appropriate Speed (km/h)**
• ONRC is Class 1 or 2 • Identified as a Freight Priority Route in a Network Operating Framework • Limited Access Road controls • Median Divided	≤ Low-Medium	Low or Low-Medium	80
• ONRC is Class 1 or 2 • Non-commercial adjacent land use	≤ Medium	Low or Low-Medium'	60
• ONRC is Class 1 or 2 • Non-commercial adjacent land use	*No road safety metric used in the assessment*	Any IRR	50
• ONRC is Primary Collector • Residential adjacent land use	≤ Medium High	Low to Medium	50
• Any ONRC • Non-commercial and non-residential adjacent land use	≤ Medium-High	Low to Medium	50
• Any ONRC • CBD/town centre • Residential neighbourhoods	*No road safety metric used in the assessment*	Low to Medium-High	40
• Any ONRC • CBDs or town centres with high place function and concentration of active road users	*No road safety metric used in the assessment*	High	30

Understanding Current and Future Operating Speeds

Road sections not in alignment with the Speed Management Framework are assessed in further detail to identify speed management intervention strategies and to assign implementation priorities. A fundamental aspect of this secondary assessment process is the understanding of travel speeds – both current operating speeds and estimated future operating speeds if the speed limit is changed to the safe and appropriate speed.

For the Waikato Speed Demonstration Project, current operating speeds for high-speed roads were calculated for 9,629 km of roads using an automation of the Austroads Operating Speed Model

(Austroads, 2009; Harris et al, 2015). The model is based on maximum desired speeds established from the speed limit, horizontal geometry and vertical terrain, and typical driver acceleration and deceleration behaviours approaching, travelling through and exiting curves. The use of a speed model is necessary where incomplete or unreliable actual speed data exists across a network.

As the Austroads Operating Speed Model is only applicable to high-speed roads, operating speeds for urban road sections needed to be estimated. Based on the analysis of some speed data in Hamilton, the following coarse assumptions were used in the estimation of existing operating speeds:

- All road sections with 'Winding' or 'Tortuous' alignment, Operating Speed = Speed Limit – 5 km/h
- If ONRC is Class 3 or 4, Operating Speed = Speed Limit
- Otherwise, Operating Speed = Speed Limit + 5 km/h

Understanding the current operating speed for a road section and how this compares with the existing speed limit and calculated safe and appropriate speed, is a critical component of the speed management process for assigning intervention strategies and priorities. Equally important is an awareness of the likely change in operating speed if changes are made to the posted speed limit. For rural parts of the network, the future operating speed is normally calculated by simulating the automated operating speed model with the speed limit set to the safe and appropriate speed. However, given the scale of the Waikato region, a different method was used to estimate future operating speeds. The method involved the detailed analysis of network-wide speed modelling completed for the Top of the South region (Marlborough, Nelson and Tasman districts) and correlating current operating speeds with future operating speeds for different speed limit and safe and appropriate speed combinations.

An example of the relationship between the change in modelled operating speed as a result of a speed limit change is shown in Figure 2. In this instance, the modelled operating speeds are based on an existing speed limit of 100km/h and a future speed limit of 80km/h.

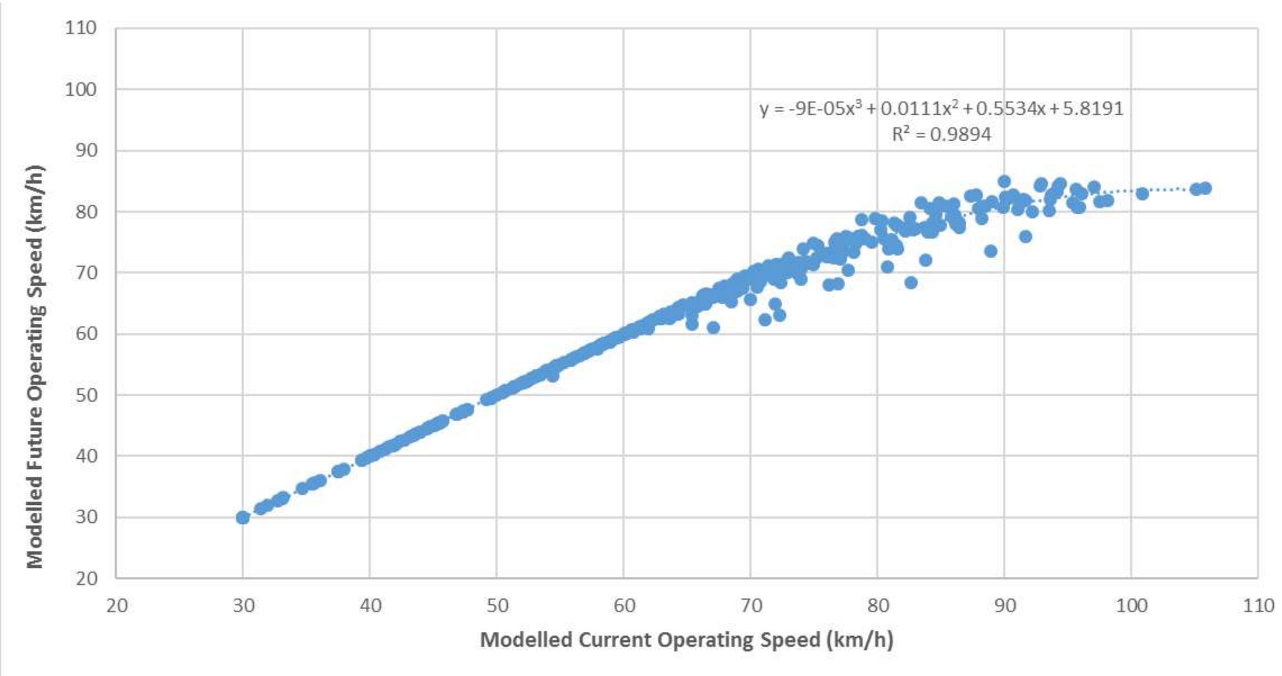

Figure 2. Relationship between Modelled Operating Speed Change from 100km/h to 80km/h

Figure 2 demonstrates that the relationship between the change in operating speed as a result of a speed limit change fits a polynomial function:

$$\begin{aligned} &\mathit{Final\ Operating\ Speed} \\ &\quad = \mathit{Existing\ Operating\ Speed} - (9E-05 \times \mathit{Existing\ Operating\ Speed})^3 \\ &\quad + (0.01 \times \mathit{Existing\ Operating\ Speed}) + 5.82 \end{aligned}$$

The simplified predictive relationship was then applied retrospectively and found to deliver a R^2 value of 0.99 for 3,262 km of rural roads assessed in the Top of the South region. This provided sufficient confidence that the simplified predictive approach for future operating speeds could be applied to the Waikato region.

Assigning Intervention Strategies to Roads

Once all four speed values (existing speed limit, safe and appropriate speed, current operating speed and future operating speed) are known, each road section not in alignment with the Speed Management Framework is evaluated against the following four speed management intervention strategies:

- **Engineer Up** – a road section that satisfies specific criteria to justify investment to bring the road section up to standard to maintain the existing speed limit or to support a higher speed limit. The main criteria are Class 1 or 2 ONRC and High or Medium-High Collective Risk.

- **Challenging Conversations** – a road section where the calculated safe and appropriate speed is below the existing speed limit and the current operating speed. The criteria for Engineer Up is not satisfied but safety performance justifies intervention.

- **Self-Explaining** – a road section where the current operating speed is comparable to or lower than the calculated safe and appropriate speed, both of which are lower than the existing speed limit.

- **Potential Speed Limit Increase** – a road section where the calculated safe and appropriate speed is greater than the existing speed limit and criteria is satisfied for a potential speed limit increase.

The evaluation of road sections against the different intervention strategies is informed by a series of factors. The factors associated witheach intervention strategy are shaded in Table 2.

Table 2. Factors Incorporated into the Evaluation of Intervention Strategies

Factor	**Intervention Strategy**			
	Engineer Up	**Challenging Conversations**	**Self-Explaining**	**Potential Speed Limit Increase**[2]
ONRC				
Crash history				
Estimated DSi Saved*				
Estimated DSi Saved / km				
Existing operating speed relative to speed limit				
Potential change in operating speed				
IRR				

- * Refer following section of paper.

Each road section is scored on a scale of 1 to 5 against each of the factors and assigned to the intervention strategy for which it scores highest.

Estimating the Safety Benefits of Speed Limit Changes

The estimation of death and serious injuries (DSi) that can be saved as a result of speed management interventions is based on a form of Nilsson's Power Model. Recent studies undertaken by Elvik (2009) and Cameron et al. (2010) confirm that speed environment is an important moderator of Nilsson's Power Model. Elvik concluded that in general, changes in speed have a smaller effect at low speeds than at high speeds. Furthermore, the analyses show that the exponents proposed by Nilsson based on speed limit changes in Sweden during 1967-1972 overestimate the expected DSi reductions due to various safety improvements in the last 40 years. However, both authors acknowledge that the Power Model remains a valid model of the relationship between speed and road safety if the exponents are adjusted according to speed environment.

Elvik's study presents separate exponents that are considered to be the best estimate to calculate DSi reductions for rural and urban speed environment. The generic form of Power Model equation for calculating future DSi is:

$$Estimated\ Future\ DSi = Estimated\ DSi \times \left(\frac{Speed\ after}{Speed\ before}\right)^{Exponent}$$

[2] This intervention strategy is only evaluated on those road sections where the calculated safe and appropriate speed is higher than the existing speed limit.

Where the exponent is set to 2.0 for urban environments (speed limit ≤ 70km/h) and 3.5 for rural environments (speed limit ≥ 80km/h). ‘Speed after’ values derived from the operating speed modelling have been moderated to ensure that potential DSi savings are not overestimated. This has been achieved by limiting the difference between current operating speed and future operating speed to a maximum rate of change of 5km/h for every 10km/h change in speed limit. This is higher than national and international experience where the change in operating speed is rarely found to exceed 5km/h per 10km/h change in speed limit without supporting measures. However, as the rate of change is only used for the assignment and priroitisation of intervention strategies purposes, the implications of the maximum rate value applied is expected to have little impact on the outcomes in a network-wide context.

In practice the use of Nilsson’s Power Model has been found to translate to an average DSi reduction of 27% for 100km/h road subject to a proposed 80km/h speed limit, and 9% for a 50km/h road changing to 40km/h.

Road sections where the current operating speed is less than the existing speed limit will attract a lesser percentage reduction in DSi than road sections where the current operating speed is higher. Likewise, road sections where the current operating speed is lower than both the existing speed limit and safe and appropriate speed will generate few DSi savings, as the future operating speed will only reduce by a marginal amount, if at all. Road sections that fall into the latter scenario are most likely to be categorised as ‘Self-Explaining’ whereas those with a greater difference between current and future operating speeds are more likely to be categorised as ‘Challenging Conversations’, especially where the road section has an established safety issue. Despite the lack of direct safety benefits that are associated with the ‘Self-Explaining’ intervention strategy, the classification is important for helping to change the conversation and behvaiours with the public around what safe speeds mean. The alignment of speed limits with operating speeds is expected to drive safer travelling speeds on other similar roads and deliver safety benefits across a wider area.

Prioritising High Benefit Opportunities

The highest benefit opportunities for speed management interventions are developed from the intervention strategy evaluation process. The highest benefit opportunities are presented as a ‘Speed Management Map’ (SMM). The purpose of a SMM is to highlight to an RCA those road sections within a network that represent the highest benefit opportunities for speed management intervention.

The SMMis developed by identifying the highest priority road sections for interventions based on the assigned scores in the intervention strategy evaluation process. For the Waikato region, the highest ranking 10% of the network by length formed the SMM.

The SMM attempts to roughly balance the length of network categorised with ‘Engineer Up’ and ‘Challenging Conversations’ intervention strategies and those classified as ‘Self Explaining’. The purpose of the balancing is to ensure there is a two-fold focus on both potential for DSi reduction from speed management interventions and also improving the public acceptability of speed limit reductions, thus giving effect to the stated objectives of the Speed Management Guide.

An example of the scoring applied to a road section section is shown in Table 3.

Table 3. Example Scoring Applied to a Road Section

Factor	**Intervention Strategy**	
	Engineer Up & Challenging Conversations	**Self-Explaining**
ONRC	3	
Crash history	4	3
Estimated DSi Saved*	3	
Estimated DSi Saved / km	5	
Existing operating speed relative to speed limit		1
Potential change in operating speed		1
IRR		3
Score	**15**	**10**

The road section evaluated above scores highest for the Engineer Up and Challenging Conversations intervention strategies. The road section is assigned to the Challenging Conversations intervention strategy because it has an ONRC of Primary Collector i.e. Class 3, which is outside the ONRC criteria for the Engineer Up intervention strategy categorisation. The road section is then ranked alongside all other roads with a Challenging Conversations intervention strategy based on the score. This ranking is then used to determine if the road section will be included in the SMM.

Implementation

Implementation is much more difficult and important than the technical analysis. This is especially true of many aspects of transport where public and political interest is high. Speed is a particularly sensitive topic.

In introducing and applying the Speed Management Framework a new approach and perspective has been implemented. This has involved actively engaging with stakeholders and the public about speed management instead of speed limits, and achieving network efficiency as well as safety. Engagement has occurred at a much earlier stage before any formal consultations. In this way the strategic objectives for an RCAs network have been explained early to gradually build public understanding and support for speed management interventions.

The pace of change has also been important. The speed management framework supports the long term objective that speed limits (and travel speeds) should reflect the function, use and safety of the network, but this will not happen overnight. Change should be at a pace that the public can accept and support.

The Agency is acutely aware that implementation of speed management on a regional and national scale to achieve desired safety outcomes whilst supporting economic activity requires extremely careful planning and consideration. To help realise this, the Agency has invested significant time and energy in building confidence and support in the technical analysis by actively engaging key stakeholders, such as the Automobile Association, Police and Road Controlling Authorities, in the process.

Although the technical analysis provides the platform for speed management decisions; it does not replacement sound professional judgement. For the Waikato Speed Demonstration Project, safe and appropriate speeds, intervention strategies and priorities have been reviewed for numerous road sections of interest. Where there has been a mismatch between the technical analysis and professional judgement, the technical processes have been reviewed, and where necessary modified to reduce the number of anomolous outputs generated from the process. The authors acknowledge there are limitations with any network-wide analytical process; however the key in building confidence and gaining support is to reduce the number of such incidents.

A key part of the process used in the Waikato Demonstration process was a local ‘sense check’, where the high benefit SMMs were critically reviewed by the road controlling authority engineering staff. Even at this stage, further refinements were able to be achieved to further improve the acceptability of the process outputs.

The engagement and willingness to modify the technical processes has resulted in an upswell of confidence and support for the speed management process in Waikato. This is seen as critical to the success of implementing speed management interventions in a nationally consistent manner.

The technical outputs of the analytical process are now being used by RCAs in Waikato to develop Speed Management Plans for local consultation.

Conclusion

Safe speed is one of the four pillars of the Safe System approach to road safety. The New Zealand Transport Agency’s Speed Management Guide, has introduced a single assessment framework that takes the road function, design, safety and use into account, to determine safe and appropriate speeds at a network level.

Where the safe and appropriate speed is different from the speed limit, a road section is said to be not in alignment with the framework. These road sections are assessed in further detail to identify speed management intervention strategies and to assign implementation priorities. A key aspect of this process is the understanding of current and estimated future operating speeds. The change in operating speed that may be realised from speed limit changes is used to estimate DSi that can be saved as a result of speed management interventions based on a form of Nilsson’s Power Model.

High benefit opportunities for speed management are developed in a manner that attempts to balance the length of network between those roads sections categorised as ‘Engineer Up’ and ‘Challenging Conversations’ with those classified as ‘Self Explaining’. The purpose of the balancing is to ensure there is a twofold focus on both potential for DSi reduction from speed management intervention and improving the public acceptability of speed limit reductions.

Whilst the technical analysis provides the platform for speed management decisions, implementation is much more difficult and important than the technical analysis. The Agency is acutely aware that implementation of speed management on a regional and national scale to achieve desired safety outcomes whilst supporting economic activity requires extremely careful planning and consideration. Early engagement with key stakeholders and openness to modifying technical processes to reflect stakeholder views are key themes that are contributing to the building of public understanding and support for speed management interventions.

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Long-term speed and safety outcomes from New Zealand's Rural Intersection Active Warning System

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Abstract

The Rural Intersection Active Warning System (RIAWS) has the aim of reducing fatal and serious crashes at high risk intersections by reducing traffic speed on major road intersection approaches when potential for a collision exists. This study builds on the initial evaluation by taking a longer-term view of RIAWS performance. Speed and crash data were analysed for up to three years since the first RIAWS pilot sites started operating. Compliance with the 70 km/h speed limit when RIAWS is active is still very high and fatal and serious crashes have almost been eliminated at the ten RIAWS intersections since commissioning up to three years ago.

Background

The development, implementation and evaluation of RIAWS is part of a wider programme to address safety at high-risk intersections as part of the government's Safer Journeys road safety strategy and associated action plans.

The RIAWS has the potential to reduce fatal and serious casualties at rural intersections by:

- Slowing motorists on major road intersection approaches and thus reducing crash likelihood (effectively increasing available stopping distance) and severity (less energy on impact)
- Increasing driver state awareness and therefore preparing motorists for a possible event (effectively reducing reaction time)
- Increasing the gaps between potentially colliding vehicles.

The development of RIAWS (Mackie 2010, 2011) has been described earlier and the initial assessment of the system was positive (Mackie et al., 2014; Mackie and Scott, 2015). The purpose of this study is to assess the longer-term performance of RIAWS.

Methods

To date, ten RIAWS systems are functioning as part of the trial. Speed data (measured using induction loops at the intersection in both directions) was collected from all ten sites so that the baseline, short-term and longer-term average and modal speed could calculated. All speed data were from 'collision risk' situations, that is, when side road vehicles were present. Crash data was collected from each of the sites using the Crash Analysis System (CAS). At each site, fatal, serious, injury and non-injury crashes were measured for the five-year period prior to RIAWS installation, and was compared with the same data in the period following RIAWS installation to the present (up to three years). To account for the different time periods, a common unit of crashes per month was calculated for each site.

Results

Traffic speed

Example speed distributions for the Himatangi site are shown in Figure 1 below. Since the RIAWS was installed, at almost all locations it has been effective in maintaining lower traffic speeds, near the target speed of 70 km/h, over the medium to long-term.

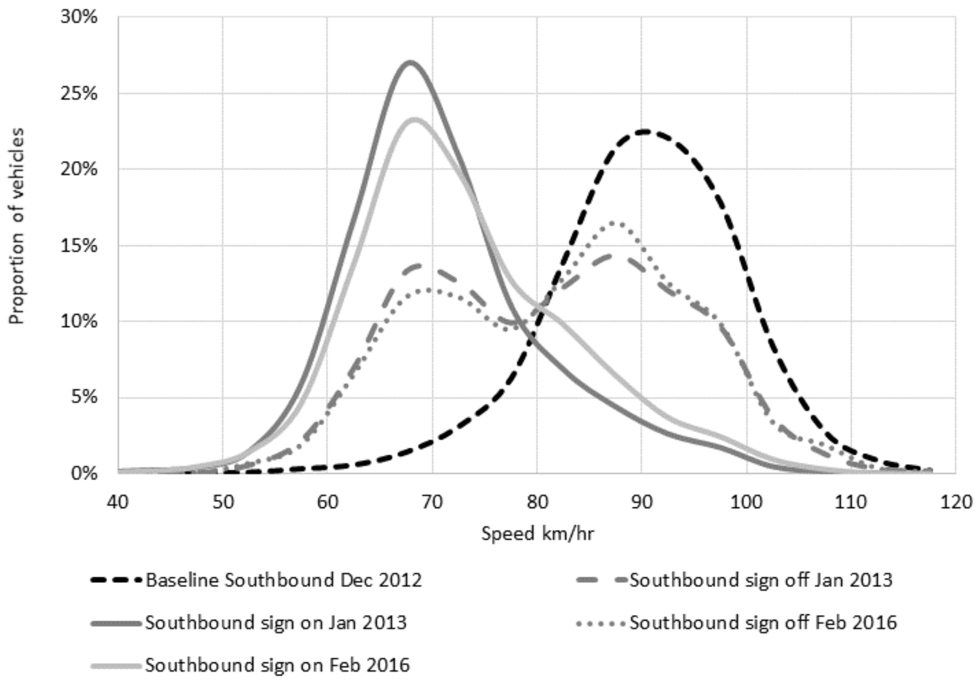

Figure 1. Typical speed distributions for baseline, and with RIAWS active and not active.

For all ten sites, the speed reductions have generally been sustained, as shown in Figure 2 below. Compliance appears to be optimal for sites where there is plenty of site distance on approach to at 70 km/h variable speed limit. The average modal ’collision risk’ baseline speed was 88 km/h across all sites, 72 km/h immediately after installation and 73 km/h 2-3 years following installation.

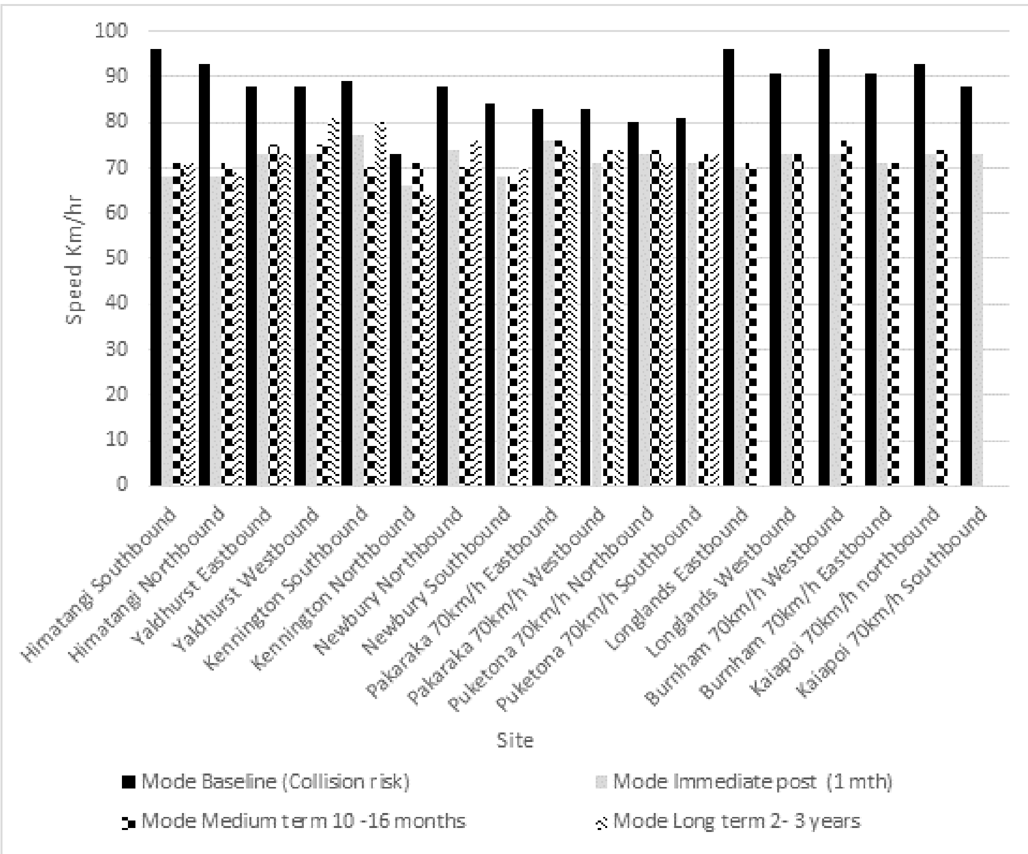

Figure 2. Modal traffic speed for each RIAWS site (both directions) for ‘collision risk’ situations

Casualties

The RIAWS were all installed at high risk intersections and across ten sites have been active for a total of 223 months. In the five years prior to the installation of each RIAWS there were a total of 1 fatal, 19 serious injury and 44 minor injury crashes across the sites (total 0.35 F&S crashes/month). In the 223 months following RIAWS installation there were a total of 0 fatal, 1 serious and 5 minor injury crashes across the sites (total 0.04 F&S crashes/month). The one serious injury crash that has happened was unrelated to the system as a motorcycle was hit from behind while waiting at a side road.

Discussion

The longer-term analysis of speed and casualties for RIAWS suggests that the system remains effective and that positive safety benefits are beginning to emerge. A longer period still (5 years) is needed before more certainty about the crash performance can be achieved. There is some variability in speed performance across the sites

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Rural Regional Roads – Reducing Motorcycle Trauma Through Speed Limits and Infrastructure

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Abstract

Analysis of 80km/h speed limit reductions and/or infrastructure treatment on high speed Victorian rural roads revealed that motorcycles had the largest observed speed reductions. Given that motorcycles are over-represented in crash statistics this result indicates that the speed limit reductions should be an effective, low cost treatment on popular motorcycle routes.

Analysis of recent crash data reveals that speed limit reduction on its own, without concomitant infrastructure, did not significantly reduce serious and fatal injuries to motorcyclists. However, these results are not statistically significant on the basis of a chi-square test and may be an artefact of the relatively short period of analysis.

Background.

On high speed rural roads with a crash history, Victoria traditionally uses infrastructure treatments and leaves the default 100 km/h speed limit. This approach is successful for high volume roads where the investment can be justified. The cost of treating low volume, high crash rate roads with expensive infrastructure treatments is difficult to justify.

Method.

VicRoads Eastern Region identified 14 road sections with higher than average crash rates. The major crash type was single vehicle run-off-road and motorcyclists were the most involved (80%). Inappropriate speeds and speeding were the major contributing factors.

In 2012 VicRoads reduced the speed limit from the default 100 km/h to 80 km/h in these 14 sections (covering approximately 225 kilometres of arterial road network). Beer, Moon & Riess (2014) detailed the process. Some sections also installed road safety treatments.

The research issues in analysing crash statistics for these road sections are: firstly, were the reduced speed limits successful in encouraging motorists actually to reduce their speed; and secondly, were the reduced speed limits successful in reducing crash rates.

The first issue was studied by Monash University Accident Research Centre (2015). We tested the second issue by examining the crash statistics per annum for five years prior to the installed treatments and comparing them to the crash statistics per annum for two and a half years after the installed treatments.

Results.

Monash University Accident Research Centre (2015) confirmed significant reductions in the point mean speed of motorcycles after reduction of the speed limit at selected locations on five of the seven roads as shown in Table 1.

Table 1: Mean speed before and after speed limit reduction: Motorcycles

Road	Mean speed before	Mean speed after	Statistically significant change (95% CI)
Omeo Highway	82.7	72.2	-10.5
Licola Rd	108.3	100.3	-8.1
Lang Lang-Poowong Rd	88.8	78.4	-10.4
Walhalla Rd	59.5	59.5	Not statistically significant
Bonang Rd	78.1	62.8	-15.3
Willowgrove Rd	74.0	51.7	-22.3
Great Alpine Rd	91.4	86.4	Not statistically significant

Comparing motorcycle crash data after installation with crash data prior to installation:

Sections with 80 km/h speed limits (with infrastructure installed)

Serious and Fatal injury crashes reduced by 52%.

Minor injury crashes reduced by 18%.

Sections with 80 km/h speed limits (without infrastructure installed)

Serious and Fatal injury crashes increased by 3%.

Minor injury crashes increased by 106%.

Sections without 80 km/h speed limits (with infrastructure installed)

Serious and Fatal injury crashes reduced by 68%.

Minor injury crashes reduced by 39%.

Discussion

Though not shown above, analysis of recorded travel speeds for cars, trucks and motorcycles, showed that the largest speed reductions were generally observed for motorcycles. We are thus confident that speed limit reductions do actually lead to reduced motorcycle speeds.

However, speed limit reduction on its own, without concomitant infrastructure did not significantly reduce motorcyclists' serious and fatal injuries and appears to have increased minor injury crashes. Is this really the case? We cannot tell because these results are not statistically significant on the basis of a chi-square test. However it is difficult to develop a convincing mechanism in which a decrease in speed leads to an increase in minor injuries. We thus hypothesise that the lack of a significant effect is an artefact of the relatively short period of analysis and note that at least another 2.5 years of crash statistics are needed to have the same length of prior- and post-treatment data.

Conclusions

Speed limit reductions lead to reduced motorcycle speeds. However, speed limit reduction on its own, without concomitant infrastructure does not appear to significantly reduce serious and fatal injuries and appears to have increased minor injury crashes. Because it is difficult to develop a convincing mechanism in which a decrease in speed leads to an increase in minor injuries we hypothesise that the ambiguous results are an artefact of the relatively short period of analysis.

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An Automated Process of Identifying High-Risk Roads for Speed Management Intervention

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Abstract

Infrastructure Risk Rating (IRR) is a significant input to the speed management framework, set to be introduced as part of NZ Transport Agency's Speed Management Guide. It is a road assessment methodology designed to assess risk based on infrastructure elements and interactions with surrounding land use, independent of crash history. The road safety risk is assessed by coding each road and roadside feature; such as land use, road stereotype and alignment; that feeds into the IRR model so that a risk rating can be determined. The methodology was originally developed as a manual coding exercise using street view imagery. However, this approach is neither economic nor time efficient when applied across a large network as is the requirement of the speed management framework.

This paper presents a geospatial process to automate the calculation of IRR. The process utilises various national and regional geospatial datasets to extract road features needed to calculate IRR. A comparison of the automated process outputs with manually coded IRR data of the same network resulted in a matching rate of almost 90 percent, hereby confirming the validity of the automated process. Aside from demonstrating the true potential of transport related data, this innovative approach will enable road controlling authorities to efficiently identify parts of their network where speed management intervention is most likely to reduce road trauma.

Introduction

Safer Journeys, New Zealand's Road Safety Strategy 2010-20 has a vision to provide a safe road system increasingly free of death and serious injury (Ministry of Transport, 2010). This Strategy adopts a safe system approach to road safety focused on creating safe roads, safe speeds, safe vehicles and safe road use. These four safe system pillars need to come together if the New Zealand Government's vision for road safety is to be achieved.

The second action plan of the Strategy, Safer Journeys 2013-15 Action Plan, aims to address speed as a cause of road death and serious injury (New Zealand Transport Agency, 2013). Therefore, NZ Transport Agency (NZTA) is tasked with delivering a Speed Management Guide that provides a framework to better align travelling speeds with road function, design, safety and use.

This speed management framework provides a single assessment method for determining safe and appropriate speeds on New Zealand's entire road network. The aim is to identify parts of the network where there is misalignment between the posted speed limit and the safe and appropriate speed and then prioritise investment to those parts where speed management intervention is most likely to reduce death and serious injuries.

Figure 1. Waikato region locality map

In order to progress the Speed Management Guide to final status, NZTA initiated a speed demonstration project in the Waikato region of New Zealand to test and inform the speed management framework. The Waikato Speed Demonstration Project is an essential element in proving the robustness of the assessment methodology and building confidence in the process.

Infrastructure Risk Rating (IRR) is one of the three metrics, along with road classification and historic safety performance, required to classify a safe and appropriate speed to a road corridor. The IRR assessment methodology was originally developed as a manual exercise of coding road attributes using street view imagery or high speed video. However, manually coding the whole of Waikato region in order to demonstrate the framework is neither economic nor time-efficient.

Therefore, as part of the Waikato Speed Demonstration Project, NZTA commissioned Abley Transportation Consultants to develop an automated process of calculating IRR across a large network. The Top of the South region of New Zealand was chosen to develop and refine the automated process before being applied in the Waikato region.

Infrastructure Risk Rating

IRR is a predictive road assessment methodology that has been developed by NZTA (Waibl et al., 2016). It is based on the Star Ratings process and involves coding a number of road and roadside attributes. These attributes then feed into the IRR model, resulting in a five-band risk rating, ranging from 'low' to 'high'. The overall IRR score for a road corridor is calculated by assigning a category-based risk score to the attributes given in Table 1.

Table 1. IRR Attributes and their Categories

Road Attribute	**Categories**
Road stereotype	• Divided – non-traversable or one-way • Divided – traversable • Multi-lane undivided • Two lane undivided • Unsealed
Horizontal alignment	• Straight or gentle, Curved, Winding, Tortuous
Lane width	• <3m – narrow • 3m to 3.5m – medium • >3.5m – wide
Shoulder width	• 0m to <0.5m – very narrow • 0.5m to 1m – narrow • >1m to 2m – wide • >2m- very wide
Surrounding land use	• No access (Freeway) • Remote rural • Rural residential • Rural town • Controlled access (Urban arterials)

	• Commercial big box/ Industrial • Commercial strip shopping • Urban residential
Traffic volume	• <1000 veh/day • 1,000 to <6000 veh/day • 6,000 to <12,000 veh/day • >12,000 veh/day
Intersection density	• <1 intersection/km • 1 to <2 intersections/km • 2 to <3 interesections/km • 3 to <5 intersections/km • 5 to <10 intersections/km • 10+ intersections/km
Access density	• <1 access/km • 1 to <2 accesses/km • 2 to <5 accesses/km • 5 to <10 accesses/km • 10 to <20 accesses/km • 20+ accesses/km
Roadside hazards	• Low, Minor, Moderate, High, Severe

The IRR assessment is designed to predict road safety risk on long sections of road. These long sections are referred to as 'homogenous sections' and are identified based on little variation in IRR features along the length of the section. In a rural environment, homogenous sections are around 5km in length, whereas urban sections are generally shorter due to frequent changes in road attributes such as surrounding land use and road stereotype.

As with other risk rating methodologies, divided carriageways are separated from undivided carriageways and coded in both directions. Short changes in IRR features such as a dividing median on the approach to an intersection or a turn along a straight corridor are ignored when identifying homogenous sections. In broad terms, homogenous sections are those where the speed limit would be same.

Methodology

A majority of the road attributes that feed into the IRR model are stored in national or regional geospatial road datasets. Therefore, to deliver the Waikato Speed Demonstration Project in a cost-efficient manner, the process of calculating IRR was automated using geographic information systems (GIS). This included the development of GIS models that accurately extract road attributes from various geospatial datasets and applying assumptions based on engineering analysis and professional judgement. This methodology is discussed, in brief, below.

Corridor Aggregation

The first step in automating the IRR methodology is to develop a method of aggregating road corridors that is comparable to manually identifying homogenous sections. Figure 2 summarises the geospatial process developed to automate this process. A road centreline dataset was initially dissolved into long corriors defined only by the posted speed limit and the road name. These corridors were then progressively segmented based on the IRR attributes that have the most significant influence on the overall score.

According to the speed management framework, the primary factor in distinguishing different road environments in terms of setting speed limits is the surrounding land use. As IRR is used to determine safe and appropriate speeds, land use has been used as the first order of segmentation.

Corridors with a uniform land use are then segmented further based on changes in road stereotype, alignment and traffic volume. These attributes were analysed to have a significant weighting to the overall score. For example, access density score has a difference of only 0.3 between the highest and the lowest risk category compared to road stereotype and alignment which have the same difference of 10 and 6 respectively (Waibl et al., 2016).

The segmentation thresholds (minimum lengths) where chosen to avoid segmenting corridors due to short changes in road attributes such as overtaking lanes or short divided medians. These thresholds have been adjusted as the methodology has been refined in order to align the automated process of corridor aggregation with manually identifying homogenous sections.

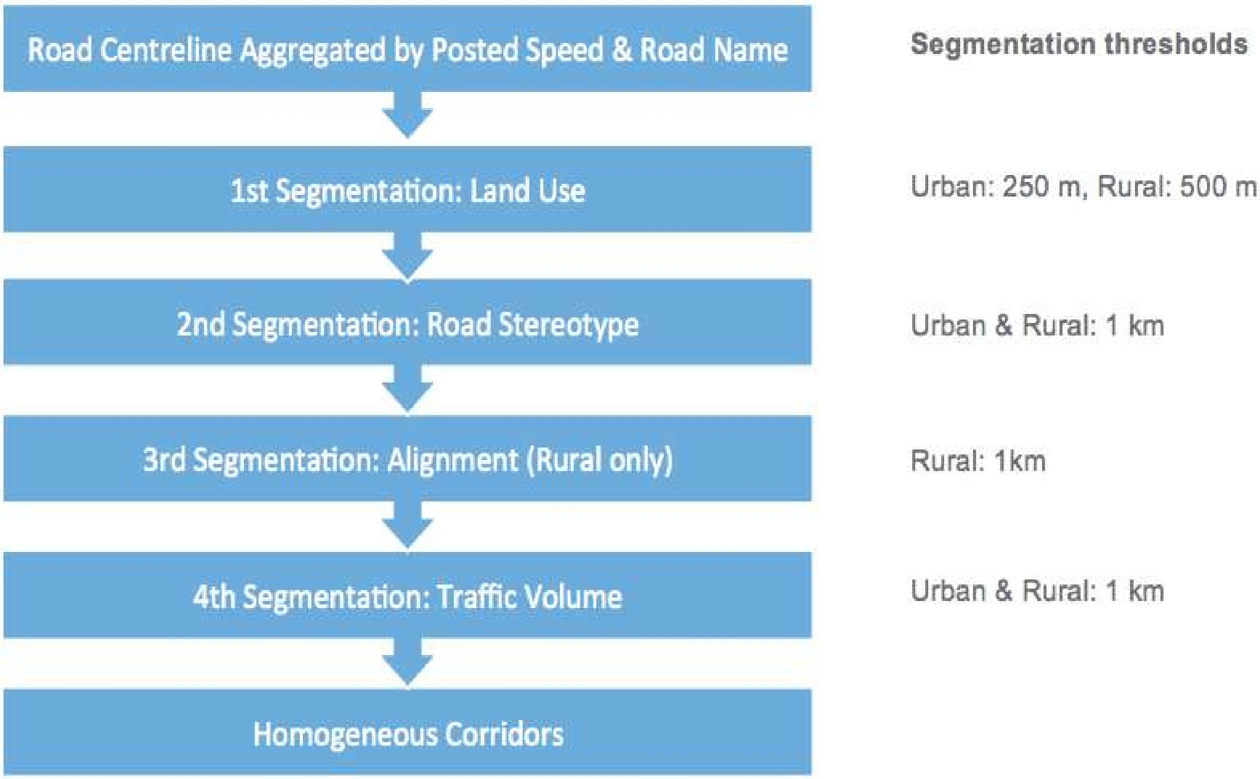

Figure 2. Corridor Aggregation Process and Segmentation Thresholds

Figure 3 shows an example of a rural corridor initially dissolved into a long section based on road name and posted speed limit. The corridor remains aggregated at the first and second order of segmentation as the land use is ‘remote rural’ and road stereotype is ‘two lane undivided’ along the entire length. There is a distinct change in alignment category that is longer than the segmentation threshold of 1km and therefore, the corridor is segmented at this stage of the process. There is no further segmentation as the traffic volume category remains consistent along the segmented sections.

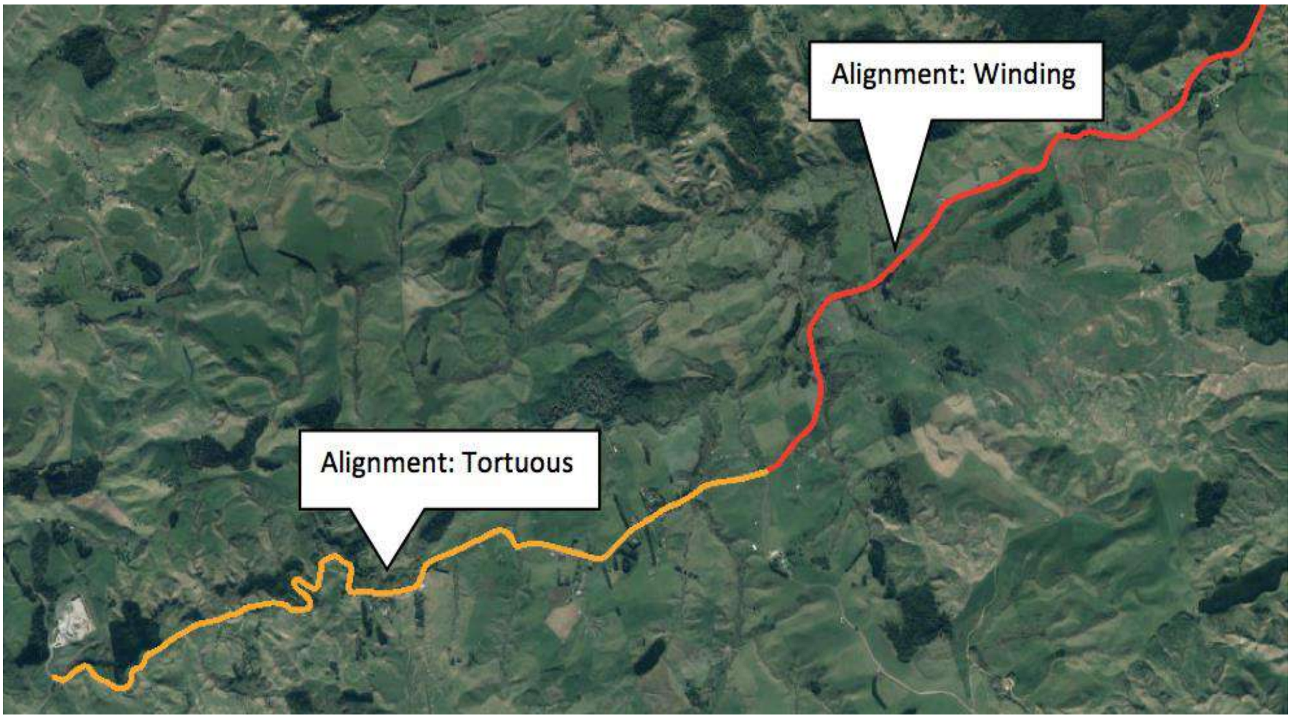

Figure 3. An Example of Corridor Segmentation

Geospatial Datasets

The GIS models have been developed to extract IRR attributes from various geospatial datasets. These include a national road centreline dataset with speed limit, road name and alignment data, and Road Assessment and Maintenance Management datasets maintained by local territorial authorities. Land use was modelled using urban and rural boundaries and the density of residential and commercial developments sourced from planning zones, Open Street Map (OSM) and Land Information New Zealand (LINZ) datasets.

Figure 4 shows how the automated process calculated each IRR attribute along with the datasets used to extract the attributes.

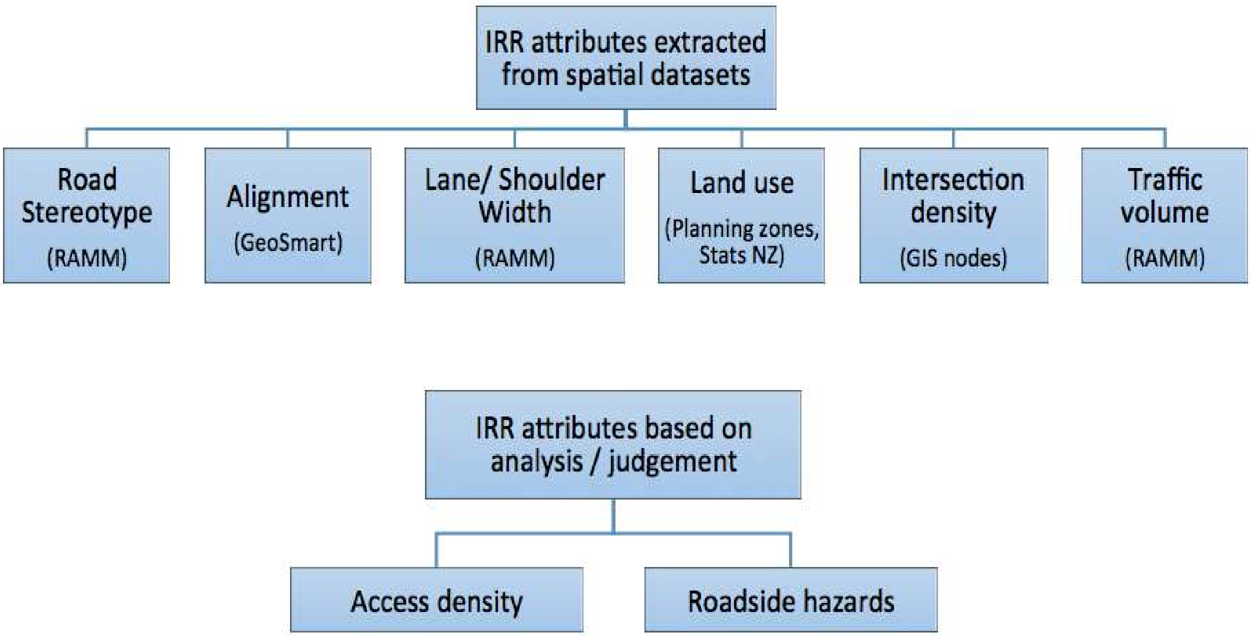

Figure 4. IRR Automation Overview and Datasets Used

Assumptions

While most IRR attributes can be extracted from spatial transport datasets, the automated process incorporates assumptions regarding access density and roadside hazards.

Regression analysis of almost 600km of manually coded IRR data identified that the combination of land use and posted speed limit is a robust predictor of access density. This data was collected for urban and rural parts of New Zealand's road network and represented a good sample upon which to base the access density model.

A comparison of actual and predicted access density categories, as shown in Figure 5, shows that the derived equation incorporating land use and posted speed limit variables predicted the right access density category for almost 70 percent of the sample network. This result is considered adequate considering that access density has the least influence on the overall IRR score.

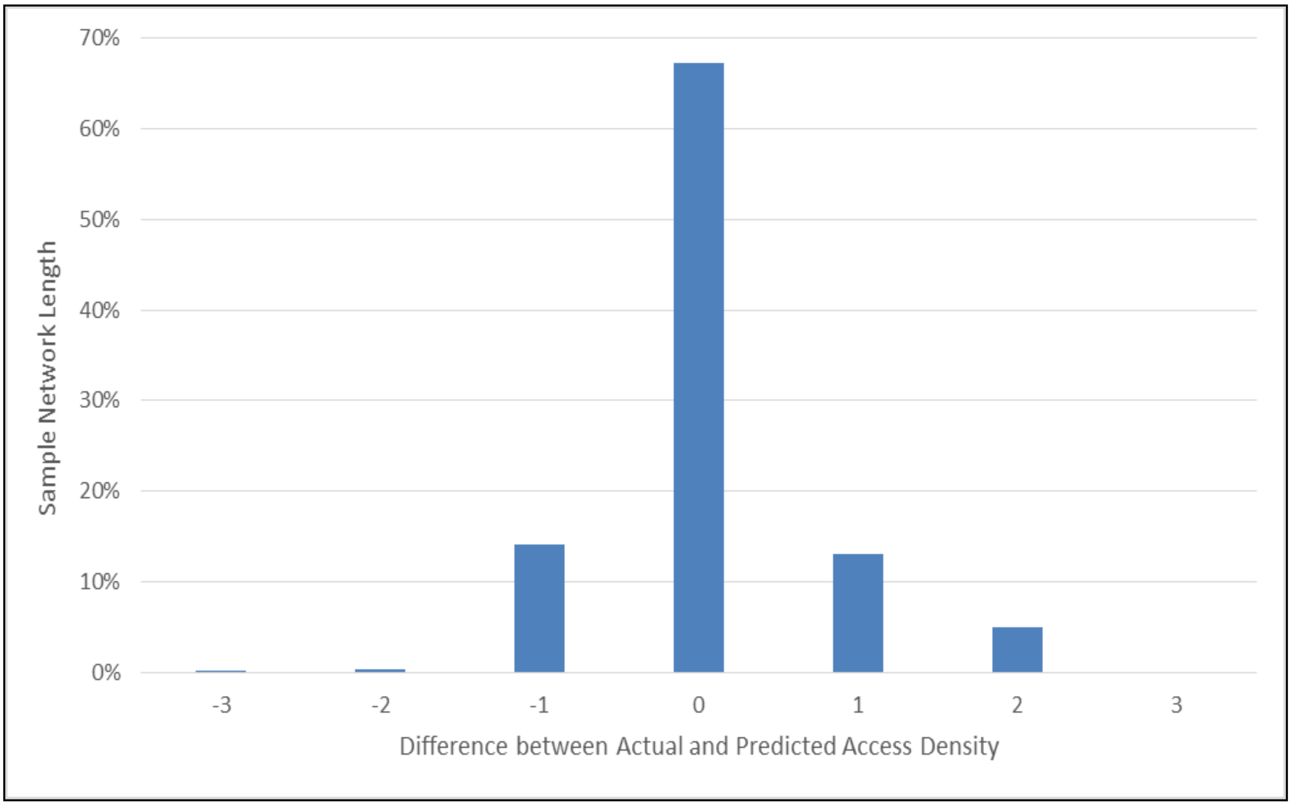

Figure 5. Comparison of Actual and Predicted Access Density

The roadside hazard attribute was determined using a combination of manual identification and applying assumptions based on sample IRR data. In addition to trees and poles, roadside hazards also include aggressive rock face, deep drainage ditches and cliffs with steep drop offs. These hazards were identified manually where possible using high quality spatial imagery and topographic maps.

Further analysis of the sample IRR data showed that the roadside hazard attribute correlates most with the combination of land use and road alignment. Generally, sample corridors with a rural land use were coded as 'moderate' to 'moderate-high' in terms of roadside hazards and urban corridors were coded as 'high'. One exception to this is corridors with the combination of 'tortuous' alignment and 'remote rural' land use which were generally coded as 'high' in terms of roadside hazards due to mountainous terrain in most cases.

In terms of speed management, assuming a consistent roadside hazard category along a particular land use ensures that the presence or absence of hazards intermittently does not have an impact on the resulting safe and appropriate speed.

Results

As part of testing and refining the methodology, 50 homogenous sections in the Top of the South region, equaling to a network length of approximately 134km, were manually coded and also run through the automated process. These roads were selected to have a mixture of surrounding land use with varied IRR attributes and included some of the highest risk corridors in the region in terms of historic safety performance.

As shown in Figure 6, the automated process successfully predicted the IRR of almost 90 percent of the sample network length while the remaining parts of the network were predicted to within one band of the manually coded rating.

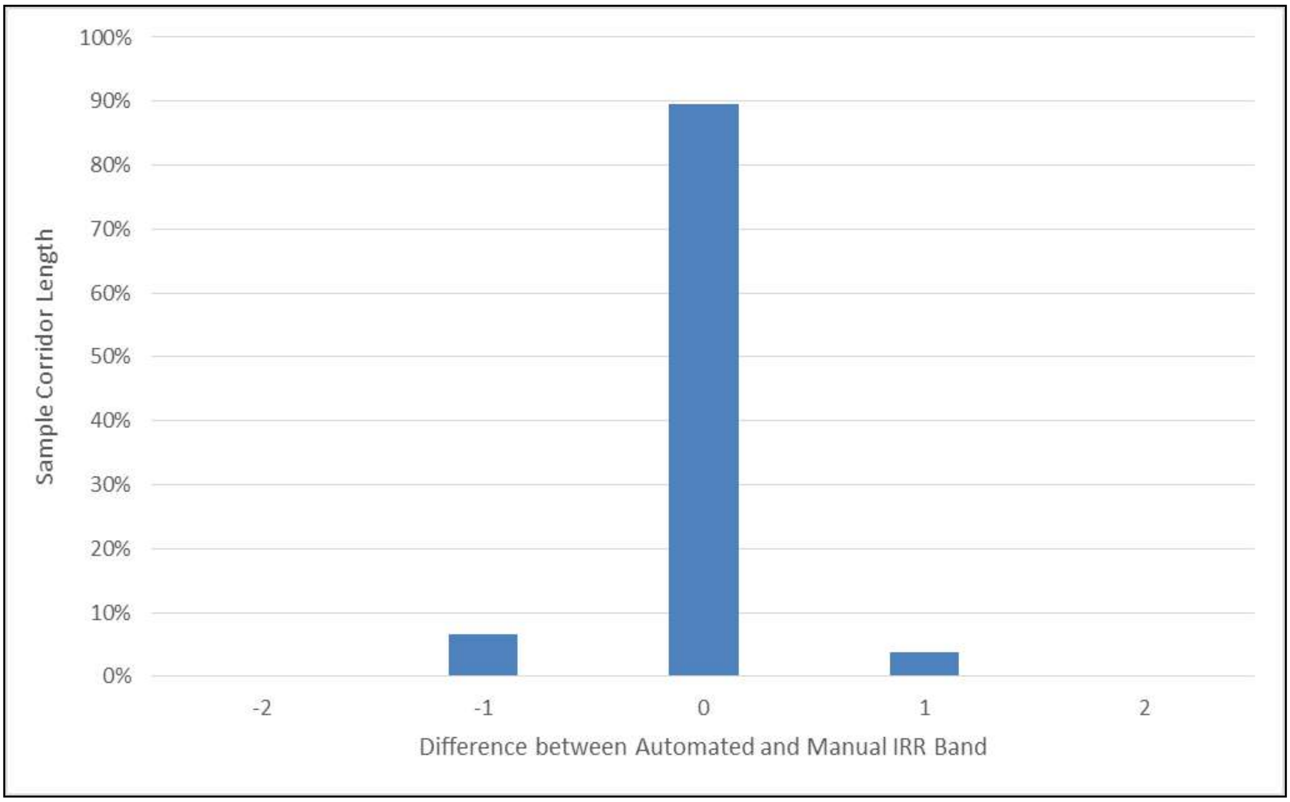

Figure 6. Comparison of Automated and Manual IRR Bands

Furthermore, the automated process successfully predicted the IRR of almost 97 percent of rural corridors in terms of network length. Whereas, only 78 percent of the urban network was successfully predicted which suggests that some refinements may be required to this part of the methodology.

IRR scores calculated from manual coding and applying the automated process were also compared in order to gain further insight into the validity of the model. These scores have been plotted in Figure 7 for the 50 homogenous sections.

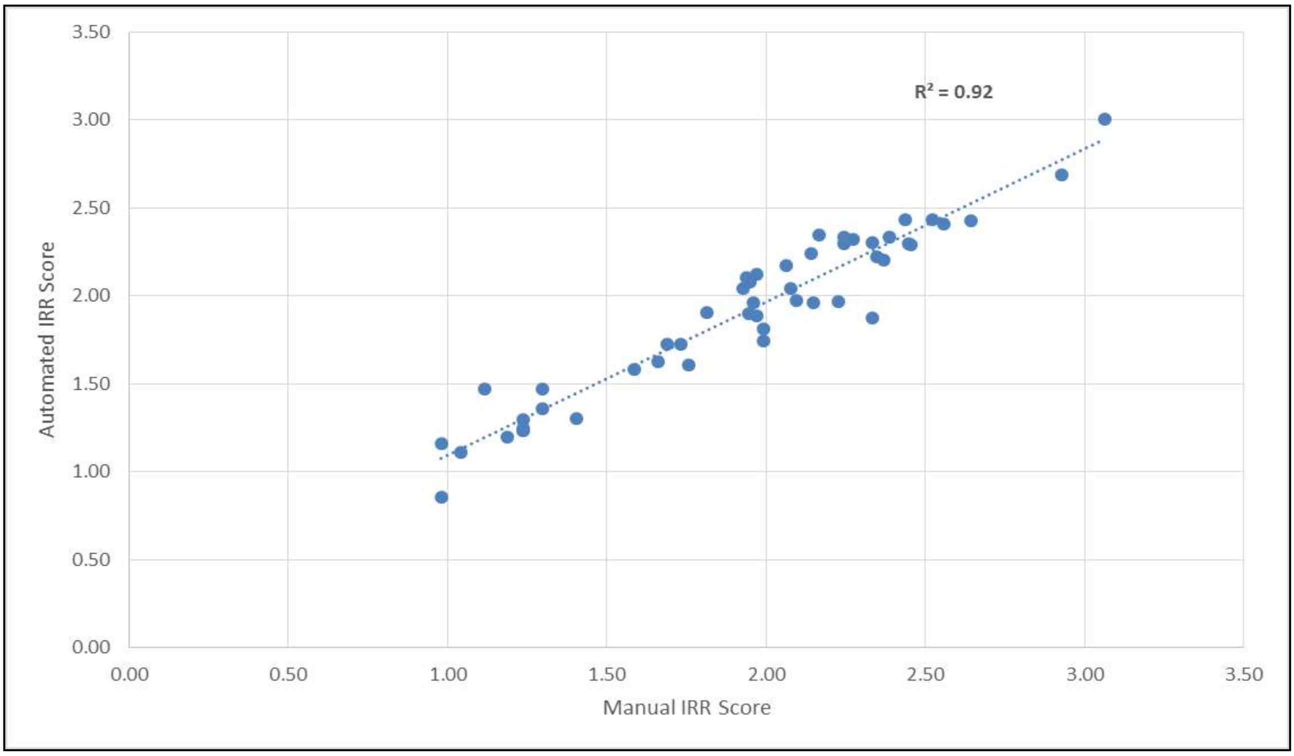

Figure 7. Plot of Automated and Manual IRR Scores

The high correlation between the manual and automated scores confirms that the GIS-based process is robust in automating the IRR methodology. This result gives confidence to road controlling authorities that the automated process is an efficient tool to proactively assess road safety risk in terms of speed management.

The outputs of this methodology were delivered through the integration of IRR with risk maps based on historic crash performance through a single mapping website. IRR attributes assigned to each corridor were displayed along with Google Street View integration to allow users to view actual road conditions. An example screenshot demonstrating the IRR outputs displayed on the website is shown in Figure 8.

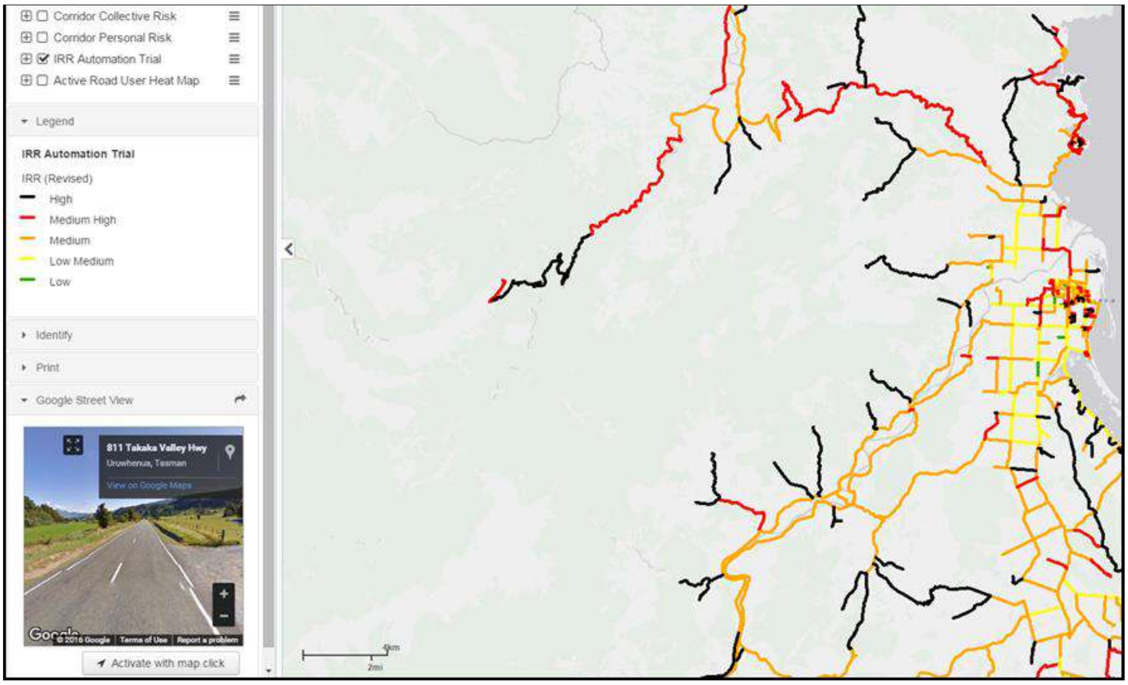

Figure 8. IRR Outputs Displayed on the Website

Discussion

The automated process developed to efficiently calculate IRR across a large network is considered a significant step in demonstrating the proposed speed management framework. The model has been developed in a manner that allows it to be applied to any transport network and therefore has the potential to provide an enduring benefit throughout New Zealand and overseas.

Effectiveness

The IRR methodology, while still being refined as part of proving the speed management framework, can be used to proactively assess road safety risk across a large network, especially on lower volume roads where crash history can be an unreliable indicator of risk. The automated process enables the methodology to be applied in a cost effective manner and the convenience of GIS allows the process to be easily adjusted.

This project required the innovative use of GIS technology to improve the affordability and scale of applying the IRR methodology. While it is technically feasible to manually code road attributes and calculate IRR, the process is hugely time-consuming and cost prohibitive when applied at network level as is the requirement of the speed management framework. Furthermore, the analysis underpinning the automated process involves using existing geospatial datasets and therefore, no new or expensive data collection is required in applying the process.

Feedback from various stakeholders regarding the IRR and resulting safe and appropriate speed outputs indicates that the automated process produces sensible results when applied as a screening tool to identify parts of the network requiring speed management intervention. As an input to the speed management framework, the GIS-based methodology is intended to be rolled-out across New Zealand in an effort to assist all road controlling authorities in identifying corridors where speed management intervention is most likely to reduce death and serious injuries.

Limitations

The automated process of calculating IRR is of greatest value to road safety practitioners when it is used as a network screening tool for speed management intervention. The methodology should be applied with care when considering individual corridors. The process incorporates assumptions regarding roadside hazards and access density due to the lack of such data. Therefore, these site specific attributes should be taken into account when identifying or prioritising speed management interventions at a corridor level. Aerial imagery, Google Street View and other contextual data can be used while undertaking desktop reviews. The simplicity of the IRR model allows users to easily modify the roadside hazard and access density categories as part of sense testing the modelled outputs.

Conclusion

The automated IRR methodology demonstrates that innovative assessment methods and tools are required in order to efficiently deliver the action plans of the Safer Journeys strategy. Current application of this methodology in New Zealand relating to the demonstration and refinement of the proposed Speed Management Guide demonstrate the potential of this methodology in supporting the safe system philosophy. The automation of corridor risk rating methodology presented in this paper will be of particular interest to any road controlling authority wanting to efficiently identify parts of their network where speed management intervention may be an appropriate response to improving road safety performance.

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An estimate of the future road safety benefits of autonomous emergency braking and vehicle-to-vehicle communication technologies

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Abstract

The aim of this study was to examine the benefits of hastening the introduction of new passenger vehicle technologies on future reductions in fatalities and serious injuries on Australian roads. This was done specifically for Autonomous Emergency Braking (AEB) and Vehicle-to-Vehicle (V2V) communications, which represent the two most promising technologies in the short-term and medium-term future. The results demonstrate that a delay in introduction, or a slower rate of introduction, can have a substantial effect on how long it takes for the safety benefits to be realised in the greater vehicle fleet.

Background

Autonomous Emergency Braking (AEB) in Australia, is a relatively new technology whereby forward facing sensors continually monitor the road ahead and are used to detect when a collision with another road user in its path is probable. When a forward collision is likely, the vehicle provides the driver with an initial warning to react, and subsequently, in the absence of any driver reaction applies a significant braking force to reduce the vehicle's speed. In an optimal situation the crash is avoided entirely, however even if the crash is unavoidable, the impact speed may be reduced thereby reducing the crash injury severity.

In Searson, Ponte, Hutchinson, Anderson and Lydon (2014), AEB was identified by every interviewed vehicle safety expert as being likely to have a significant road safety benefit in Australia over the next five to ten years. The literature has predicted that the benefits of AEB are potentially large using reconstruction and simulation techniques. Fildes et al. (2015) surveyed the literature for predicted benefits and showed estimates ranging between 4.3% and 44.0% crash reductions (for a range of impact scenarios including pedestrians). Fildes et al. (2015) also demonstrated an on-road reduction in rear-end low-speed crashes of 38% (confidence interval 18% - 53%), thereby verifying the potential magnitude of these estimates. Individual manufacturers have their own proprietary AEB systems and these act in according to their own algorithms, and at different maximum speeds (Hulshof, Knight, Edwards, Avery & Grover, 2013). Some operate as low speed AEB to avoid crashes in city traffic, while others can operate at high speed and may prevent crashes at highway speeds. The actual AEB effectiveness of an individual car is dependent on the specifics of the installed AEB system.

Vehicle-to-Vehicle (V2V) communications is another relatively new technology where vehicles communicate with each other via dedicated short-range communication devices (DSRC). If they are reporting their position, speed and direction to each other, then each will be able to determine if a crash between them is likely. If a crash is imminent the vehicle could take evasive action, including application of the brakes to avoid the crash occurring.

Searson et al. (2014) also found that V2V is a technology that interviewed experts believe may have a significant effect in the longer-term future. Although there are no results from long term trials that confirm this, research is promising and it is likely that V2V may fill the 'gaps' left by AEB by providing emergency braking that avoids or mitigates crashes. Doecke, Grant and Anderson (2015) showed that V2V communications could have a substantial reduction in crash occurrence of more than 90% under a range of crash configurations.

The rate at which each of these technologies is introduced into the vehicle fleet will be influenced by various factors. Among these is that they could be pushed into the market by government intervention, or they could be pulled by consumer demand. Government, through its design rules, potentially has the most power to encourage these technologies to be implemented quickly. Relying on individual consumers to voluntarily purchase for their own technology is possibly the slowest method of introducing the technology. More recently however, strong consumer advocacy groups such as the Australasian New Car Assessment Program have had the ability to encourage various technologies by rating cars as safer if they are equipped with this technology, and subsequently marketing the safety ratings to both fleet buyers and consumers. The speed that the technology is introduced is, however, an important factor in how effective it will be in the short and medium terms, regardless of the push and pull factors that are responsible for encouraging its introduction.

Searson et al. (2014) demonstrated that an aggressive approach to introducing these technologies into the Australian car fleet would see their benefits realised faster than a slower approach to their introduction. This paper updates that analysis to include the current rates of fitment of AEB technology.

This paper is not an analysis of the effectiveness of these technologies; it is, however, an analysis of the speed of introduction of these technologies. To achieve this aim, three different introduction rates are considered:

- an aggressive approach – possibly reflecting a design rule demanding that the technology is implemented;
- an encouraged approach – possibly reflecting a consumer organization marketing the benefits of the technology and rewarding vehicles using the technology with higher ratings; and
- a slow approach – possibly reflecting an adoption of the technology driven by individual consumers, without encouragement.

The timeframes adopted to model the effects of these different introduction rates (described in detail below) reflect the thoughts of the experts surveyed by Searson et al. (2014) about their potential availability in the market.

Method

AEB and V2V fitment rates

To model future fitment rates of the technology into new vehicles entering the fleet, a normal cumulative distribution curve was used. To define this curve, two endpoints were defined: an introduction year and a saturation year. The introduction year was the latest year in which less than 4% of new vehicles had the technology fitted. The saturation year was the latest year when less than 4% of new vehicles did not have the technology fitted. For the normal cumulative distributions, the mean was taken as the average of the introduction year and the saturation year and the standard deviation was one fifth of the time from the introduction year to the saturation year.

For the fitment of AEB, the saturation year for the aggressive introduction scenario, encouraged introduction scenario and the slow introduction scenario is 2020, 2025 and 2030, respectively. For AEB, there is already some introduction of this technology in the current Australian fleet. The rates of fitment of AEB from 2010 to 2015 are known for standard (not optional) new vehicle sales in the March to June quarter of each year (R. L. Polk Australia Pty Ltd, 2010-2015) and these are shown in Table 1. The breakdown of the operating capabilities of these AEB systems is not known. For the purposes of fitting the normal cumulative distribution curve, the introduction year in each introduction scenario was iteratively selected so that the fitment rate in 2015 was equal to 9.6% of vehicles in 2015, this being the actual percentage of vehicles fitted with AEB according to the data.

Table 1. Actual AEB Fitment rates (standard fitment) (R. L. Polk Australia Pty Ltd, 2010-2015)

Year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Actual AEB installation % (March to June Quarter)	1.5%	1.7%	2.2%	3.8%	6.6%	9.6%

It is also assumed that V2V technology will be introduced at a fitment rate that follows a normal cumulative distribution. The introduction year (less than 4% of all new vehicles fitted with V2V technology) for each of the scenarios is set to be 2020. The year of saturation (96%) of all vehicles fitted for the aggressive introduction scenario, encouraged introduction scenario and the slow introduction scenario is 2030, 2035 and 2045, respectively.

The rates of new car fitment, along with the percentage of vehicles fitted with the technologies is shown in Figure 1. The aggressive introduction curve is quite similar in shape to the electronic stability control introduction curve (ESC) in Gargett et al. (2011), although due to regulation for ESC occurring very quickly, early ESC prevalence was quite high. The initial and saturation years for the fitment rates are shown in Table 2.

Table 2. Curve fitting parameters used for future fitment rates

Introduction Scenario	**AEB**		**V2V**	
	Initial year*	**Saturation year**	**Initial year**	**Saturation year**
Aggressive	2014.25	2020	2020	2030
Encouraged	2013.50	2025	2020	2035
Slow	2012.73	2030	2020	2045

*Initial year for AEB was selected iteratively to closely match 9.6% fitment in 2015

AEB and V2V effectiveness

The effectiveness of AEB and V2V technologies will be assumed to be as is reported in the literature. As discussed previously, this paper is not about the effectiveness of the AEB and V2V technologies but an analysis of the effect of introduction of these technologies, and the consequences of different introduction rates. Consequently, the choice of effectiveness value although important, is an adjustable parameter. As discussed in the background section, there are a range of effectiveness values that can be applied to AEB and V2V technologies. Some of these have been derived using simulation and reconstruction, others after investigating the effectiveness of technologies in the market.

For AEB effectiveness, Fildes et al (2015) reported an effectiveness of AEB of 38% in on-road low speed read end crashes. Lower values of effectiveness will be used in this analyses: 34% for injury crashes and 28% for fatal crashes, effectiveness values predicted from reconstruction by Anderson et al (2012) which includes additional crash types, and differentiates between fatal and injury crashes. For V2V effectiveness, Doecke and Anderson (2014) reported the marginal benefits of

V2V as 16.0% for injury crashes and 11.9% for fatal crashes over and above the effectiveness of AEB (using their conservative 'restricted view' connected system). In this paper, the effectiveness of AEB is defined collectively over the entire fleet, ignoring the capabilities of individual installed systems.

The benefits accrued due to AEB are assumed to be proportional to the percentage of total vehicles with the technology installed. This is because AEB can be effective even when only installed in one vehicle involved in a crash. The benefits accrued due to V2V however, are assumed to be proportional to the square of the percentage of total vehicles with that technology installed. This is because both vehicles in a two car collision require the technology for it to be effective in mitigating the crash.

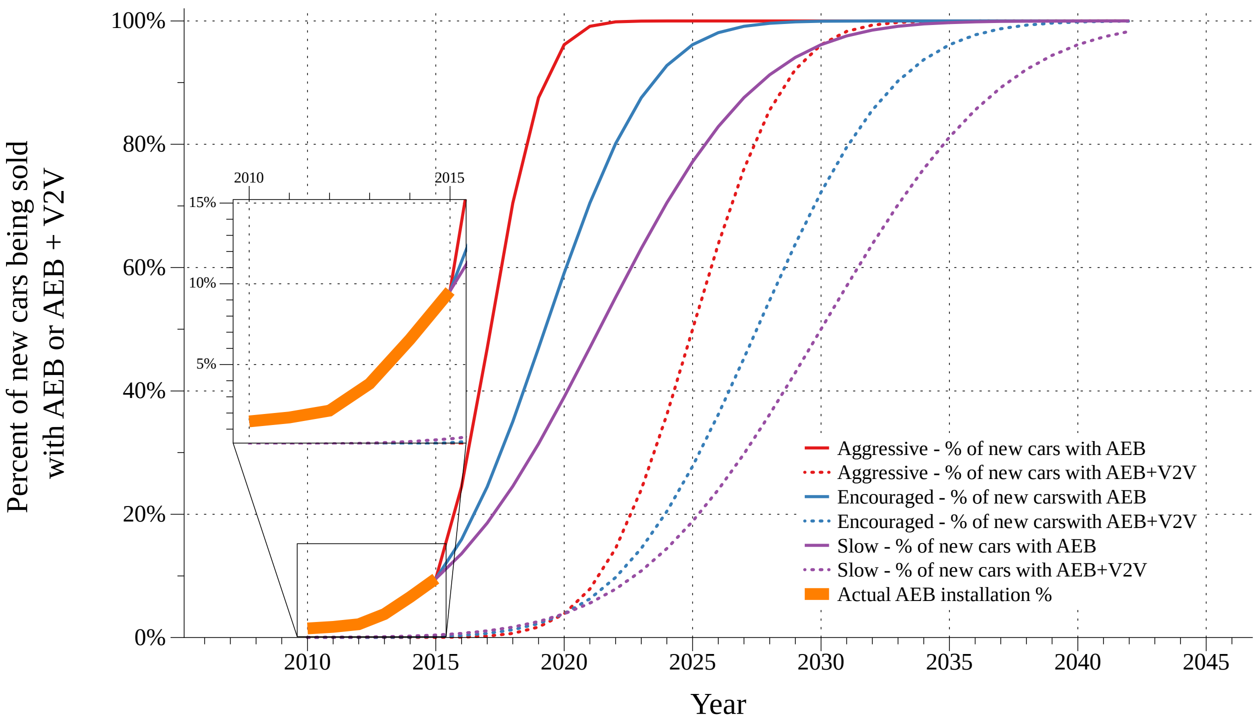

Figure 1. Actual and assumed fitment rates of AEB and AEB+V2V in Australian fleet projected until 2042

Age of vehicle fleet

The vehicle age profile was from the 2011 ABS Motor Vehicle Census (ABS, 2011). The census listed the number of registered vehicles by manufacturing year, as of 31 January 2011. As such, the data were adjusted to represent average age in years. The number of vehicles aged zero were those built in 2011 (of which only one month had passed), plus 5/12 multiplied by the number of vehicles built in 2010. The number of vehicles aged one was 7/12 multiplied by the number of vehicles built in 2010, plus 5/12 multiplied by the number of vehicles built in 2009 and so on. This adjustment reflects the concept that in January of a new calendar year no vehicles manufactured in that year have yet been manufactured, whereas by December all of the vehicles will have been manufactured, and on average throughout the year, half of all vehicles made during the year will have completed their run through the vehicle manufacturing plant.

Figure 2 shows the percentage of all vehicles by age. Note that for the grouping aged 21-30 years, this is the average percentage per year of age for vehicles in that age group, and similarly for 31-40 and 41-50. Note that the height of the bar for vehicles aged zero is approximately half the height of those following: if it is assumed that a roughly linear introduction of vehicles into the fleet during their year of manufacture, this is what would be expected.

Percentage of vehicles in the future vehicle fleet

Each year, every vehicle would become one year older. Consequently, if 40% of new vehicles were fitted with AEB technology in a given year, then 40% of all 1-year-old vehicles would have AEB technology in the next year.

The proportion of vehicles at each age was used for all future years. No attempt was made to adjust the attrition rates of vehicle that are fitted with or without the crash avoidance technology, even though these technologies could possibly reduce attrition rate because of a lower number of crashes that occur.

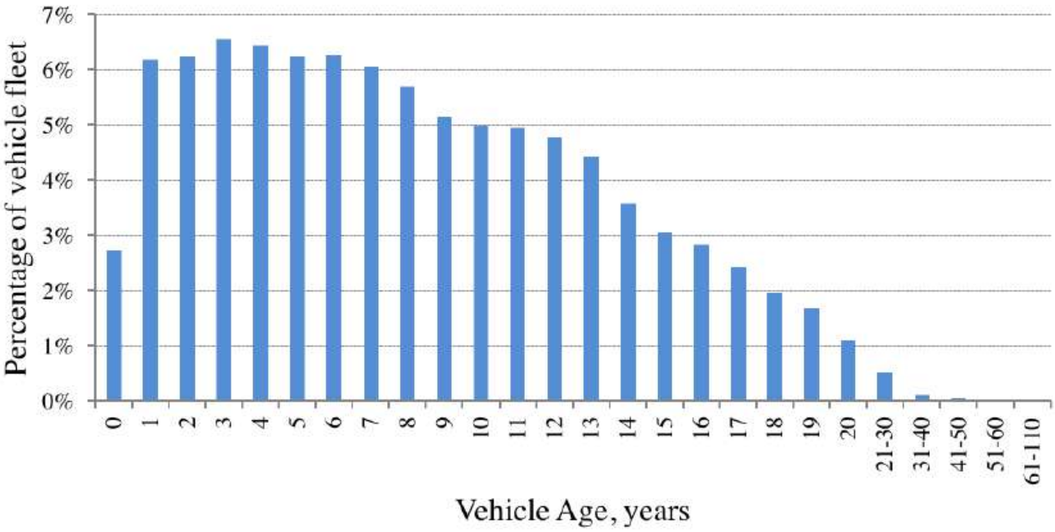

Figure 2. Age distribution of vehicles in the Australian fleet in 2011. Where range of years is given, the percentage is the average percentage per year of age for vehicles in that age group.

Outcome measures

Outcomes of interest were the penetration of the technology into the total registered vehicle fleet and the predicted percentage of fatalities and injuries that were prevented by the presence of the technologies. The safety benefits that arise because of the AEB technology ("AEB only") are evaluated separately from the benefits that arise due to both the AEB and V2V technology ("AEB + V2V") being in the vehicle fleet.

Results

The results are summarized for the effect of AEB only, in Table 3 while the combined effect of AEB and V2V are shown in Table 4. Both tables show:

- the year in which the technologies have a 50% vehicle fleet penetration
- the percent reduction in crashes for the year 2030
- the year in which 25% of crashes are prevented based on the modelling assumptions.

For the AEB only case, an aggressive introduction scenario achieves a 50% fleet penetration of AEB four years earlier than the slow introduction scenario. This earlier 'intervention' results in an additional 7.9% of injury crashes and 6.5% of fatal crashes being prevented in the year 2030 comparing the aggressive AEB introduction scenario to the slow AEB introduction scenario. A 25% reduction of both injury crashes and fatal crashes is achieved 6 years earlier under the aggressive AEB introduction scenario compared to the slow AEB introduction scenario.

Table 3. Fatality and injury reduction results for the three different introduction scenarios for AEB only.

Scenario	Year in which 50% of the vehicle fleet is equipped with AEB	Total reduction in injury crashes in 2030	Total reduction in fatality crashes in 2030	Year in which a >25% reduction in injury crashes is achieved	Year in which a >25% reduction in fatality crashes is achieved
Aggressive introduction	2026	25.0%	20.6%	2030	2036
Encouraged introduction	2028	21.2%	17.5%	2033	2039
Slow introduction	2030	17.1%	14.1%	2036	2042

Considering AEB + V2V, an aggressive introduction scenario achieves a 50% fleet penetration of the two technologies 5 years earlier than the slow introduction scenario. An aggressive introduction of the combined technologies could potentially result in an additional 9.1% reduction in injury crashes and 7.4% reduction in fatal crashes in the year 2030 comparing the aggressive AEB + V2V introduction scenario to the slow AEB + V2V introduction scenario. A 25% reduction of both injury crashes and fatal crashes is achieved 5 years earlier under the aggressive AEB + V2V introduction scenario compared to the slow AEB + V2V introduction scenario.

Table 4. Introduction scenarios for AEB + V2V. Crash reduction includes results from AEB only installations

Scenario	Year in which 50% of the vehicle fleet is equipped with AEB + V2V	Total reduction in injury crashes in 2030	Total reduction in fatality crashes in 2030	Year in which a >25% reduction in injury crashes is achieved	Year in which a >25% reduction in fatality crashes is achieved
Aggressive introduction	2034	26.5%	21.7%	2030	2033
Encouraged introduction	2036	21.9%	18.0%	2032	2035
Slow introduction	2039	17.4%	14.3%	2035	2038

These results are plotted for every year between 2010 and 2042 in Figures 3 to 5. The penetration of AEB and V2V technology into the vehicle fleet is shown in Figure 3; the percentage of fatal and injury crashes that are prevented in each year due to AEB only is shown in Figure 4; and the percentage of fatal and injury crashes that are prevented each year due to both AEB and V2V communications is shown in Figure 5.

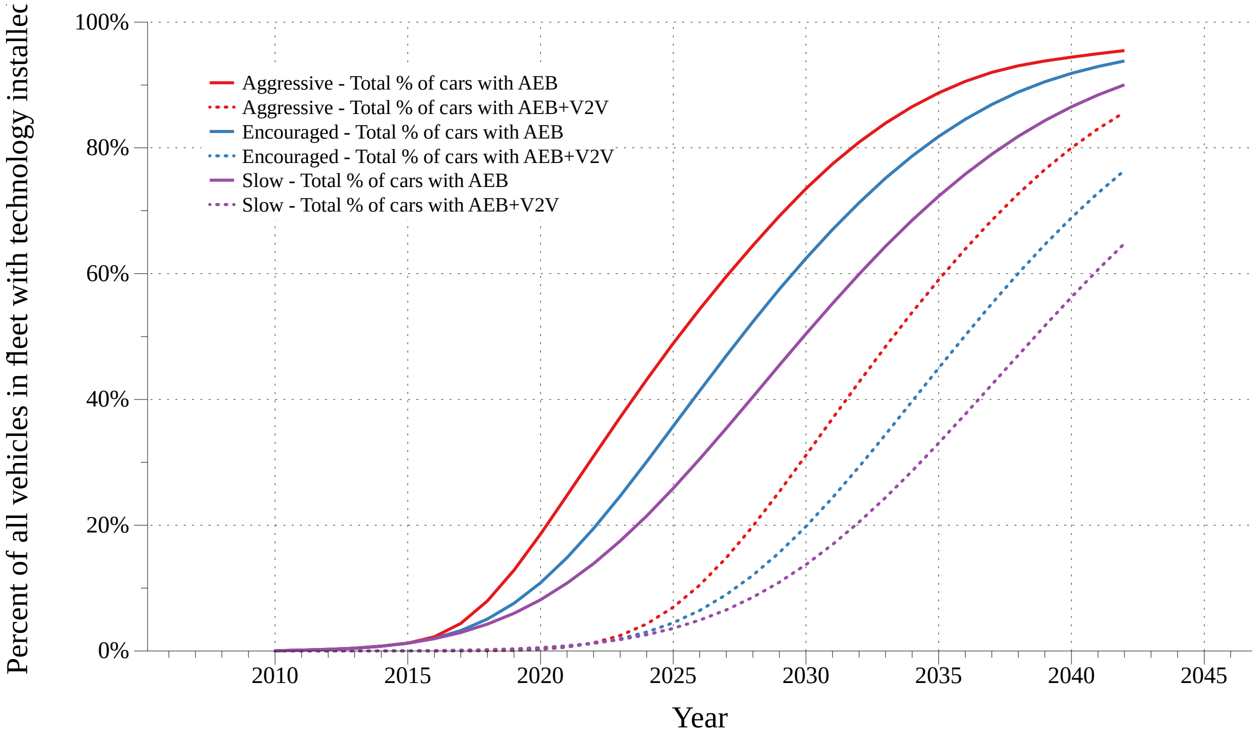

Figure 3. Percentage of vehicles in the whole fleet fitted with AEB or AEB + V2V technology

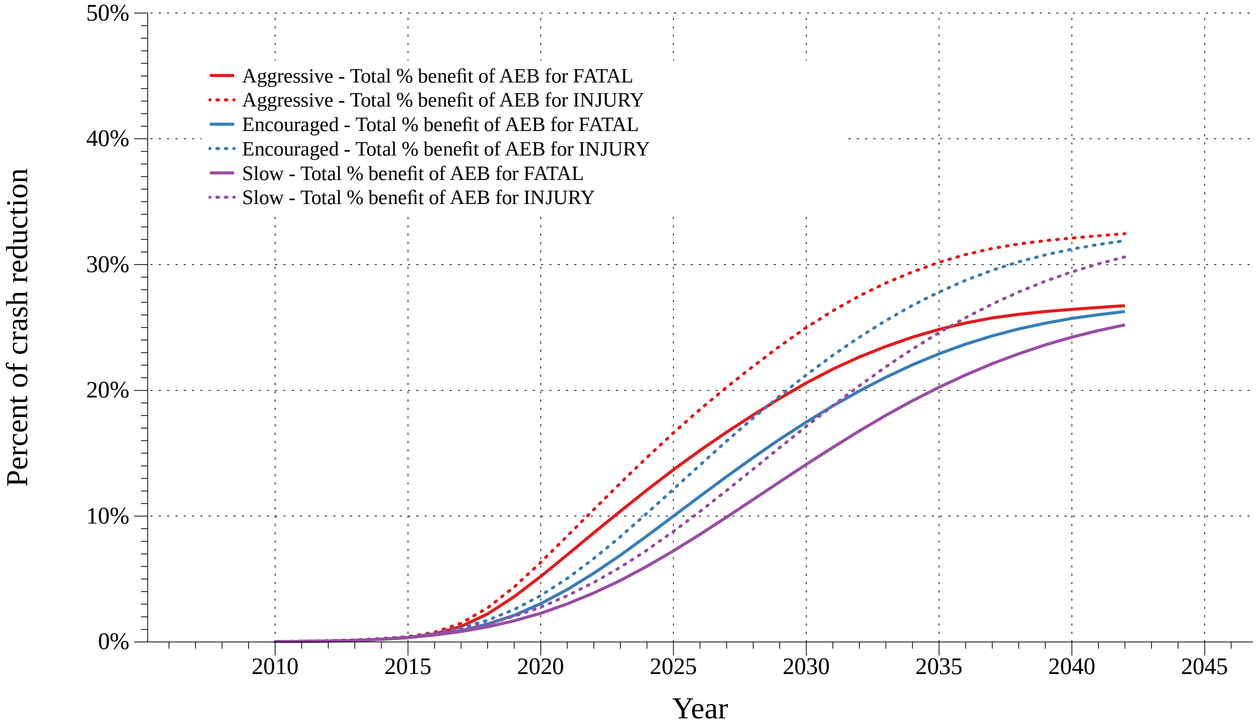

Figure 4. Benefit from the introduction of AEB technology (excluding the effect of V2V)

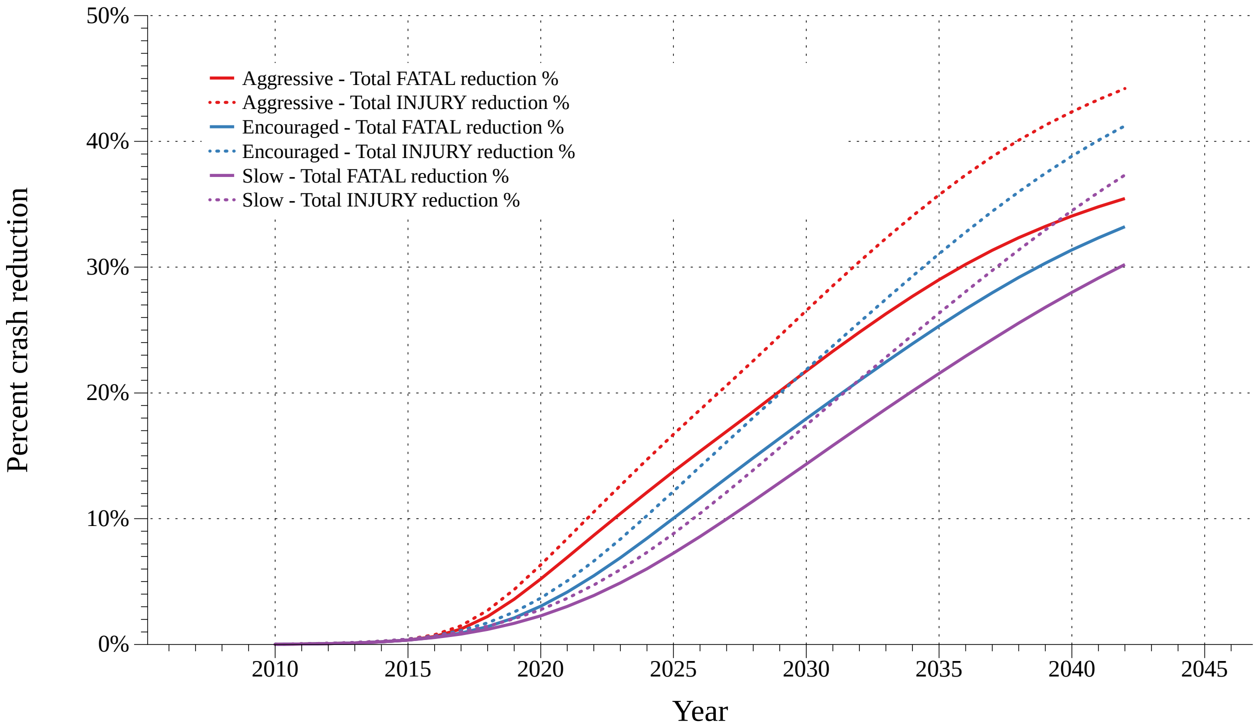

Figure 5. Benefit from the introduction of AEB + V2V technology, including the effect of those vehicles with AEB only

The figures show that the faster introduction rates prevent a higher number of fatal and injury crashes prevented in each and every year than the slow introduction rates. This means there will be a strong cumulative effect of the crashes being saved every year adding up to ever increasing number of prevented crashes over and above the number prevented by the slower introduction rate.

Conclusions

Autonomous emergency braking technology has been proven to be effective in a range of crash scenarios in the real-world (Fildes et al. 2015; Rosén et al., 2010), despite low prevalence in the vehicle fleet. Its utility has been demonstrated extensively in a theoretical sense and in the early studies of this technology.

Using assumptions about the effectiveness of AEB and V2V based on previous studies, this paper has shown that these technologies, particularly AEB, have the potential to substantially reduce both injury and fatal crashes now and in coming years. The extent to which these technologies can reduce injuries and fatalities is highly dependent on the speed in which they are introduced into new vehicles and consequently into the total registered vehicle fleet. The faster they are introduced in new vehicles, the more crashes will be ultimately prevented.

As noted previously, there are vehicles currently available with various versions of AEB. The vehicle speeds at which these systems operate vary, with some systems focussing on avoidance of low speed rear-end collisions, which may represent the most frequent crash type although may not operate at higher speeds. Other systems are designed for higher travelling speeds, focussing on crash prevention or crash severity mitigation with all road-users. Historically, the focus generally is to market and sell the safety features of AEB to the vehicle purchaser as a means to protect the occupants of that vehicle, like traditional technologies such as airbags. AEB, however, has much potential for the total road safety system, and may be able to avoid collisions and protect vulnerable road users and other vehicle occupants.

It is important to note that these technologies will be ineffective if they are not introduced into the vehicle fleet. This paper has demonstrated that the more aggressively the technology is introduced, the more effect it will have at reducing the number of crashes on Australian roads.

Just how many crashes will be affected will depend on the rate that the technology is fitted. In turn this depends on the desire of Australian society to introduce this technology. This desire may be led by individual consumers, consumer organisations or government.

This paper has not discussed the various and numerous push and pull factors that might affect speed of introduction of these technologies. Whilst a governmental design rule could be used to force all new cars to have the technology installed quickly, other less forceful options are possible. These include: making the technology compulsory in 5-star safety rated cars; convincing large fleet buyers to make the technology mandatory on their new car purchases; marketing the technology to consumers through public-health sponsored advertising campaigns; and applying insurance premium discounts to vehicles fitted with the technology. These approaches, or any of many others, when used well, could encourage increased fitment rates.

In this analysis, the reduction in fatalities and injuries were calculated as percentage reduction. The absolute values were not calculated, as it is not known what future changes there will be to the 'baseline' numbers of fatalities and injuries outside of the effects of AEB and V2V. Importantly, however, it was shown that the aggressive introduction scenario is always ahead of the encouraged and slow introduction scenarios in terms of percentage of fatal and injury crashes prevented. This has a cumulative effect that needs to be acknowledged. If an additional 10 or 100 fatal crashes can be prevented every year, on average with a faster introduction rate, then over 20 years this means that there is an additional 200 or 2000 fatal crashes that are prevented. It is difficult to quantify what the total number of crashes this cumulative effect will prevent however, because it is not known what the 'baseline' numbers of crashes will be. The baseline will also be affected by other road safety investments such as to infrastructure, driver training and, potentially, autonomous vehicles.

The calculations in this analysis were based on the current distribution of crash types, and this distribution may change in the future. As technologies for preventing vehicle-to-vehicle crashes become more common, a greater proportion of road trauma may be associated with vulnerable road users. If this is the case, then technologies that prevent crashes with pedestrians, motorcyclists and bicyclists should be encouraged. The calculations in this analysis were also based on single, and possibly conservative, estimates of the effectiveness of AEB and V2V at preventing crashes. The actual effect will be different depending on the actual effectiveness of these technologies. Despite this, however, the main analysis of this paper, which was the introduction rate of these technologies and its effect on future crash rates does not change with faster introductions leading to greater crash reductions.

This analysis has not considered the different use profiles of newer and older vehicles, including driven kilometres and driver ages. In the analysis, all vehicles were assumed to have a common baseline crash risk. Differences from this assumption could affect the results that were presented.

The technology will have a financial cost, and because this technology is fitted to individual vehicles the cost is most likely to be borne by the consumer. This needs to be balanced against the benefits that the technology is likely to have. For the consumer, there is the benefit of being less likely to be involved in an injury or fatal crash, as well as the benefit of being less likely to repair the vehicle after one of these crashes. For society, there is the benefit of fewer crashes resulting in fewer hospital admissions and economic losses. This paper has not attempted to quantify these costs and benefits, but this should be done before design rules are changed to influence the presence of these technologies.

Acknowledgements

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FleetCAT – A trial of an Advisory Collision Warning System in Government Fleet Vehicles

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Abstract

Forward Collision Avoidance Technology has been estimated to prevent up to 40 per cent of all fatal crashes and up to 50 per cent of all injury crashes. The FleetCAT Project installed advisory forward collision warning technology into 34 NSW government shared-pool vehicles to determine the effectiveness of an advisory collision avoidance system. Lane departures, headway distance warnings, forward collision warnings and pedestrian collision warnings were compared before, during and after active deployment of the technology. During the active phase, reductions in alerts per 100 km travelled were seen for lane departures, headway distance warnings and forward vehicle collision warnings.

Background

The Centre for Automotive Safety Research (CASR) estimated in 2012 that between 20 and 40 per cent of all fatal crashes and between 30 and 50 per cent of all injury crashes could be prevented with a Forward Collision Avoidance System (Anderson et al., 2012).

The New South Wales government fleet consists of more than 27,000 vehicles, making it the largest government fleet in Australia. Crashes in state-owned vehicles are estimated to cost the government more than $110 million annually (Transport for NSW, 2012).

Method

The FleetCAT Project was a three-stage Field Operational Test (FOT) consisting of an initial data collection period of 12 weeks, followed by a 12-week active period and a final four-week data collection stage. During the initial and final data collection stages both visual and audible alerts provided by the technology were disabled, thus providing no warnings to the drivers. The number of lane departures, headway warnings, forward vehicle warnings and pedestrian collision warnings were compared between stages to determine whether the technology was effective in reducing collision risk. The technology used included the Mobileye 560 camera-based collision avoidance warning device and a data acquisition system. The Mobileye 560 provides lane departure, headway monitoring, forward collision, pedestrian detection and speed sign warnings to drivers via an audible and visual display. The data acquisition system was used to record the time, date and location of lane departure and headway warnings as well as forward vehicle and pedestrian collision warnings. Speeding alerts were not collected during the trial.

A sample of five vehicles were also fitted with a dashboard camera during the active warning period. The dashcam recorded approximately 10 seconds of forward-facing video when activated by a headway warning from the Mobileye device. The video data will be analysed to determine if headway warnings were being triggered by other drivers inserting their vehicle into the gap left between test vehicles and the vehicles they were following.

Drivers and Fleet Managers were surveyed during the final stage of the project to gain an understanding of their acceptance of the technology and perception of its benefits. Results of the survey will be published in a future paper.

Results

Vehicles participating in the FleetCAT Trial travelled over 363,000 km during the FOT and recorded almost 117,000 alerts from the Mobileye 560 device.

Initial analysis indicated that between the initial blind stage and active phase of the trial, reductions in alerts per 100 km travelled were achieved for lane departures, headway distance warnings and forward vehicle collision warnings. There was a slight increase in the number of pedestrian collision warnings but very few alerts of this type were recorded during the entire trial.

Conclusion

The use of a retro-fitted forward collision and lane departure warning system was effective in positively influencing driver behaviour by increasing headway distances, decreasing unintended lane departures and reducing the likelihood of a forward collision. The deployment of this technology in fleet vehicles has the potential to reduce the cost of work-related crashes and associated injuries.

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Driverless vehicles: is it time to rethink where and how we spend our road safety research dollars?

Ian Webb

Chief Executive, Roads Australia

Abstract

Driverless vehicles represent the most significant advancement in road safety since man and woman first got behind the wheel. By removing the human factor, we will eliminate the single biggest contributor to road accidents. So, should we be revising our existing road safety research priorities? And how will the advent of fully automated vehicles impact on society at large?

Background

How much do we spend around the globe each year on road safety research and programs? It's probably impossible to come up with an accurate figure, but safe to say it would run into the billions.

Now, how much of this current spending and research will be made redundant by the arrival of the automated vehicle?

At last September's Frankfurt Auto Show, US Transportation Secretary, Anthony Fox, predicted driverless cars would be in use around the world within the next decade.[1]

In the same month, The Atlantian published an article that said the arrival of the automated vehicle could be the greatest public health achievement of the 21st century, saving nearly 30,000 lives a year in the US alone.[2]

More recently, the UK Insititute of Mechanical Engineers has released a report that says making all vehicles autonomous could prevent up to 95% of all traffic accidents.[3]

So that begs the question – should more of our road safety research budget be focused on bringing on driverless vehicle technology sooner rather than later? Are we too focused on technologies and programs that will be redundant in a decade or less? And if we were to review our current research spending priorities, what impact would it have on our short term road safety goals?

These are difficult questions, but we shouldn't shy away from asking them, nor expecting answers.

In my oral presentation I will explore these question in the context of the broader societal challenges and benefits of driverless technology.

The driverless vehicle will affect not just our mobility, but our jobs (what we do) the way we live and where. We are just now starting to think about some of the implications, and it is mindboggling.

Driverless vehicles will eliminate many existing jobs; the shift to centralised city living will be reversed, and regional towns and infrastructures will be significantly boosted; it will turn many existing financial models focused around vehicle ownership and infrastructure investment on their heads.

These are just some of the broader implications. Drill further, and we see driverless vehicles impacting on nearly every aspect of our lives and economic systems.

The big question right now is – are we reading the signs? Will we be ready to meet the challenges and adjust to the changes, or will we continue to live in a Kodak moment?

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The bumpy road towards automated vehicles: Can we smooth the path?

Ann Williamson

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Abstract

Autonomous vehicles and driver assist technologies are seen as the next-big-thing for road safety. Many authoritative organisations are predicting benefits of up to 95% reductions in crashes; levels never achieved before. Unfortunately, these forecasts are at best optimistic and at worst misleading as they are based on the false ideas that driver error is at the heart of all road safety problems and new technology is infallible. This presentation will summarise the main issues with the introduction of autonomous vehicles and explain why we need to act now to ensure that we maximize the road safety benefits from these vehicles.

The Problem

Autonomous vehicles are widely proclaimed to be the answer to many road safety problems, with estimates that they will produce 90-95% reductions in crashes. Some vehicle manufacturers are forecasting that autonomous vehicles will be available on our roads within the next five to ten years. The problem is that most of these projections are based on shaky foundations and they overlook some significant issues with many new technologies already in use. The estimates of reductions in crashes are based on the premise that since 90-95% of crashes involve driver error, taking the driver out of the transport task will eliminate these crashes. This premise is faulty as a significant proportion of the behaviours seen as driver errors occur because of poorly designed vehicles, roads and road system rules, regulations and enforcement. There are many examples of poorly usable features of the road system including: poor vision from vehicles so drivers miss important information in the driving environment, in-vehicle tools that distract drivers or require them to take eyes off road, and red light cameras that make drivers stop too quickly. Issues relating to the usability of the vehicle and the road system are unlikely to be overcome by partial or even fully automated vehicles. We have a history of inadequate and unsophisticated technologies being included in vehicles. It is unlikely that we will do better when the whole task of driving is automated. Unreliable and/or annoying features of automated technologies are still likely to be a problem. If the technologies we are currently using in vehicles are not sufficiently sophisticated and can cause errors and failures in the system, why do we think they will be perfect, or even good enough when we let the technologies take over most, or all, of the driving task?

Furthermore, vehicles touted as fully automated, that require drivers to do nothing but wait until required to take over, will present greater problems for road safety. We already know that drivers do not do well when they are not alert due to fatigue or not paying active attention (Williamson et al., 2013). Assistive technologies that simply require the driver to maintain passive attention until they are required to take-over again will always be working against the human response to find something else to do and even to fall asleep when there is not much going on (Dunn and Williamson, 2012). There is good evidence that leaving the driver 'out of the loop' when technology is in control leads to significant performance impairment when the driver is asked to resume control which seems to increase with higher levels of automation (Omnasch et al., 2014). The limited research that had been done on how long it takes drivers to resume control of an automated vehicle shows that around 8 seconds are needed: too long for safety (Gold, et al., 2013). Many of the existing driver assist technologies are unsophisticated, poorly designed and fail to address driver needs. For example, a number of studies have demonstrated that cruise control, which is becoming a standard addition to many vehicles, significantly slows driver reaction times especially in emergency situations when it is most needed (eg., Vollrath, Schleicher and Gelau, 2011; Pauwelussen and

Feenstra, 2010). More concerning, the US Insurance Institute for Highway Safety evaluated the effectiveness of forward collision avoidance systems, adaptive headlights and lane departure warnings in vehicles through tracking insurance claim frequency for vehicles containing each of these devices (IIHS, 2012, Seabaugh, 2012). While the first two devices showed some reductions in crash frequency, claim frequency for vehicles with lane departure warnings increased. Contrary to expectations that warning drivers of imminent lane departures would reduce crashes, it was associated with higher claim rates. There is a considerable literature on the consequences of inappropriately occurring warnings (Sullivan, Tsimhoni and Bogard, 2008; Navarro, Mars and Hoc, 2007) which might have discouraged, or at least modified this type of technology before it was implemented. It would clearly be preferable to determine the usability and road safety impact of in-vehicle technologies and how they interact with one another before they are introduced to the driving public rather than waiting for crashes to occur. These examples highlight the fact there has been little or no research on what functions in vehicles *should* be automated in order to assist drivers and reduce crashes nor how best to automate.

This presentation will discuss some of the major issues with driver assist technologies and automated driving systems that will need to be overcome. These include:

1. The amount of passive control required of 'drivers'
2. Who drives – when?
3. Transitions between automation and driver
4. Poor design of new technology in vehicles
5. Track record of 'selling' unsophisticated systems in vehicles
6. Issues of trust and acceptance of the technology

Overcoming these problems requires that we first acknowledge their existence, and then take action to ensure that technology is fully developed and usability is tested before being allowed on-road. Most importantly, we need to remember that vehicles are tools for people to use. We need to change focus from the current vehicle-centred approach of simply adding new technologies to vehicles because we can, to finding the best ways of assisting the driver and making the driving task easier and more efficient. This will require more research on usability of new technologies, but we already know a considerable amount about some of the major pitfalls in automation to benefit system safety and efficiency and these lessons must be incorporated into developing cases for allowing increasingly automated vehicles onto our roads. This will require systematic and concerted action, but with the current deluge of new technologies entering our road system, we need to do it now.

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The Safest System: Preventing crashes by preventing errors

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Abstract

The Safe Systems Approach [SSA] focusses on limiting the likelihood that user-errors result in serious injury. A safer system might also limit user-errors. We explored how the system contributed to errors that preceded 94 serious crashes from the Austroads Crash Investigation Study. Passenger-vehicle-occupants who were admitted to one of five NSW trauma units were interviewed, and their vehicle and the crash location were inspected. The in-depth data was reviewed by a multidisciplinary panel using an SSA framework to identify contributing factors. Features of the road and regulatory environment contributed to common errors. The panel suggested strategies to minimise errors.

Background

A decline in the pace of road safety improvement (BITRE, 2014) calls for refinement of our approaches. The Safe System Approach that drives policy and practice in Australian jurisdictions accepts that road-users make errors and focusses on developing a system (comprising road-user behaviour, particularly travel speed, as well as vehicles and the road environment) that minimises consequent injuries (e.g. Austroads, 2014). However, the system might also play a role in discouraging errors (Austroads, 2012, 2014). The recent shift away from a singular focus on road fatalities toward consideration of “serious injury” requires attention to the factors that contribute to such injuries. The Austroads Crash Investigation Study (see Austroads, 2015), used an in-hospital method to recruit vehicle occupants who were seriously injured in crashes, and collected information which is more detailed, and relevant to understanding factors that contribute to crashes and injuries, than is routinely-collected data (see McLean, 2005).

Method

Between March 2010 and February 2013, passenger-vehicle-occupants who were admitted to one of five NSW trauma units were interviewed, and their vehicle and the crash location were inspected. A Crash Review Team comprising a behavioural researcher, a forensic pathologist, a vehicle specialist, a roads specialist, a Police crash investigator, and other specialists in crash investigation, discussed the in-depth data from 94 crashes. The team identified factors that contributed to the crash and recommended road-, vehicle- and person-based strategies for avoiding crashes.

Results

Following the Finnish Crash Investigation System (VALT, 2002), first impacts were classified according to the road user movement immediately prior to the crash that allowed the crash to happen (driver error). The five most common errors were: crossing the median (28% of crashes); leaving the carriageway to the left (14%); inability to perform a sufficient evasive action (10%); inappropriate “filter” right turns at signalised intersections (9%); and red light running (7%).

Features of the road and regulatory system were often judged to have contributed to errors. Common road-related contributors are depicted in Table 1. Inappropriate filter turns are only possible where uncontrolled right turns are allowed. The Crash Review Team considered that impairment due to a medical condition or episode, and/or medication may have contributed to 9.6% of crashes. Interviews suggested that around one in five case drivers had a poor license history in terms of crashing or offending. In 13.8% crashes drivers were judged to have made errors at least partly due to their immaturity.

Table 1. Road-related factors which contributed to errors, percentage of crashes involving factor, and suggested safety strategies

Background factor	Percentage of crashes	Safety strategy
Stationary visual obstruction	26.6%	• Removing vegetation to improve sightlines • Widening cut-batters to improve sightlines • Using “no stopping” zones where stopped vehicles could be a stationary visual obstruction or a hazard
Speed limit too high	20.2%	• Reviewing speed limits ("least safe" conditions) • Using variable speed limits; responding to weather and traffic (with Intelligent Highways)
Inadequate shoulder	18.1%	• Repairing/upgrading shoulders to provide a traversable area beside the carriageway.
Inadequate or misleading cues to speed	10.6%	• Using design principles to create "self-enforcing" road environment; incl. local area traffic management devices, and increasing roundabout deflection • Installing speed advisory signs on curves
Unusual configuration	9.6%	• Considering perceptual cues in intersection design) e.g. improving alignment of intersection • Using self-explaining configurations consistently
Poor surface	9.6%	• Repairing/upgrading road surfaces • Improving drainage e.g. with surface material or drains
Adverse curvature	8.5%	• Correcting adverse curvature • Widening the lane at the curve
Moving visual obstruction	7.4%	• Not allowing filter turns where curves result in moving visual obstruction of on-coming traffic for right-turning driver
Inadequate delineation	7.4%	• Improving delineation, and perceptual cues to the curve (e.g. reflectors) • Installing audiotactile edge and centre-line • Improving procedures for audit and maintenance of line-marking
Problems with management of breakdown or works	7.4%	For breakdowns, crashes and/or abandoned vehicles: • Education about emergency procedures (e.g. use of bays/shoulders, use of hazard lights, calls to make) • Providing, improving, or relocating emergency lanes • Using “Stop in emergency only” signs in emergency lanes • Improving monitoring and response procedures; incl. Intelligent highways warning drivers, changing speed limits, initiating clearance operations For road works: • Reviewing traffic management planning, and auditing practice • Using traffic calming • Providing advance warning signs of merging traffic • Using detours in preference to contraflow on busy roads

The Crash Review team suggested specific strategies for addressing road-related contributors (see Table 1), as well as strengthening processes for restricting licences of people with medical conditions that can cause driving impairment, and making practices around licence probation/suspension more stringent. The Crash Review Team recommended "ongoing young driver initiatives" as a strategy for avoiding crashes involving young drivers. A range of vehicle technologies were specified for avoiding particular errors.

Conclusions

Results suggests that the Safe System Approach may be refined by aiming not only to minimise the consequences of user-errors (e.g. injury severity), but also to minimise the likelihood of errors occurring. The research also demonstrated the value of multi-disciplinary review of crash data to identify strategies for moving toward a safe system.

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Closing the gap between science and practice in the prediction of drowsiness-related driving events

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Abstract

Drowsy driving remains a significant contributing factor to road crashes. This paper assesses the recent developments in the detection and prediction of drowsiness-related driving events. The research reviewed here has confirmed that drowsiness can have a serious impact on driving performance in controlled, experimental settings. New findings from on-road studies however show different impacts on performance although few studies have characterised precise relationships between drowsiness and driving performance. The measurement of drowsiness-related events has progressed and recent research suggests that subjective ratings, blink duration and steering metrics show promise in being effective predictors of drowsiness-related driving events.

Background

Driver drowsiness remains a key road safety priority, remaining one of the 'fatal five' road safety issues in Australia. While it is difficult to accurately establish the prevalence of drowsiness in crashes, estimates suggest up to approximately 18% of crashes in Australia may involve a drowsy driver (Filtness et al., In press). These crashes are typically characterised as being run-off-road crashes involving a single vehicle.

Largely driven by the automotive industry's need for embedded drowsiness solutions, detecting drowsiness while driving is now the topic of much academic research and industry development. A growing body of research attempts to link a state or level of drowsiness with a driving-related outcome. As run-off-road crashes are associated with drowsiness most research adopts a lane excursion event as the safety outcome of interest. The aim of this paper is to critically review the progress of published research in achieving the aim of linking real-time drowsiness assessments to driving outcomes.

Method

To focus on the most recent developments this paper reviewed research published from 2010 onwards using search terms that included combinations of driver drowsiness/fatigue, fatigue/drowsiness detection, fatigue/drowsiness prediction, and driver performance. Databases searched were ScienceDirect, OVID and other academic databases. Human factors studies that link vehicle-based measures with drowsiness measures were reviewed by targeting articles that included: an objective vehicle-based measure of driving performance (e.g., lane position, steering behaviour); a drowsiness manipulation (e.g., sleep loss, restricted sleep), and an associated measure(s) of drowsiness (e.g., subjective ratings, physiological measures). Research that captures algorithms and detection methods emerging from the more technology-based literature of intelligent sensing was also reviewed.

Results

The initial search yielded 49 publications. In all there were 19 studies that met the inclusion criteria (13 simulator-based, six on-road studies). Table 1 illustrates the key measures and manipulations in these simulator-based and on-road studies and notes key areas where findings differ between the two methods.

Table 1. Summary of key findings from simulator and on-road studies that link drowsiness with driving events.

Study characteristics	Simulator studies	On-Road studies	Key differences in findings
Drowsiness manipulations	Partial and full sleep loss up to 24 hours without sleep	Driving during the day and after partial sleep loss (to 5am) Driving during the day after night shift	Typically, more extreme sleep loss in simulator studies Levels of drowsiness typically lower in on-road studies compared to simulator studies
Drowsiness metrics	Karolinksa Sleepiness Scale [KSS] (subjective) Observer rating scales Psychomotor Vigilance Task (reaction time) Karolinksa Drowsiness Test / EEG Ocular metrics (PERCLOS, blink duration)	KSS(subjective) Observer rating scales EEG EOG (blink duration)	Less use of PERCLOS and EEG measures in on-road studies due historically to technical limitations associated with their measurement in the field
Driving tasks	Simulated driving for periods of between 1-2 hrs. Measurement of lane position, steering, etc at high precision	Real world driving (between 1-2.5 hrs) Test track (two hour driving sessions)	Metrics related to lane position and lane excursions are measured more accurately in simulated driving environments. Lane position measures show reduced impacts of drowsiness in on-road studies.

In addition to summary findings in Table 1, it has been found that subjective sleepiness, driving behaviour metrics and ocular metrics have been linked to the occurrence of lane departure events (e.g., Hallvig et al., 2014; Lee et al., 2015). Within the human factors literature a predictive model was recently developed based on steering wheel inputs (McDonald et al., 2014). Research published in the more technologically oriented journals uses an array of video-based and other sensing methods (e.g., Azim et al., 2014; Gurudath et al., 2014), along with a range of algorithm development methods; however they need to be trained and validated using real-world data. Drawing these two areas of research together it is possible to identify the key areas of need to take the field to the next step.

Conclusion

There has been a renewed focus on linking drowsiness with driving events and significant efforts devoted to the development of new predictive algorithms. As highlighted in Table 1, there is evidence from studies using both subjective and objective drowsiness metrics that there are differences in the way drowsiness manifests in the laboratory compared with on-road driving (Hallvig et al., 2013). This places great importance on collecting data in real driving conditions, and ideally, in naturalistic driving environments. Developments in data collection technologies now support this aim. As the automotive industry seeks embedded drowsiness detection solutions, it is the combination of new real world data collection and the emerging sensing capabilities that is likely to yield the next breakthroughs in this area.

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Driver perceptions of the system-wide factors contributing to driving while fatigued

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Abstract

Fatigued driving is a well-known road safety issue. While fatigued driving is usually investigated from an individual perspective, this study used a novel approach to identify the system-wide factors influencing this issue. An online survey methodology was used to gather the perceptions of 150 Queensland drivers about the factors that contribute to fatigued driving, and recommendations for reducing its prevalence. The results suggested that drivers perceive individual factors to be the predominant cause of fatigued driving. However, some wider system-level factors and recommendations were identified. Implications for practical countermeasures to reduce the incidence of fatigued driving are discussed.

Background

Driver fatigue is estimated to be a contributing factor in 20-30% of deaths on Australian roads (Australian Transport Council, 2011). The effects of fatigue on driving performance are well-known yet few countermeasures are available to reduce its incidence beyond driver education and emerging fatigue detection systems.

Research into fatigued driving has tended to focus on individual factors such as the effects of fatigue on driving performance (e.g. Jackson, Croft, Kennedy, Owens & Howard, 2013), driver awareness of fatigue (e.g. Williamson, Friswell, Olivier & Grzebieta, 2014) and motivations and decision-making around fatigued driving (e.g. Watlin, Armstrong, Obst, & Smith, 2014). However, to date the problem of driver fatigue has not been explored from a systems perspective, an approach recently advocated as a means of taking into account the complex nature of road transport and road safety (e.g. Salmon, McClure & Stanton, 2012).

Consequently, the aim of this study was to consider fatigued driving from a systems thinking perspective to uncover the factors across the road transport system that contribute to fatigued driving.

Method

An online survey was used to gather the perceptions of 150 drivers on the factors contributing to fatigued driving. The survey collected data on demographics, driving behaviours, perceptions of the reasons why fatigued driving occurs and suggestions for preventing fatigued driving.

To date, an initial content analysis has been performed (the completed findings will be provided in the full conference paper). The findings were mapped onto a representation of the road transport system that identifies hierarchical levels of the system (e.g. Parliament; Government agencies & industry bodies; Operational management; Local Management; the Road environment). This mapping enables the identification of where the factors reside within the wider road transport system and who might be responsible for removing them.

Results

The initial results show that most factors identified by participants reside at the lower levels of the road transport system. For example, participants reported a general unwillingness to stop to rest when fatigued to avoid being late to work or appointments and being ‘time poor’. They also reported social factors (e.g. feeling under pressure from peers to drive when fatigued). While factors at the higher levels of the road transport system were less frequently mentioned, there were suggestions at this level, for instance the provision of more rest stops on highways.

Interestingly, some factors identified were outside of the scope of the road transport system itself. For example, recommendations about the availability of alternative forms of transport were made to avoid reliance on driving at times where the driver is likely to be fatigued. Others focussed on reducing time pressures experienced in everyday life such as work and study schedules, highlighting the interdependent nature of road transportation with other aspect's of drivers lives.

Conclusions

Fatigued driving is a complex issue with system-wide contributing factors. The results of this study have practical implications for road design and individual interventions such as driver education campaigns and will be extended in future research to incorporate the views of road safety experts.

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Is 40 the new 50? The case for a national reduction in the local road speed

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Abstract

Safe speeds are central to reducing road crashes and crash severity (Archer, Fotheringham, Symmons & Corben 2008, Johnston, Muir, & Howard 2013). In the late 90's the NSW, Victorian and Queensland governments led the national reduction from 60 to 50km/h on local roads. This simple and inexpensive policy innovation reduced the road toll by 15% (Haworth, Ungers, Vulcan & Corben 2001). It's time to continue this downward trend. Reducing the local road speed to 40km/h will do two things. First, it will reduce road crashes (Archer et al 2008). Second, it will transform communities by allowing more equitable and safe access to the road system (Welle, Wei, Adriazola, King, Obelheiro, & Sarmiento 2015). This paper presents an argument and conceptual strategy for changing the Australian Road Rules (ARR) to 40km/h on local roads.

Extended Abstract

Safer vehicles and safer roads are key elements to increased road safety for motorists but the effect is marginal for vulnerable road users (VRUs) (Archer et al 2008, Johnston et al 2013). Pedestrians, cyclists and other VRUs are unprotected and do not necessarily benefit from technical improvements in vehicles or road infrastructure. Moreover, road safety experts argue there is a diminishing rate of return to expensive technological fixes for vehicles and road infrastructure (International Transport Forum 2008). It is therefore timely to go back to first principles of injury prevention to develop more cost effective road safety policy that will deliver maximum impact. We argue that speed control is a fundamental element of this approach.

Increased force determines the magnitude of injury on the unprotected human body (Tillgren, Vedung, & Belin 2012). Slower speeds produce less kinetic energy resulting in less serious injuries. Slower speeds also allow for longer reaction time and braking distance, decreasing the likelihood of crashes occurring (Johnston et al 2013). In short, with lower speeds motorists have more time and space to avoid crashes (Tillgren et al 2012, Johnson et al 2013). Moreover, research demonstrates that on most urban trips lowering the speed by 10km/h makes little difference to overall travel time due to improvements in traffic flows (Archer et al 2008, Haworth et al 2001)

More people are choosing to walk, cycle, or use alternative forms of transport (International Traffic Safety Data and Analysis Group 2014). Spurs for this trend include a decrease in car use by young people and an ageing population (Welle et al 2015). Demographers also point to a general increase in inner-city populations aiming to increase 'livability' and work life balance (Welle et al 2015, Lydon et al 2015). Societal change brings new demands on public infrastructure, particularly the road network. The challenge for policy professionals and political leaders is to respond to these demands by designing policy that is innovative, inexpensive, impactful, and evidence based.

We argue that reducing the local road speed will address the dual public demands for safer roads and more 'livable' urban environments. However, political inertia regarding legislating for lower speeds is demonstrated in many local, state and federal jurisdictions. The safer speeds solution must therefore be presented in an innovative, positive way. The positive outcomes of a lower local speed limit include increased access to the road network, increased community connectivity, and a decrease in the road toll (Welle et al 2015, Lydon et al 2015). Economic factors must also be acknowledged as governments are under pressure to do more with fewer resources. Again the message should be framed in a positive way. Although a change in the speed limit is not cost free (e.g. education, signage and enforcement) these are marginal when compared with more expensive and often less effective technology or infrastructure based policies. In short we claim that foregrounding the positive impacts and the low cost of reducing the local road speed provides an effective antidote to political inaction.

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Innovative Weather-Activated Variable Speed Sign Trial – a first for road safety in New Zealand

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Abstract

Linking the Waikato and Bay of Plenty is the nationally strategic State Highway 29 (SH29) over the Kaimai Range. Between 2007 and 2015 there were 267 crashes and data identified 70% were in wet weather with 40% driving too fast for the conditions. This prompted development of a system which encourages people to drive at speeds appropriate to the road and conditions. The system is New Zealand's first weather-activated road signs with adjustable speed limits commissioned in November 2015. The objective of the innovative two year trial is to educate drivers to better understand speed limits in adverse weather.

Background

The development and implementation of the Weather Activated Variable Speed Limit signs (WAVSL) trial is part of the Government's *Safer Journeys* road safety strategy, to reduce the number and severity of crashes. Managing speeds is crucial as the outcome of all crashes is strongly influenced by the impact speed. The *Safer Speeds Programme* promotes helping people increasingly understand what travelling at safe speeds means.

The SH29 Kaimai Range has a poor crash history, with unpredictable, and at times dangerous, weather at the summit. The 100km/h speed limit did not take into consideration adverse weather and studies show that drivers did not adjust their speeds, attempting to travel 100km/h in poor conditions, compromising theirs and others' safety.

As the existing static reflective signs were not able to show temporarily reduced speed limits another solution was sought.

Innovative thinking

The WAVSL system aims to encourage drivers to drive at safe and appropriate speeds during adverse weather conditions.

It does this through an operational system for varying the speed limits on a road where significant changeable conditions result in increased risk, initiating the variable speed limits only during the time of the adverse conditions. Once activated, the speeds are enforceable by Police.

The 12km trial site has two zones; the eastern flank is 8km and the western flank is 4km. Following comprehensive consultation with the community, Transport Agency safety advisors and NZ Police it was agreed that the speed reductions for adverse weather would be set for 80km/h for the eastern flank and 60km/h on the western flank.

A MetService weather station located near the summit captures most of the weather data relevant for WAVSL. Existing sensors in the station measure rain, wind, ice and surface water on the road. A visibility sensor was installed to capture fog and visibility information.

The weather station collects data which is transmitted to the team at the Auckland Transport Operations Centre (ATOC) at one-minute intervals. When predetermined weather thresholds are reached an alarm is triggered whereby an ATOC controller can monitor web cameras to ensure the alert is correct and if so, which zones are affected. The WAVSL response is triggered by rain, ice, wind and fog.

Effectiveness and results

From activation in November 2015 to end of January 2016 (12 weeks) the WAVSL signs had been activated 97 times.

Results showed when the signs were activated (due to rain or poor visibility) traffic speeds have reduced significantly. A strong link between reduced travel speed and improved road safety is commonly accepted in road safety literature and so it is expected that WAVSL will lead to reduced crashes and fatalities.

While there was a moderate increase in travel time when the signs were activated, the overall travel time impacts were negligible as 86% of the traffic flow was not impacted by the activated signs.

Ongoing monitoring and further tweaking of the innovative WAVSL system will optimise the trial and ensure the system has a positive impact on drivers' speed and safety.

Figure 1 WAVSL Trial in operation on SH29 Kaimai Range

Table 1. Example of data gathered from WAVSL eastern flank – downhill speeds

	Eastern flank downhill Baseline Sign off	Eastern flank downhill Baseline Sign would be on	Eastern Flank Downhill System Off speeds	Eastern Flank Downhill Slippery Road speeds	Eastern Flank downhill Limited visibility speeds
Mean	88	89	87	80	80
Mode	90	93	93	79	79
85th%tile	98	99	99	91	90
St dev	10	11	13	13	10
Effect size				0.54	0.54
Count	68,343	5,852	235,506	30,483	10,414
% of Vehicles	92%	8%	85%	11%	4%

Results for both uphill and downhill on the Kaimai eastern flank show that WAVSL has been very effective at reducing speeds to an operating speed of approximately 80km/h during adverse weather events. The baseline speeds in wet weather show the inadequate driver response to wet weather conditions, which may help to explain the high crash rate in wet weather, and reinforces the justification for WAVSL.

Enhancing Public Demand for Safer Speeds on the Road: Input from Australian and New Zealand Stakeholders

Judy Fleiter, Ioni Lewis, Sherrie-Anne Kaye, David Soole, Andry Rakotonirainy, Ashim Debnath

Queensland University of Queensland (QUT), Centre for Accident Research and Road Safety–Queensland (CARRS-Q)

Abstract

Community engagement to effectively manage speeding is an important priority and changing community perceptions about speeding is critical to reducing road trauma. Stakeholder consultations were conducted to identify interventions that could create, increase, and/or sustain public demand for safer speeds in Australia and New Zealand. Twenty-one stakeholders provided feedback on a proposed Campaign Strategy containing nine aims and evidence-based countermeasures. Overall, support was expressed for the Campaign Strategy, many noting success was dependent on long term political support and sustained resourcing. The proposed Campaign Strategy documents countermeasures to be trialed and evaluated to enhance demand for safer speeds.

Background

Changing community perceptions about speeding is an important priority. Improving compliance with speed limits and engaging more effectively with the community on the role of speed in road safety are identified in Australia's National Road Safety Strategy 2011-2020 (ATC, 2011). Similarly, New Zealand's national strategy, Safer Journeys, recognises the need to implement a communications strategy to alter community dialogue on speeding, including increasing understanding and acceptance of safer speeds by road system designers and users (NRSC, 2013). This paper documents stakeholder consultation as part of an Austroads-funded research project aimed at identifying interventions that could create, increase, and/or sustain public demand for safer speeds in Australia and New Zealand. Drawing on evidence from various disciplines, an overall Campaign Strategy containing nine aims was proposed (Table 1), including potential implementation facilitators and barriers and evaluation considerations. Feedback was sought in order to prepare a final Campaign Strategy for future trial and evaluation.

Method

Sixty-one organisations and individuals from Australia and New Zealand were invited to participate in stakeholder consultations to provide feedback on a draft Campaign Strategy that was developed from a review of road safety and behaviour change literature. Invitations were sent to a range of road user advocacy groups and individuals, jurisdictional transport authorities, Members of Parliament, and road safety and advertising/ behaviour change researchers to obtain a diverse range of views about demand for safer speeds. Prior to questionnaire completion, participants were asked to read a literature review summary, the rationale for categorisation of nine aims within the overall strategy derived from the literature, and the proposed Campaign Strategy containing a range of countermeasure options to address each aim. Comment was sought on suitability and feasibility of, and likely barriers to, the countermeasures within the draft Campaign Strategy and applicability to the Australian/New Zealand context. Twenty-one key stakeholders participated.

Table 1. Nine aims to address the need to create, increase and/or sustain public demand for safer speeds in Australia and New Zealand

	Aim
Create demand for safer speeds	1. To enhance community understanding of risk associated with speeding
	2. To enhance community understanding that increased speeds result in increased crash severity, based on uncontested laws of physics
	3. To increase awareness of purpose and benefits of speed enforcement
Increase demand for safer speeds	4. To challenge the prevailing descriptive norm that 'everyone speeds'
	5. To challenge the injunctive/moral norm that speeding is acceptable and approved of by others (i.e., that speeding is no big deal)
	6. To challenge the perception that speeding saves a large amount of time, and/or that it is possible to make up a large amount of lost time by speeding
Sustain demand for safer speeds	7. To challenge the perception that complying with speed limits is hard/impossible and to promote individual responsibility for and ability to choose and control one's speed
	8. To continue to build a positive culture surrounding road safety more broadly, and speeding more specifically
	9. To challenge language associated with speeding in order to alter public perception of its importance

Results

The majority of respondents expressed support for the Campaign Strategy; many noting that it addressed key misperceptions and complemented existing approaches. Success was noted by many as dependent on long term political support and sustained resourcing. A number of barriers were identified including: lack of awareness of the 'true' picture of how much speeding occurs and that enforcing low level speeding may be viewed solely as revenue-raising by some. The need for ongoing evaluation and for the Strategy to complement what is already in place was highlighted. A small number of respondents expressed some concerns, including that parts of the Strategy may backfire if not carefully implemented. Feedback was incorporated into the final proposed Campaign Strategy to enhance potential effectiveness.

Conclusion

The proposed Campaign Strategy provides countermeasures for trial and evaluation to enhance public demand for safer speeds. It also highlights current knowledge across disciplines that may be harnessed to create effective change. A range of barriers and facilitators are identified in the Campaign Strategy to assist jurisdictions to determine the likely feasibility from their unique perspective. Implementation issues to be addressed include speed limit setting policies, resourcing, messaging/advertising strategies, and political will for promoting safer speeds.

References

Australian Transport Council. (2011). *National Road Safety Strategy 2011-2020*. Canberra: Australian Transport Council.

National Road Safety Committee. (2013). *Safer Journeys Action Plan 2013-2015*. Wellington: New Zealand Government.

Compliance with reduced speed limits at roadworks: What can we learn from other speeding attitudes and self-reported behaviours?

Nerida Leal, Samuel Bailey, Coryn Hedges

Queensland Department of Transport and Main Roads

Abstract

To understand factors associated with self-reported compliance with reduced speed limits at roadworks, the Department of Transport and Main Roads added roadworks items to its annual Road Safety Perceptions and Attitudes Tracking Survey. Self-reported compliance with reduced speed limits at roadworks was better when workers were present, at sites the respondent was not familiar with, and when other motorists were complying with the speed limit. Survey results will be further analysed to enhance our understanding of speeding at roadworks, its relationship with other risky driving behaviours, and to inform the identification and evaluation of interventions.

Background

Evidence shows that many motorists disregard reduced speed limit signage at roadworks sites, putting the safety of traffic controllers, road workers and other road users at risk. The Department of Transport and Main Roads is committed to ensuring the effectiveness of traffic management at roadworks, including consistent and credible speed limits and signage, enforcement, and better education for road users explaining the need to slow down at roadworks. To inform this work, and complement anecdotal and other sources of information about speeding at roadworks, a need to collect and analyse Queensland data was identified.

Method

The Department of Transport and Main Roads commissions the Road Safety Perceptions and Attitudes Tracking Survey to monitor trends over time for a variety of road safety topics. The survey uses an online panel to recruit a representative (in terms of the gender, age and regional characteristics of licence holders) sample of 600 Queenslanders over the age of 16 who have ever held a licence. Data collection typically occurs in April and May of each year. Three items about travel speeds through roadworks sites were included in the 2015 survey to measure:

- Self-reported frequency of exceeding reduced speed limits at roadworks in eight circumstances (road workers present/not, length of site less than/more than 1km, whether the site was familiar or not, and compliance/non-compliance of other motorists
- Agreement with six statements about speeding at roadworks
- What would encourage them to slow down at roadworks (this question was only presented to those who indicated they exceeded the limit in at least one of the circumstances in the first question. Response options were presented, in addition to a free text field for “other” responses, with multiple responses permitted).

Results

Self-reported compliance with reduced speed limits at roadworks sites varied by circumstances, and was better when workers were present, at sites the respondent was not familiar with, and when other motorists were complying with the speed limit. The length of the site did not influence compliance.

Among the 463 respondents who indicated that they exceeded the reduced speed limit at roadworks sites at least occasionally for one or more of these circumstances, the most common factors likely to encourage them to slow down were the presence of road workers (57%), if reduced speed limits were understandable based on the prevailing road conditions (50%), and more signage throughout the site to remind them of the reduced limit (48%). The most common suggestion in the “other” responses was removing the reduced speed limit signs when work was not occurring / workers were not present.

Conclusions

Survey data will be further analysed to profile individuals likely to exceed reduced speed limits at roadworks sites, and compare roadworks item responses with other items, such as attitudes towards speeding more generally, and speeding in school zones (where presence of children is an important signal to slow down). Survey data will be used to enhance our understanding of speeding at roadworks sites, and inform the identification and evaluation of interventions.

Green Reflector Marking of Informal Truck Bays

Rod Hannifey

Truckright

Abstract

There is a recognised and confirmed lack of sufficient truck rest areas in Australia. Changes to the laws and penalties under which truckdrivers operate and more trucks on the road, has seen even more pressure put on these sites. The growing number of "Grey Nomads" on the road at certain times of the year, many of whom "freecamp", often in designated truck bays, is yet another factor.

The cost of new rest areas is substantial and the long time to build is yet another delay, so a cheap and effective alternative, even if only as an interim measure, was needed.

Background

I'm an interstate truckdriver and on one trip on an unfamiliar road, found myself tired and looking for somewhere to sleep. Not knowing this road, I found it difficult to find a safe place and had to travel on whilst fatigued, till I did. There were areas, which had they been marked to show me they were there, would have allowed me to sleep, but in a loaded fuel tanker, you cannot simply pull up on a road verge to sleep. Following this trip, I sought a way to mark such sites efficiently so other truck drivers wouldn't find themselves in the same situation.

I approached an RTA Transport Industry Liason Officer with the problem and my idea of marking these sites with blue reflectors on guideposts. The guideposts are in place, so no major cost or labour is required to put in posts, the posts have reflectors fitted with room for more and the reflectors are cheap. We agreed on the layout of three blue reflectors on a post at least 300m before the site, two on the next and one blue reflector immediately before the site, with blue being the colour used on truck rest area signs.

This allowed the three to be seen first clearly from a vehicle on highbeam, gave time to slow and call up a truck behind to inform them what the driver was doing and gave good indication of where the site was. Many of these sites have been used for years by drivers who knew they were there, having run that road regularly and possibly having needed a rest in that area, possibly due to a lack of truck bays. Many of these sites have shade from trees, where many formal truck bays lack this important need and so the reflectors are still valuable in the daytime.

An unofficial trial was started on the Newell Highway from Parkes north to Peak Hill in December 1999 and was extended to Gilgandra in 2000 by the RTA officer. In 2005, Queensland Department of Transport and Main Roads adopted a formal set of guidelines setting out site distances and requirements for "Blue Reflector Marking of Informal Truck Bays" and finally NSW RMS, did the same in 2008. Vicroads and WA refused to use blue citing a conflict with fire hydrants and green was trialled in Qld and then adopted in 2013.

I have pursued this road safety initiative since the initial idea was put forward to national road safety inquiries, to every state in Australia and am still trying to see it adopted nationally. I have had drivers tell me the idea saved their life and many still comment on the simplicity and effectiveness of the idea.

In 2015 the Federal and NSW Governments have contributed $200,000 each over two years towards completing 4 major north western NSW Highways The Newell Highway from Brisbane to

Melbourne is very nearly completed now, following recent marking of many sites. I have been in contact with RMS and will be able to participate and offer advice when the rollout begins. My understanding is that sites are currently being scoped and that not only will the funding cover marking of suitable sites, it will also allow for sites to be installed where there are large gaps without any truck rest areas at all now.

I want to see this national and with such a low cost, the cost benefit ratio to save even one life, makes this a worthwhile initiative.

This is from the List of recommendations from the National Road Safety Inquiry 2004.

The Blue Reflector Marking of Informal truck Rest Areas was also included in my written and oral submissions to the House of Representatives National Inquiry into Road Safety, Eyes on the Road Ahead, June 2004. As per the recommendation below it was adopted and the inquiry suggested an immediate roll out of this road safety initiative.

Recommendation 31 114

The Committee recommends that the Australian Government request the Australian Transport Council to:

- devise standards for truck rest areas;
- establish a program of works based on those standards; and
- immediately commence a program for establishing temporary truck rest areas based on interim measures such as standardised coloured reflector stops.

Unfortunately, none of the above have been completed since that time.

There are guidelines for formal, signposted truck rest areas and recommendations for the size and number of trucks and spacings between such sites. However a national rest area audit done in 2006 by ARRB for Austroads found, none of the audited routes complied.

In August 2006, Austroads commissioned ARRB to undertake a national audit of Rest Areas1 against the National Guidelines for Provision of Rest Area Facilities (NTC, 2005). The audit concentrated on three tasks:

1. examination of siting, design, layout and facilities information for a sample of heavy vehicle Rest Areas across Australia to determine the degree of compliance with the National Guidelines and the level of national consistency

2. site investigations of a limited sample of Rest Areas to validate the accuracy of the supplied information

3. review of existing literature on safety and economic benefits of provision of Rest Areas for heavy vehicles.

The audit has assessed the Rest Areas along the 12,700 km of mostly AusLink freight routes. The siting analysis found that none of the audited routes fully met the spacing recommendations of the National Guidelines. Sixty per cent of the audited routes had substantial deficiencies in the frequency or provision of rest opportunities.

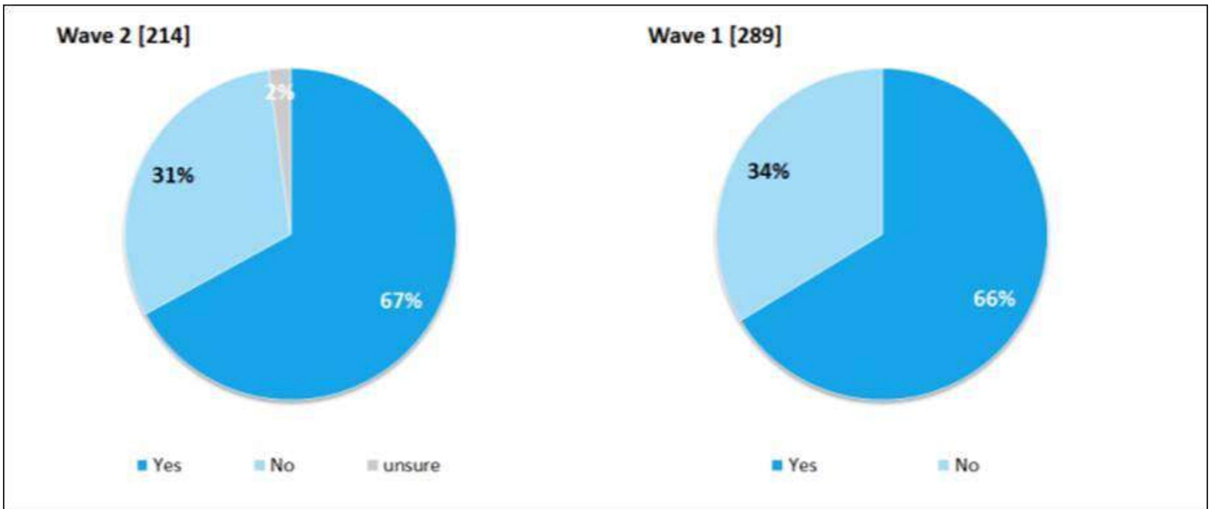
I have recently been approached to offer comment on the Golden Highway Corridor Strategy and in discussing rest area needs, was told of research done by RMS prior to the request for feedback.

Your interest in the Green Reflector stops initiatives sounds commendable and any effort to educate within the industry will have good effect. As I mentioned, we did do our own evaluation of rest stop signage in 2013 and 2014. In that research we asked heavy vehicle drivers some survey questions on green reflector sites. The report is an internal one and was not intended to be published so it lacks much of the context required for a public document. I am happy to provide a summary on the green reflector signage findings below. If you have further specific questions about the study I am happy to try and answer them also.

Survey Wave 1 – October November 2013 – 289 respondents

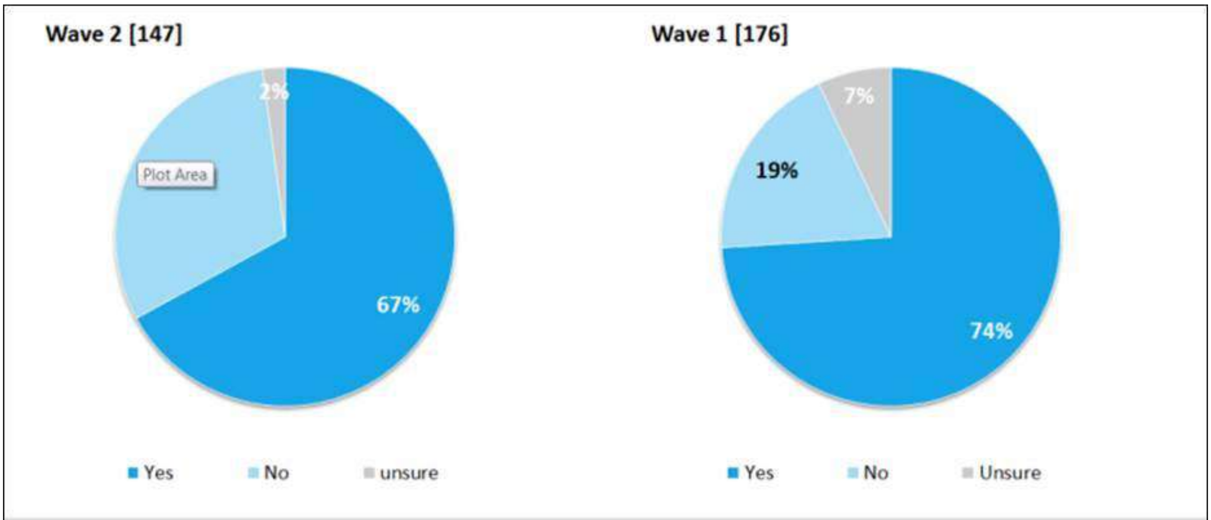
Survey Wave 2 – November 2014 – 214 respondents

Both surveys were conducted as face-face interviews with truck drivers at heavy vehicle inspection bays & roadhouses.



QB9. Are you familiar with informal truck stopping bays marked with blue reflectors/green reflectors on guide posts in advance of those stopping bays? ***Base:*** *Total Sample (n=in [...])*

This is a good result for a signage scheme that is largely informal and has no specific targeted education at this point in time that I am aware of. It also shows that there is room for promotion and education in the industry to improve on the awareness.



QB10. Do you use the blue reflector/green reflector system to find/use of the informal truck stopping bays?
Base: *Total Familiar (n=in [...])*

We have no further information on why the use of the green reflector system dropped in the year between these surveys. The change that did occur in that year between surveys was the implementation of over 90 rest-stops ahead signs along the Newell Highway, Great Western Highway and Mitchell Highway.

Regards, **Joshua Parkin**, Leader Network Optimisation Planning (Western) Journey Management - Network Optimisation

There is a three tier standard for formal or recognised truck bays and guidelines on where or how far apart, they should be placed. This is also linked to the number of heavy vehicles using that road, other facilities, eg truckstops, towns and distances between them.

The left hand photo shows truck parking ahead and recognition of a Truckstop, Service Centre or Petrol station. In the background, where the ute is parked, is an informal truck bay which has shade and only room for a couple of trucks and at the time, was not marked in any way whatsoever. There is now wire fencing and green reflectors, marking this site.

The right hand photo shows a site which would be deemed a truck parking area, but it is sited over the crest of a hill and leaves the truckdriver sleeping on a slope.

Categories of rest areas

"Three categories of rest area should be reflected in the *Rest Area Strategy Plans* developed by road agencies for all major highways and significant freight routes: *Major Rest Areas*, *Minor Rest Areas* and *Truck Parking Bays*." - *Page 26* ***National Guidelines for the Provision of Rest Area Facilities***

Major Rest Areas: These areas are designed for long rest breaks, offering a range of facilities and separate parking areas for heavy and light vehicles where possible. They are designed to allow drivers to take rest and sleep breaks required under current driving hours regulations.

Minor Rest Areas: These areas are designed for shorter rest breaks, and at a minimum should provide sufficient parking space for both heavy and light vehicles. While it is not anticipated that these stops will be used for long rest breaks/sleep opportunities, separate parking areas for heavy and light vehicles may be required at some locations.

Truck Parking Bays: These areas are primarily designed to allow drivers of heavy vehicles to conduct short, purpose-based stops including load checks, completing logbooks and addressing associated operational needs.

There is considerable variation in the categories of *Rest Areas* applied across Australian jurisdictions. However, the majority of State and Territory policies differentiate between *Major* and *Minor Rest Areas* that are designed for long rest breaks, and other types of stopping places designed for short-term stops. While the categories may differ in terms of the facilities offered and the layout and spacing intervals between them, these *Rest Areas* generally fall into one of the three categories defined above.

On a given highway or freight route, a mix of the three rest area categories should be provided.

You will note above that informal truck bays are not even listed in the above description. This has changed in some states with Queensland and New South Wales now not only recognising informal truck bays, but marking and recording them.

The above photos show a site on the Nullabor Plain, where there are some large gaps between truck rest areas and little signage giving you any idea how far to the next one. You will note there is an informal bay on each side of the road and drivers do sometimes need to stop and meet or help another truck, which is why these sites over time, can end up being opposite one another. The first set of 3 green reflectors goes on a guide post a minimum of 300 metres from the site, 2 on the next and a single green reflector is attached to the last post before the bay, allowing a driver to pick up the reflectors on high beam at night and, should there be a truck following, he can then tell the truck of his intention to stop via the UHF radio, rather than seeing the bay at the last minute and trying to stop in a hurry and often, taking the truck behind by surprise. In the right hand photo and in the one below, you can see the truck parked in the opposite bay.

Whilst this bay has no shade, green reflector bays are often chosen by drivers for a number of reasons, many have shade which is very much missing in truck rest areas and hard to even supply in herringbone, or side by side parking bays. This makes them of value in the daytime, where yes, you can see them, but again, without any warning of them being there, a driver looking for a safe spot to stop, whether for a call of nature, to inspect damage from an animal strike, to check the load, or simply because they are tired and need to stop for rest and may not know how far to the next formal truckbay.

Many informal bays are only big enough for one truck and so you will not have your sleep interrupted by other trucks. The cost to mark such a bay, is only the reflectors, 6 at $5 each plus the labour and it can be done in about 15 minutes, walking up and down, cleaning the post and fitting the adhesive sticker, so if you save one life by providing a safe place to stop for a tired driver, then you will never get a better cost benefit ratio from any other road safety initiative.

I am hoping the current roll out on the four highways in NSW will see further interest from other states and in the long term at some point in the distant future, when there are suitable and sufficient truck and car rest areas available, that we will not need informal green reflector bays, but that is a long way off. Building new formal truck bays can take years, with preliminary planning, site acquisition, ecological issues, funding approval and finally building and yet it can still not provide the necessary facilities and needs of those looking to manage their fatigue. I have also pursued national guidelines for truck rest areas and hope these will over time, come to be, but until that time, this green reflector initiative is simple, cost effective and will save lives. Thank you, Rod Hannifey.

Township Entry Treatments – Queensland Pilot Program

Peta Peterson

Queensland Department of Transport and Main Roads

Abstract

Formally known as Gateway Treatments in New Zealand and the United Kingdom, initial assessment of a potential Township Entry Treatment mass action program on state controlled roads in Queensland was undertaken by Queensland Department of Transport and Main Roads.

Six towns throughout Queensland were chosen for the pilot study to determine the treatment's effectiveness in reducing vehicle speeds in Queensland by comparing before and after implementation data. In the main, the speed threshold treatments proved successful with 85 percentile vehicle speeds in one particular location reducing by 13 km/h.

Background, Method, Results and Conclusions

Formally known as Gateway Treatments in New Zealand and the United Kingdom, initial assessment of a potential Township Entry Treatment mass action program on state controlled roads in Queensland was undertaken by Queensland Department of Transport and Main Roads.

A township entry treatment is a threshold speed management measure at the point of transition from a rural high speed situation to a lower speed condition through a rural town. Evaluation of an extensive program of such treatments in New Zealand using a variety of signs and road pavement designs had shown success in reducing crashes due to reduced speeds by motorists in towns and villages.

Despite there being great potential for a mass action program with a good anticipated benefit-cost ratio, it was deemed more appropriate to implement a pilot program in the first instance to gauge public and motorist reaction to the new speed threshold treatment. Six towns throughout Queensland were chosen for the pilot study to determine the treatment's effectiveness in reducing vehicle speeds in Queensland by comparing before and after implementation data. In the main, the speed threshold treatments proved successful with 85 percentile vehicle speeds in one particular location reducing by 13 km/h.

Life-Cycle Cost Analyses for Road Barriers – Example of a Swedish research

Thomas Schroeck, DELTA BLOC International

Abstract

The initial cost for road barriers is a crucial factor affecting the selection of barrier type. Life-cycle costs for barriers are seldom considered when selecting barrier types. This fact could be due to limited information regarding maintenance costs which obstruct an adequate consideration of maintenance aspects during the road planning and design process. Another problem regarding calculating life-cycle costs, when selecting road barriers, is the limited information available regarding costs for injuries associated with barrier collisions.

This analysis presents a study aimed at implementing and evaluating an approach for analysing life-cycle costs for road barriers under consideration of repair, maintenance and injury aspects.

Abstract – long version

The cost of a road construction over its service life is a function of design, quality of construction as well as maintenance strategies and operations. An optimal life-cycle cost for a road requires evaluations of the above mentioned components. Unfortunately, road designers often neglect a very important aspect, namely, the possibility to perform future maintenance activities. Focus is mainly directed towards other aspects such as investment costs, traffic safety, aesthetic appearance, regional development and environmental effects.

One of the problems identified in the above mentioned study as an obstacle for due consideration of maintenance aspects during road design was the absence of a model for calculating life-cycle costs for roads. Because of this lack of knowledge, the research project focused on implementing a new approach for calculating and analyzing life-cycle costs for roads with emphasis on the relationship between road design and road maintainability. Road barriers were chosen as an example. The ambition is to develop this approach to cover other road components at a later stage.

A study was conducted to quantify repair rates for barriers and associated repair costs as one of the major maintenance costs for road barriers. A method called "Case Study Research Method" was used to analyse the effect of several factors on barrier repairs costs, such as barrier type, road type, posted speed and seasonal effect. The analyses were based on documented data associated with 1625 repairs conducted in four different geographical regions in Sweden during 2006. A model for calculation of average repair costs per vehicle kilometres was created. Significant differences in the barrier repair costs were found between the studied barrier types.

In another study, the injuries associated with road barrier collisions and the corresponding influencing factors were analysed. The analyses in this study were based on documented data from actual barrier collisions between 2005 and 2008 in Sweden. The result was used to calculate the cost for injuries associated with barrier collisions as a part of the socio-economic cost for road barriers. The results showed significant differences in the number of injuries associated with collisions with different barrier types.

To calculate and analyse life-cycle costs for road barriers a new approach was developed based on a method called "Activity-based Life-cycle Costing". By modelling uncertainties, the presented approach gives a possibility to identify and analyze factors crucial for optimizing life-cycle costs. The study showed a great potential to increase road maintenance efficiency through road design. It also showed that road components with low investment costs might not be the best choice when including maintenance and socio-economic aspects.

What works when providing safe road infrastructure? 10 treatments that need to be used more.

Blair Turner, Chris Jurewicz, Tariro Makwasha

ARRB Group Ltd

Abstract

This paper describes a number of road infrastructure safety treatments applied internationally, evaluated and shown to be highly effective in reducing road trauma. However, their application within Australia and New Zealand has been limited to date. Based on several projects conducted on behalf of Austroads and for individual road agencies, this paper brings together the evidence on road safety effectiveness of these treatments, and makes the case for greater use of each. These treatments include: raised intersection and midblock platforms, wombat (raised pedestrian) crossings, road diet, signalised roundabouts, rest-on-red signals, consistent curve design and treatment, wide centreline treatments, vehicle-activated signs for curves and intersections, and gateway treatments. The paper shows how many of these have been applied successfully on both high-speed rural and lower-speed urban arterial roads.

Background

Provision of safe infrastructure is a key pillar in delivering Safe System outcomes. Although human error is often attributed as the cause of many crashes (Sabey 1980; Treat 1980), the solutions can often be found through addressing other elements of risk. Research by Stigson (2008) suggested that the greatest determinant of severity when a crash occurs is the infrastructure that is provided. Improvements in infrastructure can help reduce the severity of crash outcomes when they do occur through provision of more forgiving roads and roadsides. Infrastructure can also reduce the likelihood of road user error, and a crash, by providing better guidance on conditions ahead, and greater cues regarding appropriate driving decisions and behaviour.

Some infrastructure treatments have been found to be highly effective at reducing death and serious injury and are well known to road safety practitioners. Examples include roundabouts at intersections (with reductions of up to 80% of deaths; BITRE, 2012) and edge and centreline wire rope barrier systems (up to 90% reduction in deaths and serious injury; Larsson et al., 2003). Information on commonly applied treatments can be found from several sources, including the Austroads Road Safety Engineering Toolkit website (www.engtoolkit.com.au); the review of the federal black spot program (BITRE 2012); Elvik et al. (2009), PRACT-repository (http://www.pract-repository.eu/), and the CMF Clearinghouse (FHWA 2016).

However, there are a number of infrastructure treatments that have been applied overseas, but only to a limited extent within Australia and New Zealand, that have been shown to be highly effective, or show great promise in reducing death and serious injury. A greater awareness of effective treatments that can be applied at high risk locations will assist road agencies improve the safety of roads.

This paper provides a synthesis of research conducted by ARRB Group Ltd and others on effective road safety infrastructure treatments. The intention is to provide practitioners with easy access to information on the safety benefits of these treatments in the hope that they will be more widely applied, thereby resulting in greater reductions in death and serious injury.

Individual evaluations have been undertaken on these treatments through a number of studies conducted on behalf of Austroads and for individual road agencies. Some of the results are drawn from literature reviews, but most are based on direct evaluations based on application in Australia and/or New Zealand. These evaluations typically involve before and after studies with control groups that attempt to account for extraneous variables. Assessments are made on the crash reduction benefit (or the 'crash modification factor') for these treatments, and where possible, information is provided on the expected reduction in fatal and serious injury. Information on fatal and serious injury reduction is of greatest interest, as these are the crash types that we would like most to reduce. However, the evidence base is far more limited regarding higher severity crash outcomes.

Information on broader issues relating to each treatment (e.g. cost, impact on traffic etc.) are not provided in this review but are also recognised as important issues in treatment selection. In some cases, limited information on these issues is available in the references provided. Similarly, information on design considerations is not provided, but can in many cases be found in the references.

Outcomes from the review

Information is provided on crash modification factors for the following 10 treatments:

- Raised intersection platforms
- Raised midblock platforms and wombat crossings
- Road diets
- Signalised roundabouts
- Rest-on-red signals
- Consistent curve design and treatment
- Wide centreline treatments
- Vehicle activated signs for curves
- Vehicle activated signs for intersections
- Gateway treatments.

These treatments were selected as they have been found to be highly effective, but not yet applied as widely as they might be. The list is not exhaustive, but rather provides examples only. Practitioners are advised to continually seek information on emerging treatments, although care should be taken to ensure information is sourced from robust research and that any treatments used conform to appropriate local requirements.

Raised intersection platforms

Speed management is an effective tool in improving road safety. Raised intersection platforms (Figure 1) have been applied on the local road network in Australia, but have been used extensively on higher order roads in some European countries for many years. This treatment operates by reducing the speed of vehicles entering intersections. At lower entry speeds, crashes are less likely, and any crashes that do occur are far less likely to result in fatal and serious injuries. Existing designs aim to reduce intersection entry speeds to 50 km/h or less.

Several evaluations have been undertaken on effectiveness, particularly in the Netherlands where the treatment is reasonably widespread. As an example, Van der Dussen (2002) studied the effectiveness of 10 raised platforms. The intersections were in urban areas but with relatively modest vehicle flows of 3000–6000 per day. The study concluded that raised plateaus reduced the number of crashes by 70%. Makwasha & Turner (2016) evaluated the effectiveness of raised intersection platforms at 10 sites across Victoria, New South Wales and Queensland. Based on this evaluation and a review of international literature, Makwasha & Turner (2016) identified an overall crash reduction of 40% (CMF 0.60) for casualty crashes.

Figure 1. Raised intersection treatment (Source: VicRoads)

Raised midblock platforms and wombat crossings

Using the same speed reduction principle as intersection platforms, midblock platforms and raised pedestrian or 'wombat' crossings (Figure 2) have also shown great promise, and are used on both local and arterial roads in Europe.

Figure 2. Wombat crossing (Source: Hawley et al. 1993).

Midblock platforms can be used to create a lower speed environment, along a route, or at specific locations where there are higher risks (e.g. presence of vulnerable road users at shopping precincts). The design profile of the ramps and height of the platform can be altered to provide design speeds appropriate to the road environment. Where pedestrians are crossing, a design speed of 30 km/h or less is desirable. At speeds below this level, the chance of survival is greatly increased if a pedestrian is struck by a vehicle. Both midblock platforms and wombat crossings have been used occasionally on local roads, but very rarely on higher volume roads. Hawley et al. (1993) reported that wombat crossings were first introduced in 1991 in Sydney.

There have been few robust evaluations on the effectiveness of raised midblock platforms and wombat crossings in Australia or New Zealand. Several studies have assessed typical speed reduction (e.g. Department of Territory and Municipal Services 2006 found reductions of up to 10 km/h in 85th percentile speeds), while assessments of crash reduction were harder to come by. In a review of international literature and a before/after evaluation of 14 wombat crossings on higher traffic volume roads across Victoria, Makwasha & Turner (2016) have identified a 40% reduction

(CMF 0.60) in casualty crashes, 30% (CMF 0.70) reduction in serious and minor injury crashes and 45% (CMF 0.55) reduction in vehicle-pedestrian crashes.

Road diets

The term 'road diet' originated in the United States, and refers to a conversion of an undivided four lane roadway (two lanes in each direction) to a two lane road with a central turning lane (Figure 3).

Figure 3. Road Diet (Source: ARRB Group Ltd)

Sometimes cycle lanes are also included. A similar approach has been used in New Zealand for a number of years (wide 'flush' or painted medians), and there are some applications in Australia. Austroads (2016) suggests that the treatment might be effective for roads with traffic volumes up to 20,000 vehicles per day. A study by Makwasha & Turner (2016) draws together material from overseas literature as well as a before/after evaluation of results from 11 sites across New South Wales and Victoria. The study identified a 35% (CMF 0.65) reduction in casualty crashes, with overall reductions in the more severe crash outcomes. Further findings indicated reductions in speed differentials and reduced crossing widths for pedestrians.

Signalised roundabouts

Roundabouts are a highly successful type of treatment, and are commonly applied at urban and rural intersections. However, there are certain circumstances which mean traditional roundabouts cannot be applied. Signalised roundabouts have some advantages over traditional roundabouts. Signalised roundabouts can be applied in situations where there are high peak hour traffic volumes, unequal traffic flows from different approaches, or high circulating speeds. This makes them very useful for management of large urban arterial intersections. Existing roundabouts can be converted to partially or fully signalised roundabouts (Figure 4). Partially signalised roundabouts have part-time metering that only operates during peak periods, and normal roundabout priority is used at all other times. Fully signalised roundabouts have signals at all approaches which operate at all times.

Several evaluations have been undertaken on the effectiveness of signalised roundabouts, particularly in the UK. Institutes of Highways and Transportation (2005) found significant crash reductions from converting 10 existing roundabouts to fully signalised roundabouts. Total crashes were 28% lower. According to a study by County Surveyors Society (cited in Turner and Brown 2013), signalisation of existing roundabouts led to 11% reduction in casualty crashes, and a 44% reduction in FSI crashes for full-time operation. Based on a review of literature Austroads (2016) suggests that installation of this treatment will typically reduce casualty crashes by almost 30% over the benefits of existing roundabouts (CMF of 0.72). Benefits were also noted for pedestrians from the addition of signals at existing roundabouts.

Figure 4. Signalised Roundabout (Source: Google Maps 2015, 'Carlton, Victoria map data, Google, California, USA).

Rest-on-red signals

The rest-on-red (or dwell-on-red) treatment involves an additional 'all-red' signal phase, typically in off-peak periods such as in the evening. The default phase for signals is all-red, and this only switches to green when a vehicle arrives at the intersection, with the consequence that vehicles are required to slow or stop on approach. The treatment can be applied in activity centres where there is high night-time pedestrian activity, including situations where pedestrians are likely to be intoxicated. The overall aim of rest-on-red signals is to reduce vehicle speeds and bring down the proportion of vehicles travelling at a speed that threatens severe pedestrian injury.

Several evaluations have been conducted on this treatment in Australia. Lenne et al. (2007) found this treatment was associated with mean speed reductions of 3.9 km/h at the 30 m detector point and 11.0 km/h at the stop line detector, while Archer et al. (2008) also found significant reductions in average speed. Austroads (2016) synthesised the results from these evaluations as well as more recent data from a before/after evaluation of 8 sites across Victoria, and suggested that reductions of 45% (CMF of 0.55) could be expected from the use of this treatment.

Consistent curve design and treatment

In various locations across the rural road network, treatments have been installed at curves to address crash problems. However, if treatments are installed in an ad-hoc manner, it is likely that route inconsistencies will emerge. Signs and markings will be used in one location, but not at another with a similar design. This can lead to confusion for motorists, and difficulties in judging the severity of curves. In order to address this problem, a number of systems have been developed that provide advice on the consistent application of treatments to address safety at horizontal curves across the whole road network (Figure 5).

Herrstedt and Griebe (2001) developed a model to identify risk for different types of curves. Their model is based on the approach speed to curves, and the curve design speed. Based on an assessment of these factors, curves are categorised into one of five risk categories. Standard treatments are used for each of these categories meaning that motorists are presented with clear and consistent guidance on curve severity. Cardoso (2005) developed a series of statistical speed-crash predictive models and then a treatment regime for use in Portugal. In the UK, Helman et al. (2010) evaluated a risk rating scale for rural curves developed by Devon County Council.

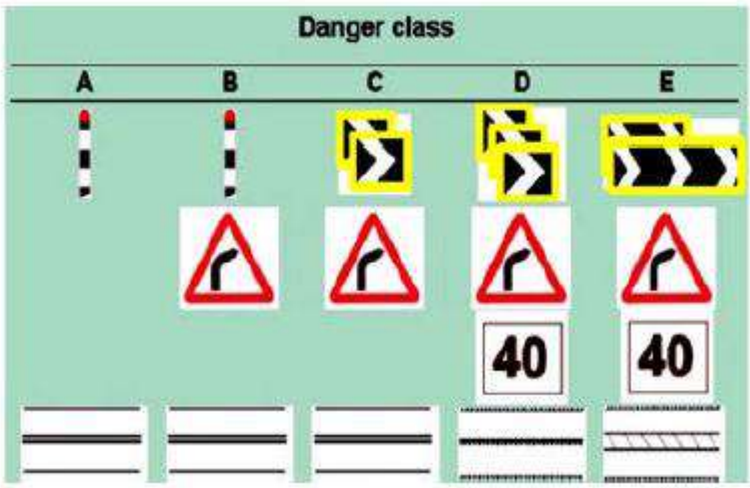


Figure 5. Consistent Curve Design and Treatment (Source: Kirk, Hills & Baguley 2002)

Jurewicz et al. (2013) applied this approach to curve safety in Victoria, Australia. They developed a method and guidelines for assessing curves, and a corresponding package of treatments for each curve within a risk band. Although yet to be evaluated, the estimated combined benefit of treatments in each band ranged from 22% casualty crash reduction at low risk curves (using guideposts, edge and centreline) through to 57% (CMF of 0.43) for high risk curves (using chevron alignment markers, speed advisory signs, pavement widening, hazard removal and safety barriers).

Wide centreline treatments

Wide centreline treatments can be used in urban settings, but are particularly effective for rural, high-speed environments. The treatment typically involves provision of a wide painted median, and in some cases also includes audio-tactile centreline markings (Figure 6). The treatment provides greater separation between vehicles travelling in opposite directions, and narrowing of the lane widths which can help encourage a lower speed (especially when coupled with a lower speed limit). Wide centreline treatments also offer the potential for future fitting of wire rope barrier systems (given adequate width), opening a path towards even greater safety benefits.

The treatment reduces potential head-on crashes, and has also been shown to reduce run-off-road crashes (possibly due to improved opportunity to recover from centreline crossing events).

A review by Whittaker identified casualty crash reductions of around 60% from this treatment (CMF 0.4), although this analysis was based on limited data. Further evaluations are being conducted, and so it is expected that more definitive results will be available in the near future.

Figure 6. Wide Centreline Treatment (Source: ARRB Group Ltd)

Vehicle activated signs for curves

Vehicle activated signs (VAS) are electronic warning signs that are triggered by road users, typically when they exceed a recommended safe speed. At all other times the sign is blank. Once triggered, the sign displays information regarding the hazard ahead. This may include a message to slow down or an indication of the appropriate travel speed. VAS at curves typically provide a message or indicate the appropriate advisory speed for a curve ahead (Figure 7).

Figure 7. Vehicle Activated Sign at Curve (Source: Warwickshire County Council)

The installation of vehicle activated signs at bends in the UK resulted in speed reductions of between 3.4 to 11 km/h. At two sites where crashes were recorded, there was a reduction in crashes of 54% and 100% (although numbers were initially low at the latter site; Winnett and Wheeler 2002). A study undertaken in Queensland found the average speed dropped by similar amounts at curves (5-10 km/h; Burbridge et al. 2010) while a study from New Zealand found more modest speed reductions (5 km/h; Gardener and Kortegast 2010). Makwasha and Turner (2014) conducted a meta-analysis of data from several previous studies and newly collected data. A total of 16 rural curves were included in the analysis. A 2 km/h reduction in mean speed, and a 4 km/h reduction in 85th percentile speed was identified from this treatment. The evaluation of crash performance showed a reduction of around 35% in casualties (CMF of 0.65).

Vehicle activated signs for intersections

VAS an also be applied in advance of intersections as an enhanced warning device (Figure 8). This alerts the driver to the presence of the intersection with the aim being that they increase their alertness and reduce their speed to negotiate the intersection safely.

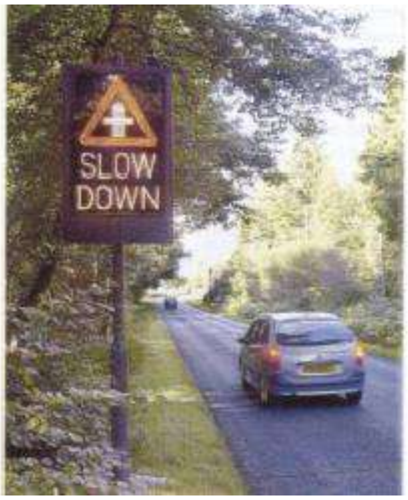


Figure 8. Vehicle Activated Sign at Intersection (Source: Winnett & Wheeler 2002)

The installation of vehicle activated signs at intersections in the UK resulted in an average reduction of around 6 km/h. VAS have also been used in Australia and New Zealand. Makwasha and Turner (2014) conducted a meta-analysis based on several previous studies and newly collected data. A total of 37 mostly rural intersection sites were included in the analysis. The evaluation identified a 2 km/h reduction in mean speed, and a 4 km/h reduction in 85th percentile speed from this treatment. A casualty crash reduction of 70% was identified (CMF of 0.3).

Gateway treatments

Gateway treatments (also referred to as entry treatments or thresholds) are used to delineate transitions from high-speed to low-speed environments, or mark a change from a major to a residential road (Figure 9). Enhanced signs, road narrowing (often using painted or constructed islands) and different road surface colouring are used to produce a contrast between different speed environments.

Figure 9. Gateway Treatment (Source: Transport and Main Roads)

In a UK study, Taylor and Wheeler (2000) examined the effectiveness of gateways for 56 village traffic calming schemes. The report summarised the effectiveness of gateway treatments in terms of speed and crash reductions. They found a 50% reduction in fatal and serious crashes and a 25% reduction in all casualty crashes. There was around a 5 km/h reduction in mean speeds. The NZ Land Transport Safety Authority (2002) produced guidelines for urban/rural speed thresholds. The guide reports that thresholds have been found to reduce vehicle speeds by 2–15 km/h, depending on design and location. Makwasha & Turner (2013) conducted an evaluation of gateway treatments in New Zealand that included 102 treated sites and 62 control sites. An overall casualty crash reduction of around 25% was identified from this treatment, but the effect on serious crashes was even greater (over 30%). A sub-analysis identified that gateways that used ‘pinch points’ or some form of road narrowing had a far greater benefit, with a casualty reduction of 35% (CMF of 0.65), and a reduction in fatal and serious injury of around 40% (CMF of 0.6).

Summary and Discussion

Despite significant improvements in road safety over recent decades, there is a lot more that could be done to reduce risk to road users. Provision of safe road infrastructure has a significant role to play in facilitating such improvements. There are already a large number of treatment options available for improving infrastructure safety. However, recent research provides a greater evidence base on treatments that could be applied to make a stepped improvement in future. A number of treatments exist that are known to be effective, either from application in other countries, or from limited application in Australia and New Zealand. A greater understanding on the availability and effectiveness of these treatments is required so that more targeted action can be taken to address safety. The safety benefits of several such road safety infrastructure treatments are provided in this paper. The treatments highlighted are used overseas (often extensively), but have now also been assessed here in Australia and/or New Zealand. In some cases there is a good evidence base from local application, but in other cases there is ‘emerging evidence’ that the high benefits seen overseas are likely to be replicated here. It is expected that each of the highlighted treatments will provide strong safety benefits in Australia and New Zealand. Table 1 provides a summary of the results for the casualty crash reduction benefits for each of these. Note that in some cases the values provided are indicative only. Further information on the robustness of each value can be found in the relevant references provided.

Table 1. Typical crash modification factors for treatments assessed

Treatment type	**Casualty crash reduction (CMF)**
Raised intersection platforms	0.6
Raised midblock platforms and wombat crossings	0.6
Road diets	0.65
Signalised roundabouts	0.72
Rest-on-red signals	0.55
Consistent curve design and treatment*	0.43
Wide centreline treatments	0.4
Vehicle activated signs for curves	0.65

Vehicle activated signs for intersections	0.3
Gateway treatments	0.65

*this result is estimated

It is likely that if each were applied more widely there would be substantial road safety benefits.

As noted earlier, the evidence base regarding fatal and serious injury reduction is of high interest, but unfortunately information is typically not available regarding crash severity. Fatal and serious crash outcomes are far less common than more minor injuries, and the issue primarily relates to lack of statistical power to produce significant results. This is highlighted again in the results assessed and presented above. Larger studies including international collaborations will be required to address this knowledge gap (see OECD/ITF 2012 for a discussion on this, and a proposed methodology for addressing this issue).

It is recommended that the treatments identified in this paper be considered by road agencies for inclusion in practitioner guidelines in order to increase their application and improve road safety outcomes.

It is also recommended that efforts continue to identify emerging infrastructure treatments that could be used to reduce the incidence and severity of crashes. Where new treatments are identified, these should be trialled at multiple sites and evaluated to determine their effectiveness, and results from such trials should be disseminated widely.

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The INDEMO Project – an innovation and knowledge transfer project for enhancing ambulance design

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EMS Safety Foundation, New York, New York;

Abstract

Optimizing ambulance safety and design has not kept pace with innovation for standard passenger vehicles. The safety of the design of an ambulance is dependent on the interplay of 3 dimensions - automotive safety, human factors and ergonomics and clinical care delivery. The Ambulance Safety INnovation DEsign MOdule (INDEMO) project was developed to integrate optimal features that reflect the interrelationship of these disciplines, and to engage the EMS community to adopt these changes. A number of interactive tools were utilized to enhance engagement, including full scale and 1/6 scale interactive models, a ceiling mounted video camera and a telepresence robot.

Background and Methods

Ambulance transport has a concerning safety history with well documented safety hazards both in the USA(1, 2, 3) and also Australia(4). In the USA ambulance vehicles have also not fundamentally changed in operational design in 30 years - despite a global environment in the transportation arena of major advancements in technology, engineering, automotive safety and human factors over that time. Ironically, most USA ambulances are designed by health care providers with no training or technical background in vehicle safety or design. The INDEMO Project is a radically new approach to operational design for ambulance vehicles - that is science and technology driven. A broad based interdisciplinary team of automotive safety expertise, human factors and ergonomics, industrial design, systems engineering, operational EMS, public health and transportation science expertise collaborated to advance ambulance design. Technical literature and design principles in the related fields(5,6,7) were searched and a design model determined by the interdisciplinary team. To enhance end users ability to appreciate the design features a transparent full scale interactive model was developed and built on a mobile platform to facilitate its use across North America. A number of approaches to enhance change adoption were also developed including 1/6 scale interactive models and use of a GoPro camera mounted in the ceiling of the module to demonstrate spatial relationships as regards clinical procedures and a QR Coded banner and pocket instruction sheets were positioned at the INDEMO displays, so that descriptive information was available instantly onsite, and could be also accessed off site. A telepresence robot which could be self driven from a cloud based platform from anywhere globally was utilized to share the INDEMO design features beyond its physical location. In addition to a focus on occupant protection design and human factors principles, cost efficient innovative design augmentation included use of LED lighting on the ambulance console and also on the stretcher, as well as voice activation of switches for these LED lights and the strobe lights. From September 2013-March 2016 the INDEMO Project was deployed at 4 USA national conferences and 3 regional events, as well as a regional event in Canada.

Figure 1. The INDEMO interactive project on display with the full scale model with QR codes, the ceiling mounted live video aerial image, the 1/6 scale models, and the telepresence robot

Results and Discussion

Beyond our research team, the INDEMO project has featured in numerous presentations by leaders in EMS as a cutting edge gold-standard, and also on twitter, instagram and periscope by end users, with numerous requests by end users and corporate industry organizations for design information. Though 2D tools are the mainstay of ambulance design education of the North American EMS community, this project uses 3D interactive tools to address this challenge. Focusing on working smarter, not harder, techniques for enhancing engagement and change in operational culture and design practice for end users included encouraging hands on experience with scale models of the current old style approach - contrasted with scale and full size models of the new innovative designs of INDEMO. The use of this interactive hands-on model and virtual access has been a most valuable tool to engage the EMS community in the USA and beyond.

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How one company is using IVMS to improve driver safety in Australia, are they doing it right? (20 word limit)

Stewart O'Brien

MiX Telematics Australasia

Abstract

By 2019 it is expected that over 8.9 million European commercial vehicles will be fitted with in-vehicle monitoring systems (IVMS). The usual model for IVMS use within organisations is that it is programmed to measure critical safe driving metrics and providing regular feedback on how staff are driving and what they need to improve on. MiX Telematics has started working with clients on an expanded driver improvement model that focusses on four key areas that influence driver behaviour within an organisation: the employee, the employee's team mates, the employee's supervisor and employer's organisational culture. This expanded model has resulted in our clients achieving a more sustainable safe driving culture.

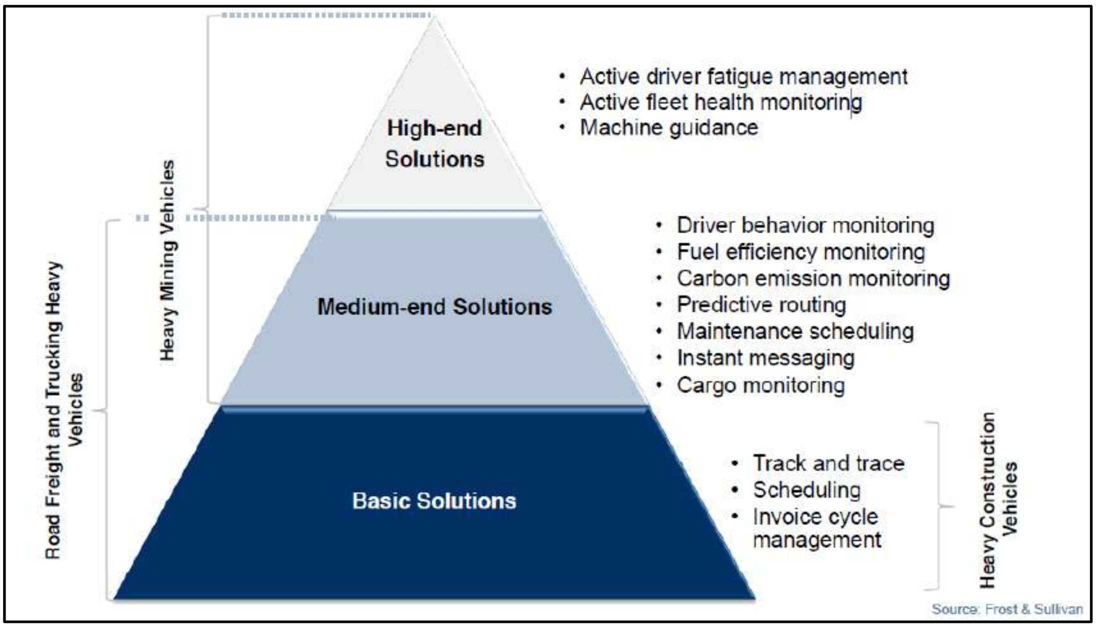
Introduction

Borg Manufacturing is a leading manufacturer of melamine products, operating a fleet of over 200 vehicles, including plantation trucks working on unsealed forestry roads, medium and heavy rigid trucks in suburban and city environs and multi combination (B double) vehicles travelling on national highways and regional single lane roads.

In January 2015 Borg began to roll out IVMS, initially in 20 vehicles, with the goal of reducing the risk of roll-overs within their fleet, meeting Chain of Responsibility obligations and reducing insurance liability.

IVMS Selection

A range of IVMS solutions were available to Borg's, from basic 'plug and play' solutions through to real-time monitoring of driver behaviour, fatigue and engine and performance. Borg selected a solution at the upper medium end of the spectrum shown by Frost & Sullivan.



The Borg's required a solution that could measure proven leading safety indicators in order to identify at risk drivers and provide opportunities for coaching and improvement. Their requirements included:

- Evidentiary standard driver identification
- Accurate measurement of elevated g-force events (braking and cornering)
- Speed zone geo-fencing for state forest roads and high-risk routes,
- In cab audible alerts to inform drivers when an adverse event had occurred, and
- Forward and in-cab facing cameras that would record adverse events.

The last requirement, initially quite contentious, not only improved driver coaching but has also served to support driver's explanation of on road incidents and had become an invaluable tool for managers and drivers alike.

Supporting Safe Driver Behaviour

As well as supplying the IVMS solution, MiX Telematics also worked with Borg to develop an organisational model would support a change in driving behaviour and the acceptance of IVMS by drivers. This model consisted of:

- An organisational policies and culture that supports safe drivers
- Peer networks that encourage safe driving and discourage dangerous behaviour
- Supervisors who are able to interpret IVMS data, provide meaningful feedback and examples to drivers and an evidence based pathway to improvement, and
- Individual drivers who feel that they have the support and skills to driver in as safe a manner as possible and will be rewarded for their efforts.

This program included an increased headcount in the driver safety team and the daily interrogation of adverse events and corresponding video footage.

Results

In January 2015 IVMS was installed in 20 vehicles and units were programmed not to sound in-cab alerts if an adverse event occurred. During that month Borg vehicles travelled in the region 120,000km, with nearly 15 hours 'over-speed' (in excess of 103km/hr).

In the six months after the activation of in-cab alerts and the implementation of their driver improvement program, Borg's had experienced a reduction of over-speeding to less than four hours for nearly 400,000km travelled!

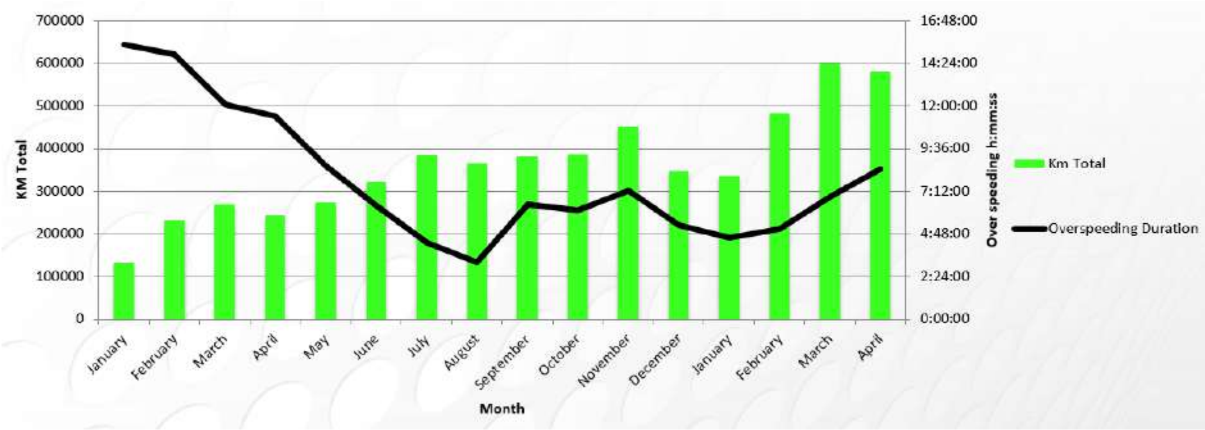


Table 1. Comparison of over-speeding events with kilometers travelled

Conclusion

As Borg's have developed their driver improvement program and increased the number of vehicles in their fleet equipped with IVMS they have continued to see a reduction in their safe driving leading (over-speeding) and lagging (crashes) indicators and are well on their way to achieving their stated goals.

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The Transport for New South Wales FleetCAT (Fleet Collision Avoidance Technology) Trial: Drivers Attitudes to the Technology

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Abstract

In 2015, Transport for New South Wales undertook a trial of collision avoidance technology in a fleet of 34 vehicles across three government departments for a period of seven months. The technology assessed was the Mobileye 560 CAT system, which provides Headway Monitoring, Forward Collision, Lane Departure and Pedestrian Collision Warnings using both audio and visual alerts. As part of the trial, drivers using vehicles fitted with the system were invited to complete an on-line questionnaire about their experiences with, and attitude to, the system. One hundred and twenty two drivers completed the questionnaire (out of the total 199 individuals who drove the vehicles). In general, the surveyed drivers recognised that the system could improve safety but most did not wish to use the system in future themselves as they found it distracting and felt that it would not prevent them from having a crash.

Background.

Recent years have seen the development of a variety of active in-vehicle safety technologies, which have been designed to reduce the likelihood of a crash occurring. Some of these technologies involve the provision of warnings given to the driver when the system detects the possibility of a collision unless the vehicle's speed or position is altered through driver intervention.

In 2015, Transport for New South Wales undertook a trial of collision avoidance technology (CAT) in which a system was installed in a sample of 34 government fleet vehicles for a period of seven months. The technology assessed was the Mobileye system, which provides auditory and visual warnings to the driver in four situations: (1) insufficient headway to the vehicle ahead, (2) risk of a forward collision, (3) lane departure without the activation of an indicator, and (4) risk of a pedestrian collision. The system is advisory only, requiring intervention by the driver in response to the warnings. The intention of the trial was to determine whether this technology could improve the driving behaviour and safety of government fleet vehicle drivers and whether it may, therefore, be of benefit if introduced more widely in the state's general vehicle fleet.

For vehicle safety technology to be successfully implemented, it has been argued that there has to be a high level of acceptance[1] of it by the drivers who use it (Bordel et al., 2014; Regan, Stevens, and Horberry, 2014). If a technology is unpopular with drivers, they will not use it and vehicle manufacturers will not wish to install it in their vehicles. Moreover, for technologies (such as warning systems) that will only be effective if they elicit appropriate responses from drivers, it is imperative that users' experiences and interactions with the technology are examined carefully. For example, users may come to disregard the warnings, or may find them more distracting than useful. As a result, the technology will not deliver the intended road safety benefits (Regan et al., 2014). Consequently, government employees who drove the vehicles that were fitted with the technology were asked to complete a questionnaire on their experiences of, and attitudes to, the Mobileye

[1] The extent to which drivers approve of a technology after using it is called its 'acceptance', as distinct from their approval of the idea of a technology before trying it, which is called its 'acceptability' (see Adell, Varhelyi, and Horberry, 2014).

system. The present study examined the questionnaire data to determine whether the drivers accepted the technology and whether they thought that it improved their driving.

Methods.

Participants

The Mobileye systems were trialled in the pool fleet vehicles of three NSW government departments: Transport for NSW, NSW State Emergency Services and NSW Public Works. Therefore, the participants for this research were any employees of these three departments who drove the fleet vehicles during the trial period. As per the regulations of the NSW government for driving fleet vehicles, the participants were required to hold a driver's licence for a car (class C licence, entitling a person to drive non-commercial motor vehicles not exceeding 4,500kg). The total sample of individuals who drove the fleet vehicles was 199, while the total sample of those who completed the questionnaire was 122 (a response rate of 61%). Personal background information relating to the participants was not collected, as Workplace Surveillance Laws required that this information remain confidential so that individual participants could not be personally identified. As a result, it was not possible to compare the drivers who completed the questionnaire to those who did not to determine whether they differed demographically.

Materials

Collision Avoidance Technology

Thirty-four vehicles were retrofitted with Mobileye 560 CAT Warning Systems. The Mobileye system uses a forward facing digital camera located on the front windscreen and a specially designed processor to calculate dynamic distances between the vehicle and relevant road objects (i.e. car, cyclist, pedestrian, lane markings). These calculations form the basis for the provision of Forward Collision Warnings (FCW), Headway Monitoring Warnings (HMW), Pedestrian Collision Warnings (PCW), and Lane Departure Warnings (LDW). These warnings are given to the driver using visual and audio alerts on a small display unit. The nature of the alerts are explained below:

- FCW – the visual alert is a red symbol of a car and a measure of headway distance in time (seconds). The headway distance is the number of seconds it would take for the vehicle to reach the current position of the relevant road object (e.g. another vehicle). The audio alert is a loud tone. The system alerts the driver up to 2.7 seconds before a collision occurs.
- HMW – the visual alert is either a green symbol of a car and a measure of headway distance in time (seconds) or a red symbol of a car and the headway distance when the time is 0.6 seconds or less. The audio alert tone increases in volume as the headway distance decreases. Alerts are provided when the headway distance is equal or below a pre-determined level.
- PCW – the visual alert is a red symbol of a person. The audio alert is a loud tone. The system alerts the driver up to two seconds before a collision occurs.
- LDW – the visual alert is a broken white line on the side of the display that corresponds to the left or right side of the lane that the vehicle has departed. The audio alert is a loud tone. An alert is provided when the vehicle crosses over the left or right lane markings.

FleetCAT Driver Questionnaire

The development of the FleetCAT Driver Questionnaire, including many of the items and scales that were used, was informed by two previous studies by Barnes and Johnson (2010) and Cuenca et al. (2010). Both studies evaluated the attitudes and opinions of New South Wales drivers of non-government private company fleet vehicles and privately owned vehicles involved in a trial of Intelligent Speed Adaptation (ISA) technology. This evaluation of ISA had similar objectives to the current study, namely to examine the acceptance, benefits and concerns about the technology. Therefore, many of the items were applicable to the current project, although the wording usually had to be altered slightly. The current questionnaire was also informed by the constructs that Regan, Mitsopoulos, Haworth, and Young (2002) used to define user acceptance of driver assistance systems, including: usefulness, ease of use, effectiveness, affordability and social acceptability.

The questionnaire was divided into five sections. The *Driver Comfort/Awareness of the Mobileye System* section required participants to indicate whether the Mobileye system bothered or distracted them (four-point scale: from ‘strongly disagree’ to ‘strongly agree’). The *Warnings* section contained questions about the visual and auditory warnings, such as whether the participants understood what they meant, whether they ignored them and whether they received false warnings (five-point scale: ‘never’ to ‘always’); whether the warnings attracted their attention and whether they adjusted their driving to avoid the warnings (four-point scale: from ‘strongly disagree’ to ‘strongly agree’); and whether the warnings had made them more aware of the driving events (e.g. lane departure without indication) that caused them (five-point scale: from ‘strongly disagree’ to ‘strongly agree’). The *Perceived Benefits* section sought information on whether the participants thought the Mobileye system would prevent them having a crash and whether it made them feel safer (four-point scale: from ‘not at all’ to ‘very much’); and whether they thought it could lead to an overall reduction in crashes and whether their driving had improved since using the system (five-point scale: from ‘strongly disagree’ to ‘strongly agree’). The *Acceptance* section asked whether the participants thought all new vehicles should have Mobileye in them (scale from 0 to 10: ‘not at all support’ to ‘totally support’) and whether they would like to own a vehicle with Mobileye (scale from 0 to 10: ‘not interested at all’ to ‘very interested’). The final section asked about the participants’ *Overall Experience with the Mobileye System*, including whether it was useful, accurate and user friendly (four-point scale: from ‘strongly disagree’ to ‘strongly agree’); how they would rate its overall performance, usability, functionality and acceptability (scale from 0 to 10: ‘very poor’ to ‘excellent’); and whether they thought there were any problems with it (open response field). Care was taken to keep the questionnaire to a reasonable length to ensure participants remained engaged and co-operative, and to maximise the completion rate. It took approximately 20 minutes to complete.

Procedure

FleetCAT Trial

Drivers were assured that their confidentiality would be protected throughout the trial. They drove the vehicles as part of their normal daily work routine. The trial was run in three stages: Baseline (Stage 1), Active (Stage 2), and Silent (Stage 3). In Stage 1 (three months), warnings and events were logged by the system but were not conveyed to the driver either audibly or visually. This phase represented a baseline indication of typical driver behaviour before the introduction of the warning system. In Stage 2 (three months), the Mobileye system was active and drivers received audible and visual alerts warning them of potential forward collisions, reduced headway, lane departures or pedestrian collisions. It was anticipated that this stage would result in gradual changes in driving behaviour from baseline, as drivers recognised the risks in their standard driving behaviours. In Stage 3 (one month), the alerts were again switched off, which allowed for determination of whether any identified behaviour changes between Stages 1 and 2 in response to the warning system had been maintained despite the absence of further warnings. In other words, the data collected in Stage 3 allowed for determination of whether experience with the warning system had resulted in a sustained alteration of driving behaviour or whether any changes in behaviour had regressed to the baseline. The objective driving data collected in the trial (i.e. FCWs, HMWs, PCWs and LDWs logged by the system) will be examined in future research.

FleetCAT Driver Survey

The questionnaire was completed by the fleet drivers online through the Survey Monkey website (https://www.surveymonkey.net). Emails with a link to the questionnaire were sent to the drivers in December 2015. This directly followed the end of Stage 2 of the project, during which alerts were given to the drivers, in late November 2015. Timely delivery of the survey soon after the end of Stage 2 ensured that the experience of the Mobileye system alerts was fresh in the minds of the participants. They were sent a $20 fuel voucher to thank them for their involvement in the project.

Results.

Driver Comfort/Awareness of the Mobileye System

Generally, the respondents were not comfortable with the Mobileye system in the vehicles. Table 1 shows that 60% reported that it 'bothered' them, 67% reported that it 'distracted' them, and 55% reported that it 'is distracting because the warning tones are too loud'.

Table 1. Drivers' agreement (percentages of participants) with statements relating to their comfort with the Mobileye system in the vehicles

	Strongly disagree %	Disagree %	Agree %	Strongly agree %
The Mobileye system bothered me.	5.1	35.0	41.0	18.8
The Mobileye system tended to distract me.	2.6	30.8	42.7	23.9
The Mobileye system is distracting because the warning tones are too loud.	2.6	42.7	30.8	23.9

Warnings

Table 2 shows that there was ambiguity in interpreting the different warnings, with only 33% of respondents able to 'often' or 'always' judge what they meant. Seventy percent suggested that the warnings were 'sometimes', 'often' or 'always' false. Similarly, 76% reported that the warnings were 'never', 'rarely' or 'sometimes' justified. It is therefore not surprising that 70% reported 'sometimes', 'often' or 'always' ignoring the warnings.

Table 2. Responses (percentages of participants) to questions relating to the warnings provided by the Mobileye system

	Never %	Rarely %	Sometimes %	Often %	Always %
Could you judge what the different warnings meant?	5.5	16.5	45.0	27.5	5.5
How often did you experience any false alarms?	11.1	19.4	43.5	23.2	2.8
How often were the warnings justified (warned of real risk)?	10.1	35.8	30.3	21.1	2.8
How often did you ignore the warnings?	10.2	19.4	34.3	31.5	4.6

Furthermore, 58% of the respondents did not believe that the 'warnings were reliable and accurate' (see Table 3). Therefore, it is not surprising that 56% reported that they did not alter their 'driving style in order to avoid receiving warnings'. However, 91% reported that 'the warnings were effective at getting their attention'.

Table 3. Drivers' agreement (percentages of respondents) with statements relating to the warnings provided by the Mobileye system

	Strongly disagree %	**Disagree %**	**Agree %**	**Strongly agree %**
The warnings were reliable and accurate (the system provided warnings when it needed to).	13.3	45.1	38.9	2.7
The warnings were effective at getting my attention.	0.9	8.0	77.0	14.2
I altered my driving style in order to avoid receiving warnings.	8.0	47.8	40.7	3.5

Table 4 shows that the Mobileye system had not increased the participants' awareness of the risk of the driving events that generated the various warnings. In each case, a majority of respondents did not 'agree' or 'strongly agree' that they are now more aware of the event. The data in Table 4 were examined further by combining the number of responses for 'agree' and 'strongly agree'

Table 4. Drivers' agreement (percentages of respondents) with statements regarding awareness of the driving events that generate Mobileye warnings

Since having driven a vehicle with a Mobileye system, I am now more aware of…	**Strongly disagree %**	**Disagree %**	**No difference %**	**Agree %**	**Strongly agree %**
The risk of forward collisions.	17.0	17.9	39.3	23.2	2.7
Safe distances between my vehicle and vehicles in front of me.	14.4	16.2	37.8	25.2	6.3
Potential pedestrian collisions.	21.2	17.3	49.0	10.6	1.9
Unintentionally drifting out of my lane.	17.9	19.6	40.2	21.4	0.9

Perceived Benefits

Sixty-five percent of the respondents did not believe prior to using the system that it would actively stop them from having a crash and 48% did not feel at all safer driving a vehicle with the system in it (see Table 5). However, 80% responded with 'somewhat', 'reasonably' or 'very much' when asked about the extent to which the system could 'potentially help to avoid a crash'.

Table 5. Responses (percentages of respondents) to questions relating to driver safety as a result of the Mobileye system

	Not at all %	**Somewhat %**	**Reasonably %**	**Very much %**
Prior to using the Mobileye system, did you expect that it would actively stop you having a crash?	64.5	22.7	10.0	2.7
Do you feel safer driving a vehicle with a Mobileye system in it?	48.2	30.9	17.3	3.6
To what extent could the Mobileye system potentially help to avoid a crash?	19.8	49.5	23.4	7.2

The respondents were optimistic about the broader potential benefits of the Mobileye system. Table 6 shows that 59% ‘agreed’ or ‘strongly agreed’ that it ‘could lead to a reduction in the number of crashes’ and 54% ‘agreed’ or ‘strongly agreed’ that it helps drivers ‘to notice potential hazards sooner’. However, only 21% ‘agreed’ or ‘strongly agreed’ that they are now a safer driver.

Table 6. Drivers’ agreement (percentages of respondents) with statements relating to perceived benefits to driver safety as a result of the Mobileye system

	Strongly disagree %	Disagree %	No difference %	Agree %	Strongly agree %
The Mobileye system could lead to a reduction in the number of crashes.	8.0	9.7	23.0	54.9	4.4
The Mobileye system helps you to notice potential hazards sooner.	8.9	11.5	25.7	46.9	7.1
You are a safer driver because you have used the Mobileye system.	17.7	14.2	46.9	18.6	2.7

Acceptance

The respondents were accepting of the technology for general use, but were not as accepting of it for themselves. Figure 1 shows that slightly more of them ‘support policy that all new vehicles have Mobileye or similar technology installed in them’ than do not support it. However, fewer were interested ‘in owning a vehicle with Mobileye installed in it’ than not owning one (see Figure 2). The mean rating (4.89, SD = 3.28) of support for ‘policy that all new vehicles have Mobileye or similar technology installed in them’ was significantly higher that the mean rating (3.77, SD = 3.45) of interest ‘in owning a vehicle with Mobileye installed in it’ according to a paired samples t-test, $t(112) = 5.77$; $p < .001$.

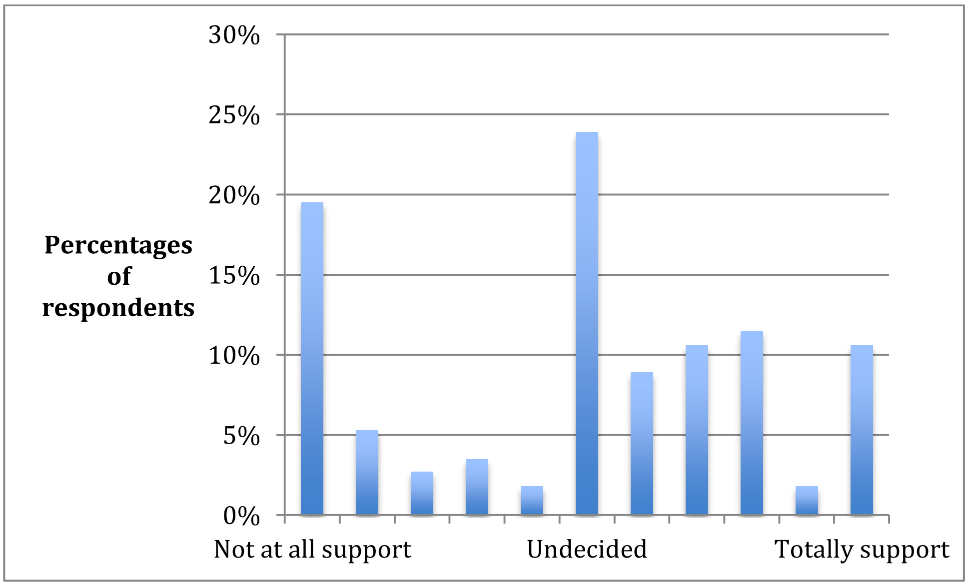

Figure 1. Driver’s support on a scale from 0 to 10 for policy that all new vehicles have Mobileye or similar technology in them

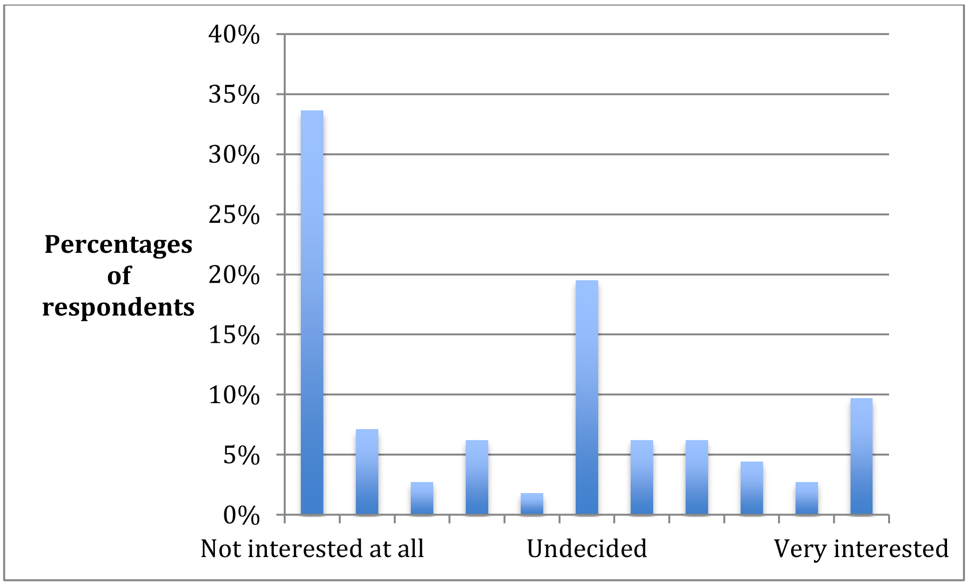

Figure 2. Drivers' interest (scale 0 to 10) in owning a vehicle with Mobileye in it

Overall Experience with the Mobileye System

The respondents were positive with regard to the use of Mobileye in general terms, with 64% 'agreeing' or 'strongly agreeing' that it 'is useful technology to have in a vehicle' and 53% 'agreeing' or 'strongly agreeing' that it 'is user friendly' (see Table 7). However, 67% 'disagreed' or 'strongly disagreed' that it 'has been of great use to them personally' and 53% 'disagreed' or 'strongly disagreed that it 'is reliable and accurate'. The positive view of the general application of Mobileye was again demonstrated in Figure 3, with 58% of the respondents rating 'the overall performance, usability and their acceptance of the system' as good.

Table 7. Drivers' agreement (percentages of respondents) with statements relating to their overall experience with Mobileye

	Strongly disagree %	Disagree %	Agree %	Strongly agree %
Mobileye is useful technology to have in a vehicle.	11.5	24.8	54.9	8.9
Mobileye has been of great use to me.	20.4	46.9	29.2	3.5
Mobileye is reliable and accurate.	18.6	34.5	43.4	3.5
Mobileye is user friendly.	16.8	30.1	47.8	5.3

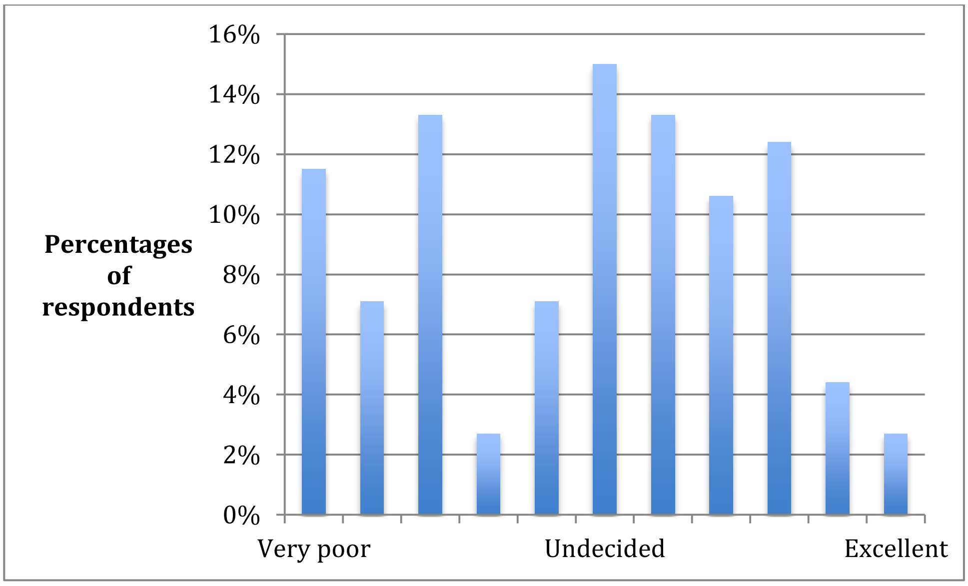

Figure 3. Drivers' ratings of the overall performance, usability and acceptance of Mobileye (scale 0 to 10)

Fifty-two percent of respondents encountered problems with the Mobileye system and 48% did not. They were asked to specify the problems and many related to: the distracting, and therefore potentially dangerous, nature of the audio and visual warnings and the difficulty to interpret them.

Discussion.

This survey of drivers involved in the Transport for New South Wales trial of Mobileye collision avoidance technology in government fleet vehicles examined their experience with, and attitudes to, the technology. The intention was to determine whether they accepted the technology so that it could potentially be introduced more widely into the general vehicle fleet and achieve the eventual objective of delivering road safety benefits. The predominant finding was that the drivers viewed the Mobileye system positively with regard to its general use for the wider public but were negative about its use specifically for themselves. For example, their support for policy that all new vehicles have Mobileye or similar technology installed in them was significantly higher than their interest in owning a vehicle with Mobileye in it. Furthermore, 64% of the respondents believed that it is useful technology to have in a vehicle and 59% reported that it could lead to a reduction in crashes. However, 67% did not believe that the system was of great use to them personally, 65% did not think that it would actively stop them having a crash, 48% did not feel at all safer driving a vehicle with Mobileye in it, 67% reported that it distracted them, and only 21% thought that they were a safer driver because they had used Mobileye. Also, most respondents did not believe that Mobileye had increased their awareness of the driving events that triggered the various warnings.

This finding could be an example of the psychological phenomenon commonly referred to as "Optimism Bias". This is where people consistently believe that negative events, such as involvement in a car crash, are less likely to happen to them than to others (Gouveia and Clarke, 2001; Klein and Helweg-Larsen, 2001; Sharot 2011; Shepperd, Carroll, Grace, and Terry, 2002; Weinstein 1980). It has been shown that people are more optimistically biased when they believe that they have more control over future events than others (Klein and Helweg-Larsen, 2001; Harris 1996). Consistent with this, it has been demonstrated that drivers tend to rate their own skills and ability more favourably than those of other drivers and believe that they are, therefore, at less risk of a crash (Freund, Colgrove, Burke, and McLeod, 2005; Gosselin, Gagnon, Stinchcombe, and Joanisse 2010; Harré, Foster, and O'Neill, 2005; Horswill, Sullivan, Lurie-Beck, and Smith 2013; Horswill, Waylen, and Tofield, 2004; White, Cunningham, and Titchener, 2011). Thus, the drivers who completed the current survey were likely to believe that they are at less risk of a crash than others, particularly if they perceived themselves as better drivers than other people.

Past research by Barnes and Johnson (2010) and Cuenca et al. (2010) surveyed NSW non-government fleet and private drivers involved in a trial of Intelligent Speed Adaptation (ISA) to determine the acceptance, benefits and concerns of this technology. Consistent with the Mobileye technology, the ISA technology was advisory only (i.e. provided warnings when the driver exceeded the speed limit and allowed them to decide on what action to take). Sixty-five percent of participants in these studies agreed that the ISA technology was of great use to them. However, 67% of the respondents in the current study disagreed that the collision avoidance technology was of great use to them. Therefore, it seems that the drivers in the ISA study viewed the application of ISA to their driving more positively than the drivers in the current research viewed the application of CAT to their driving. While this could be due to different samples, it could also be due to differences in the technology. ISA warnings may occur due to events that justify the warning for the driver (e.g. exceeding the speed limit). In comparison, some of the CAT warnings may be in response to actions that are necessary in certain situations (e.g. driving close to a vehicle when about to overtake). This may frustrate the drivers and make them view CAT less positively. It is also possible that ISA was viewed more favourably because it would reduce the likelihood of being caught speeding, while Mobileye had no such benefit. However, 54% of drivers believed that ISA had increased their frustration levels while driving, and they reported that ISA did not allow a leeway to travel a few kilometres over the speed limit and beeped as soon as the limit was reached.

Correspondence between the ISA research and the current study was demonstrated with the majority of respondents in each study agreeing that the technology would lead to a reduction in crashes, although the proportion of respondents was smaller in the current research (59% compared to 73%). Ratings of the overall performance, usability and acceptability of ISA and CAT were similar between the two studies, with 61% of respondents giving ISA a positive rating and 58% giving CAT a positive rating. Common concerns were noted in both studies, namely that both technologies could be distracting, frustrating and unreliable, and that the warnings were too loud.

Fifty-two percent of the respondents in the present study encountered problems using the Mobileye system. They reported that the system was distracting and annoying. Furthermore, it was often suggested that the distractions of the warnings made driving more dangerous because they took the drivers' focus away from the road. This represents a substantial limitation of the technology. However, Barnes and Johnson (2010) have discussed the notion that warnings have to be annoying in order to change behaviour. Consistent with this, 91% of the participants reported that the warnings were effective at getting their attention. However, only 44% reported that they had altered their driving style in order to avoid receiving warnings.

The respondents questioned the validity of the four warnings. Seventy percent suggested that the warnings were 'sometimes', 'often' or 'always' false, 76% reported that the warnings were 'never', 'rarely' or 'sometimes' justified, and 58% did not believe that the 'warnings were reliable and accurate'. If these reports accurately reflected a high rate of false alarms provided by the Mobileye system then this is another limitation of the technology and would explain why the technology bothered and distracted the participants. This would need to addressed to achieve greater acceptance of the technology. It may be possible to at least adjust the threshold settings of the Mobileye systems to reduce any warnings where the drivers do not perceive them to be necessary (e.g. headway monitoring warnings where they were driving close to a vehicle when about to overtake).

The sample was comprised of government employees. For confidentiality reasons, their demographic information could not be collected and, therefore, the sample could not be compared to the general public. As a result, the findings are not generalisable to the wider public. Future research could include a broader sample and examine whether CAT would be acceptable to the wider driving population. Also, the drivers of the fleet vehicles who completed the study could not be compared to those who did not. It is possible that certain drivers, or those with stronger attitudes towards the technology, would more readily complete the survey. A final limitation of this study relates to the use of self-report measures, which can be unreliable because participants may be innacurate in their recall of information. However, the survey was purposely delivered soon after the end of Stage 2 (during which alerts were given to the drivers), so that the experience of the Mobileye system was fresh in their memory.

Conclusion

The findings of this study demonstrate that a sample of drivers of government fleet vehicles viewed Mobileye Collision Avoidance Technology negatively with regard to its application to their own driving, despite viewing its wider application to the general community positively. They recognised that the system could improve general driving safety but most did not wish to use it in the future themselves as they found it distracting and felt that it would not prevent them from having a crash. It appears that more effort needs to be targeted at educating drivers about the potential benefits of this technology for their own driving. This could lead to greater acceptance of collision avoidance technologies and the capacity for governments and other organisations to deploy such technologies more widely in their fleets. This, in turn, could lead to greater penetration of collision avoidance technology within the overall vehicle fleet.

Acknowledgements

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Heavy vehicle driver acceptance of safety applications in a trial of CITS

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Abstract

The Cooperative Intelligent Transport Initiative is the first large-scale permanent deployment of Cooperative Intelligent Transport Systems (CITS) in Australia, and the only one in the world to focus on heavy vehicles. Sixty heavy vehicles and three traffic signals have been fitted with CITS. Participating drivers receive visual and auditory safety messages on an in-vehicle display. Messages include collision avoidance warnings and alerts when exceeding the heavy vehicle speed limit or approaching red traffic signals. In February 2016, qualitative research will be conducted to explore attitudes of participating heavy vehicle drivers towards the technology including acceptability, usability, benefits and concerns.

Background

Cooperative Intelligent Transport Systems (CITS) use Dedicated Short Range Communications (DSRC) to transmit information between vehicles and between vehicles and infrastructure. CITS increases the quality and reliability of information available to drivers about their immediate environment, other vehicles and road users by providing information that may not be directly visible. For example, it can alert drivers of a potential collision, weather or congestion. Anticipated benefits include improved road safety, increased network capacity, reduced congestion and lower vehicle operating costs. The technology is sometimes referred to as connected vehicles.

Transport for NSW has established Australia's first CITS testbed in the Illawarra region of NSW, known as the Cooperative Intelligent Transport Initiative (CITI). This is the world's first CITS testbed dedicated to heavy vehicles. It includes:

- 58 heavy vehicles equipped with CITS, including in-vehicle display of safety alerts
- 3 traffic signals equipped with CITS, broadcasting signal phase information to equipped vehicles
- 1 portable roadside unit broadcasting speed limit information to equipped vehicles
- 2 portable roadside units receiving and collecting data from equipped vehicles.

The CITS technology installed in the 60 heavy vehicles allows them to communicate with other equipped vehicles and with CITS-equipped infrastructure. Each heavy vehicle is fitted with a DSRC Radio and DSRC antennas, GPS and a 7-inch in-vehicle audiovisual display. Drivers receive the following messages: forward collision warning, intersection collision warning, heavy braking ahead alert, red signal phase alert and truck speed limit information. Over time, more alerts will be added.

Method

The 60 heavy vehicles and 150 drivers participating in the initiative are from three transport companies operating in the Illawarra. The vehicles operate 24 hours a day, 7 days a week. A comprehensive driver induction package was delivered to all drivers prior to the installation of the CITI device. Installation began in February 2015 and was completed in September 2015.

Transport for NSW has commissioned Ipsos Social Research Institute to undertake qualitative research to explore attitudes of participating drivers towards the CITI device including acceptability, usability, benefits and concerns. The research includes in-depth interviews with the fleet managers from each company and group discussions with heavy vehicle drivers. Key areas of exploration include past and current driving behaviour; driver understanding of the device and technology; feedback on device usage; and perceived impact on attitudes and behaviours.

Results

The results of the research are not available at the time of writing. They will be provided in the full submission.

Potential implications

The results of the research may influence changes to the design of the Human Machine Interface (HMI), including the frequency of alerts, visual display and audible sounds. The research may also inform the types of safety applications introduced in the next phase of the initiative.

The emergence of increased automation and driver assistance systems raises questions about the changing role of the driver. This research will add to our understanding on the potential impacts on driver behaviour and safety of providing visual and auditory warnings on an in-vehicle display.

Differences in drivers' perception and interactions with boom-controlled rail level crossings in urban versus rural environments

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Abstract

Efforts to improve rail level crossing (RLX) safety are hampered in part by the sheer number of RLXs; approximately 10,500 in Australia, with diverse characteristics. The plethora of RLX environments means a single standard RLX design may not be appropriate, since the same infrastructure could generate distinct interactions depending on its surrounding context. Using instrumented vehicles, we compared drivers' perceptions and interactions with boom-controlled active RLXs in two vastly different on-road environments: urban and rural. Results suggest that although urban RLX environments are more complex and demanding, drivers in rural areas are more likely to perceive RLXs as hazardous.

Background

RLXs continue to pose a substantial safety risk within road and rail networks. In Australia alone there are approximately 10,500 RLXs on public roads and paths (RISSB, 2014), which vary in both their infrastructure and the surrounding environment. Our previous research has revealed differences in drivers' behavior and expectations between crossings with different infrastructure when comparing actively-controlled crossings (i.e., boom barriers, lights and bells) to passively-controlled crossings (i.e., Stop or Give Way sign; Lenné et al., 2013; Salmon et al., 2013, 2014). However, the plethora of RLX environments means there may also be functional differences in crossings that have similar infrastructure with different surrounding context, e.g., in suburban Melbourne vs. regional Victoria (see Figure 1). The current study sought to empirically examine this by comparing driver behavior at boom-controlled RLXs that were embedded in either urban or rural driving routes.

North Road, Ormond Williamson Street, Bendigo

Figure 1. Examples of boom-controlled rail level crossings included in the urban (left) and rural (right) on-road study routes

Method

Forty-two participants drove a pre-specified test route in an instrumented vehicle, in either an urban or rural environment, while providing concurrent verbal protocols, which provide a measure of situation awareness. Eye and head movements were recorded, together with all vehicle parameters. Following the drive, participants completed structured interviews regarding two RLX encounters. Verbal protocol and post-drive interviews were audio recorded and then transcribed verbatim. Together these measures provided a range of objective (speed, stopping behavior, eye glances and head checks) and subjective data (situation awareness, decision-making strategies, etc.) to give a comprehensive assessment of driver behavior at RLXs.

Urban route

Twenty drivers (12 novices aged 18-22; 8 experienced aged 29-53) completed an 11km urban drive in the south-eastern suburbs of Melbourne. The route incorporated six active RLXs, which were all protected with boom barriers, lights and bells.

Rural route

Twenty-two drivers (11 novices aged 19-21; 11 experienced aged 33-55) completed a 30km drive in and around rural Bendigo. The route incorporated six active RLXs (five with boom barriers, lights and bells, one with lights and bells only) and four passive RLXs. To maximize comparability with urban RLXs, the current analysis included only the five boom-controlled RLXs.

Results and Conclusions

Drivers were significantly more likely to encounter a train at urban vs. rural RLXs, due to higher volume of trains on urban lines. Despite this, data across a range of measures suggest that rural drivers were more likely to view the RLXs as a safety threat: they were more likely to actively check for trains, even after noting that the signals were inactive, and expressed more safety-related concerns (e.g., possibility of signal failure, need to double-check to confirm no trains were approaching, and other potential dangers of RLXs).

In contrast, urban drivers showed more distributed situation awareness (Stanton et al., 2006), that is, they derived considerable information about the RLX situation from other road users (e.g. other drivers slowing or stopping) or from traffic signals (i.e., lights being active/inactive), and used this information to guide their decision-making without necessarily having to comprehensively assess the situation themselves (i.e. by making extensive visual checks). Drivers in urban areas were more likely to view RLXs primarily as a source of delays rather than a potential hazard.

The results highlight two important points. First, our findings reinforce previous research suggesting that drivers' perceptions of safety and threat potential are not necessarily aligned with objective data (e.g., Charlton et al., 2014). Second, these findings provide a reminder of the need to appropriately adapt infrastructure designs within local contexts, rather than assuming that solutions that function well in urban areas will exhibit equivalent performance on rural roads, and vice-versa. This is consistent with the existing Australian Level Crossing Assessment Model (ALCAM), which is used to identify risks and priorities for RLX upgrades, whereby local knowledge about the specific RLX is used to review the appropriateness of available treatment options. However, the current findings highlight the potential for additional customization when developing future treatment options; that is, that the diversity of local contexts should be used to develop new designs that are intended to capitalize on local knowledge, which in turn would permit for further optimization of the safety of RLXs.

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Anticipated Regret and Risky Driving: A Focus on Texting Behaviour

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Abstract

Numerous psychosocial factors have been identified in the prediction of texting while driving including attitudes, perceived norms and behavioural control. Less is known regarding the role of anticipated emotions, such as regret, which may be important and potentially modifiable influences on texting while driving. We conducted a survey of young drivers aged 17-24 years in the ACT and examined the role of anticipated emotions in sending/reading text messages while driving. Other variables, such as attitudes, norms and control were also measured. We present results regarding the influence of anticipated emotions on texting and implications for road safety messages.

Background, Method, Results and Conclusions

Many studies examining intentions to engage in risky behaviours, such as texting while driving, have employed the framework of the Theory of Planned Behaviour (TPB; Ajzen, 1991). This model proposes that behavioural intentions (such as intending to text while driving) are predicted by attitudes (how one feels about performing a behaviour), subjective norms (how one thinks significant others would feel about performing a behaviour) and perceived behavioural control (one's perceptions of how much control one has over performing a behaviour). While this model has been successfully applied to texting while driving (e.g., Nemme & White, 2010), it assumes rational cognitive and intentional decision making processes which may not apply to behaviours that are not premeditated. Likewise, this approach has been criticised for ignoring the role of affective variables. The TPB only provides a partial explanation of intentions to engage in risky driving behaviour. Importantly, variables such as attitudes, norms and perceived behavioural control may be resistant to change, providing obstacles for the design and delivery of relevant road safety messages (Koche, 2014).

The inclusion of anticipated emotions, such as anticipated regret, provides an opportunity to improve the explanation of texting while driving. These factors may be more readily modifiable than traditional TPB variables. Anticipated regret refers to prospective feelings and thoughts (often aversive) that influence decision making (Koche, 2014). It has been suggested that there are two types of anticipated regret, namely action and inaction regret. Anticipated action regret refers to the regret felt when thinking about performing an action (e.g., texting while driving) whereas anticipated inaction regret is related to not performing a behaviour (e.g., not answering a text while driving). Anticipated regret has been shown to influence health and safety decisions in a number of different domains, including road safety (see Koche, 2014, for a review). However, most studies involving anticipated regret and road safety have examined the role of anticipated regret in speeding (e.g., Elliott & Thomson, 2010). There is little research examining the role of anticipated regret in intentions to engage in texting while driving. One recent study (Gauld, Lewis & White, 2014) examined the role of anticipated regret on concealed texting behaviour. However this study only measured action regret and not inaction regret. This second form of anticipated regret is likely to be especially relevant to decisions made by young adults with respect to texting (e.g., regret at missing out on an important message) and provides a potential target for road safety messages. We will examine both action and inaction anticipated regret in the current study.

We present findings from a recent project supported by an NRMA ACT Road Safety Trust Grant. An online survey of drivers aged 17-24 years in the ACT region measured TPB variables as well as anticipated regret. The role of anticipated regret in the prediction of reading/sending text messages while driving will be investigated to determine whether this variable provides additional explanatory power, beyond measured TPB variables, in explaining texting intentions and behaviour. Implications for road safety messages will be discussed.

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Understanding driver distraction associated with specific behavioural interactions with in-vehicle and portable technologies

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Abstract

In-vehicle distraction contributes significantly to road trauma. Consequently, there is a need to understand the level of crash risk or performance degradation associated with driver engagement with in-vehicle technologies. This study had two aims: (a) to develop a driver distraction by technology taxonomy that links different technologies, their functions and the specific actions required of the driver when interacting with them, to crash risk and performance decrements; and (b) to identify any gaps in knowledge about crash risks involved in distracting engagements with in-vehicle technologies that could be explored in the future.

Background

In the Australian National Crash In-depth Study (Beanland, Fitzharris, Young, & Lenne, 2013), 57.6% of serious injury crashes involved driver inattention as a contibuting factor, and 16% involved distraction. Frequent sources of distraction were in-vehicle distractions such as interactions with passengers and mobile phones, which accounted for 20% of the distraction-related crashes. There is a need to understand the level of crash risk and performance degradation associated with driver engagement with in-vehicle technologies. To this end, VicRoads commissioned ARRB Group to:

(a) Develop a driver distraction by technology taxonomy that links different technologies, their functions and the specific actions required of the driver when interacting with them, to crash risk and performance decrements.

(b) Identify any gaps in knowledge about crash risks involved in distracting engagements with in-vehicle technologies that could be explored in the future.

Method

Using information gleaned from a literature review and a series of task-analyses, a driver distraction by technology taxonomy (in table form) was developed containing information pertaining to:

1. The technology and its function (e.g. mobile phone and text messaging).
2. The actions associated with the driver performing that function (e.g. writing versus reading a text message).
3. The sub-actions associated with the driver performing that function (e.g. manual writing of text-message versus voice activated production of text message).
4. The type of distraction associated with the driver performing that function (e.g. visual, cognitive, auditory and manual interference).
5. The driving performance decrements associated with the driver performing that function for the associated behaviours.
6. The crash risk associated with the driver performing that function for the associated behaviours (where available).

Results

An initial taxonomy was developed that links distraction-related driving behaviours with performance degradation and changes in crash risk for mobile phones (e.g. calls, texts and using social media), navigation, email and music systems, video screens, head mounted displays (e.g. texting with Google Glass) and head-up displays. For example, driver engagement with mobile phones (e.g. texting, checking social media) tended to be associated with a number of driving decrements (e.g. increased reaction time) and increased crash risk. One specific behaviour, conversing on a hands-free mobile phone, appeared to reduce crash risk, although it was associated with a number of driving performance decrements.

There was not enough research evidence to cover tablets, portable computers and other wearable technologies, such as the I-Watch in terms of crash risk. However, performance decrements are discussed for tablets and computers. Therefore the link between behaviour, performance and safety outcomes could not be discerned for all technologies and their associated functions.

Discussion and conclusions

The aim of this project was to attempt to discern, from a literature review and task analysis, driving behaviours associated with the use of modern in-vehicle and portable technology, and their associated driving performance and safety outcomes. Development of the taxonomy highlighted gaps in knowledge and suggested avenues for future research to assist in developing countermeasures for distraction- related behaviours.

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Off the beaten track: situation awareness in experienced and novice off-road drivers

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Abstract

Off-road driving describes a driving task undertaken on a surface other than an engineered durable roadway surface such as concrete or asphalt. This may include activities such as driving on beaches, dirt roads, or traversing open country with no designated roadways. It is both a popular pastime and a necessary undertaking for drivers worldwide. Indeed it is conservatively estimated that globally more than 50% of government controlled and managed roadways are unsealed. As with conventional driving, crashes and fatalities occur in off-road driving. Despite this, the study of these common driving environments has been limited (Stevens & Salmon, 2016). A notable aspect of recent fatal crashes in beach driving has been the identified role of inexperienced drivers in causing the crash. This paper presents the results of an exploratory off-road naturalistic driving study which utilised Verbal Protocol Analysis to assess situation awareness in novice and expert drivers. The findings revealed important differences between the novice and expert drivers relating to the information used, the strategies adopted, and the general driving approach. The implications for off-road driving such as beach driving are discussed.

Background

Off road driving, such as on beaches, is a unique driving task. Its description encompasses both recreational and purposive driving on private and public unsealed roadways. These roadway environments often present as loose surfaces which may require specialised vehicles including four wheel drives (4WDs). As such it is a driving task that requires distinct skills to minimise the associated risks of wheel slippage; obstacle avoidance and immobility resulting from the surface inconsistency (Stevens & Salmon, 2016). Perhaps unsurprisingly, off-road driving environments experience fatal crashes. For example, in 2009 three foreign tourists were killed on Fraser Island (K'gari) as a result of two independent motor vehicle rollovers that occurred in April and December. All three of the fatalities were passengers in 4WD vehicles being driven by a fellow tourist, driving in sand for the first time.

Despite this, the factors underpinning off-road crashes remain largely unexplored. Two such factors are the level of off-road driving experience and situation awareness. Whilst both have been identified as key causal factors in beach driving crashes (Stevens & Salmon, 2016), to date there has been no research examining the impact of experience on driver situation awareness and behaviour in beach driving environments. This paper is a response to this, presenting the findings from an exploratory study which aimed to assess, naturalistically, novice and expert beach driver situation awareness.

Method

This exploratory study used a semi-naturalistic on-road study method incorporating Verbal Protocol Analysis (VPA) to capture the thought processes of a novice and experienced off road driver whilst driving in two off-road environments. VPA (Ericsson & Simon, 1993) involves participants providing concurrent verbal protocols during task performance (e.g. Banks et al., 2014). The transcripts can then be analysed to examine situation awareness (e.g. Salmon et al., 2014). The approach has been used in many areas and is recently becoming popular in studies of driver behaviour (e.g. Banks et al., 2014; Salmon et al., 2014; Young et al., 2013; Walker et al., 2011). In the present study, participants (one novice and one experienced driver) undertook two off-road driving tasks on the world heritage listed Fraser Island (K'gari). The first was a 15km round trip on inland sand tracks, while the second was a 15km drive on the beach of K'gari. The vehicle for the study was a 4WD fitted with four on-board cameras. These cameras captured; the drivers view of the road; the view from the rear of the vehicle; the driver from front-on (audio equipped); and the driver from over the shoulder – revealing the instrument panel; driver gestures and interactions with the vehicle controls.

The verbal transcripts were analysed using the Leximancer content analysis software tool. Leximancer identifies themes, concepts and the relationships by using algorithms and by focussing on features within the transcripts such as word proximity, quantity and salience. The output is a network representing concepts and the relationships between them reflected within the verbalisations (e.g. 'car' has 'speed', 'water' is 'hazard'). Leximancer has previously been used for situation awareness network construction (e.g. Salmon et al., 2014; Walker et al., 2011) and is especially important to analyses of this kind since it provides a reliable, repeatable process for constructing situation awareness networks. The resultant networks were then examined to identify differences in situation awareness between the novice and experienced driver.

Results and Discussion

The situation awareness networks (to be presented in the full conference paper) provide some important conclusions regarding the differences between novice and experienced beach driver situation awareness and indeed the beach driving task. First, the information used by both drivers was markedly different, both in terms of the information itself and the amount of information used. Importantly a number of these difference appear to introduce risks for the novice drivers. Second, a significant portion of the information being used is not related to the primary task of driving and is potentially distracting (e.g. information relating to wildlife, creeks, pedestrian users of the beach). Third and finally, the situation awareness networks show significant differences between those identified previously in studies of on-road driving (e.g. Salmon et al., 2014). This provides further evidence that treatment of beach driving environments as a gazetted road, and the adoption of conventional road safety measures, may not be appropriate.

In closing the practical implications for improving safety in beach driving environments are discussed. In particular, interventions around education, training, 'road' design, and licensing are outlined.

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Who Rules the Road? Pedestrian Road Rules Assessment in Victoria

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Abstract

The 942 “older” pedestrian crashes that occurred in Victoria from 1 July 2009 to 30 June 2014, indicate that there is an issue that needs to be addressed.

Would a consistent requirement for vehicles to give way to pedestrians at non-signalised intersections increase road safety and eliminate current road user confusion about when drivers are or are not required to give way to pedestrians?

A risk assessment of such a requirement indicates that in Victoria a number of road rules would need amendments, yet it is not clear that changes to these road rules would not introduce new risks.

Background

Nieuwesteeg & McIntyre (2010) surveyed pedestrians in Victoria injured in 40, 50 and 60 km/h speed zones. They explored the crash circumstances and pre-crash behaviour from the perspective of pedestrians. Key insights include:

* Injured pedestrians are usually not at fault when crossing at intersections, but mostly at fault when crossing the road mid-block.

* They are usually injured in familiar locations while on routine journeys.

* A particularly problematic interaction is that of a vehicle turning right at an intersection, failing to give way to a crossing pedestrian.

Legislative provisions about giving way to pedestrians are inconsistent – for example, a vehicle turning from a continuing road into a terminating side street is required to give way to pedestrians crossing the terminating road; however, if the driver is turning from the terminating road into the continuing road, the driver is not required to give way to pedestrians crossing the terminating road. This could result in a pedestrian being able to cross one half of a side street, yet needing to stop halfway and give way to a vehicle on the other half of the side street.

Accordingly it has been suggested that a consistent requirement for vehicles to give way to pedestrians at non-signalised intersections could increase road safety and eliminate current road user confusion about when drivers are or are not required to give way to pedestrians

This assumption was examined by undertaking a scenario-based risk assessment.

Risk Assessment

To study the possible impacts of requiring all vehicles to give way to pedestrians at non-signalised intersections, the risks were estimated for ten scenarios:

1. Four way intersections
2. T intersections
3. Left-turn slip lane

4. Multiple lane side road approach – a T intersection with separate right and left turning lanes for traffic from terminating road into the continuing road
5. Channelised right turn lane on a continuing road
6. Seagull intersection – a T intersection with channelised lanes on the continuing road for traffic turning right, both into and out of the continuing road.
7. Shared off-road pathway
8. Off-road bicycle pathway
9. Bus bays
10. Left in – Left out intersections – a T intersection with the exit of the terminating road angled so as to facilitate left turns and to prohibit right turns.

The risks were estimated using the risk matrix method of the 2006 Austroads Guide to Road Safety (Turner et al., 2006) which is based on the Australian risk management standard AS/NZS 4360 that subsequently became the international risk management standard ISO 31000. The results of the risk assessment indicate that some of the risks to either driver, vehicle or pedestrian may not be negligible.

Conclusions

Other Australian States also have problems with pedestrians and motor vehicles (King et al., 2009). All Australian States and Territories operate with the same road rules as Victoria in relation to pedestrian priority in relation to: turning at intersections; U-turning; Giving way to a pedestrian at or near a Stop Sign or Stop Line; Giving way to a pedestrian at or near a Give-Way Sign or Give-Way Line; Slip lanes.

There should be a full study of the risk treatments needed to ensure that the risk of the relevant scenarios are at a level of medium or lower. If such risk reduction is not possible then solutions other than legislation – such as infrastructure, enforcement or education – should be sought.

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The Safe System Hierarchy of Control Framework for Local Roads

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ARRB Group

Abstract

There remains a significant gap amongst practitioners between understanding and application of the Safe System approach, particularly on local government road networks.

The reasons for this are as complex as they are diverse, but a key deficiency is a lack of a structured framework that guides practitioners through the thought process of analysing, evaluating and determining the opportunities for developing Safe System solutions to managing their road safety risk.

This paper will outline a framework designed to assist practitioners apply the Safe System approach to their road networks and then allow them to communicate the outcomes to a diverse audience of technical, management, community and elected representatives.

Why A Safe System Hierarchy of Control Framework?

Overview

For over 10 years the Safe System approach to road safety has presented a simple, clear and readily accepted theory for improving road safety. It has been adopted in national and jurisdictional road safety strategies across Australia and New Zealand and is a framework that has many and varied potential applications for informing and improving road safety. As a framework it has been actively promoted to local government as an important means of dealing with their disproportionate contribution to road trauma in both countries.

But local government, as a road manager of over 80% of the Australian public road network, seems not to have embraced Safe System principles to the full extent that they could. The reasons for this are often put down to a lack of funding being available to upgrade local road networks to implement best practice (Safe System) measures.

This response perhaps reflects a lack of understanding of the core road safety issues that exist on local roads; it also indicates a misunderstanding of the diversity of potential opportunities available across a local council's area of responsibilities to apply Safe System principles to address their local road safety issues.

In turn, this can be put down in large part to a lack of effective local government focused Safe System information and readily accessible tools that assist council practitioners to evaluate road safety issues with a Safe System perspective and then guide them to develop responses through a Safe System lens.

Are local roads a safety concern?

It is too often the view amongst local government managers and elected officials that road safety is not a local government responsibility. Commonly it is believed that road safety rests with state and territory level agencies, typically in the form of more effective driver training, restricted licensing, and better targeted policing, or that federal and state governments should increase funding for black spot programs etc.

It is the case that local councils are the sole responsible entity for approximately 82% of the public roads in Australia, and a review of crash data indicates that 52% of casualty crashes and 40% of fatal crashes occur on these local council managed roads (Austroads 2010).

While initially this seems to suggest local roads are under-represented in casualty crashes, it is the case that they tend to carry a far smaller proportion of traffic in terms of vehicle kilometres travelled (VKT) as compared to state roads. Consequently, the relative risk of a casualty crash occurring on a local road is between 1.5 and 2.0 times that compared to state managed roads, and this can be even higher for certain types of roadways. For instance, there is over twice the risk of a casualty crash occurring on unsealed roads and more than three times the risk occurring on local streets, as compared to that on primary arterial roads (Austroads 2010).

The National Road Safety Strategy sets the target of a 30% reduction in the annual road crash fatalities and a 30% reduction in serious road crash injuries by the end of 2020 (Australian Transport Council 2011). If these targets are to be achieved then action to address crashes on local government managed roads is important, and core to this action is local government applying the Safe System approach to its road networks.

How Can Local Government Contribute?

The review of the National Road Safety Strategy 2011 – 2020 by Austroads (2015) reported agency and stakeholder feedback ‘that much more needs to be done within road and traffic authorities and particularly in relation to local government’, that there is ‘insufficient capacity within local government to fully implement the Safe Systems approach’ and that there is ‘the need to breach the significant gap between understanding and acceptance of the Safe Systems approach and the practical application of agreed safety principles’.

A considerable amount of information about the principles of the Safe System approach has been developed since it was adopted in Australia over 10 years ago. This material provides discussion and explanation about the theory, its core principles – human error, forgiving road environment, lower (speed) impact forces, limits of human tolerance, shared responsibility – the aspiration of zero death and serious injury on our roads, safe travel and the four (or five) pillars, etc.

But much of the action on the ground, particularly for local government, remains focused almost exclusively on road infrastructure, and in this, priorities tend to be primarily about fixing existing roads through black spot and road repair style funding programs. While these are an important and necessary part of delivering Safe System outcomes, they are overshadowing the many other areas that local government can contribute to achieving road safety objectives and are effectively creating this ‘significant gap’ referred to by Austroads (2015).

Local government is arguably the largest provider of new road infrastructure in Australia and every road user – drivers, passengers, cyclists and pedestrians – interact with local roads on a daily basis, since they will at the very least begin and end their journey on council managed road networks. New residential, commercial and industrial development necessitate the construction of new and upgraded infrastructure such as footpaths, cycleways, new and wider roads and intersections. Before any works begin a significant amount of land-use planning effort occurs with councils preparing and approving masterplans, development control plans, development applications and ultimately development consent.

Once built, local government must maintain this road infrastructure, repairing failures, renewing signs and linemarking and upgrading the traffic facilities to cater for the greater demand placed on the network due to development growth.

Since the early 1990's, road safety officers (RSOs) have been active road safety advocates within local councils. Their role has primarily been to develop road safety education and awareness at the local level, working collaboratively with police, local health services and their state road agencies. But RSOs are also able to work internally to council to create an awareness amongst town planners, asset managers, designer engineers, council management, the elected councillors, and school and community groups.

With the diverse and intimate involvement of local government in the day-to-day planning and management of local roads there is great opportunity to embed the Safe system approach into local councils in a fundamental and sustainable way. However, breaching the 'significant gap' between understanding, acceptance and practical application requires appropriate practitioner tools that capture the full range of measures on offer from the Safe System paradigm.

Developing a Safe System Framework for Practitioners

Overview

The Austroads project *ST1769 Safe System Roads for Local Government* was developed by ARRB Group for Austroads 'to develop a greater understanding of Safe System principles amongst local government practitioners and through this, increase application of the Safe System approach on local government-managed roads' (Austroads 2016a). The research report was published in April 2016 (see Figure 1) and is the culmination of a four-year project that reviewed the crash experience on local government roads across Australia and New Zealand. It also looked at cost effective treatments that may be considered relevant to council managed roads, and assessed how content of the Austroads guide series could be expanded and made more relevant to local government practitioners.

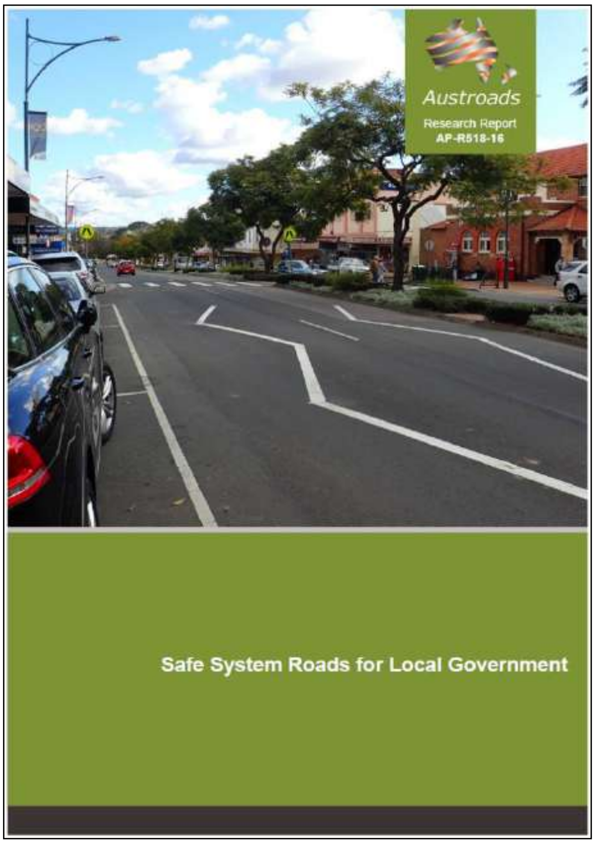

Figure 1. Safe System Roads for Local Government Austroads Report

The primary outcome of the project was the development of the Safe System Hierarchy of Control Framework (the Framework) as a means of gaining greater local government application of the approach to road safety.

The Framework combines the four Safe System pillars – Safe Roads, Safe Speeds, Safe People and Safe Vehicles – with the risk management hierarchy of control, a structure that is familiar to local government practitioners and regularly utilised as part of their workplace health and safety responsibilities.

The combination of these two safety approaches is designed to assist local government practitioners to assess road safety problems in the context of the Safe System approach, with particular attention given to each of the System pillars. This Framework is applicable to all manner of road safety problems, ranging from a general concern as perhaps raised by the community (e.g. traffic issues outside a school), to a developing road safety trend as perhaps identified through analysis of mass crash data (e.g. the local government area experiences a high proportion of single vehicle run-off road type crashes), and it can be used to evaluate a problem location, route or intersection that may have been raised via a road safety audit or a black spot analysis.

The intention of this approach is for the framework to place the Safe System approach readily in the forefront of practitioner thinking when analysing a road safety problem. It seeks to do this by providing a clear structure for evaluating potential measures to address road safety risk issues under each of the Safe system pillars and on the full treatment spectrum of removing (eliminating) the road safety hazard through to providing protection, education and awareness to road users who are exposed to it.

In this way, it aims to maximise the potential involvement of all areas of council in a multi-faceted solution.

For local government, consultation and communication is so often a fundamental element to any project or work outcome. This is particularly the case when dealing with road safety concerns, which the community might see or be exposed to on a daily basis. In this regard, the framework has been designed so that it can be used to clearly communicate the all the factors contributing to a road safety issue and to outline the options available for dealing with it across the full potential provided through the Safe System pillars and risk management approach.

The format of the Framework has been prepared so that it can be easily utilised within council's reporting processes via the Local Traffic Committee or as an attachment for main reports. The content and structure of the Framework is designed to promote discussion not only amongst and with council's technical road safety/road infrastructure staff, but also in reporting back to council managers, the community and the elected representatives.

Stepping through the Safe System Hierarchy of Control Framework

Safe System pillars

The Framework has the potential to be applied to the broadest of road safety issues that may be faced on local road networks, and it therefore intentionally references all four of the pillars currently represented in the Australian Safe System approach model – i.e. Safe Roads, Safe Speeds, Safe People and Safe Vehicles.

While some may hold the view that the Safe Vehicle pillar is of limited relevance to local government, it is important that no area of potential action and response under the Safe System approach be omitted from consideration. To omit any part of the Safe System approach, automatically places constraints on the possibilities available to councils to address a local issue, removing a potential partnership or community promotion etc., and with the advent of smart and driverless vehicle technology, it is only a matter of time before council roads will need to have embedded in them support for co-operative intelligent transport systems (CITS).

The Framework can also be added to, if required, in order to fit with changes that may occur over time. For instance, the United Nations Global Plan for the Decade of Action 2011 - 2020 promotes a fifth pillar – Post Crash Response. This fifth pillar is increasingly being included in discussions about the Safe System approach in Australia, and has application in many local government areas through their involvement in the local rural fire services/country fire authority (RFS/CFA) or volunteer rescue associations (VRAs) etc., which are often first responders to motor vehicle crashes.

Risk management and hierarchy of control

The starting position of any risk management response is, and should be, the elimination of a hazard or risk. Similar to the approach taken to include all Safe System pillars, the Framework does not seek to limit the consideration of potential measures in response to a road safety concern.

It is often the case that local communities and councillors seek from their council solutions that eliminate a road hazard. However, this call for action is often made without understanding the cost or practical implications. It is also the case that for many road safety problems complete removal of risk is not possible and so alternate measures, and the risk benefit they offer, need to be considered.

The Framework has adopted a hierarchy of control approach that is derived from the established and familiar structure outlined in the Austroads Guide to Road Safety *Part 7 Risk Management* (2006), and updated to apply the revised approach presented in AS/NZS ISO 31000:2009 *Risk Management* (Standards Australia, 2013). The outcome is the four-tier risk control hierarchy described in column 4 of Table 1, titled Road Safety Hierarchy of Control.

Table 1. Hierarchy of risk control

Hierarchy of Control level	Austroads (2006a)	IS0 31000:2009	Road safety Hierarchy of Control
1	Eliminate	Removing the risk source	Remove the risk
2	Substitute	Avoiding the risk by deciding not to start or continue with the activity that gives rise to the risk	Reduce the risk
	Isolate		
	Engineer		
3	Administration	Changing the likelihood	Change road user behaviour
4	Personal protective equipment	Changing the consequences	Protect the road user
		Taking or increasing the risk in order to pursue an opportunity	Not applicable
		Sharing the risk with another party or parties (including contracts and risk financing)	Not applicable
		Retaining the risk by informed decision	Not applicable

An explanation of each risk control level, along with examples of the types of countermeasures is given in Table 2. It is acknowledged the examples in Table 2 are by no means exhaustive and over time a greater range of non-engineering countermeasures covering all the Safe System pillars will be added to the library in the Road Safety Engineering Toolkit.

Table 2. Example risk mitigation actions under the hierarchy of control

Hierarchy	Risk control method	Effect of control	Example(1, 2)
1	Remove the risk	Remove the hazard from the road and traffic environment	• Remove a tree or utility pole from the roadside area • Grade separated pedestrian crossings • Fully separated cycleway.
2	Reduce the risk	Replace one hazard with another, less severe and more controllable, hazard Physically separate road users from the hazard to minimise road user interaction with it, or modify the design of the road infrastructure to reduce road user interaction with the hazard and/or assist road user control	• Road safety barrier • Roundabout (replacing priority controlled cross or T-intersection) • Wide median or verge area with or without a safety barrier • Traffic signal control pedestrian crossings • Off-road cycleway • Increase lane and sealed shoulder width • Improve delineation of the carriageway • Provide pedestrian crossing with refuge island • On-road cycleway and shared zones • Improve Australian New Car Assessment Program (ANCAP) rating of vehicle fleet.
3	Change road user behaviour	Provide warning/advice to seek appropriate behaviour	• Curve warning/speed advisory signs • Reduced speed limit and school zone alert signing • Vehicle safety features such as speed alerts, lane departure warning, blind-spot monitoring, etc. • Enforcement, education and training.
4	Protect the road user	Use equipment to protect road users from death/injury	• Seat belts, anti-lock braking system (ABS), electronic stability control (ESC), automatic emergency braking (AEB) • Pedestrian airbags and bonnet designs • Replace a rigid lighting pole with a frangible pole.

1 The examples listed are not exhaustive. A range is provided to help illustrate the Hierarchy of Control approach.
2 Examples do not necessarily fall exclusively into one category of risk control.

Source: ARRB Group.

Evaluating road safety issues and problem locations

At the centre of the Framework is the pro-forma evaluation and road safety assessment report, which is comprised of two parts. When applied, the two part essentially break the process into two assessment stages:

- Stage 1 - Site Crash Risk Safe System Analysis form (see Table 3).
- Stage 2 - Safe System Hierarchy of Control Assessment form (see Table 4).

Each of these stages of the assessment are briefly discussed below.

Site Crash Risk Safe System Analysis

The intention of the first stage of the assessment is to assist collating safety issue/site information, including photographs and sketches that aid understanding issues and constraints, to document (in terms of a road location) the current conditions that may be contributing to the road safety issue or crash risk, and perhaps most critically have the assessment team critically analyse the problem as it relates to each of the Safe system pillars.

Importantly, this stage does not involve identifying any possible actions, treatments or countermeasures.

Table 3. Pro-forma Site Crash Risk Safe System Analysis form

<table>
<tr><th colspan="2">Site description (provide an outline of the current site configuration, key features of construction, traffic management, etc.)</th></tr>
<tr><td colspan="2">• Provide an outline of the road and traffic arrangements at the site, covering the geometry, speed limit, signing, delineation, condition, roadside, etc.
• Describe road user interactions and limitations of infrastructure to provide for all road users.
• If available, summarise the crash history of the site (three and five years, FSI outcomes, top three crash types, dominant road/weather conditions, etc.).</td></tr>
<tr><td colspan="2">Crash risk identification (briefly summarise the crash experience and/or type of road safety issue/s at the site)</td></tr>
<tr><td colspan="2">Outline the road safety concerns that are present at the site; cross-reference crash data, road safety audit issues, observations of contributing behaviour from assessors, and how issues under the Safe System pillars might contribute to crashes or safety concerns.</td></tr>
<tr><td colspan="2">Safe System pillar analysis (identify hazards and road safety issues grouped under the relevant pillar)</td></tr>
<tr><td>Safe roads:
• What is it about the road that contributes to the safety concerns/problem?</td><td>Safe people:
• What is it about road users and their behaviour that contributes to the safety concerns/problem?</td></tr>
<tr><td>Safe speeds:
• What is it about the road speed environment that contributes to the safety concerns/problem and FSI severity of the crash?</td><td>Safe vehicles:
• What is it about the road/vehicle interaction that contributes to the safety concerns/problem?</td></tr>
<tr><td colspan="2">Site photographs (supplement the site description and problem definition using selected site photographs)</td></tr>
<tr><td>Provide a map or aerial image of the site/route.</td><td>Provide images that highlight safety concerns, illustrate crash locations.</td></tr>
</table>

Safe System Hierarchy of Control Assessment

The purpose of the second stage of the assessment is to collate the results of brainstorming potential countermeasure responses across all four (or five) of the Safe System pillars, and to assign the most likely level of risk control (mitigation) that each might achieve if adopted.

There is the potential in this process for more than one countermeasure to be available under each risk control level, which results in options being available for a treatment program.

Once the countermeasure described across the first three columns – crash type, cause/hazard and control method – the assessment team should identify which pillar (or pillars) are applicable to each identified countermeasure.

It is possible that a countermeasure may address actions for more than one pillar and this should be acknowledged by noting it accordingly on the assessment form as shown in the pro-forma presented in Table 4.

A strength of presenting the assessment in this manner is that it provides a simple and quite visually easy method for identifying potentially higher value options. Countermeasures listed higher in the risk control hierarchy and across more than one Safe system pillar, suggest a higher road safety value could be achieved by adopting that particular option.

Equally, measures listed lower along the risk control hierarchy and addressing just specific Safe System pillars, may initially suggest a lower road safety value. However, it can be quickly determined that these may actually highlight niche or specialist responses/actions by areas of council that are not traditionally seen as being involved as a road safety responder, e.g. the town planning, road asset managers, and community services areas.

Table 4. Pro-forma Safe System Hierarchy of Control assessment form

Crash type	Cause/hazard	Control method	Safe System pillars			
			Safe roads	Safe speeds	Safe people	Safe vehicles
Remove the risk						
Describe the particular type/s of road crashes under consideration.	Describe the contributing factors to the cause of the crash (or potential crash), or the type of hazard under consideration.	What mitigation measures could be adopted to remove the hazard, or the likelihood of the particular type of crash resulting in a fatal/serious injury outcome?	✓			✓
Reduce the risk						
Describe the particular type/s of road crashes under consideration.	Describe the contributing factors to the cause of the crash (or potential crash), or the type of hazard under consideration.	What range of control measures could be adopted to isolate/separate road users from the hazard, or the likelihood of the particular type of crash resulting in a fatal/serious injury outcome?	✓	✓	✓	
Change road user behaviour						
Describe the particular type/s of road crashes under consideration.	Describe the contributing factors to the cause of crashes (or potential crashes), or the type of hazard under consideration.	What type of control measures could be adopted to inform and warn road users about the hazard, or the likelihood of the particular crash type fatal/serious injury outcome?		✓	✓	
Protect the road user						
Describe the particular type/s of road crashes under consideration.	Description of the type of hazard or particular crash type under consideration.	What type of measures could be adopted to protect road users from the hazard, or the likelihood of the particular type of crash resulting in a fatal/serious injury outcome?			✓	✓

Note: The Safe System pillar checked with a tick is for illustrative purposes only.
Source: ARRB Group.

The Safe System Hierarchy of Control Framework is not intended to be the end of the road safety assessment process. Indeed, it should be considered just the beginning as it is designed to assist practitioners to collect their thoughts about a road safety hazard and the full range of potential countermeasure responses in a manner that reflects the Safe System structure.

Once this assessment is completed, it is then necessary to develop the potential countermeasures to a feasibility, concept or development/design stage, followed by an evaluation their cost benefit effectiveness to assist prioritising implementation within a road safety program. With this in place, the council will then need to seek appropriate funding, either from internal programs or other sources, including state and federal government agencies, or third parties such as grants via motor accident insurers or commercial sponsors etc.

Working with other guidelines and assessment tools

The Safe System Hierarchy of Control Framework is complemented by, and complements, other practitioner tools and advisory guides prepared by ARRB Group for Austroads. Of particular relevance to local government are the research reports Safe System in the Planning Process (Austroads 2015) and Safe System Assessment Framework (Austroads 2016b), see Figure 2. Each provides local government planners and engineers with guidance about the applying the Safe System approach to their areas of managing council road and traffic infrastructure. Of particular note is the Safe System Assessment Framework, which provides a formulaic approach to assessing the level of Safe System compliance of potential treatment measures.

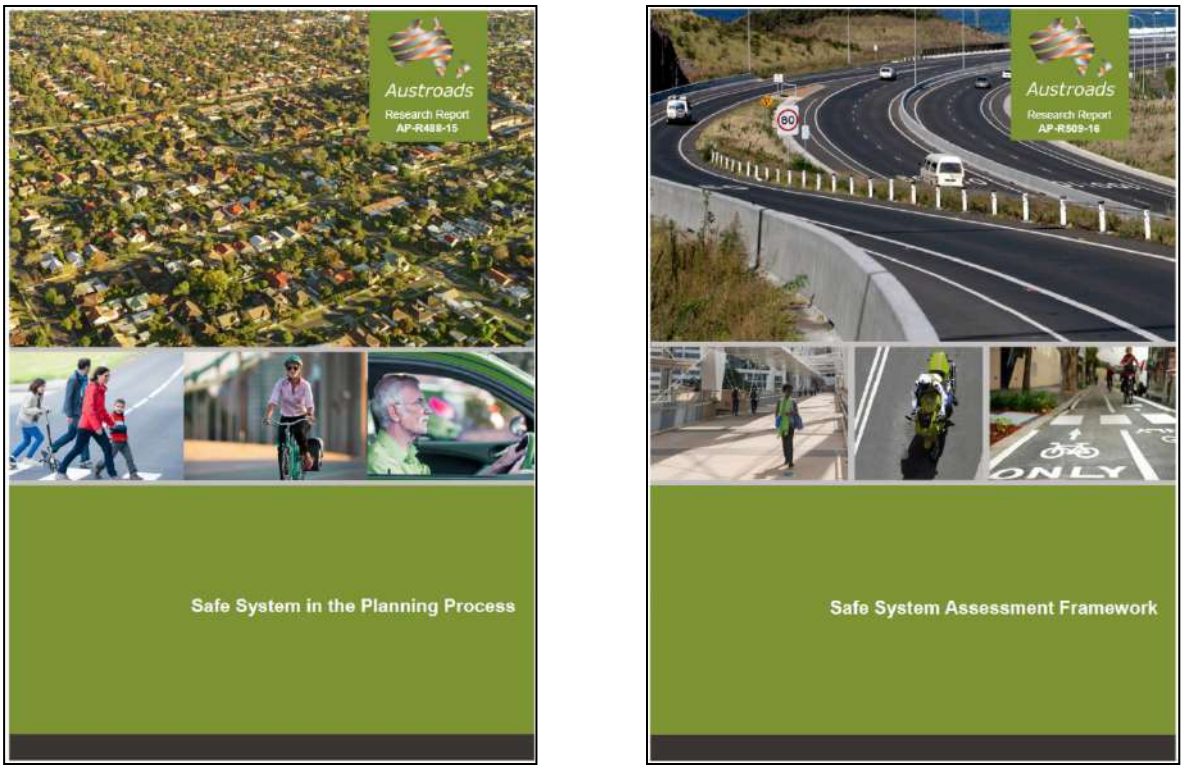

Figure 2. Companion Austroads Project Reports

Conclusion

The Austroads project *Safe System for Local Roads* (2016a) aligns well understood risk management principles with the Safe System pillars structure to provide a framework of analysis, evaluation, and application for local government.

The Safe System Hierarchy of Control Framework can be applied easily to locations with a documented crash history or just as readily to perceived and undefined road safety problems that are regularly brought to the attention of Council by the community and elected representatives.

The Framework seeks to establish Safe System thinking amongst practitioners rather than directing them to a more effective crash data and benefit cost analysis approach. The Framework is very much intended to be inserted into the early part of the whole road safety investigation process, working to provide a solid Safe Systems platform to later, more detailed assessments.

In this way, the Safe System Hierarchy of Control Framework is designed to first and foremost inform decision-makers of the range of options available to them via all the Safe System pillars, and to provide a clear indication of the level of effectiveness of each countermeasure to reduce the risk of fatal and serious injuries on their road network. Armed with this information, council managers, elected officials and the community can be shown what is required to remove a road safety risk, or how alternative solutions might reduce it, change road user behaviour or otherwise protect road users in a more cost effective manner.

Armed with the Safe System Hierarchy of Control Framework, local government practitioners across all areas of council – the engineers, the land-use planners, community services, councillors and community - are expected to be encouraged to have a greater involvement in road safety, and from this develop their own expertise in the Safe System approach.

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Standards Australia, 2013. Risk management guidelines (SA/SNZ HB 436:2013) – Companion to AS/NZS ISO 31000:2009. Sydney, Australia.

Estimating the value of contributions to community-level action for road safety

Andrea Smithson and Terri Anne Pettet
WA Local Government Assocation's RoadWise Program

Abstract

The WA Local Government Association (WALGA) RoadWise Program supports a state-wide network of groups and individuals involved in road safety. The Program has undertaken a study which sought to measure the in-kind and financial contributions made by the community road safety network. The results of the study have quantified the additional value that is leveraged from the State Government's investment in the Program. The results provide insight into the range of inputs that are made to the network across the state, which have enabled community participation in a shared responsibility approach to road safety.

Background

Community road safety programs are recognised for playing a role in generating the community support, partnerships and engagement that is central to achieving a safe road transport system. The Austroads Guide to Road Safety Part 4 (Cairney 2009, p.10) lists "mobilising resources to tackle road safety issues at a local level" as one of the four key objectives of community road safety.

The community road safety network (the network) in Western Australia (WA) consists of a wide range of individuals and organisations with an interest in working in a partnership approach to prevent or reduce death and serious injury from road crashes. With State Government funding (Road Trauma Trust Account and the State Road Funds to Local Government Agreement), the WALGA RoadWise Program supports the network by assisting local road safety committees; providing access to resources and training; and increasing road safety skills and knowledge, all of which contribute to building the capacity of the network to make an effective contribution to road safety in WA. This approach benefits the community by improving the reach of programs, and increasing the level of local participation, engagement and commitment to action (Liberato, Brimblecombe, Ritchie, Ferguson & Coveney, 2011).

The network has been built up since the establishment of RoadWise in 1994 and now reaches across remote, rural and urban areas of the state (see Appendix A). More than 4500 individuals, 61 RoadWise or local road safety committees and around 50 other groups with an interest in road safety are involved (as recorded in the RoadWise Network database as at 27 April 2016). The network participates in the planning and implementation of local road safety activities associated with programs, projects and campaigns aligned to the WA road safety strategy. In 2014-15, the year of this study, 983 local level road safety activities[1] were reported via the RoadWise network.

In addition to the funding that enables the delivery of the RoadWise Program, resources are generated and contributed through the network itself to enable these activities to take place. This includes the time contributed by individuals to plan and implement road safety activities; facilities and equipment provided by Local Government or State Government agencies; and sponsorship by local businesses.

It was recognised that this contribution, including both in-kind and financial support, was of significant value and important information that was not already captured or readily able to be

[1] The WALGA RoadWise Program recorded 983 road safety activities generated by the network as part of the RTTA quarterly reporting process 2014/15

reported. This study was undertaken to explore and quantify these contributions from the network, supported by the RoadWise Program, to enable local road safety activities to be planned and implemented.

Method

The challenge for this project was to develop a means of capturing the relevant information across 11 regions, each operating with a unique mix of characteristics and capacity for road safety. Work undertaken by ARRB for the Department of Infrastructure, Energy and Resources to value a Community Local Government Road Safety Partnership in Tasmania provided valuable background for this study (ARRB Group Ltd, 2014). The ARRB study provided particular guidance on the identification and valuing of the range of inputs (the resources required for the group to function) into a community road safety group.

The initials steps involved identifying the elements to be included. Broadly, the criteria was that the input must be assessed to be in support of the network, rather than as core business of the individual or agency involved. It was important not to include resources that are provided by the RoadWise Program as part of the State Government's direct funding allocation.

Data was collected retrospectively for a three month timeframe (1 February – 30 April 2015) by RoadWise Program staff in liaison with members of the network, and as follows:

- The number of paid and unpaid hours contributed by individuals within the network to:
    - Attend and participate in road safety meetings,
    - Plan road safety activities,
    - Implement road safety activities, and
    - Evaluate road safety activities.
- The in-kind and financial support provided for the following road safety activities in the network:
    - Meetings,
    - Events,
    - Presentations/workshops/seminars,
    - Displays/trailers, and
    - Media print articles.
- The level of direct financial support provided to road safety committees via budget allocations, local sponsorships, and/or grants;
- The level of hosting arrangements including:
    - Provision of office space for Regional Road Safety Advisors; and
    - Provision of storage space and maintenance for road safety display trailers.

The range of inputs into the network required extensive research in order to apply specific values to each item. The ARRB project outlined two broad approaches to valuing inputs:

- Market value method – which values the product or service according to the market value (when such a product or service is available commercially); and
- Direct costs method – which rely on documented costs (or estimates of costs) for items such as paid and unpaid time, kilometres travelled, etc. (ARRB Group Ltd, 2014)

This study utilises both methods, as appropriate, and applied the Regional Price Index to reflect regonal variation in the cost estimates (Department of Regional Development, 2013). The value of individual hours was calculated by using the position title for each individual to code into the major employment groups utilised by the ABS (Australian Bureau of Statistics, 2013). Using these groups, an average hourly rate (as calculated by the ABS) was applied, multiplied by 1.5 to estimate the additional costs such as leave, training etc (ARRB Group Ltd, 2014). For volunteers, the hourly rate of $32.53 was used as recommended by Volunteering WA (Volunteering WA, 2015). Detailed costs and relevant references can be found in Appendix B.

Results and Discussion

Summary of total contributions

The overall value of financial and in-kind contributions to road safety through the community road safety network in the three-month period from February – April 2015 was **$404,321**. Table 1 shows that the most significant inputs were in the form of individual hours (both paid and unpaid), and contributions to road safety activities.

Table 1. Total value of inputs, by activity type (Feb-Apr 2015)

Item	Value ($)	% of total
Individual hours	233,489	58%
Activities (events, meetings, displays, presentations, media)	129,998	32%
Financial contribution	26,875	7%
Hosting and storage	13,959	3%
TOTAL	**404,321**	**100%**

Almost half of the contributions to the network can be attributed to Local Government. Table 2 shows the value and percentage representation of the contribution from each organisation type. It should be noted that the private sector category includes the value of print media articles.

Table 2. Total value of inputs, by organisation type

Organisation	Value ($)	% of total
Local Government	198,159	49%
Private sector	101,714	25%
State Government	59,420	15%
Community group	23,392	6%
Non-government agency	13,860	3%
Other/combined	7776	2%
TOTAL	**404,321**	**100%**

The following sections explore the results in more detail.

Hours contributed to road safety by individuals

Data was collected on the number of hours contributed by individuals within the network during the reporting period; whether paid or unpaid; for the type of activity undertaken; and the type of organisation the individual was representing. The sample included in the study was limited to individuals who had taken part in network activities during the specified time period, giving a total of 681.

The total number of hours contributed to network activities in the period 1 February - 30 April 2015 was 4077 hours (an average of just under 6 hours per person in the sample), representing a value of $233,489. As outlined in Table 3, almost two thirds of the total hours were contributed by Local Government staff and elected members (2488 hours, 61%), followed by State Government agency employees (630 hours, 15%) and people from community groups (577 hours, 14%). Overall, just under three quarters of the hours contributed were paid hours (71%), with the remainder contributed as unpaid hours (29%).

Table 3. Hours contributed, by organisation type

Organisation type	**% of sample**	**Hours contributed**	**% of total hours contributed**	**Value of hours contributed ($)**	**Paid vs unpaid**
Local Government	48%	2488	61%	153,163	83% paid 17% unpaid
State Government	22%	630	15%	39,390	82% paid 18% unpaid
Community group	18%	577	14%	18,785	8% paid 92% unpaid
Non-government organisation	8%	213	5%	12,477	76% paid 24% unpaid
Private sector	5%	169	4%	9674	64% paid 36% unpaid
TOTAL	**100%**	**4077**	**100%**	**$233,489**	**71% paid 29% unpaid**

When considering the type of activity, as seen in Table 4, the majority of hours were spent planning road safety activities (1665 hours, 41%), followed by implementing road safety activities (1313 hours, 32%). Attending road safety meetings, to enable collaboration and coordination, made up a quarter of all hours contributed (1039 hours, 25%).

Table 4. Hours contributed, by activity type

Activity type	**Number of hours**	**% of total**	**Value of hours ($)**	**Paid vs unpaid**
Planning	1655	41%	104,066	82% paid 18% unpaid
Implementing	1313	32%	73,517	70% paid 30% unpaid
Attending meetings	1039	25%	52,938	56% paid 44% unpaid
Other	37	1%	1544	27% paid 73% unpaid
Evaluating	23	1%	1424	78% paid 12% unpaid
TOTAL	**4076**	**100%**	**$233,489**	**71% paid 29% unpaid**

Regional variations evident in the hours contributed are highlighted in Table 5. The Metro North region contributed the highest number of hours (1415 hours, 35% of the total), which may be attributable to the number of large, relatively well resourced Councils in that region, which in several cases employ their own specialist road safety staff and generate a large number of activities. By contrast, other regions encompass a small number of Local Governments (for example, there are four Local Governments in each of the Gascoyne, Kimberley and Pilbara regions), are vast in size and significantly smaller in population.

There are also noteworthy differences in the split between paid hours and unpaid hours, ranging from 100% paid hours in the Gascoyne and Pilbara regions, to a more even split in the Metro South, South West and Metro South regions. The Kimberley region recorded 100% volunteer hours during this period, however this is considered atypical and reflects the re-establishment of relationships after the Road Safety Advisor position had been vacant for some time.

Table 5. Hours contributed, by region

Region	% of sample	Hours contributed	% of total hours contributed	% paid	% unpaid
Gascoyne	1%	26	1%	100%	0%
Goldfields-Esperance	6%	271	7%	75%	25%
Great Southern	13%	419	10%	69%	31%
Kimberley	3%	23	1%	0%	100%
Metro North	10%	1415	35%	91%	9%
Metro South	10%	298	7%	50%	50%
Mid West	15%	392	10%	66%	34%
Pilbara	3%	111	3%	100%	0%
South West	10%	760	19%	45%	55%
Wheatbelt North	11%	201	5%	64%	35%
Wheatbelt South	19%	161	4%	65%	35%

Support for network activities

Data was collected on the financial and in-kind support provided for road safety activities including meetings, events, presentations/workshops, displays (including display and speed trailers) and print media. Each activity was broken down into separate elements for valuation (such as the provision of venues and catering; the chairing and administration of meetings; provision of event equipment; size of media articles) to capture the scope of contributions. This excludes hours contributed by individuals. The activities recorded for this study are only those that required a financial or in-kind contribution, therefore it is not an exhaustive list.

Using this methodology, the value of the financial and in-kind contributions to road safety network activities during the February – March 2015 period was $129,998, generated from the 191 activities that were implemented by the network with support from RoadWise. Table 6 provides a summary of the number and value of each activity type.

Table 6. Contribution to road safety activities, by activity type

Activity type	Number of activities	Value ($)	% of total
Media	42	81,284	63%
Events	47	21,484	16%
Meetings	76	15,708	12%
Displays	21	8613	7%
Presentations	5	2909	2%
TOTAL	**191**	**$129,998**	**100%**

Largely due to the value of media related activities, the majority of contributions were made by the private sector ($87,139; 67%), followed by Local Government ($23,372; 18%) (see Table 7).

Table 7. Contribution to road safety activities, by organisation type

Organisation type	Value ($)	% of total
Private sector	87,138	67%
Local Government	23,372	18%
Other	7776	6%
State Government	5822	4%
Community group	4607	4%
Non-government organisation	1283	1%
TOTAL	**$129,998**	**100%**

Direct financial contributions

In addition to the in-kind support provided for road safety activities in the network, there are a number of important direct financial contributions made to support road safety committees. For this study, data was collected on the financial contributions made in the reporting in terms of budget allocations to road safety committees, and grant funding awarded for road safety activity.

The value of the direct financial contributions for this period was $26,875. Just over half of this total ($13,600; 51%) was in the form of road safety grants awarded by the State Government, with the remainder from Local Government budget allocations to support road safety committees ($8375; 31%), and an RAC grant to fund road safety activities in the Goldfields-Esperance region ($4900; 19%).

Contributions to hosting and storage

Another important contribution to the road safety network is the support provided in the form of hosting and storage arrangements. Included in this study were the provision of office space for RoadWise Road Safety Advisors (RSA) as well as the storage and maintenance of display trailers. In five regions, RSAs are hosted within host Local Government offices. In six regions, Local Governments also provide storage space for road safety display trailers, which are a RoadWise resource available to the network.

The values allocated for these items were based on current market rates. Using this methodology, the value of the support provided for hosting and storage was valued at $13,958.

Limitations

The nature of this study meant that much of the data relied on the knowledge and judgement of the individual officers involved in collecting and reporting data. Given that these officers are involved and engaged with their networks on a daily basis, it is feasible to expect that the data entered would be reasonable and realistic. However, it is possible that some items have been under or over estimated. It should also be acknowleged that the validity of the study findings is reliant on the suitability of the methods used to calculate the market value or direct costs of each item.

Using a relatively short time period (three months) for the data reporting, while allowing for greater accuracy, means that there is the potential for regional variations to be overly emphasised. The level of activity in each region is determined by a range of factors, including other major regional events and local industry/agricultural activity (e.g. grain harvest). Fluctuations occur in the level of support from agencies, and their cycle of planning and implementing which in turn influences local activity. However, this three month cross sectional capture was considered reasonably representative of the activity of the Network.

Given the challenges in assigning a value to online social media (e.g. Facebook and Twitter) and the limited capture of regional and local media by WALGA’s media monitoring service, the economic value attributed to media was restricted to print media. It is therefore known that this study understates the value of media generated.

Conclusions

This study sought to explore and quantify the in-kind and financial contributions made by the community road safety network, supported by the RoadWise Program, to enable local road safety activities to be planned and implemented. This is the first time a study of this kind has been undertaken for the RoadWise Program, and has allowed the additional value leveraged from the State Government’s investment in the RoadWise Program to be quantified. The results also provide insight into the range of inputs that are made to the network, which facilitates the local level road safety activities that are integral to achieving positive road safety outcomes, across the state.

The total value of in-kind and financial contributions generated by the community road safety network in the three month period 1 February – 30 April 2015 was $404,321. On an annual basis, this represents a contribution of around $1.62 million. This is additional value leveraged from the $1.87 million support provided by the State Government to the RoadWise Program, through allocations from the Road Trauma Trust Account and State Road Funds to Local Government Agreement.

The more than 4000 hours contributed by individuals in the network during the study represents over 16,000 hours on an annual basis, which enabled the delivery of 983 road safety activities[2]. Local Government staff and Elected Members contributed 61% of all hours, and the sector contributed 49% of the value of contributions in total, which is an indication of the level of commitment and support by Local Governments to community road safety partnerships. The spread of contributions from other organisation types (State Government, Non-Government organisations, community groups and the private sector) suggests that community partnerships are effectively generating support for local road safety activity across all sectors. The contributions have come from metropolitan, regional and remote areas of WA, with differences between regions reflecting the varying levels of activity and capacity within each region.

[2] The WALGA RoadWise Program recorded 983 road safety activities generated by the network as part of the RTTA quarterly reporting process 2014/15

The findings of this study may provide important information for lead agencies and Governments in making road safety investment decisions. The results demonstrate that in addition to the social benefits associated with community road safety programs, the economic value of funding such programs can be almost doubled. For WALGA, this study has been useful in strengthening stakeholder relationships and the results have provided a catalyst to celebrate with and acknowledge the contribution of the community road safety network in working to reduce road deaths and serious injuries.

This study has demonstrated that by working in a collaborative, community partnership approach, the road safety network has mobilised substantial resources to deliver local road safety activities, aligned to the WA road safety strategy. The RoadWise Program plays an important role in this process by fostering partnerships, providing support for road safety committees, and building the capacity of the network. The study reinforces the strength of the RoadWise Program's well established partnership approach, which continues to play a significant role in generating additional value from the State Government funding allocated for community road safety.

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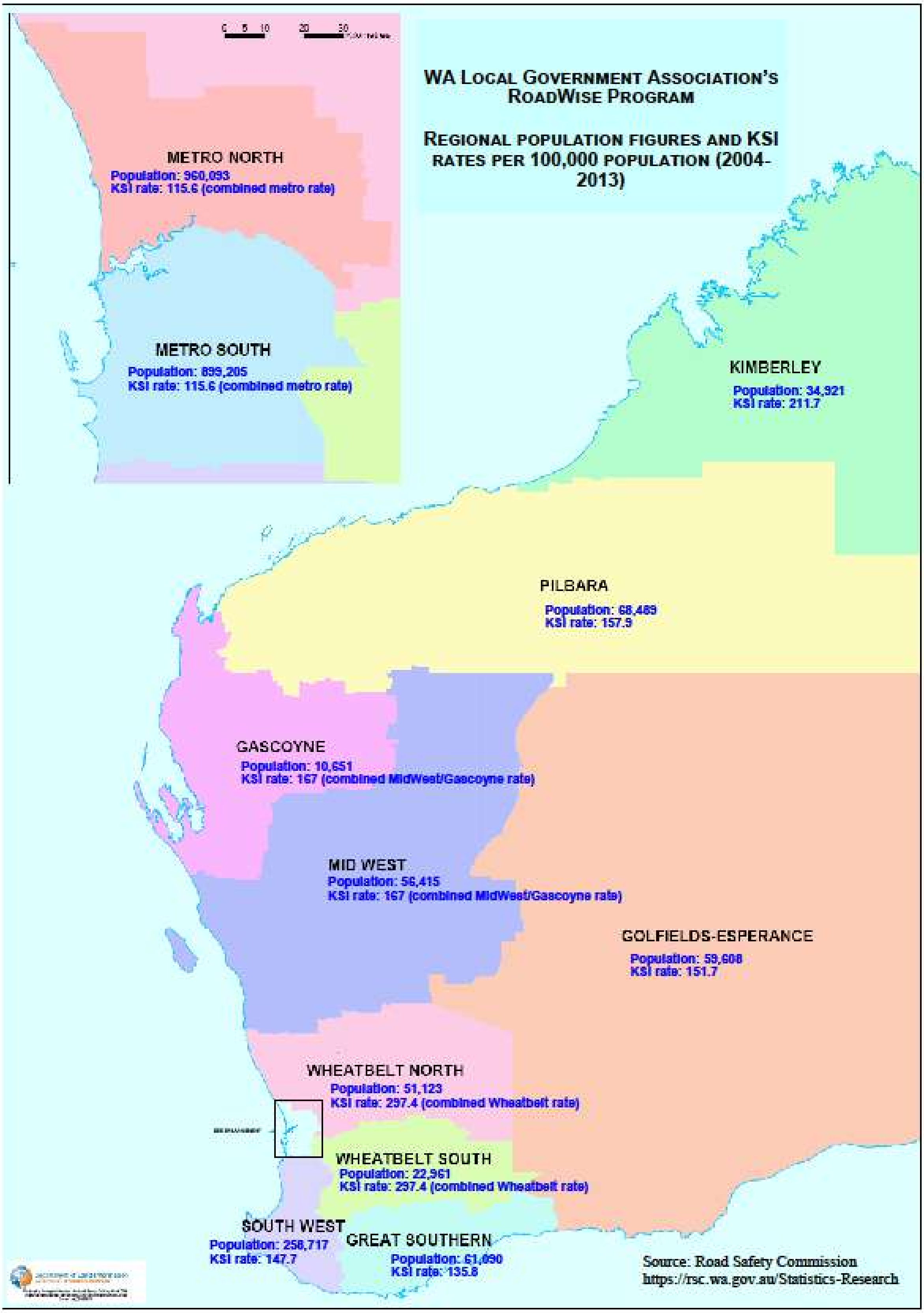
Appendix A: Regional population figures and KSI rates per 100,000 population



Appendix B: Allocated values

ITEM	CATEGORY	VALUE	SOURCE
Paid hours	Individual hours	Managers: $68.40/hr Professionals: $71.40/hr Technicians/Trade Workers: $52.50/hr Community/Personal Service Workers: $44.10/hr Clerical/Administrative Workers: $47.40/hr Machinery Operators/Drivers: $51.75	Hourly rates were calculated by coding position titles according to the ABS Cat. No. 1220.0 ANZSCO – Australian and New Zealand Standard Classification of Occupations (http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1220.0Main+Features12013,%20Version%201.2?OpenDocument), and applying the average hourly earnings estimated in the ABS 6306.0 – Employee Earnings and Hours, Australia, May 2014 (http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/6306.0Main%20Features3May%202014?opendocument&tabname=Summary&prodno=6306.0&issue=May%202014&num=&view). Hourly rates were multiplied by 1.5 to include estimated additional costs such as annual leave, training etc.
Unpaid hours	Individual hours	Volunteers: $32.53/hr	The volunteer hourly rate used is recommended by Volunteering WA (http://volunteeringwa.org.au/resources.aspx)
Chairing meetings	Meetings	$80 per meeting	The Salaries and Allowances Tribunal outlines rates for Committee Meeting and Prescribed Attendance Fees (http://www.sat.wa.gov.au/LocalGovernmentElectedMembers/Pages/Determination2013June.aspx). The rates for a Council Member (including the chairman) for all regional Local Governments ranged from $44 to $116. A median rate of $80 was used for this item. While not all Committee chairs are Local Government Elected Members, this rate was used to give an indication of the costs involved to an organisation or group to provide a chair person.
Meeting admin	Meetings	$31.60 x number of meeting hours	This rate is the average hourly rate for Clerical and Administrative Workers (without loading) as per the ABS (reference as per paid hours). This rate gives an indication of the costs involved to an organisation or group to provide administrative support to committee meetings.
Venue	Meetings	$21 per hour	Hourly costs were sourced for meeting rooms in each region at venues such as Local Government facilities or community venues (e.g. Lotteries House). The rates ranged from $13/hr (Wanneroo Library) to $35/hr (Pilbara Lotteries House), with an average rate of $21/hr.
Venue	Events Presentations Displays	Estimated by RSAs	
Catering	Meetings	Morning/afternoon tea: $11.70 per person Lunch/dinner: $15.26 per person	Indicative costs for basic catering in Perth were obtained (http://www.missmaud.com.au/OnlineOrdering/CateringPlatters/SandwichBaguetteWrapPlatters.aspx, http://temptationscatering.com.au/page/morning-afternoon-tea/), calculated for each region using the Regional Price Index, and then averaged.
Catering	Events Presentations Displays	Estimated by RSAs (using rates above where appropriate)	
Printed material and merchandise	Events Presentations Displays	Estimated by RSAs	
Event equipment and logistics	Events Presentations Displays	Estimated by RSAs	
Prizes	Events Presentations Displays	Estimated by RSAs	
Kilometres travelled	Events Presentations Displays	Cost per km travelled: 66c per km	The rate used was the new standard rate which is applicable from 2015/16. While it is acknowledged that this rate did not apply during the reporting period, it is lower than the average of the previous rates that were in use.

			https://www.ato.gov.au/general/new-legislation/in-detail/direct-taxes/income-tax-for-individuals/simplify-the-car-expense-substantiation-methods/
Advertising and promotion	Events Presentations Displays	Estimated by RSAs	
Media	Events Presentations Displays	$9.56 per column cm	http://www.westregionalsales.com.au/index.php/2012-07-19-17-38-59 - The West Regional Rate Card – p5 http://www.fairfaxregionalmedia.com.au/view.asp?show=rate&state=WA – Fairfax Regional Paper http://www.communitynews.com.au/pages/advertise.php - Community Newspaper Group (WA) – Metro Regional newspapers - average value per ccm $7.32 (ex GST) – no page or colour loading Metro newspapers – average value per ccm $11.43 (ex GST) – no page or colour loading Average state-wide print media value per column centimetre $9.56 (inc GST) – no page or colour loading
Budget allocation to committee	Direct financial contribution	Quantified by RSAs	
Local sponsorship	Direct financial contribution	Quantified by RSAs	
Grants	Direct financial contribution	Quantified by RSAs, along with review of media release from Minister for Road Safety	https://www.mediastatements.wa.gov.au/Pages/Barnett/2015/03/Community-groups-receive-road-safety-grants.aspx
RSA office space	Hosting and storage	Mid West: $1786.20 Goldfields Esperance: $1783.37 Wheatbelt North: $1760.55 Great Southern: $1568.19 South West: $1740.40	Using the rent paid for the Kimberley office as a base ($9204 p/a), relevant regional rates were calculated using the Regional Price Index (Housing Commodity Group).
RSA storage space	Hosting and storage	Mid West: $465.06 Goldfields Esperance: $464.58 Great Southern: $408.30 South West: $453.15	Using average Perth price of $159 per month for a 3x2m storage space, relevant regional rates were calculated using the Regional Price Index (Housing Commodity Group). http://www.spaceout.com.au/self-storage-price-survey/western-australia-self-storage-prices-data.php
Display trailer storage	Hosting and storage	Goldfields Esperance: $464.58 Great Southern: $408.30 Pilbara:$666.84 Wheatbelt South: $458.39 Metro North: $477 South West: $453.15	Using average Perth price of $159 per month for a 3x2m storage space, relevant regional rates were calculated using the Regional Price Index (Housing Commodity Group). http://www.spaceout.com.au/self-storage-price-survey/western-australia-self-storage-prices-data.php
Display trailer maintenance	Hosting and storage	$100	Estimated using experience of RSA's and discussion with Local Government staff.

Working Toward Effective Integration of Road Safety into Major Transport Projects: Learnings from NSW

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Abstract

Road safety engineering treatments play a key role in reducing serious casualties on NSW roads. Despite a recent record investment in safety infrastructure in NSW, there is an even bigger investment in major transport infrastructure projects.

The Safe System approach is widely adopted by road safety practitioners, but less widely applied to major transport projects.

This paper outlines how embedding road safety principles into major infrastructure projects is critical to achieving long-term safety benefits. It draws on collaborations such as Sydney's light rail projects, and looks to further opportunities to reduce serious casualties as NSW continues to grow.

Background, Summary and Conclusions

Road trauma costs the NSW community around $5 billion per year. The NSW Government is strongly committed to improving road safety for all road users and the *NSW Road Safety Strategy 2012-2021* (Transport for NSW, 2012) aims to achieve at least a 30 per cent annual reduction in fatalities and serious injuries by the end of 2021.

Road safety infrastructure improvements play a key role in reducing serious casualties on NSW roads, and there has been a recent record investment in safety infrastructure improvements in NSW. At the same time, there is an even bigger investment in major infrastructure projects throughout the broader transport sector including new and/or improved motorways planned or under construction, increased major road infrastructure investment at a State and National level, and increased investment in light and metro rail systems that connect with other transport modes in the road environment.

The Safe System approach to road safety is adopted worldwide to reduce road trauma, and underpins all road safety work in NSW. The approach recognises there is a limit to the forces humans can withstand in a crash, while accepting that human error on our roads is inevitable (International Transport Forum, 2008). While this approach is widely understood and adopted by road safety practitioners, it is less widely applied to major projects outside of road safety.

The Centre for Road Safety has been working closely with Transport for NSW's light rail teams to improve safety on their projects, which has resulted in road safety audits being mainstreamed into all new projects at the design, planning and construction phases. Embedding core road safety principles into major infrastructure programs, such as light rail projects, the construction of Sydney's Metro Rail expansion and the revitalisation of the Sydney CBD allows the whole transport sector to achieve sustainable long-term safety benefits. This is also a cost-effective approach to achieving these benefits, given the substantially greater investment that would be needed to retrofit safety improvements in the future.

There is already overlap between road safety and the Government's wider programs and objectives, such as greater pedestrianisation. As Sydney and other areas in NSW continue to grow and change, there will be opportunities for further integrating road safety principles into the broader core business of government – such as the design of urban renewal areas, and congestion management strategies. Taking these opportunities to embed road safety into the broader transport agenda will greatly improve road safety outcomes across the entire existing and future NSW road network.

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The role of supervisors in ensuring learner driver compliance with road laws: An application of Akers' Social Learning Theory

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Abstract

This paper uses Akers' social learning theory as a framework to explore the extent to which supervisors encourage their learner drivers' to comply with road laws. The sample consisted of 552 individuals from Queensland and New South Wales who had supervised a learner driver in the 12 months prior to completing the online survey. The results suggest that Akers' social learning theory variables provide additional explanation over and above socio-demographic variables and perceptions of risk associated with driving. This suggests that there may be benefits in providing additional support to parents and other supervisors of learner drivers.

Background

Young drivers experience the highest crash rates when compared with all other age groups of drivers (Bates, Davey, Watson, King, & Armstrong, 2014; Elvik, 2010; Williams, 2003). Graduated driver licensing (GDL) systems which incorporate learner, provisional and open phases mitigate this risk for new drivers (Bates, Allen, et al., 2014; Steadman, Bush, Thygerson, & Barnes, 2014). Both Queensland and New South Wales, as well as other Australian states, use a GDL process for new drivers to enter the licensing system (Faulks & Irwin, 2009; Senserrick, 2009).

The involvement of parents in the learner phase is vital for the success of GDL systems (Brookland, Begg, Langley, & Ameratunga, 2014; Williams & Shults, 2010), with this support necessary in order for most learner drivers to accumulate sufficient driving experience (Harrison, 2004; Jacobsohn, Garcia-Espana, Durbin, Erkoboni, & Winston, 2012). Additionally, novices may develop driving attributes by watching their parents driving, both before and during the learning to drive process (Bianchi & Summala, 2004). Survey based research suggests that mothers tend to provide more hours of supervised practice when compared with fathers (Bates, Watson, & King, 2013). However, while parents appear to be the primary providers of supervised hours of practice, others such as siblings also play an important role in the supervision of learner drivers (Bates, Watson, & King, 2014b).

While theories such as deterrence theory (e.g. Allen, Murphy, & Bates, 2015; Bates, Darvell, & Watson, 2015, online first), procedural justice (e.g. Bates, Allen, & Watson, 2016) and the theory of planned behaviour (e.g. Cestac, Paran, & Delhomme, 2011; Gauld, Lewis, & White, 2014) have been used to explore young driver behaviour and driver licensing, most GDL research is still atheoretical in focus. Akers' social learning theory is one theory that could be applied to GDL.

This theory combines social learning principles with elements of Sutherland's differential association theory (1947) and Skinner's operant conditioning theory (Burgess & Akers, 1966). A meta-analysis by Pratt et al. (2010) concluded that the empirical evidence for Akers' social learning theory compared to other criminological models is strong. This model, or aspects of this model, have been used to explain a number of behaviours including adolescent drinking and drug use behaviour (Akers, Krohn, Lanza-Kaduce, & Radosevich, 1979; Oostveen, Knibbe, & De Vries, 1996), adolescent smoking (Akers & Lee, 1996), domestic and intimate partner violence (Cochran, Maskaly, Jones, & Sellers, 2015 ; Wareham, Boots, & Chavez, 2009) and computer crime (Morris & Blackburn, 2009).

According to Akers' theory, there are four factors that influence behaviour: differential association, differential reinforcement, imitation and personal attitudes (Akers & Lee, 1996; Wareham et al., 2009). Differential association refers to interaction, both direct and indirect, with individuals such as friends and family and organisations. These individuals and groups provide patterns of reinforcement, normative definitions and exposure to models (Akers, 1985; Hwang & Akers, 2003) explaining why people behave in a similar way to those with which they associate. There are two aspects to differential association: behavioural and normative (Capece & Akers, 1995; Cochran et al., 2015). The behavioural dimension refers to the amount of association an individual has with the other individuals and organisations while the normative dimension refers to the overall shared climate or perceptions found within the groups towards to the shared behaviours (Capece & Akers, 1995).

The positive and negative reinforcements that are linked to the current behaviour, as well as alternative behaviours, is known as differential reinforcement (Akers et al., 1979; Morris & Blackburn, 2009). Positive reinforcement is the provision of a pleasurable experience while negative reinforcement is the removal of a painful experience (Capece & Akers, 1995). Reinforcements can be internal, such as feeling stronger, as well as external, such as being provided a financial reward.

Imitation represents a means of learning through observation or modelling (Akers & Lee, 1996; Cochran et al., 2015). Imitation suggests that behaviours are a result of watching others who are important to the individual in some way engage in the behaviour. The perceived consequences of the behaviour are an important component of imitation. While modelling is important for the initial behaviour, as the behaviour continues it becomes less important (Akers et al., 1979). Models can come from social groups including parents and peers as well as through the media.

Personal attitudes (which are known as 'definitions' when the theory is applied outside road safety and psychology) are learnt through interactions with significant groups and include norms, attitudes and orientations. Personal attitudes can define a behaviour as positive or negative. They act as cues to behaviour that can be directly reinforced. If an individual defines an action as good or, at a minimum, justified, they are more likely to engage in that behaviour. They are less likely to engage in a behaviour that is defined as adverse. These definitions are known as positive, neutralising and negative respectively (Akers et al., 1979; Wareham et al., 2009).

Akers' social learning theory has been used in road safety research to examine unlicensed driving (Watson, 2004), speeding (Fleiter, 2010; Fleiter & Watson, 2005), hooning (Gee Kee, Steinhardt, & Palk, 2007), drink driving (Armstrong & Ryan, 2006) and drug driving (Armstrong, Wills, & Watson, 2005). It has also been used to examine the risky driving behaviour of young drivers (Scott-Parker, Hyde, Watson, & King, 2013; Scott-Parker, Watson, & King, 2009). Therefore, it appears that there is merit in using this theory to explore supervisory practices. Thus, this study aims to apply Akers' social learning theory to investigate the factors that encourage supervisors to support learner driver compliance with road laws.

Method

The sample consisted of 552 individuals from Queensland and New South Wales who had supervised a learner driver in the past 12 months. They were recruited using a combination of convenience and snowballing techniques. Participants completed a 15 – 20 minute online survey between July 2009 and May 2010. At the conclusion of the survey, participants were able to provide their contact details in order to receive a $20 shopping voucher. The study received approval from the QUT Human Research Ethics Committee. This study was part of a larger program of research examining the experiences of supervisors within GDL systems (Bates et al., 2013; Bates, Watson, & King, 2014a; Bates, Watson, et al., 2014b).

The survey asked participants to provide socio-demographic information such as gender, age, marital status, occupation and whether they lived in Queensland or New South Wales. Participants were also asked to provide their assessment of the risk associated with driving for individuals at the start of the learner period and at the end of the learner period as this may have affected the level of support that they provide their learner driver. This was measured on a five point scale from ‘not very risky’ to ‘very risky’.

Several scales were created to measure the dimensions of Akers’ social learning theory. Differential association has two dimensions: the behavioural dimension and the normative dimension. The behavioural dimension of differential association was operationalised in terms of what other private supervisors known to participants did while supervising a learner on the road. The scale, which was created for this study, asked four questions about what other private supervisors including partners, relatives, friends and others do while supervising a learner on the road. This scale had a Cronbach’s alpha of .73. A second behavioural dimension of the differential association scale asked three questions about the behaviour of professional driving instructors in relation to ensuring that learners complied with the road rules (Cronbach’s alpha .82). The personal attitudes scale used within this study consisted of six items and had a Cronbach’s alpha of .77.

Differential reinforcement is the balance of anticipated rewards and punishments linked to current and alternative behaviours. These reinforcements can be extrinsic or intrinsic and they also include a non-social reinforcement element. Punishments were measured using a six item scale that had a Cronbach’s alpha of .86. Rewards were measured using a 12 item scale with a Cronbach’s alpha of .89. Imitation was not measured in the survey. This is similar to research conducted using Akers’ social learning theory in criminology where imitation is not included (Cochran et al., 2015).

An eight item scale was used to assess the extent to which supervisors ensured their learner complied with the road rules while driving. This scale had a Cronbach’s alpha of .91. Further information regarding the scales, including the specific items included, can be found in Bates (2012).

Results

Of the 552 participants within this study, 39.3 per cent were male and 60.7 per cent were female. The ages of the participants ranged from 18 to 85 with a mean of 38.58 years (sd = 12.36). Most of the sample were married (47.5 per cent) although 26.8 per cent were single, 18.5 per cent were in a de facto relationship and 7.2 per cent were previously married. More participants indicated that they lived in New South Wales (58.7 per cent) than Queensland (41.3 per cent). The convenience and snowball recruitment methods used within this study meant that it was not possible to calculate a response rate.

A hierarchical regression was conducted to assess the usefulness of Akers’ social learning theory in predicting the extent to which supervisors ensure compliance with the road laws over and above socio-demographic influences. Therefore, socio-demographic variables were entered as step one, risk perception as step two and social learning factors were entered at step 3. The results are shown in Table 1.

Table 1 Hierarchical regression of socio-demographic factors, risk perception and Akers' social learning theory on supervisors ensuring compliance with the road laws

Variable	*M*	*sd*	*B*	Std. error	β	sr^2	R^2	*Adj* R^2	*Change* R^2
Step 1 – Socio-demographic									
Gender	.63	.48	1.47	1.77	.09				
Age	44.45	9.22	.21	.05	$.24^{***}$	.05			
Income	.59	.49	2.63	.98	$.16^{**}$	.02			
Marital status	.79	.41	3.18	1.13	$.16^{**}$	.02			
State	.51	.50	5.37	.92	$.33^{***}$	.10			
First time supervisor	.41	.50	.04	.98	.00				
Primary supervisor	.31	.47	2.78	.98	$.16^{**}$	.02			
Perception of difficulty to find time to practice	2.71	.92	.10	.51	.01				
Receive guidance	.38	.49	2.19	.93	$.13^{**}$	.02			
Relationship with learner	.36	.48	-2.42	1.78	.14				
							$.28^{***}$	.25	
Step 2 – Risk perception									
Risk perception (start learner)	4.20	1.06	2.46	.46	$.32^{***}$	.07			
Risk perception (end learner)	3.23	1.26	-.01	.39	-.00				
							$.37^{***}$	.34	$.08^{***}$
Step 3 – Social learning									
Differential association of the behavioural dimension (supervisors)	13.25	2.87	.13	.17	.01				
Differential association of the behavioural dimension (instructors)	15.53	3.35	-.11	.16	.05				
Differential association of the normative dimension	29.83	7.49	.13	.07	$.12^{*}$	.01			
Personal attitudes	31.66	6.95	.03	.08	.02				
Personal attitudes (alternative behaviour)	29.92	6.18	.19	.07	$.14^{*}$	.01			
Anticipated punishment	16.02	7.62	-.02	.07	-.02				
Anticipated rewards	63.46	13.71	.16	.04	$.27^{***}$	.04			
							$.51^{***}$	.47	$.14^{***}$

* *p* < .05; ** *p* <.01; *** *p* < .001

Overall the model was statistically significant with the socio-demographic factors, risk perception and Akers' social learning theory predicting approximately 47 per cent of the variance in the extent to which supervisors ensured that their learner complied with the road laws. The first step in the hierarchical regression was statistically significant (*F* (10) = 9.72, *p* <.001). This step explained 28 per cent of the variance. The significant predictors within the personal variables were age (β = .24, *p* <.001), income (β = .16, *p* <.01), marital status (β = .16, *p* <.01), state of residence (β = .33, *p* <.001), whether they were the primary supervisor (β = .16, *p* <.01) and whether they received guidance (β = .13, *p* <.01).

The second step of the hierarchical regression was statistically significant (*F* (12) = 11.79, *p* <.001) and explained an additional eight per cent of the variance over and above the socio-demographic factors. Within this step, the supervisors' perceptions of risk associated with driving for the learner at the start of the learner licence was a significant predictor, predicting seven per cent of the variance ($\beta = .32$, $p <.001$).

The third step of the hierarchical regression was statistically significant (F (19) = 12.77, $p <.001$) and explained an additional 14 per cent of the variance. The significant predictors within the social learning theory variables were the normative dimension ($\beta = .12$, $p <.05$), personal attitudes towards an alternative behaviour (the use of professional driving instructors; $\beta = .14$, $p <.05$) and anticipated rewards ($\beta = .27$, $p <.001$). Overall, it appears that supervisors who are older, have higher incomes, are partnered, live in New South Wales, are not the primary supervisor, do not receive guidance from friends, government websites or driving instructors and perceive the start of the learner licence as riskier are more likely to ensure that their learner complies with the road laws. Supervisors with more positive personal attitudes towards driving instructors, interacted with significant groups that ensured learners complied with the law and anticipated more rewards were also more likely to ensure that their learner complied with the road laws.

Discussion

Like other studies in the area of road safety (e.g. Armstrong & Ryan, 2006; Fleiter & Watson, 2006; Watson, 2004), this study supports the use of Akers' social learning theory to explain road user behaviour. In this case, the theory helped predict the extent to which supervisors ensured their learner complied with the road laws. The significance of the normative dimension of differential association suggests that social factors have an important role in supervisors encouraging compliance by learner drivers with the road rules. Thus, it is important to develop a shared culture within supervisors, as a group, that identifies the supervision of learner drivers as a positive element of the GDL system.

Consistent with research suggesting that the frequency of speeding is greater when individuals have experienced rewards for engaging in the behaviour (Fleiter & Watson, 2006), anticipated rewards was a significant predictor of the extent to which supervisors ensured that their learner complied with the road laws. While further research will help to identify which elements of supervised practice are rewarding for private supervisors, it appears from the items included in the anticipated rewards scale within this study that having a positive supervision experience is one form of reward. For instance, bonding with the learner and spending time with the learner could be considered rewarding. Additional anticipated rewards could include support from others such as partners and friends or long-term benefits of having a licensed learner. There may be an opportunity to promote these anticipated rewards to private supervisors in order to continue to ensure that they encourage compliance with road laws.

Additionally, personal attitudes towards an alternative behavior (the learner driver having professional driving lessons) were a significant predictor of the extent to which supervisors ensured compliance with the road laws. This finding is consistent with research conducted by Watson (2004) into unlicensed driving.

The overall significance of the Akers' social learning theory variables, and the individual significant predictors, suggests that there are ways to enhance GDL systems, including the learner licence, in Australia and internationally by providing additional advice and support to supervisors. This could include educating supervisors about the rewards of providing supervision and encouraging working relationships between private supervisors and professional instructors. The significance of supervisors' perception of risk at the start of the learner period indicates the importance of ensuring that they are aware of the risks associated with learning to drive.

A key strength of this study was that it explored the experiences of both parental and non-parental supervisors of learner drivers across two Australian states. Traditionally, many studies have focused on parents when considering the supervision of learner drivers. This study has also used theory to help explain behaviour in an area that has traditionally been studied from a data-driven perspective. The limitations of this study include sampling issues associated with the use of an internet survey.

For instance, not all potential participants have access to the internet. It is also not possible to clearly identify the target population in order to assess the quality of the sample or calculate response rates. Further research, that utilises a different research method, would help address the sampling and self-report issues present in this study. Additional studies could also consider the role of parents and non-parental supervisors in Australia once the learner obtains a provisional licence.

Conclusions

This study has demonstrated the usefulness of Akers' social learning theory in predicting the factors that influences the extent to which the supervisors of learner drivers to ensure that their learner adheres to the road rules. This is consistent with other research within road safety indicating the value of this theory to the road safety and traffic psychology fields. The findings of the study suggest that it is possible that the GDL system could be enhanced by providing a greater level of support to the supervisors of learner drivers as opposed to making further changes to the GDL system. This support could include educating supervisors about the rewards of providing supervision.

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Parental experiences of encouraging compliance with restrictions of Graduated Driver Licensing (GDL) during their children's provisional licensing phase

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Abstract

Parental support is an important part of how young novice drivers navigate Queensland's Graduated Driver Licensing (GDL) program. During this process parents may have a greater influence on enforcing the restrictions of GDL when compared with traditional policing. However, despite the likely critical value of this role, little is known about parental views or experiences of this process, or how best to support parents effectively in guiding their provisional drivers. For this study, qualitative analysis of interviews with 16 parents of current provisional drivers suggest that parents may fulfil third party functions consistent with concepts of Third Party Policing (TPP).

Background

It is well established that novice drivers face the highest crash risk, especially within the first 6 months of obtaining a licence (Bates, Davey, Watson, King, & Armstrong, 2014b). GDL systems, which consist of learner, provisional and open licence phases, are designed to address this elevated crash risk by restricting the novice drivers exposure to high risk situations while still allowing them to gain driving experience (Bates et al., 2014a; McCartt, Teoh, Fields, Braitman, & Hellinga, 2010; Williams & Shults, 2010).

Traffic law enforcement is the most commonly used initiative to modify driver behaviour and therefore reduce the incidence of traffic crashes (Bates, Soole, & Watson, 2012). However, the provisions within a GDL system are difficult for police officers to enforce (Allen, Murphy, & Bates, 2015; Hedlund, 2007) and such systems rely on parental influence (Chaudhary, Williams, & Casanova, 2010; Shults, 2010; Williams, Leaf, Simons-Morton, & Hartos, 2006). However, whilst parental TPP may provide a useful model to improve compliance, little research has investigated the applicability of this model or of parental experiences of enforcement functions.

Method

Qualitative, semi-structured telephone interviews with 16 parents of 18 provisionally licenced drivers (13 in their first year, and 5 in their second year of provisional licensure) were conducted. Participants were recruited by promotion of the study to employees of a large metropolitan university in Brisbane, Queensland, Australia. Questions focussed on parental knowledge of restrictions on provisional licences and their experiences with encouraging compliance. Analysis of transcripts was conducted by a Psychologist using NVivo software to extract themes.

Results

Broad knowledge of the restrictions was strong with all parents aware of zero alcohol requirements for provisional drivers, and most knew that restrictions on passengers and mobile phone use were in place, but frequently did not know the specific details of the GDL requirements. Most parents implemented their own, complementary rules and restrictions. For example:

"One person in the car after about 10 o'clock at night, outside of family members…we have our own family restrictions as well…we don't allow him to take friends in the car".

Parents developed teaching relationships with their children using linguistic forms and non-language based methods. They expressed beliefs that, although their children did not like the rules, they were sensible, found it easy to comply with parental and GDL restrictions, and parents perceived that their children planned ahead. Some parents suggested that compliance was assisted by processes of social norming amongst similar-age provisionally-licenced friendship groups. Rather than resenting or resisting the responsibility for providing practical and emotional support for compliance, parents viewed the tasks of encouraging compliance with restrictions as part of their parental responsibility. Parents expressed support for the GDL rules, believing that these make it easier for parents to keep their children safe, and reported that they were happy to reinforce them.

Conclusions

Parents endorse GDL rules and traditional enforcement methods. However, their lack of knowledge of specific GDL requirements may motivate the development of their own complementary restrictions. This and other themes identified in the transcripts of the focus groups suggest that parents are operating as TPP agents. Future research to see if this is consistent across states and GDL programs is planned as well as research into the provisional drivers' experience of parental TPP.

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Night driving and the situation awareness of learners and parents: Are they seeing the same road?

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Abstract

Young drivers remain overrepresented in road crashes, particularly in darkness. In Queensland minimum graduated driver licensing practice requirements sees parents providing the most supervision to meet the required 100 logbook hours, including a minimum of 10 night-time hours. This study compared the situation awareness of parents and learners as they provided a verbal commentary regarding 'what they were looking at' during a 15-minute segement of real-world driving footage projected in a cave-simulation environment. Despite some similarities, analyses revealed considerable differences in situation awareness, with implications for the safety and nature of driving during supervised (learner) and restricted (provisional) driving.

Background

In Australia novice drivers must progress through a graduated driver licensing (GDL) program, with Queensland requiring a minimum of 100 logbook hours, a minimum of 10 which must be driven at night. Unsurprisingly parents are typically the most common supervisor (Scott-Parker et al., 2011). Rather than being professional instructors, parents tend to be experienced drivers who impart driving skills and knowledge based on their own driving experience, with driving practice the ideal opportunity to develop the situation awareness skills (SAS) of the young driver. Importantly, SAS emerges from a complex dynamic of perceiving, comprehending, and projecting risks, and as such SAS are vital for safe road use, including driving at nighttime. However the SAS of parents and learner drivers remains relatively unknown, therefore the similarities and differences in SAS for learners and parents, during nighttime driving, was explored.

Method

Twelve learner-parent dyads provided verbal commentary regarding 'what they were looking at' (insight into SAS) during separate viewing of a 15-minute segment of real-world nighttime driving footage, captured via three GoPro cameras and projected in a cave-simulation environment. Commentaries were recorded and transcribed verbatim. Word counts and frequencies (using NVivo version 10) were examined for learners, for parents, and for learner/parent comparisons. Verbal transcripts were analysed using Leximancer^{TM} version 4 to identify themes, concepts, and relationships between them to create the learner concept map which was overlaid manually with the parent concept map to identify similarities and differences in situation awareness during the nighttime driving task.

Results

Words and Concepts

Learners on average uttered 1,249 (*SD*=454) words (total=14,991 words). Parents uttered a non-significantly larger average of 1,642 (*SD*=557) words (total=19,700 words) in the nighttime driving condition, $t(22) = 2.15$, p=.072. Learners had 30 concepts and parents had 29 concepts; learners had 10 (e.g., direction, people, street) and parents had 9 (e.g., intersection, zone, clear) unique concepts, with 20 (e.g., car, left, lane) shared concepts overall. Concept frequencies can also suggest importance within and contribution to the SAS network, and as can be seen in Table 1, the majority of concepts (as indicated by shading) were fairly consistent across learners and parents. Notable differences remain, however, with learners commenting regarding other road users (e.g., cars) and infrequent driving manuevres (e.g., merging) more commonly than parents, and parents commenting regarding the surrounding driving environment (e.g., traffic) more commonly than learners.

Table 1. Concept counts for shared and unique concepts, by learner and parent

Shared concepts	**Count**		**Shared concepts**	**Count**	
	Learner	**Parent**		**Learner**	**Parent**
Car	277 (22.2)	187 (11.4)	Turning	63 (5.0)	47 (2.9)
Left	271 (21.7)	445 (27.1)	Down	55 (4.4)	73 (4.5)
Lane	236 (18.9)	319 (19.4)	Front	52 (4.2)	88 (5.4)
Lights	225 (18.0)	250 (15.2)	Truck	52 (4.2)	74 (4.5)
Ahead	135 (10.8)	155 (9.4)	Speed	50 (4.0)	53 (3.2)
Road	111 (8.9)	181 (11.0)	Straight	49 (3.9)	41 (2.5)
Sign	106 (8.5)	168 (10.2)	Red	46 (3.7)	46 (2.8)
Green	104 (8.3)	160 (9.7)	Stop	43 (3.4)	57 (3.5)
Coming	89 (7.1)	195 (11.9)	Traffic	40 (3.2)	174 (10.6)
Merging	72 (5.8)	52 (3.2)	Roundabout	27 (2.2)	37 (1.6)
Unique concepts	**Learner Count (%)**		**Unique concepts**	**Parent Count (%)**	
Continuing	54 (4.3)		Hand	160 (9.7)	
Bus	45 (3.6)		Vehicles	69 (4.2)	
Direction	44 (3.5)		Intersection	59 (3.6)	
People	43 (3.4)		Zone	59 (3.6)	
Bridge	42 (3.4)		Clear	46 (2.8)	
Roadworks	40 (3.2)		Exit	40 (2.4)	
Driving	37 (3.0)		Tunnel	27 (1.6)	
Street	33 (2.6)		Highway	26 (1.6)	
Hour	27 (2.2)		Hats	22 (1.3)	
Heading	19 (1.5)				

NOTE: The relative frequency count of the concepts was calculated by ([count/average] X 100). Using this formula the frequency concept count for car for learners can be calculated by 277/1,249 x 100 to arrive at a relative frequency of 22.2. Shading indicates relative frequencies for shared concepts < +/- 2%.

Concept map

To further understand the situation awareness of learners and parents, the concepts were mapped to reveal the connections between the concepts. Figure 1 shows the concept map of the situation awareness of the learners (the foundation for the mapping exercise) with the concept map of the situation awareness of the parents overlaid. As can be seen by the double-bars, only a handful of concepts map with the same concept connections for learners and for parents. Overwhelmingly it appears that – while the concepts themselves are quite similar overall during the nighttime driving context – the structure of the concept maps differs considerably.

Conclusions

The analysis of the verbal commentary captured during the presentation of real-world nighttime driving footage in a cave simulation environment revealed interesting similarities and differences in the SAS of learner drivers and parents. In addition to education regarding the apparent differences in what is attended to in the driving scene by the vehicle's front seat occupants, resources to support parents through the novice licence phases could emphasise the importance of SAS, encourage

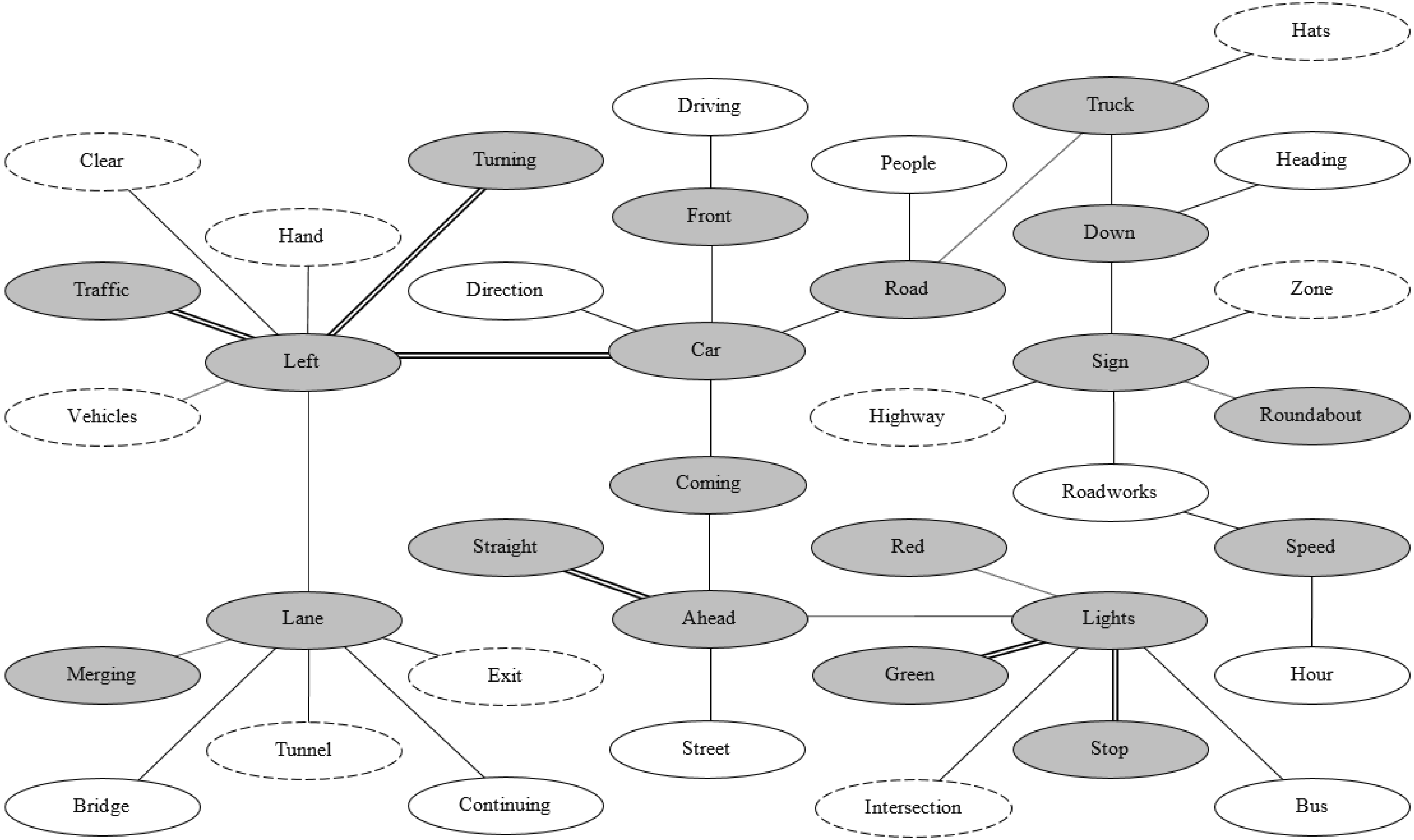

Figure 1. Learner/parent concepts, nighttime driving

Development of a road safety program for young offenders

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Abstract

One group of young people particularly at risk of performing unsafe road behaviours is those who have entered or are at risk of entering the justice system. Many of these young people have either committed an offence involving motor vehicles or were involved in high-risk situations involving motor vehicle use.

The Transport Accident Commission (TAC) has developed two programs for young people who have appeared before the courts and been given diversion orders or supervision orders. The aims of the programs are to provide the participants with important information, education and behavior change strategies to be safer road users.

Background

Although school-based educational programs have been created and implemented in an effort to curb young driver and passenger risk, the cohort of young offenders, including motor vehicle offenders, many of whom are disengaged with school, has been largely overlooked. Well-intentioned community groups and organisations interested in young driver safety have developed and implemented programs, particularly for 'at risk' young people. However there is very little evidence to demonstrate the effectiveness of most of these programs, and some approaches and programs have been found to either have no effect or have even increased the level of risk among some participants (Harris et al., 2013).

To identify possible opportunities for practical, evidence-based road safety interventions for this group, a series of expert workshops were hosted by the Transport Accident Commission in Melbourne, Victoria during 2014-2015. The workshops included experts from Youth Justice (DHHS) and CARRS-Q as well as forensic psychologists. Through this process it was decided that two interventions would be developed in order to suit the differing needs of the young people involved. One program for offenders aged 15-18 who have been placed on supervision orders; and another program for offenders aged 15-18 who have been given diversion orders by the court to complete a road safety program.

Program Development

Both TAC programs were developed based on the principals of cognitive and behavioural change. Small groups are encouraged to discuss 'case studies' and scenarios allowing for exploration of situations similar to their own experiences, with comparable decisions and consequences. This approach helps foster an environment that is supportive, but also challenges existing belief systems and motivates participants to adopt safer behaviours. Participants are also able to access information about road safety and the graduated licencing system that they may previously not have been able to access. Through guided discussions the participants learn to identify possible barriers and protective factors in their own lives as well as developing behavioural strategies and a personalised plan to help them make safer decisions. Flexible program design has allowed for one-to-one delivery of the program if a group setting is unsuitable for any participant.

Next Steps

It is expected that initial piloting and refinement of the programs will continue during most of 2016. Details of the program content and outcomes of the pilot phase will be presented. A detailed evaluation framework is also being developed to assess the impact of the programs on the future offending and road safety behaviours of the participants. This framework will also be presented.

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Getting Children Riding Again - Making Local Streets Safer for Cycling

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Abstract

Local streets have traditionally been the proving ground for most urban bicycle trips – particularly among children. With the increase in car ownership over the years, more children are driven to schools and less are riding, even though distances are frequently less than 2km. This decline is due to a number of factors including: safety fears (real and perceived), lack of separated infrastructure, driver attitudes towards cyclists and speed. Councils need to adopt a multi-faceted approach to reclaiming local streets for active travel for the whole community.

Issues, Opportunities and Tools

Separating cyclists from traffic is typically the goal in most municipalities. It is true that this separation generally affords the greatest safety benefit to riders and can maximise the range of users supported by the facility. More often than not however, the luxury of space is not available to provide such facilities – particularly in local residential neighbourhoods which are the training grounds for most cycling trips.

It is, therefore, appropriate and pertinent to ensure that the local streets within our neighbourhoods are safe places to nurture and develop confident young riders. To achieve this, there must be a combination of measure that include modifying driver perceptions to positively view sharing of the road with riders, implementing area-wide speed limits (30km/h) consistent with international best practice, providing safe routes to schools (low traffic streets), altering the street network to provide direct routes and encouraging more functional riding trips (e.g. to school, shops, restaurants entertainment).

This presentation will consider some of the tools available to encourage more riding in mixed traffic environments in the local street network where many bicycle trips originate from. This will include the concept of filtered permeability, speed management, line marking options and bicycle parking at destinations.

Qualitative Consumer Input for Enhancing Child Restraint Product Information to Prevent Misuse: Preliminary Results

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Abstract

Child restraint system misuse is a global public health issue leading to increased risk of injury and death in motor vehicle crashes. Although some interventions are effective at reducing misuse, they are prohibitively costly to adopt at a population-level. We aim to develop a novel, consumer-driven intervention to counter misuse embedded in product information supplied with child restraints. If effective, this cost efficient measure can be broadly implemented via product standards. The first stage of this project involved using a semi-structured discussion guide to conduct six in-depth focus groups (N = 44; 95% female) to elicit problems and preferences with current product information. There are some distinctions between the different populations of child restraint users sampled here (i.e., reliance on graphics versus text instruction), but preliminary results suggest that at a minimum, restructuring information, improving graphics, removing text, and providing links to other sources of information will increase the attractiveness and ease of understanding instructions and labels supplied with child restraint systems.

Background

Child restraint systems (CRS): *Nonuse, misuse, and age-inappropriate use*

The use of child restraint systems (CRS) for children travelling in motor vehicles is common in most developed countries and it is becoming the norm for legislation to cover the protection of children in cars worldwide (WHO, 2013). In Australia, the law requires that children under seven years of age be restrained in an approved booster seat or child restraint system that is appropriate for the child's height and weight. Recent estimates of use have predicted that more than 99% of children 0-7 years are restrained (Brown et al., 2010).

The same estimates predict that about half of all children are *incorrectly* restrained (Brown et al., 2010). While mandating the use of a child restraint might promote use, it does not ensure the seat is being used correctly; that is, installed and used as intended by the manufacturer. Correct use is predominantly measured by the presence or not of errors in installation (CRS in vehicle) or securing (child in CRS) (e.g., Rudin-Brown et al., 2004). Very loose or twisted harnesses, seatbelts routed incorrectly, and non-use of a top tether are examples of serious errors that would reduce the restraints' crash protection potential (Brown et al., 2011). As more countries mandate restraint use and population estimates of use increase, the focus of child passenger safety is now shifting to preventing misuse from promoting appropriate use. A number of studies have identified demographic factors associated with an increased likelihood of errors in use. Brown et al. (2013) found that children from a family who speak a language other than English at home are more than twice as likely to be incorrectly restrained. Children from low-income families have also been found to be substantially more likely to have errors in child restraint or booster seat use (Bilston, Du, & Brown, 2011). While Bilston et al. (2011) did not find a significant relationship between education level and restraint use, other research indicates that lower health literacy (ability to understand and use health information) is associated with low injury prevention behaviours

(Heerman et al., 2014). Lack of information and experience with restraints are also predictors of misuse (Arbogast, 2014; Bilston et al., 2011; Rudin-Brown et al., 2004).

Some predictors of incorrect use (i.e., lack of information and experience, low health literacy, etc.) suggest that the misuse of restraints is due to a user's skill deficit. Information on how to use a restraint is communicated on the labels and instruction manuals accompanying the restraint. It is inevitably the first point of communication for new restraint users. In Australia, all child restraints must be approved under the Australian Standard AS/NZS 1754. It is this product standard that stipulates the content and layout of information given to consumers about installation and use of child restraint devices. And while product information provides instructions on correct use and warnings against misuse, continuing high rates of errors in use suggest there is a gap between the correct use messages being sent and how users are responding (using) the restraint.

Basic communication principles suggest that there are characteristics of the message (i.e., correct use), channel (i.e., instruction manuals/labels), recipients (i.e., child restraint users), and environment (i.e., first time) that will affect how information is processed. Although most research on communication for health is focused on patient decision-making in clinical care situations, there are some public health and literacy principles concerning risk communication and medical product information (Fischhoff, Brewer, & Downs, 2011). The gold standard in health communication also involves taking a consumer centric approach to the development of information materials. While child restraint users have typically been seen as passive recipients of safety information, there is a move in health research toward designing consumer-centred information.

Researchers in Australia, Canada, and North America have recently developed some educational interventions targeting restraint misuse that involve consumer-centred design processes. In Australia, the product standard for child restraints (AS/NZS 1754; 2010) was amended to include shoulder-height marker labels affixed to restraints that visualised for parents when a child had outgrown their restraint (child's shoulders are above dotted line). Although the law still makes recommendations of appropriate restraint use based on age, the shoulder height markers being used were designed using size of child (height) as a proxy for appropriate use – an indication leading to more appropriate use (Brown, Fell, & Bilston, 2010). In 2002, Rudin-Brown et al. (2004) designed new 'optimal' labels for child restraint systems that were aligned with human factors principles that performed better than the traditional label for rearward-facing mode installation and use. More recently, Klinich et al. (2010) and Kramer et al. (2015) found similar results with instruction manuals and labels they designed. However, despite the fact these studies used best practice in designing the information, and the participants in these studies were highly motivated to perform correctly, and had access to correct information in an appropriate format, the absolute improvement in errors was relatively small. This indicates that a communication gap between the information being conveyed in the instructions and labels and the information received and enacted continues to exist.

We believe that the critical step to ensuring users can understand and act on instructions and labels is by involving them in the process of design, and continuing re-design until the behaviour is being performed correctly. A modified consumer-testing and consensus design method is being used to design new instructions, labels, and videos that aim to increase the correct use of restraints. The consumer-centred design *process* is the critical step to success, not the re-designing of materials themselves. With the final prototypes of enhanced instructions and labels, we will then be able to look retrospectively into the critical elements of design and feedback that made the most significant changes and translate these processes into recommendations for manufacturers.

The first stage of this consumer-centred design process is qualitative focus groups to identify barriers to using and understanding current child restraint product information in a diverse population of users.

We aim to elicit specific feedback on how to improve current child restraint informative materials. The preliminary results presented below are being used to design the first prototype of new child restraint product information to be tested in a consumer-testing cycle and later laboratory trial.

Method

Six focus groups were conducted to explore consumer preferences on content, format, and appearance of current child restraint system product information. To capture the diversity of child restraint users and their needs, we conducted two groups of participants who are from high income and high education brackets (high SES), two groups of participants from culturally and linguistically diverse (CALD) communities, and two groups of participants who are classified as living in an area of socioeconomic disadvantage (low socioeconomic status; low SES) according to the Australian Government Socioeconomic Index For Area (SEIFA; Australian Bureau of Statistics, 2013).

Sample

High socio-economic status participants were recruited using a study brochure and email distribution through university and research channels, and asked to register their interest to participate in an online screening survey. CALD community participants were recruited using study brochures given out by moderators in community playgroups in southeastern Sydney. Local community organizations for CALD parents assisted with the recruitment of these participants. We recruited potential low SES participants through community playgroups in low SEIFA areas in the greater Western Sydney area. Participants were eligible to participate if they: a) were aged over 18 years of age, b) have used a child restraint system to transport children, and c) were conversant in English.

Procedure

Focus groups were held at Neuroscience Research Australia (NeuRA - two focus groups) and in the community (four focus groups). Each group was moderated by a member of the research team using a semi-structured discussion guide, and one other researcher attended the group to take notes. Participants provided written consent and completed a screening questionnaire either online or in person which included demographic information and past experience with child restraint use.

The focus groups were structured such that participants were first asked to reflect on their experiences using child restraint systems. Next, participants were presented with five convertible child restraint systems currently on the market in Australia. Restraints were selected that fulfilled the following criteria: a) with and without self-adjusted headrest and harness combinations; b) convertible design (high propensity for misuse); c) currently on the market in Australia and expected to stay on the market for the next five years; and d) conforms to the Australian Standard for Child Restraints (AS/NZS 1754:2013).

The restraints included three rearward facing/forward facing convertible restraints, and two convertible forward facing/booster restraints.

The discussion guide was developed using review of the literature on consumer preferences related to health communication, principles in communicating with people with lower health literacy, and previous research on problems using child restraint system. The guide was formulated to encourage reflection of potential modification of content and format of product information typically supplied with child restraint systems. Some specific prompts included: finding specific pieces of information related to areas of high misuse propensity, general impressions of instruction manuals or labels, ordering of information, previous experience and feedback on text size, drawings, and manufacturer videos.

The focus group discussions were audiotaped and then transcribed and de-identified. Audio-recordings were deleted following transcription. The University of New South Wales Human Research Ethics Committee (HC15547) approved the study.

Data Analysis

Six focus groups were conducted, with four audio-recordings transcribed in full. Two focus groups (one CALD group and one low SES group) were held during playgroup hours and extensive background noise prevented transcription. For the purposes of thematic analysis, the combined discussion notes taken by the group moderator and observer are used in place of transcripts.

Two researchers read each transcript and discussion note document independently and identified key content areas. These key content areas were used to code the transcripts and discussion notes into relevant themes. Overlapping themes were merged. The use of flexible content analysis allowed us to capture all instances of a theme being present in conversation, explore the context in which these issues were raised, and general agreement or disagreement within and between groups. The results presented below are the preliminary higher-level findings.

Results

A total of 44 participants (95% female) attended the six focus groups. Two groups were classified as having high income and education (high SES; n = 8), two groups of participants from CALD communities (CALD; n = 12), and two groups were held with participants from low socio-economic areas in Sydney (low SES; n = 24). Key themes emerged across the following content and format areas: appearance, format, readability, information needs, and videos.

Within and between groups, there was consensus on installation being an important but difficult task, and consensus that instruction manuals and labels do not provide sufficient information to ensure correct use.

Appearance of instructions and labels

Colour. The instruction manuals and labels were viewed by all groups as having sufficient colour coding to determine differences between modes of configurations. Important information presented in yellow and warnings presented in red were congruent with the participant's pre-conceived knowledge and preferences for use of colour.

Pictures/diagrams. The high SES group found that instruction manuals had sufficient diagrams and pictures to aid installation; the low SES reported the need for more diagrams and pictures; and the CALD groups rated the current pictures as unrealistic and uninformative. It was noted that CALD participants are more likely to use pictures as the sole source of instruction, whilst other groups use pictures to help understanding of text. The same was true for CALD participants concerning the pictures and diagrams on labels affixed to the restraint:

"Yeah maybe more pictures. More pictures, more than letters, but pictures that we can understand better" (CALD)

And both the CALD and low SES groups called for more realistic diagrams and graphics to be used for pictures on the restraint.

"…more real life, that would be easier…" (Low SES)

Location of labels. When examining labels affixed to the restraint, the high SES group pointed out that text heavy information was typically toward the bottom of the restraint; manufacturers should consider placing labels in the line of sight of the user when the seat is in the car.

Readability

For CALD groups, instruction manuals not being available in their primary languages was the main concern expressed. Labels can be improved by simplifying text, removing unnecessary words, providing other language options, and increasing font size. All groups reported that instructions and labels are text heavy and would benefit from less text and more diagrams or pictures. While most high SES participants found the instructions easy to read, all groups reported that text should be simplified.

"I look at that and – I'm the person that reads every word and instruction – but honestly I look at that and I just shut down 'cause it's too much information. There's too many words" (Low SES)

Format

Order of information. There was a consensus across both the high and low SES groups that the instruction booklet should be ordered to reflect the order of tasks: pre-installation adjustments, installation, and then securing information. The high SES group recommended that each instruction manual have a quick set up guide and triage system at the beginning of the manual to guide the user through subsequent tasks. It was also recommended that the booklet should be separated based on mode of installation; different sections of the manual should focus on only one mode of configuration or separate manuals completely for different modes. For the labels, the CALD group asked specifically for simple, ordered, and numbered steps to perform the installation.

Warnings. Although group members in the high education group noticed and valued the warnings on the restraint, one participant pointed out that they would become redundant over time with exposure. While all focus group members seemed generally concerned with the safety of their children in cars and ensuring that they were correctly using seats, one group called for better labeling and warnings on the restraint to prompt other people securing their children in the car to do so correctly:

"Definitely for your partner … have a big thing saying: fasten me tight!"

And also to remind users to untwist straps on the harness by placing labels on the straps themselves prompting removal of twists:

"… So I think if there was a big warning that your child is going to have a punctured spleen or something if this [strap] is twisted… the more information there is on the seat - I think - the better"

Information needs

Mode of configuration. The CALD groups expressed confusion about installing the seat in the mode that is appropriate for their child. The instructions and labels report on age, size, and weight requirements indicators for choosing the mode to install the restraint. The CRS has shoulder height markers as well. One CALD participant gave an example of conflicting information regarding which configuration to use for their child:

"*That's why it's a little bit confusing, because it says from two to three […] but then they said forward facing from twelve months to four years so they have two information?"*

How to correct misuses. More specific information is needed on how to act on warning information when warnings are made about incorrect use. For example, providing information about how to make adjustments to tether straps:

"… No, I'm not even sure it clearly tells you how to remove the slack, it just tells you to make sure the slack is removed."

Need for feedback on performance. The high SES and CALD groups consistently expressed the need for reassurance that they were performing installations successfully. One participant noted that the use of checkpoints for critical behaviours would increase confidence of installation success.

"It's all very well having a statement saying, 'Make sure strap is finely secured', but what about a test or demonstration to yourself that you've achieved that part of the task?"

Links to more information. All groups provided information about consulting other sources of information regarding restraint installation and use (i.e., YouTube videos, websites, manufacturer hotline). It was recommended by the high SES and CALD groups that links to other reliable sources of information be provided in the instruction manuals. It was suggested that a link to online video tutorials for installation demonstration should be permanently affixed to the restraint.

Videos

Across all groups, participants are receptive of video demonstrations as sources of instruction. Users are actively looking for videos on the web to clarify issues with installation (e.g., needing to adjust seat before threading belt through belt paths). However, the CALD group found manufacturer videos to be too general and not focused on problem solving:

"I did [see manufacturer's videos]. I tried to find manufacturers video but it didn't show me what I found in the YouTube video".

This group also spoke about the importance of using instructors/models on demonstration videos that are relatable and 'real'. The high SES group valued information coming from a trusted source. They noted that videos should be recorded and distributed through the manufacturer's official media channels, with direct links to these on the products and in instructions.

Discussion

The findings from this work have been used to develop a set of preliminary recommendations pertaining to re-design of instruction manuals, labels, and videos. These include:

i. Re-ordering information in manuals and on labels to reflect the order of performing installation

ii. Provide a triage or checklist system at the beginning of the manual and in labels to guide use

iii. Simplify text, and remove unnecessary text and repetitive warnings on labels

iv. Provide specific warnings for tether and harness twisting on the labels

v. Provide instructions in languages other than English, and if not possible then:

vi. Make diagrams and pictures more realistic to aid understanding (both manuals and labels)

vii. Provide feedback on performance for key tasks, for example installation checks and information for the user to self-check their performance

viii. Provide links to other reliable sources of information or videos in manuals and on labels

ix. Simplify by separating manuals by mode of installation and removing ambiguous information

x. Place labels in line of sight of user, and increase font size

xi. Manufacturer video should be short, problem-focused, and feature relatable role-models

Even though the recommendations above were not brought up in all focus groups, there were no disagreements between groups on the majority of suggestions made. For example, even though two high SES groups were the only to suggest change in placement of labels on the restraint, no information from other groups contradicted this recommendation. It is important to note that different themes emerged from different groups, and this highlights the need to ensure work with child restraint users samples a diverse range of users to address universal needs.

The only disagreement between demographics groups in this study was on preference for diagrams and pictures over text in instruction manuals. The high SES group found that the number and type of diagrams were sufficient in addressing their needs, while the CALD groups identified a need for more and better pictures. As mentioned by one CALD group, pictures and diagrams are used in the place of text as the main source of instructional information when instructions were hard to read and understand. This could explain the reliance on pictures.

Participant recommendations versus previous CRS research

In their report for the U.S. Department of Health and Human Services, Fischoff et al. (2011) provided a guide to best practices in labeling medicine products to promote correct use. As both labels on medicines and on child restraints aim to authoritatively persuade user's to perform a specific sequence of behaviours, it is not surprising that recommendations in this report overlapped with the themes that emerged from this study: a) organize label components to reflect how the instructions will be processed, b) emphasize critical information, c) simplify language, d) limit auxiliary information, e) address English proficiency by providing multiple language translations, and f) font – high-contrast, simple, large.

Although information needs tend to be similar across health disciplines, direct comparison with the findings of previous studies using child restraint information is pertinent. Similar to findings relating to labels and/or instructions designed by Rudin-Brown et al. (2004) and Klinich et al. (2010), participants in this study asked for information to be ordered in the sequence it needs to be performed and for text to be simplified to increase readability. In the current study, participants requested that the pictures and diagrams resembled the actual seat and tasks more realistically (e.g., using a photo of the restraint instead of a black and white 2D drawing). The only condition to decrease errors in use significantly after controlling for other conditions was improved graphics (Klinich et al., 2010). A high preference for video instructions in the current sample is in support of Klinich et al. (2010).

A key finding here is that the warnings for misuse in instructions and on labels are not engaging. A participant noted that they wouldn't pay attention to the risk statement due to familiarity. Reducing large text warnings was a recommendation made by Kramer et al. (2015) in their report to Transport Canada.

Kramer et al. (2015) reported that instructions should be explained using a combination of pictures and text, with *text being used for more abstract tasks*. With inclusion criteria requiring participants to have no difficulty reading or writing English, expectedly, this is in direct disagreement with the needs of the CALD participants sampled in this study who rely on pictures and diagrams in place of text due to English literacy problems. Further, at least 80% of Kramer et al.'s (2015) population had at least a tertiary level education.

The results of these focus groups support the suggestions made by Klinich et al. (2010), Kramer et al. (2015) and Rudin-Brown et al. (2004) that instructions and labels can and need to be improved to address consumer needs. This is interesting because the different populations of users across the Canada, North America, and Australian studies are converging on best-practice recommendations for instructions and labels. Across all three studies, there has been sampling of high and low education, literacy, income, and experience. The focus groups conducted here now provide consumer-centred recommendations from culturally and linguistically diverse child restraint users.

While understanding that focus groups are snapshots of user behaviour and not a complete picture of consumer needs, we are now well placed to use the results here and in past literature to draft a prototype of new instructions, labels, and videos to increase the correct use of restraints.

Both Rudin-Brown et al. (2004) and Klinich et al. (2010) found significant increases in user satisfaction and preference for re-designed materials, but only limited success at increasing actual correct restraint use compared to current products. And while Kramer et al. (2010) was able to significantly increase percentage of correct installations, more than 60% of all installations were still incorrect. To ensure that errors in use are reduced in new prototype information, the next stage of the project will focus on iterative prototype design involving consumer-testing until at least 90% of all participants in a testing cycle are able to install and use the prototype without significant error (guidelines developed by Sless and Wiseman, 1997).

Limitations

The results outlined in this paper are preliminary. Saturation of themes related to how information is currently communicated was not reached in this small number of diverse focus groups. However, the data generated will be extremely useful input into the first stage of the prototype material design. The next step is to consult the focus group data to explore motivational and emotional factors relating to correct child restraint use.

Socio-economic Index for Areas was used as a proxy for education and income for sampling purposes. While it is not as important to look at the distribution of recommendations from participants based on their demographics in this first round of user-input, the next stage of this project requires more and complete demographic data and assurance that all key child restraint users are being captured by sampling strategies. Homogenous groups were chosen to increase participation's comfort with expressing opinions. However, this meant that groups were selected by researchers based on demographic information. The next stage of this project will use randomisation to allocate participants to user-testing cycles so that diversity of needs is addressed.

Conclusion

The qualitative results in this study have extended previous research efforts to improve instruction manuals and labels for child restraint products. Guidance from child restraint users from diverse backgrounds is necessary to ensure that consumers' needs are driving the direction of design, and focusing attention on the key factors for change at the outset of re-design. We have elicited 11 key recommendations from users that will be applied to re-design new prototype instruction manuals, labels, and videos. Through iterative design and user-testing, this project as a whole will result in new product information that is designed according to user needs, and effective at reducing errors in child restraint use. Eventually, the products will be tested in a laboratory trial against current materials in Australia.

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Child restraint use among Aboriginal and Torres Strait Islander children in 12 communities in NSW

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Abstract

Despite the over-representation of Aboriginal and Torres Strait Islander children in road related deaths and serious injury, little is known about how Aboriginal and Torres Strait Islander children travel in cars. We conducted interviews with 601 parents and carers and 367 observations of children in cars as they arrived at preschools, day care centres and Mums and Bubs groups across 10 Aboriginal and Torres Strait Islander communities in New South Wales. While 93% of children were observed to be restrained in some way (323/349), 16% (54/329) were not in the right restraint for their age, highlighting the need for a community based child restraint program working with Aboriginal and Torres Strait Islander communities targeting optimal restraint use.

Background

Aboriginal and Torres Strait Islander children are over-represented in fatalities and serious injury with road related injury being a leading cause of death for this group.(Australian Institute of Health and Welfare, 2012) Despite the known safety benefits of child restraints and recent changes to the road rules regarding child restraint use, previous research has shown only 31% of children are optimally restrained (child correctly restrained in an age-and size-appropriate restraint).(Keay et al., 2012) Despite this, little is known about how Aboriginal and Torres Strait Islander children are travelling and whether or not they are being correctly restrained in age appropriate child restraints.

Method

Working with community and following extensive consultation and engagement in Aboriginal and Torres Strait Islander communities in New South Wales, Australia, we recruited and trained 42 local Aboriginal and Torres Strait people to conduct surveys with parents and carers and to observe how children were restrained as they arrived at early childhood services in 10 communities. Communities were classified according to the Australian Standard Geographical Classification - Remoteness Area (ASGC-RA) two were ‘outer regional’, three ‘inner regional’ and five were ‘major city’.(Australian Government - Department of Health) Data presented here form the baseline data for the evaluation of a pragmatic trial (*Buckle-Up Safely*) targeting optimal restraint use among Aboriginal and Torres Strait Islander children.

Results

Participants

In 2015-2016, we conducted interviews with 601 parents and carers and completed 349 observations of child restraint use. Parents or carers provided responses to the structured survey for 601 children. The average age of the child was 3.3±1.6 years (range 0-7 years) and 338/560 (60%) were Aboriginal or Torres Strait Islander children. Of the children observed, 16% (54/329) were not in the right restraint for their age; significant errors ranged from belt buckle not being engaged (11%) to internal / shoulder harness being incorrectly or not used (31%).

Conclusions

These findings are the first stage of the baseline data collection for a large scale pragmatic trial measuring the effectiveness of a culturally appropriate child restraint program among Aboriginal and Torres Strait Islander people in Australia. Core messages of the *Buckle-Up Safely* program, delivered by local Aboriginal Community Workers, will focus on correct use of child restraints, targeting key errors in observed use and highlighting the safety benefits of correct and age-appropriate use. Program messaging will be tailored to address the needs of the local communities. The program is guided by a Steering Committee comprising both non-Aboriginal and Aboriginal and Torres Strait Islander people representing community organisations, government and non-government agencies.

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Dry Drivers and Mates Motels – Creating Social Change through Integrated Marketing Communications

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Abstract

Drink driving remains a major problem on Queensland roads, accounting for one in five fatal crashes and one in ten serious casualty crashes. A survey of 3,000 Queenslanders found that those who admit to driving after drinking are more likely to be males, aged under 40, in particular 25-39 years[1.] Offence and crash data shows that males account for almost eight in ten (79.4%) drink driving offences and 80% of drink driving serious casualties involved male drivers/riders.

This paper will detail the recent Queensland Department of Transport and Main Roads strategy of education and engagement initiatives being used to reduce the incidence of drink driving, and bring about social change in this area of road safety.

Introduction

Road safety is a major issue in Queensland with the annual cost of road fatalities and injuries to the Queensland economy estimated to be $5.4 billion. The emotional costs for the community are immeasurable.

Compounding the problem of the road toll, is the apparent community acceptance of human trauma resulting from road crashes. Complacency presents a real challenge for Queensland. As the state continues to grow, more people use the roads as part of their daily lives, but people are detached from the ever-present consequences of risky driver behaviour.

In 2014, the Queensland Government launched the Join the Drive to Save Lives Social Change Strategy (Join the Drive), a new approach in Australia incorporating Social Change theory into road safety campaigns. This theory suggests communities are more likely to succeed if they are empowered to develop a shared agenda and their own solutions, driven by cohesive values, behaviours and norms.

Drawing on this approach, the Join the Drive strategy is a multi-dimensional program incorporating marketing, advertising and education approaches, as well as communication and mass media campaigns.

The strategy breaks new ground in many ways. It draws together international road safety research with key elements of behavioural and social change theory. Other ground -breaking characteristics include:

- It is a repeatable and outcome-focused model - It increases ownership, engagement and action on road safety issues – and is constructed in a way that will help to make it self-sustaining.
- Community involvement is key and moves activity beyond the ‘marketing’ realm
- The program is holistic - a concerted effort in key areas from infrastructure improvements, vehicular safety, support and action from businesses, strategic and legislative support and direction from government, and importantly,

1 *Risky Driving Behaviour*, Footprints Research, 2014

- Integration is key – multiple communication disciplines, audiences, channels, and operational activities

Drink Driving Campaigns

The Join the Drive strategy focuses on a number of road user behaviors, however a focus during 2014/15 was drink driving. Two mass media campaigns ("Mates Motel" and "Dry Driver") were developed with the objectives of encouraging Queensland drivers to plan ahead and avoid drink driving, and to provide practical alternatives to drink driving. Longer term, as part of the overarching Join the Drive strategy, objectives include fewer motorists willing to risk drink driving and maintaining the social unacceptability of drink driving.

The Mates Motel campaign ran over the 2014/2015 Christmas/New Year period, and focused on the idea of providing alternative strategies to drinking and driving as represented by the concept of a 'Mates Motel'. A second advertising burst coincided with the May long weekend.

The Dry Driver campaign ran over the 2015/2016 Christmas/New year period and focused on the idea of encouraging people to plan their transport needs before they start drinking by designating a 'dry' driver. Both campaigns incorporated TV, print, radio and outdoor advertising, whilst Mates Motel also included event specific sponsorship (Big Bash cricket and Brisbane Heat).

Post Campaign Results

A full campaign evaluation of Mates Motel was conducted, showing the campaign had a positive effect on drivers surveyed, including:

- 83% of respondents mentioning at least one of the Mates Motel campaign key messages, with very strong recall of the 'stay at your Mates Motel rather than drinking and driving'

- 69% of those who had seen the Mates Motel campaign agreed they are more likely to plan ahead to avoid drinking and driving

- 62% of all respondents agreed they are more likely to ask if they can stay at a friend's place to avoid drinking and driving

- Mates Motel website achieved over 26,000 hits over the initial 3 month period, with the campaign video reaching over 226,600 views via the campaign Facebook page

Initial evaluation results from Dry Driver are equally encouraging, with full campaign evaluation results to be available mid-2016.

Conclusion

The Join the Drive to Save Lives strategy has been a change of direction for the Queensland Department of Transport and Main Roads, with the Queensland community being encouraged to challenge the acceptability of road trauma. The recent campaign approaches to the issue of drink driving has shown significant traction with the target audience. This paper will expand on the evaluation of both campaigns, as well as detail future directions for the wider Join the Drive strategy and the Queensland Government's commitment to a long-term vision of zero deaths and serious injuries on our roads.

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Market Research Findings Post Campaign Evaluation: Mates Motel, Footprints Market Research, 2015

Risky Driving Behaviours, Footprints Market Research, 2014

Coming out of nowhere: Attention and motorcycle detection

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Abstract

Looked-but-failed-to-see crashes describe situations in which drivers look directly at an unexpected object on the road yet fail to see it. Motorcycles are well represented in such crashes. Psychologically, these crashes could be explained by inattentional blindness; this occurs when observers fail to notice unexpected, though clearly visible objects when their attention is engaged elsewhere. Here, a driving-related IB task demonstrated that motorcycles were less likely to be detected than other vehicles such as taxis. Participants were also more likely to report expecting to fail to see a motorcycle. This has important implications for increasing motorcycle awareness in terms of familiarity, salience and expectations of road users.

Background

Many crashes involving motorcycles, are due to looked-but-failed-to-see crashes where the driver of a car looks directly at the motorcyclist but still fails to see him/her (e.g., Brown 2002). These types of crashes map onto a cognitive/psychological phenomenon called inattentional blindness (Mack & Rock, 1998). Thus understanding inattentional blindness allows us to understand why we might miss some objects when driving, but not others (Pammer & Blink 2013, Pammer et al, 2015), and has particular relevance for detecting motorcycles when driving. The aim of this experiment was to explore whether motorcycles are more likely to be missed compared to other vehicles such as taxis, and some of the underlying cognitive factors that might help explain why this might be the case.

Method

Seventy six participants were presented with static images of driving scenarios in a static IB design. Each presentation was a single fast snapshot of a typical driving situation presented in the centre of the computer screen. For each snapshot, the participant was to respond with an explanation as to whether they thought the image represented a safe or unsafe driving environment. In one of these trials – the critical trial – an additional object was present in the scene that was not present in any of the other scenes. In this experiment the additional object was either a taxi or a motorcycle. These additional objects were presented as a between subjects factor, and matched as closely as possible in terms of physical conspicuity. The DV was whether or not participants detected the unexpected object. This method has been used elsewhere (e.g., Pammer, et al, 2015; Pammer & Blink 2015)

Results and conclusions

The rate of IB varied depending on the type of vehicle, such that motorcycles were detected significantly less frequently than other vehicles such as taxis. Possessing a motorcycle licence did not predict noticing in the taxi condition, however, this predictor approached significance in the motorcycle condition, indicating that participants who possess a motorcycle licence were more likely to notice the motorcycle stimulus. It was also found there was a significant difference between the personal ratings of the likelihood of missing a taxi compared to a motorcycle, indicating that non-noticers thought they were more likely to miss a motorcycle on the road compared to a taxi. The results are consistent with the idea of attentional set and that drivers may be more likely to miss motorcycles of the road because they don’t expect to see them. This has implications for increasing motorcycle awareness in safety campaigns and making salient the motorcycle experience in all driver training.

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Digital Billboards and Road Safety: How can we best assess the risk?

Paul Roberts and David McTiernan

ARRB Group

Abstract

There has been a long standing concern about the distracting effect of roadside advertising and its potential negative effect on road safety. In recent years this concern has been further amplified by the introduction of digital technology for billboard displays. This paper outlines a practical and defensible approach to assessing the safety risk associated with digital billboards based on the approach outlined in AP-R420-13 (Austroads, 2013). The assessment process will be illustrated by reference to examples and case studies.

Background

Most jurisdictions in Australia are currently experiencing an influx of applications for approval of digital billboard installations. This includes new sites and also the digitization of existing static sites (see e.g. The Australian, February 22nd, 2016).

There has been a long standing concern about the distracting effect of roadside advertising and its potential negative effect on road safety. Fundamental human factors considerations raise concerns that the unique characteristics of digital billboards increase distraction and with it an increase in crash risk, beyond that which holds for traditional billboards. In particular, in some driving situations it is likely that image and luminance changes will involuntarily capture attention and that particularly salient emotional and engaging material will recruit attention to the detriment of driving performance, particularly in inexperienced drivers. Where this happens in a driving situation that is also cognitively demanding, the consequences for driving performance are likely to be significant. Furthermore, if this attentional capture also results in a situation where a driver’s eyes are off the forward roadway for a significant amount of time this will further reduce safety. Additionally, road environments cluttered with driving-irrelevant material may make it difficult to extract the information that is necessary for safe driving, particularly for older drivers (Austroads 2013).

Digital billboard safety assessment

It is clear that not all locations and billboard designs are likely to be equally risky and indeed some are likely to be acceptable from a safety perspective. For this reason it is important to have a process for assessing the road safety risk associated with digital billboard installations and proposals. AP-R420-13 (Austroads, 2013) sets out the key principles that must be considered in assessing risk but does not provide details of how to apply these principles in practice. This paper outlines a practical and defensible approach to assessing the safety risk associated with digital billboards, based on the approach outlined in AP-R420-13.

Information about the key variables identified in AP-R420-13 generally can be obtained relatively easily from application proposals, site visits and road agency databases. That information must then be interpreted and combined in a way that allows a decision to be made about the risk associated with an installation. Since much of the risk associated with digital billboards is associated with the changing of the display, attention must be focused on the relationship between dwell time, visibility distance, travel speed and exposure of the traffic stream to image changes. In general, dwell time durations that would result in a large proportion of the traffic stream being exposed to one or more display changes, in road environments that are cognitively demanding, would generally be seen as unacceptably risky. The details of this and other aspects of the assessment process will be illustrated by reference to examples and case studies.

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Driver stress in response to infrastructure and other road users: Simulator research informing an innovative approach to improving road safety

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Abstract

Recent research suggests the psycho-biophysical impact of stress can negatively impact health long after stressor exposure, in addition to increasing on-road discourteous driving behaviour. Twenty-two drivers participated in a simulated drive during which biophysical markers of stress (e.g., heart rate) were measured in response to interactions with stress-inducing/reducing infrastructure (roadworks, roundabouts; straight roads), manoeuvres (merging, overtaking; open roads), and road users (rude/oblivious/distracted/nice drivers). Findings suggest drivers experience increased stress during stress-inducing interactions, therefore recommendations regarding minimising longer-term negative impact of stress and which also improves road safety through courteous driving include interventions framed within enforcement, engineering, education and/or engagement.

Background

As part of a larger research project, driving conditions and circumstances which increase stress and are associated with driving discourtesy (either generated by the participant or by other road users) elucidated through focus group research (Scott-Parker, Jones, & Tucker, 2015) were used to inform the development of a simulated drive. This study aims to deepen our understanding of the relationship between driving dis/courtesy of other road users, and the nature of the interaction and infrastructure, and the stress experienced by drivers in the simulated driving environment.

Method

Twenty-two drivers aged 21-76 years (average of 45 years, 8 females) participated in two simulated drives over consecutive weekends. During drive one, participants were exposed to rude and distracted (or nice and oblivious, ‘courteous drive’) drivers, and during drive two, participants were exposed to nice and oblivious (or rude and distracted, ‘discourteous drive’) drivers, as they drove the same simulated driving course which contained key stress-provoking infrastructure and required key stress-provoking manoeuvres. In addition, key stress-reducing infrastructure and stress-reducing manoeuvres were also incorporated. Bio-physical markers of stress included alpha amylase (pre- and post-drive) and cardiac indicators.

Results

Cardiac measures

For drivers who completed the courteous drive on their first drive, there was only a moderate increase in heart rate, central systolic pressure, and central augmentation index, suggesting that the drive generally was not experienced as a stressful drive (see Table 1). In comparison, for drivers who completed the discourteous drive on their first drive, there was a moderate increase in diastolic blood pressure, mean arterial pressure, heart rate, central systolic pressure, central augmented pressure, and central augmentation index, suggesting that these drivers experienced the drive as a stressful drive. Interestingly, drivers experienced considerably more (less) physiological stress when they completed the discourteous (courteous) drive on the second occasion.

Table 1. Comparison of biophysical measures for drivers by stressful nature of each drive, by driving order, n=12

Variables	Courteous day 1			Courteous day 2	
	Pre PD (*n*=5)	**Pre ED (*n*=5)**	**Post ED (*n*=5)**	**Pre ED (*n*=7)**	**Post ED (*n*=7)**
Systolic BP (mmHg)	143±15	140±12	141±10	124±2	122±3
Diastolic BP (mmHg)	85±5	87±5	87±5	79±2	79±3
Mean arterial pressure (mmHg)	105±7	104±7	105±6	93±2	92±3
Heart rate (bpm)	79±2	78±4	81±4	79±4	74±5
Central systolic pressure (mmHg)	128±12	124±10	126±9	110±2	109±3
Central pulse pressure (mmHg)	42±11	37±7	38±8	29±3	28±3
Central augmented pressure (mmHg)	11±6	8±3	8±4	3±2	2±1
Central augmentation index (mmHg)	23±8	18±7	22±8	8±5	7±3
Variables	**Discourteous day 1**			**Discourteous day 2**	
	Pre PD (*n*=7)	**Pre ED (*n*=7)**	**Post ED (*n*=5)**	**Pre ED (*n*=5)**	**Post ED (*n*=5)**
Systolic BP (mmHg)	124±4	127±3	128±11	132±11	139±11
Diastolic BP (mmHg)	77±4	79±4	83±4	81±4	87±4
Mean arterial pressure (mmHg)	91±3	93±4	98±4	98±7	105±6
Heart rate (bpm)	66±3	69±4	72±5	78±3	84±5
Central systolic pressure (mmHg)	111±4	113±3	115±5	117±9	123±8
Central pulse pressure (mmHg)	33±3	32±2	30±3	35±6	34±7
Central augmented pressure (mmHg)	4±2	2±2	4±3	6±3	5±3
Central augmentation index (mmHg)	7±5	3±5	9±8	16±8	16±8

Values are presented as the mean ± standard error. PD = Practice Drive; ED = Experimental drive.

Heart rate variability

The average heart rate for each participant was calculated for every consecutive 30-second segment of driving, with the magnitude of heart rate variability determined by subtracting the average heart rate for the preceding 30-second interval from the heart rate for each second of the drive (starting from 30 seconds after driving commences). For the purposes of these analyses, it is assumed that 5bpm (+/-) variability at rest is an indicator that the participant is not stressed, therefore +/- 10bpm is considered meaningful and indicative of increased/ reduced stress experienced by the participant during the simulator driving activities. Figure 1 graphically depicts the heart rate variability for Participant 1, showing the increased stress experienced during the discourteous drive (second drive) compared to the courteous drive (first drive).

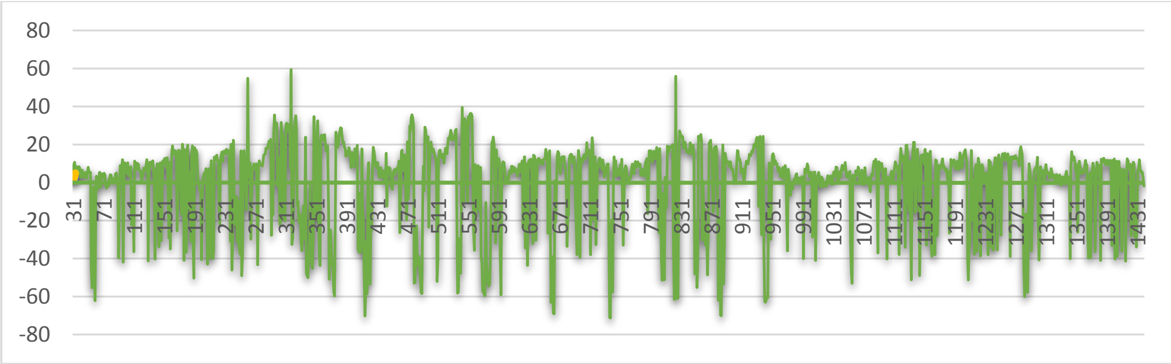

Figure 1a. Heart rate variability for Participant 1 during the courteous drive

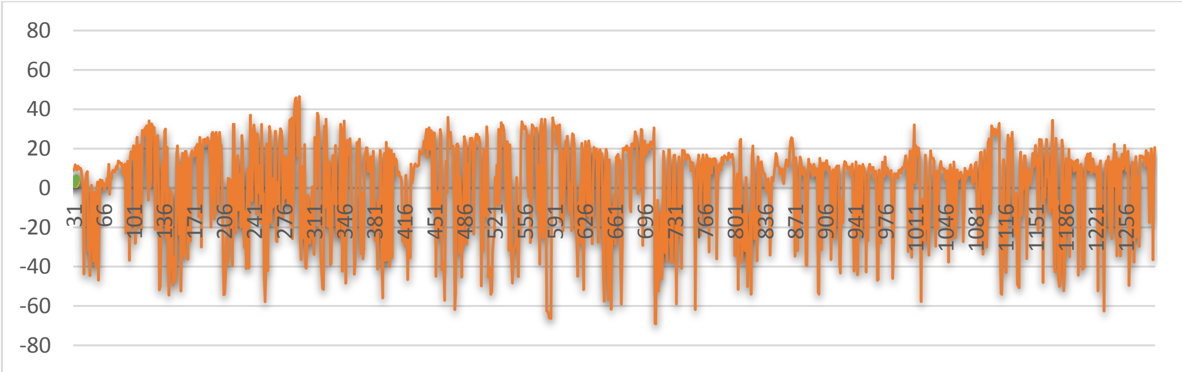

Figure 1b. Heart rate variability for Participant 1 during the discourteous drive

Analyses are currently underway in which the second-by-second heart rate response is examined in relation participant driving and other behaviours (e.g., gesticulations, speech) to (dis)courteous interactions. It is noteworthy that preliminary analyses indicate that driver behaviour changes in a negative manner, in addition to the biophysical markers of stress, in response to discourteous interactions. The study findings are expected to contribute to an innovative road safety campaign that improves road safety through increasing driver courtesy and decreasing driver discourtesy as a way to improve driver health both during and after the drive.

Conclusions

It appears there is a breadth of infrastructure-related and/or other-road-user-related interactions that contribute to driver stress which not only have impacts on the road user, both during and after the interaction, but that can potentially have long-term impacts on driver health beyond the road itself. In addition, such stress appears to evidence itself as discourteous driving behaviour during and immediately after the discourteous interaction. Intervention to reduce driving stress – a novel way of improving road safety – should focus upon education (e.g., merging rules), enforcement (e.g., posted speed limits), engineering (e.g., roadwork signage and practices), and engagement (e.g., encouraging road users to transfer non-stressful interactions and circumstances to stressful interactions and circumstances).

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Do motorcyclists have greater exposure to situations in which another driver fails to give way?

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Abstract

This study investigated the possible increased exposure of motorcyclists to situations in which another driver is more likely to fail to give way. Leading and trailing time gaps for passing motorcycles compared to those for other vehicles were measured at 178 urban and rural sites in Victoria, and categorised into 4 distinct time periods. Motorcyclists significantly more frequently had larger time gaps around them compared to other vehicles. This in turn may mean that motorcyclists are more exposed to scenarios where another driver fails to give way to them as the approaching vehicle.

Background

One of the most common scenarios for motorcycle injury crashes involves another driver failing to give way to the motorcyclist (Allen et al., 2013; Brown et al., 2015; Pai, 2011). There is also evidence that motorcyclists are over-represented (as the "through vehicle") in these crash types (de Craen, Doumen, & van Norden, 2014; SWOV, 2010). Previous research has explored a number of explanations, including differences in physical or sensory conspicuity of motorcyclists (Wells et al., 2004), cognitive conspicuity factors (Beanland, Lenne, & Underwood, 2014; Olson, 1989), motorcyclist speed (Clabaux et al., 2012), and crash risk or driver responses such as look-but-fail-to-see (LBFTS) errors. However, one potential contributing factor not yet investigated is a greater exposure of motorcyclists to scenarios where driver error (related to failing to give way) is more likely. This includes circumstances where the approaching traffic is a single vehicle well clear of other vehicles travelling in the same direction. The purpose of this study was therefore to test this hypothesis, by comparing time gaps around passing motorcyclists to that of other vehicles at selected road sites in Victoria, Australia.

Methods

The study population were motorcycles and other vehicles observed on public roads within a 150km radius of the city of Melbourne, Australia. The data was collected as part of a larger case-control study of serious non-fatal motorcycle crashes. A motorcycle was defined as a powered two wheeler (PTW) vehicle registerable for use on Victorian roads, including mopeds and scooters. The study was approved by the Monash University Human Research Ethics Committee.

Measurement of time gap for both motorycles and other vehicles was available from 178 of 204 sites sampled (87%), with a total of 101,224 vehicles (0.5% motorcycles) assessed. Sites were selected based on the location of a recent motorcycle injury crash occurring between the hours of 6am and midnight from May 2012 to August 2014. Traffic observations and measurements were sampled for a mean of 2 hours at each site on the same type-of-day (weekday, Saturday or Sunday), within 1 hour each side of the crash time.

Time gap between vehicles was recorded using a traffic counter radar (Sierzega SR4, Sierzega Elektronik GmbH,Thening, Austria). The device measured time gap between passing vehicles, as well as vehicle speeds and lengths. Vehicle length allowed identification of motorcycles from other (larger) passing vehicles, which was confirmed using time synchronized digital photographs taken within close proximity to the traffic counter.

Time gap between vehicles was categorised into 4 distinct periods: 0-2 s, 2-4 s, 4-6 s, and >6 s, with 0-2 s assigned as the reference category. Statistical comparisons of time gaps between motorcycles and other vehicles used a generalized Poisson (log-linear) regression model

Results

Motorcycles showed significantly higher rates of large time gaps (> 2 s) both behind and in front when compared to other vehicles (see **Figure 1**). Motorcycles were almost 3 times more likely to have a 4-6 s gap behind, and 2.5 times more likely to have a 4-6 s gap in front, when compared to other vehicles. This effect was present (to a lesser extent) for all other larger gap categories (2-4 s and >6 s), and was significant for all categories except > 6 s in front.

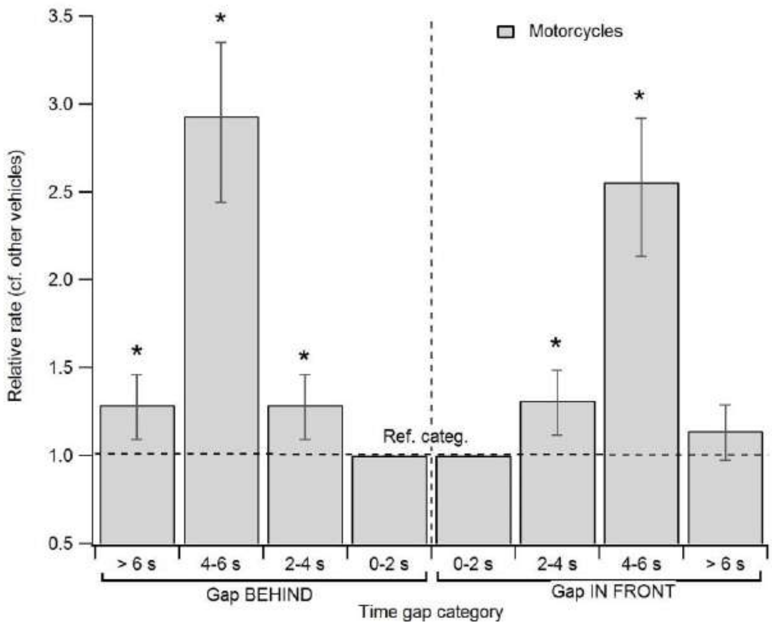

Figure 1. Leading and trailing time gaps of passing motorcycles, expressed relative rate to other vehicles (using 0-2 s as the reference category). * = significantly different to other vehicles (p<0.05).

Conclusions

These findings support the notion that motorcyclists travel with greater distances to other (same-direction) traffic more frequently when compared to other vehicle types. If we assume that the probability of a driver error involving failure to give way to another vehicle (including a look-but-fail-to-see error) is higher when an approaching vehicle is ‘alone’, our results suggest that motorcyclists have greater exposure to these situations. This, combined with other factors such as conspicuity (Beanland et al., 2014), may provide a more complete understanding of one of the most common motorcycle crash scenarios. The higher rate of longer time gaps around motorcycles may reflect vehicle characteristics unique to motorcycles that increase opportunities to move ahead of a traffic stream (eg. agility, size) and/or active strategies of riders to move clear of vehicles in close proximity. This finding provides a potentially important contribution to our understanding of motorcycle injury crashes involving another vehicle failing to give way, and may be useful for reducing their occurrence. Further research is needed to determine whether particular riding strategies in traffic can reduce risk of a serious crash involving another vehicle.

Acknowledgments

The case-control study from which this data was sourced was funded by the Australian Research Council (LP110100057), VicRoads, the Transport Accident Commission of Victoria, and the Victorian Government Department of Justice, with in-kind support from Victoria Police and the Victorian Automobile Chamber of Commerce. We are grateful to Rob Jackel who provided technical expertise to inform data collection methods and collected field-based data with assistance from Lindsay Lorrain.

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Enhanced Maintenance Strategies for Popular Motorcycle Routes

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Abstract

Motorcycles are more susceptible to crashes than other vehicles because of road surface issues. The road risk action categories and road maintenance categories VicRoads uses to determine the timing of remedial actions were based on traffic volumes and the road's function. While heavy vehicle use was factored into this assessment, motorcycles were not.

If, instead of cars or heavy vehicles, motorcycles become the designated 'maintenance design vehicle', then road repairs, maintenance and reinstatement works need to be carried out in a slightly different manner.

Using the Great Alpine Road as an example, this paper specifies enhanced maintenance strategies that are suitable for motorcyclists.

Background

Motorcycles and scooters are susceptible to crashes associated with problems at the road surface (IHIE, 2010 & CROW, 2003). Especially so where the rider may be braking and/or turning, such as at an intersection or on a curve in the road (MAIDS, 2009). The road needs to have uniform and predictable surface friction (skid resistance). Any change in surface that may reduce surface friction should be avoided, and where this is not possible it should be clearly signed and made visible during all weather conditions and at night.

The road risk action categories, A to F, that are used in Victoria to determine the timing of remedial action to road surfaces are shown in Table 1. Road maintenance categories (using numerical values of 1 to 6 in Victoria) are commonly aligned with road classifications that reflect the strategic importance of the route and total traffic volumes. This reflects the total risk exposure of all road users so that the standards are highest on the busiest, most important roads. In urban areas the current approach is generally appropriate for motorcyclists. However, many popular recreational motorcycle routes, such as the Great Alpine Road, are lightly trafficked rural routes in hilly terrain with low strategic importance. They attract motorcyclists because they have low volumes and the terrain provides an enjoyable riding experience that includes the 'thrill' (higher risk riding).

Such routes are often in less frequent road maintenance categories and on higher speed roads (usually with a default 100km/h speed limit). As a consequence, there is a higher probability of encountering a pavement defect on these routes and a potentially higher probability of a motorcycle casualty crash as a consequence of the defect, road alignment, travel speeds and roadside conditions. This higher exposure to defects compounds the higher risk that such defects present to motorcyclists.

Available traffic volume data do not provide a comprehensive picture of motorcycle volumes on all arterial roads or enable the identification of high volume motorcycle routes. However, available motorcycle volume data and motorcycle trauma rates provide an appropriate means to identify roads for more frequent maintenance activities.

Table 1 Road Risk Action Response

Response Code	Control Mechanism	Response Time
A	Inspect and rectify, if feasible, or provide appropriate warning.	Within 4 hours of inspection or notification
B		Within 24 hours of inspection or notification
C		Within one week of inspection or notification
D		Within one month of inspection or notification
E		Within 3 months of inspection or notification
F		Within 6 months of inspection or notification

Results and Conclusions

Following a road safety audit of the Great Alpine Road conducted by an experienced motorcycle rider, it was determined that the standard VicRoads Hazard Response matrix needs amendment when motorcycles are the 'road maintenance design vehicle'.

Figure 1 and Table 2 amend the standard VicRoads Hazard Response matrix that is used to determine maintenance action. Thus the Great Alpine Road is presently considered to be in road maintenance category three (RMC = 3) on the basis of its traffic volumes, which means that daytime inspections are undertaken weekly, and night-time inspections every six months. We have indicated, in red, the amended hazard definitions that are needed for motorcyclists (on the basis of the expert judgement of experienced riders) and indicated that for motorcyclists the pothole hazards and the deformation hazards are sufficiently serious that the RMC should be reduced to 2 (RMC = 2) which means that daytime inspections should be undertaken twice per week.

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Table 2 VicRoads Hazard Response matrix amended (in red) for motorcycles as the 'maintenance design vehicle'. Red rectangles denote recommendations for the Great Alpine Road

Description Of Hazard	RMC 1	2	3	4	5	6
Pavements						
Obstructions and Substances in Traffic Lanes						
Materials fallen from vehicles, dead animals, wet clay and other slippery substances, hazardous materials, accumulation of dirt or granular materials on the traffic lane of sealed roads	A	A	B	B	C	F
Ponding of water >300mm deep, fallen trees, oil spills, stray livestock	A	A	A	B	B	F
Pavement or Surface Defects						
Potholes in traffic lane of a sealed pavement greater than 200mm in diameter and greater than 75mm deep, or greater than 100mm in diameter and 50mm deep on a curve or on the approach* to the curve	A	B	C	C	D	F
Where assessment in accordance with the skid resistance policy indicates remediation is required.	C	D	D	D	D	F
Deformations > 75mm under a 3 m straight edge, or in the sealed traffic lane on a curve (or on the approach* to the curve) greater than 50mm deep under a 3 m straight edge.	A	B	C	C	D	F
Edge drops onto unsealed shoulder >100mm	n/a	B	C	C	D	F
Drainage						
Damaged or missing drainage pit lids, surrounds or grates in pedestrian areas or traffic lanes	A	B	B	D	D	F

*the approach to a curve is the area where a motorcyclist is braking and then begins to lean before the curve. Depending on the approach speed, this area can be up to 100m in advance of the curve. See Figure 1 below.

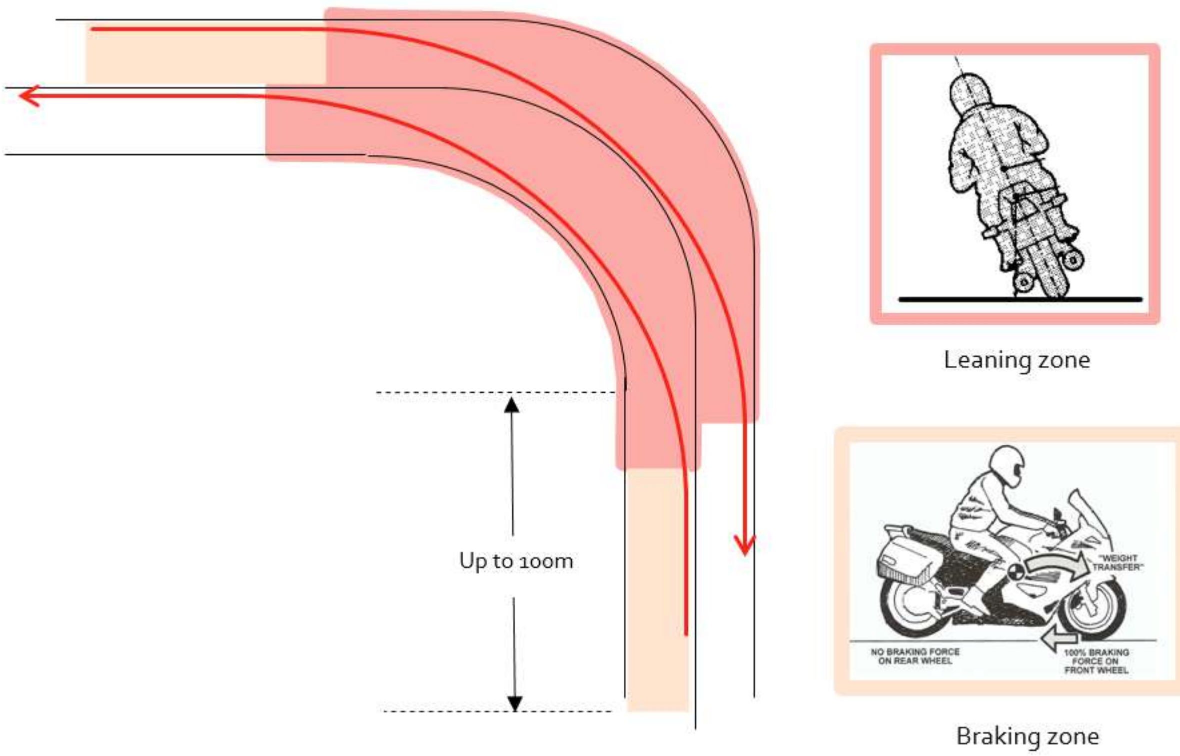

Figure 1. Typical motor cycle ride paths around curves. The shaded light pink areas indicate the extra approach distance for motorcyclists that needs to be kept free of road defects

Motorcycle Passenger Helmet Use in Cambodia – A turning Point?

Pagna Kim and Katherine Klaric

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Abstract

This abstract examines January 2016 start of enforcement of Cambodia's road traffic law as a potential turning point for passenger helmet use (PHU) among motorcyclists. Focus is on Kandal, Kampong Speu, and Phnom Penh provinces, where concerted efforts toward increased PHU have been underway since 2010, first with the Cambodia Helmet Vaccine Initiative (CHVI); and its scale up under the 2014-2016 USAID-DIV funded "Head Safe. Helmet On." (HSHO); implemented by AIP Foundation. School-based education, helmet/voucher distribution, public awareness campaigns, and advocacy and capacity building are combined to steadily increase PHU rates, which jumped subsequent to enforcement start.

Background

In Cambodia, there were 2,226 deaths and 6,005 serious injuries in 2014 (RCVIS, 2015); based on traffic police data in 2015, the fatality rate continued to increase by 5% (GCNP, 2016). Motorcycle users accounted for 73% of fatalities in 2014, while only 12% wore helmets at the time of collision. Helmets are proven to reduce the risk of death by 42% and of serious injury by 69% (Liu et al., 2008).

In 2009, the Cambodian Government endorsed the UN Decade of Action for Road Safety (2011-2020). In 2010, the Government and AIP Foundation launched CHVI in order to increase passenger, including child, helmet use in the three aforementioned, high-risk provinces. The campaign continued three years until HSHO kicked off in 2014 on a broader scale.

Throughout 2014, together with other stakeholders, HSHO's advocacy supported the Government, to draft a new road traffic law that for the first time would require passengers – in addition to drivers – to wear helmets when traveling by motorcycle. The new law containing this provision was officially promulgated on January 29th, 2015. On July 8th, 2015, the Sub-decree on Fines was approved with rates of fines five times higher than under the previous law (AIP Foundation, 2015).

On January 1st, 2016, enforcement began. At the same time, HSHO supported the drafting and approving of national and sub-national level enforcement action plans.

Methodology behind observed PHU rates

HSHO uses methodology developed with technical support from the United States Centers for Disease Control and Prevention. Quarterly helmet observations are conducted by our research partner Handicap International using a filming method to collect data on helmet use rates in 18 target and 6 control communes on the same day during two 1-hour periods at one intersection in each commune, between a local road and a main road such as national highway. The following data

KIM et al. is collected: direction of motorcycles, drivers and passengers wearing helmets, number of passengers, use of chin strap, gender of riders, identification of children below 15 years old (excluding babies). Observations are conducted during weekdays with normal conditions and weather (HI, 2014).

Results of post-enforcement observations

Table 1. Passenger Helmet Wearing Rates *(HI, 2016)*

	August 2014 (Baseline)		**August 2015 (pre-enforcement)**		**January 2016 (post-enforcement)**	
	Target	*Control*	*Target*	*Control*	*Target*	*Control*
PHU (averaged across 3 provinces)	10.00%	12.00%	12.78%	13.82%	29.90%	27.90%

Conclusions

PHU rates rose 17.2 percentage points in target areas and 14.08 percentage points in control areas in from August 2015 (pre-enforcement) and January 2016 (post-enforcement). Previous to that, rates from baseline (August 2014) to August 2015, when target areas saw rises of 2.78 percentage points in target areas and 1.82 percentage points in control areas. It is therefore reasonable to conclude that enforcement played a key role in boosting PHU rates.

Alongside this conclusion, however, there is the recognition that observations were conducted two weeks into January – a time at which enforcement was not yet as broad and robust as it is envisioned to be in the future. A new directive from the head of the police calls for stringent enforcement from mid-March. Rates are expected to rise again after.

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NSW Motorcycle Strategy: A Model for Consultative Strategy Development and Implementation

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Abstract

The *Motorcycle Safety Strategy: 2012-2021* was one of a series of projects initiated in response to a 21 per cent increase in the NSW road toll between 2008 and 2009. A key objective was to incorporate the skills and knowledge of the motorcycle community within a safe systems framework to strengthen the evidence base, improve problem definition, and increase the relevance of key actions. This approach has been successful in achieving stakeholder buy-in to the development and ongoing implementation of the strategy.

Background

The *Motorcycle Safety Strategy: 2012-2021* specifically sought to address an overrepresentation of motorcycle riders in both fatalities and serious injuries on NSW roads. In 2009, motorcycles made up less than four per cent of registered vehicles; however motorcyclists accounted for 15 per cent of fatalities and 11 per cent of serious injuries.

Approach

The development of the *Motorcycle Safety Strategy* was premised on establishment of a strong evidence base and a robust consultative model with the motorcycle community.

Initial consultation in 2010/11 was undertaken through a series of workshops which were structured to maximise stakeholder involvement. Generally, the workshops were conducted in two phases. The first phase provided participants with an overview of current research and analysis on motorcycle safety. The second phase invited participants to contribute to problem definition and development of potential actions through facilitated work groups led by subject matter experts. Each work group was focused on a different element of the safe system approach – safe roads, safe vehicles, safe people and safe speeds.

The combination of a strong evidence base and robust consultation supported the development of 36 targeted actions for implementation in the first three years of the strategy.

This consultative model was continued through the establishment of the Implementation Working Group. The Group has been meeting quarterly since June 2012, monitoring implementation and providing input on approach to key actions. The Group also worked on the review and development of the next three year action plan (2016-18) in 2015 which contains a further 22 targeted actions.

Results and Conclusions

The collaborative and evidence based approach taken in developing the *Motorcycle Safety Strategy* has delivered a number of key benefits including:

- Improved problem definition with research and analyses strengthened by stakeholder input, as reflected in the evidence based Strategy and the two Three Year Action Plans.

- Development of targeted actions based on a safe system approach addressing vehicle, people, speed and road issues including:

  - Annual $3M motorcycle safety program - improvements on popular motorcycle routes, research and implementation of underrun barrier protection
  - Launching the "Ride to Live" website
  - Research on fatigue and returning riders
  - Adopting the global standard for motorcycle helmets.
- High level of stakeholder buy-in and relationship development – which assisted with the development and communication of key deliverables including the introduction of motorcycle lane filtering laws and motorcycle in-depth crash study.
- Effective delivery – monitored and driven by the Implementation Working Group.

While it is too early to measure the success of the strategy in terms of the impact on the road toll, early indications are that it is stemming the increase. Since 2009, although over 50,000 additional motorcycles have been registered in NSW, the number of motorcycle fatalities has remained fairly constant, with 70 fatalities in 2009 and 66 in 2015 (provisional).

What are stars made of? : The process of "star rating" the state controlled road network in Queensland

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Abstract

In 2014, the Queensland Department of Transport and Main Roads embarked upon the epic journey of coding and star rating the entire state controlled road network, a length of over 33,000km. The objective of the project was to capture and code 72 road-related attributes that would allow the Department of Transport and Main Roads to analyse the safety indicators on the network, using the AusRAP and ANRAM methodologies. It would also allow for the captured data to inform other road infrastructure business program development for the department, including asset management and maintenance.

Objective

In 2014, the Queensland Department of Transport and Main Roads embarked upon the epic journey of coding and star rating the entire state controlled road network, a length of over 33,000km. The objective of the project was to capture and code 72 road-related attributes that would allow the Department of Transport and Main Roads to analyse the safety indicators on the network, using the AusRAP and ANRAM methodologies. It would also allow for the captured data to inform other road infrastructure business program development for the department, including asset management and maintenance.

Method

The Department engaged ARRB-Qld to undertake the coding and rating exercise, principally due to ARRB being an iRAP certified star rating assessor and also having worked with them previously to rate the safety of the network using the previous NetRisk methodology. ARRB used Digital Video Road (DVR) images, which are captured annually, to code the attribute data and then used the iRAP ViDA tool to process the data and generate star ratings according to the AusRAP methodology.

Results

Since this is the longest and most diverse network worldwide to have been rated in this way, including single lane, unsealed roads through to 8-lane motorways, and including urban sections, which had previously been excluded from rating, a number of issues and challenges were encountered during the project. However, these were overcome through stronger project definition, clarification of criteria, scenario testing, and rigorous quality assurance processes. The result is a robust dataset that can be used by various business units of the Department, both now and into the future, and a set of star ratings that allow the Department to set a road safety benchmark and track progress towards the 2020 target set out in the Queensland Road Safety Strategy 2015-21 and Action Plan 2015-17.

Interim Evaluation of the Victorian Safer Road Infrastructure Program Stage 3 (SRIP3)

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Abstract

The Safer Road Infrastructure Program Stage 3 (SRIP3) is a $1b road infrastructure improvement program delivered over 10 years from 2007 aimed at reducing the incidence and severity of crashes at high risk locations across Victoria. This paper presents the results of an interim evaluation of 553 projects completed under SRIP3 up to 2014 at a cost of $481M. Evaluation has been conducted in terms of the impact of the program on reducing the frequency and severity of crashes both for the program as a whole as well as for both broad and specific treatment types implemented under the program.

Background

Following on from the successful implementation of the Safer Road Infrastructure Program Stages 1 and 2, in May 2006 the Victorian Government announced the allocation of Transport Accident Commission funds to implement the third stage of the Safer Road Infrastructure Program. SRIP3 is a ten year program (2007-2017) with an indexed funding of $722 million. Unlike stages 1 and 2, the third stage, SRIP3, not only addresses sites identified by high crash frequencies, but also includes safety upgrades at locations that do not neccessarily have a current idenitified crash problem but are considered to have potential for high crash rates in the future (known as '*Greyspots*') and 40 km/hr speed limit treatments along arterial shopping centre roads. SRIP3 also includes additional road segment treatment types not included in stages 1 and 2, such as mass action edge line installation on class C roads and tactile centrelines for class A roads. At the end of 2014, SRIP3 comprised 721 projects: 543 projects were at sites identified by high crash frequency with 375 of these at intersections and 168 along lengths of road, six were projects completed under a special Princess Highway East program, 148 were Greyspot projects located at intersections and the remaining 24 projects were 40km/h speed limit reductions at strip shopping centre sites.

Aims and Scope

The overall aim of this study was to undertake an evaluation of projects delivered under the SRIP3 program over the period January 2007 to December 2014. The evaluation aimed to measure the extent to which treatments were associated with reduced number of casualty crashes, serious casualty crashes, casualties, and serious casualties at treated sites which had sufficient after treatment history to be included in the analysis. A single generic null hypothesis was tested: that implementation of SRIP3 was not associated with a change in casualty crash frequency at project sites. This was assessed against a 2-sided alternative hypothesis allowing for the analysis to detect either increases or decreases in road trauma associated with the program. As well as providing program level estimates of effectiveness, where possible the study also estimated reductions in crash frequency for different broad and narrow types of treatments and for specific crash types, as well as reductions in injuries for specific road users. Estimates of the economic worth of the program were also derived.

Of the 721 projects approved under SRIP3 funding, crash data from 553 projects with sufficient after treatment history were used to determine the interim benefits of the program. 6 projects were excluded because the treatment had not been completed prior to 30/12/2014. A further 64 Greyspot projects and 16 other projects were excluded because no crash data, either before or after treatment were available, or becuase of problems identifing required information on the treatments. In addition to the 553 high crash frequency site treatments, 82 Greyspot projects were analysed separately. The six projects identified by VicRoads on the Princess Highway East were not able to be analysed due to three being incomplete and because one of the incomplete projects completely confounded the after treatment period of the completed projects. The capital costs of implementing the 553 projects was $481M ($AUS 2015). The capital costs of the 82 Greyspot projects was $23M.

Methods

The evaluation used a quasi-experimental study design where treated sites were matched with comparison sites in order to adjust estimates of SRIP program effectiveness for the effects of other influences on crash risk and injury outcome (Hauer, 1997). These factors include other road safety programs, changes in exposure and socio-economic measures. Sites where treatments were completed as part of Stages 1 and 2 of the SRIP program were excluded as potential comparison sites.

Once the location of each project had been identified, rather than choosing a single untreated site to contribute comparison data for each project, all non-treated sites with the same local government authority (LGA) served as potential comparison sites. Not all untreated sites in an LGA containing a SRIP3 site were selected to contribute comparison data. For intersection sites (including Greyspot sites), comparison sites were restricted to untreated sites that were intersections. If the treated intersection was signalised prior to treatment, comparison sites were further restricted to signalised intersections. Intersection sites that were not signalised prior to treatment were matched to non-signalised intersections within the group of potential comparison sites. For road segment and 40 km/h SSC treatments, comparison sites were not restricted to sites defined as road length: they could either be intersections of untreated roads, or untreated lengths of road. Generally only classified roads were eligible to be comparisons for road segment project sites. Furthermore, road segment project sites that were divided roads prior to treatment were only matched to comparison roads that were also divided. Similarly, road segment project sites that were undivided sections of road prior to treatment were only matched with undivided comparison sites. For road segment project sites that contained both divided and undivided sections of road, the dominating feature in terms of number of crashes in the before period was used to determine whether comparison sites should be divided sections of road. Comparison sites were further limited to classified roads (i.e. a highway, freeway, main road, forest road or tourist road). In addition to the matching by LGA, dividedness and signalisation, comparisons for 40 km/h SSC projects were also matched to the project before treatment speed zone. This was because this treatment was specifically testing reduced speed limits.

Where there were multiple project sites of similar type within the one LGA, these sites were matched to the same group of comparison sites (providing the treated sites were similar in terms of whether they were intersections, or occurred on divided roads, etc.). Generally, where a road segment project site passed through multiple LGAs, the pre- and post-treatment data at this site were matched to comparison sites in each LGA. Exceptions were made for some sites that passed through several LGAs, but for which relatively few crashes at the SRIP3 site occurred in one LGA compared to the others. Using these strategies for matching treated and comparison sites, the 553 projects included in the evaluation of SRIP3 and the 82 Greyspot projects, were matched to 224 distinct sets of comparison sites.

For each group of treated sites matched to the same group of comparison sites, the pre-treatment period was defined as the period beginning on the 1st of January 2000 to the day before the first commencement of works at any of the treated sites. The post-treatment period was defined, for each group of treated sites matched to the same group of comparison sites, as the period from a day after the last treatment works had been completed at any of the treated sites to the 7th of February 2015. For the 553 high crash risk projects and for the 82 Greyspot projects, the earliest date on which treatment works commenced was the 11th of March 2007. The earliest date for a comparison group pre-treatment period to end was 10/03/07. Not all comparison group pre-treatment periods began January 1, 2000; the latest date for the pre-treatment period to start was the 1st of December 2012. Truncation was to avoid conflicts with SRIP1 and SRIP2 projects. Using this approach, 86% of project pre-treatment periods were 8 years or more; 4% had a period of 4.5 to 7.5 years and 7.6% had a period of 1.5 up to 4.5 years. 39% of the project post-treatment periods were more than 2.5 years long; 41% were 1.5 up to 2.5 years and 19% were 0.5 up to 1.5 years long

As noted, it is acceptable to have pre-treatment and post-treatment periods of differing durations as long as for each treatment-comparison pair, the pre-treatment period for the treated sites covers the same time-span as the pre-treatment period at the comparison sites and that the same applies for the post-treatment periods.

Poisson regression was used to estimate the percentage change in casualty crash frequency from before-treatment to after-treatment at the treated sites relative to that at the comparison sites. This methodology is well established in the literature for analysing quasi-experimental designs (Breslow & Day, 1987; Hosmer & Lemeshow, 1989).

Two important issues to be considered when using a quasi-experimental study design to evaluate road safety programs are *accident migration* and *regression-to-the-mean*.

Accident Migration

One possible outcome of treating sites on the road network is accident migration, which involves the casualty crash risk being moved, either entirely or partly, from the treated site to another site nearby by such mechanisms as changing exposure patterns or risk compensation behaviour by drivers after they have passed through a treated site (McGuigan, 1985). The most likely cause of an accident migration effect in this study would be through a treatment altering traffic volume at the treated site. However accident migration effects are unlikely to be large provided that treatments do not lead to substantial shifts in traffic volumes. Traffic volume data required to measure changes in traffic volume at treated sites and neighbouring sites were not available for the study since such data are not routinely collected for all treatment sites analysed and neighbouring sites to which traffic may have migrated. Furthermore, the types of treatments completed under SRIP3 were not those likely to significantly limit mobility at treated sites hence it is considered unlikely that traffic migration was a likely outcome from the program.

Regression-to-the-Mean

Regression-to-the-mean is caused by selecting sites for treatment from a set with the same underlying crash rate that have a high casualty crash frequency measured over a narrow window in time, due to the expression of an extreme in random variation. Selecting sites for treatment on such a basis means that the likelihood of the casualty crash frequency at the selected site reducing in the immediate next period, merely due to chance, is high. If the treatment effect at the site is evaluated using the same inadequate casualty crash data from which the site was selected for treatment, the results of the evaluation will be spurious.

One way of minimising the effect of regression-to-the-mean is the use of adequate pre-treatment casualty crash histories to give an accurate estimate of the true pre-treatment casualty crash frequency at the chosen site. Simulation of crash count data (Nicholson, 1986) suggested that the effects associated with regression-to-the-mean are only very small when five years of pre-treatment data are available. For this study, most treated sites that were evaluated had more than 5 years of pre-treatment casualty crash data. Furthermore, an analysis technique was used that properly recognised the level and distribution of random variation in the data and that computed confidence limits and significance probability levels that properly reflected this variation. Furthermore, the distribution of crashes per site in the before treatment period for comparison sites were compared to treatment sites. The distributions for the treatment and comparison sites were found to be similar. In addition, analysis of pre-treatment differences in crash histories were carried out using propensity scores (Sasidharan & Donnell, 2013), which were, for each comparison group, the odds of a higher crash frequency per intersection in treatment sites obtained through logistic regression. The propensity scores showed that for 81% of comparison groups, there was no evidence of a significant difference in pre treatment crash histories between treatment and comparison sites.

Evaluation Output Measures

In order to test the primary null hypotheses of the evaluation, the percent reduction in crash or injury frequencies at treated sites in the post-treatment period compared with the pre-treatment period adjusted for parallel changes at the comparison sites were estimated. Net percent changes in crash or injury frequencies were measured for casualty crashes, serious casualty crashes, specific crash types, casualty injuries, serious casualty injuries and specific injury types for the whole program, and by region, program type, by region and program type, by two levels of aggregated treatment types and by project. Measures of economic worth considered were: benefit-cost ratio (BCR) and cost-effectiveness of preventing a casualty or serious casualty crash over the treatment life. All measures of cost and savings were based on year 2015 Australian dollar values and BCR was estimated using a discount rates of 5%.

Data

VicRoads provided data on all SRIP 3 projects completed to mid 2015 including desciption of treatment type, location of treatment, installation start and completion dates, capital cost of works and treatment life. Using the descrition of treatment types, treatments were classified into groupings for analysis at various levels including intesection versus midblock treatments, metropolitan Melbourne versus regional treatments as well as specific treatment type categories (e.g. signal installation, guard rail, shoulder sealing etc). Each treatment location was mapped using a GIS system in order to match police reported crashes occuring at each treatment site. Data on the 226,132 police-reported casualty crashes that occurred during the period 1st of January 2000 to 31st December 2014 were provided for the evaluation. This data was linked to TAC claims data to verify hospital admission status for the purposes of defining serious injury. Of the 226,132 crashes, 70,321 were used in the analysis due to occurring in either a treatment or control area in the defined before or after study periods. Crash cost data for the economic analysis was taken from the Bureau of Infrastructure, Transport and Regional Economics estimates based on the human capital valuation approach (BITRE, 2010).

Results

Overall Results

Implementation of the SRIP3 program was estimated to be associated with a 21% reduction in the number of casualty crashes and a 26% reduction in the number of serious casualty crashes relative to crash frequency changes at matched comparison sites ($p<0.0001$). Corresponding reductions in casualties and serious casualties were estimated at 25% and 29%. All of these results were highly statistically significant. The overall casualty crash reduction estimated is slightly smaller than that previously estimated for the SRIP1 (24%, p<0.0001,(L. Budd, Scully, J., Newstead, S., 2011)) and the SRIP2 evaluation (33%, p<0.0001,(L. Budd, Newstead, S. , Scully, J., 2011)).

Across the 553 projects evaluated in the Phase 2 evaluation, a 21% reduction in casualty and a 26% in serious casualty crashes translates to an estimated saving of 377 casualty crashes (resulting in 630 injuries) and 169 serious casualty crashes (resulting in 238 serious injuries) per annum and a saving of 6,440 casualty crashes (resulting in 10,819 injuries) and 2,927 serious casualty crashes (resulting in 4,133 serious injuries) over the life of the program. The average life of the 553 SRIP3 treatments was 17 years. This translates to an estimated present value of savings in community costs from reduced road trauma estimated over the life of the program of $1,815M (using a discount rate of 6.5%), with a 95% confidence interval of $1,362M to $2,239M. When compared to the cost of completing and maintaining the 553 projects ($507M), the program is estimated to deliver a benefit-cost ratio of 3.6 (95% confidence interval of 2.7 to 4.4). The estimated BCR shows that the total benefits that the program provides by reducing injury and death statistically significantly exceed costs of completing and maintaining the treatments.

Results by Location, Treatment and Crash Type

The evaluation also provided separate estimates of crash savings associated with the program for sites located in metropolitan Melbourne and sites located in rural areas. It was estimated that the treatment of sites located in Melbourne were associated with an 18% reduction in casualty crashes and a 24% reduction in serious casualty crashes (p<0.0001). The treatment of rural sites was associated with a 31% reduction in casualty and in serious casualty crashes (p<0.0001).

The evaluation also considered the associated effectiveness of different broad types of treatments. There was strong evidence that implementation of both road segment and intersection treatments were associated with reduced casualty and serious casualty crashes, and that intersection treatments had statistically larger casualty crash reductions. Serious casualty crash reductions for intersections were greater than 40%. Road segment serious casualty crash reductions were less than half that for intersection treatment types (21%). It was estimated that casualty crashes were reduced by 37% (95% C.L. 32% to 42%) for intersection treatments compared with 13% (95% C.L. 6% to 20%) for road segment treatments. Due to limited data at Greyspots and 40 km/h strip shopping centre treatments and difficulties with the evaluation design for these projects, the evaluation was generally unable to draw conclusions about the effectiveness of these treatments

Road segment treatments were found to be more effective at reducing casualty and serious casualty run-off crashes than at reducing casualty and serious casualty on-path/overtaking/head-on crashes. The most effective road segment treatments for casualty crashes were shoulder sealing with safety barriers and tactile edge or centre lines without shoulder sealing or safety barriers, with significant casualty crash reductions greater than 50%. Run-off road casualty and serious casualty crashes were best reduced by shoulder sealing with safety barriers without delineation and non-tactile line marking without safety barriers or shoulder sealing. On-path/head-on/overtaking casualty and serious casualty crashes were most improved by safety barrier treatments without shoulder sealing or tactile lines but with culvert extensions/end walls. Furthermore there was some evidence that road segment treatments of this evaluation were associated with a greater (16 percentage unit) reduction in serious casualty crashes than those of SRIP1.

Intersection treatments were more effective at reducing opposite and adjacent style (47%) crashes than same direction (16%). The most effective treatments for preventing casualty crashes were hazard removal, installation or modification of splitter islands, control of left turn with signals, installing or extending right turn lanes with or without fully controlled right turn, new traffic signals and new roundabout installations, all with significant casualty crash reductions greater than 50%.

The most effective treatment at improving opposite and adjacent intersection casualty and serious casualty crash outcomes were roundabout installations and installation of both fully controlled right turn and installing/extending the right turn lane. The most effective for same direction serious casualty crash reduction was skid resistance surfaces with or without other treatments and traffic signal treatments.

Table 1 summarises the key overall estimates of effectiveness of the program and their 95% confidence limits:

Table 1. Estimated crash and injury reduction effects of SRIP3 overall and by major treatment groupings

Program Level	**Casualty Crash Reduction**	**Serious Casualty Crash Reduction**	**Casualty Reduction**	**Serious Casualty Reduction**	**BCR**
Whole Program	21% (16%, 26%)	26% (18%, 32%)	25% (19%, 30%)	29% (21%, 36%)	3.6 (2.7, 4.4)
Intersection Treatments	37% (32%, 42%)	41% (32%, 50%)	42% (35%, 49%)	46% (35%, 55%)	6.1 (5.2, 7.0)
Road Segment Treatments	13% (6%, 20%)	21% (10%, 30%)	14% (4%, 24%)	23% (11%, 34%)	2.0 (0.9, 3.0)
Metropolitan	18% (14%, 23%)	24% (15%, 31%)	23% (19%, 27%)	28% (21%, 35%)	4.1 (3.0, 5.1)
Rural	31% (22%, 29%)	31% (19%, 41%)	30% (23%, 36%)	31% (19%, 41%)	3.2 (2.3, 3.9)

Results by Road User

The program and region level analyses showed no significant associations of casualty or serious casualty reductions of injured pedestrians. However the treatments involving installation of both fully controlled right turns and installing or extending the right turn lane were found to be associated with a 90.3% reduction in casualty pedestrian injuries (p=0.017).

For bicyclists a strongly significant 46% (95% C.I. 28%, 59%) casualty reduction was associated with intersection treatments. A significant reduction of 44% was associated with metropolitan intersection treatments; no significant reductions in bicyclist injuries were observed for rural intersections. However significant reductions for the program as a whole and on road segment treatments were observed for cyclists in rural areas: 66% (95% C.I. 12%, 87%) and 89% (95% C.I. -3%, 99%) respectively. No significant reductions in bicyclist serious casualty injuries were found due to limited data on bicyclist serious casualties. The specific intersection treatments that were associated with measurable reductions in casualty bicyclist injuries were of the traffic signal type and right turn modification type, particularly those involving new installations, modifications such as LED upgrades, right turn bans and fully controlled right turns. Lane modifications which included bus and bicycle lane installations at intersections also proved effective at reducing bicyclist injuries (78%, p=0.006).

The program and region level analyses showed no significant associations with casualty reductions of injured motorcyclists. A reduction in serious motorcyclist casualties was associated with the whole program (37%, p=0.0002) and with intersection treatments (63%, p=0.0003). Intersections treatments associated with large significant reductions in serious casualty motorcycle injuries were new traffic signals and right turn modifications, particularly those involving fully controlled right turns with extended right turn lanes.

Crash Savings and Economic Benefits

Economic analysis showed that SRIP3 is expected to return favourable economic benefits over the life of the treatments implemented. Specifically, it was estimated that the reduction in casualty crashes associated with the 553 SRIP3 projects considered in this evaluation would result in an annual saving of $118M. The present value of future savings expected based on treatment lifetime and the estimated annual crash cost savings at treated sites was estimated to be $1,815M. The capital expenditure required to complete the 553 treatments was $434M, and when future maintenance costs are added to this value, the present value of completing and maintaining treatments using a discount rate of 6.5% was estimated to be $507M. This equates to an estimated net present worth of the program which is significantly greater than zero dollars ($1,308M, varying from $856M to $1,732M with 95% certainty) and a benefit-cost ratio significantly greater than one (3.6, varying from 2.7 to 4.4 with 95% certainty). Furthermore, the internal rate of return of SRIP3 was estimated to be 23%, varying from 17% to 29% with 95% certainty.

It was estimated that the 21% (16%, 26%) estimated casualty crash reduction associated with the 553 SRIP3 projects evaluated will prevent 6,440 casualty crashes and 10,819 casualties over the life of treatments, with this estimate ranging from 4,835 to 7,944 casualty crashes with 95% certainty. This translated to a cost effectiveness of $78,660 spent per casualty crash saved, ranging from $63,767 to $104,771 with 95% certainty.

Statistically significant economic worth as a result of associated casualty crash reduction was observed for regional and program level aggregations including intersection and road segment treatments. Intersection treatments exhibited a greater economic worth than road segment treatments with three times the BCR of road segment treatments (6.1 c.f. 2.0) and slightly higher %IRR (22 c.f. 20) and a four times better cost effectiveness ($40,320 c.f. $164,844). Although exhibiting only a slightly higher BCR (4.1 c.f. 3.1), metropolitan treatments proved their economic worth over rural treatments with more than double the %IRR (31.1 c.f. 12.7) and almost double the cost effectiveness ($64,686 c.f. $109,833). The trend to greater economic worth in metropolitan treatments was observed through both intersection and road segment treatments reflecting the higher crash numbers at metropolitan treatments.

Discussion

There was strong evidence that the overall effect of SRIP3 was an associated reduction in the number of casualty and serious casualty crashes at treated sites. There was strong evidence ($p<0.001$) that both road segment and intersection projects were associated with reductions in casualty crashes. Statistical evidence for the effectiveness of 40km/h SSC projects and Greyspot treatment was less certain. This largely shows a need to further evaluate these treatment types after full implementation of the SRIP3 program and when more post implementation crash data are available. Methodology for evaluation Greyspot type treatments might also need to be reconsidered considering the primary purpose of such treatments is to prevent the development of future crash problems at sites where traffic volume and subsequent crashes are expected to increase dramatically. A methodology for accurately estimating the likely future crash problem based on this growth is necessary to properly evaluate the effectiveness of these treatments. The question the SRIP3 program poses in this area is how to effectively balance the treatment of anticipated problem areas through a Greyspot program against the treatment of the many site with current crash problems identified and treated under SRIP3.

It was estimated that road segment treatments were associated with a 13% (95% CI: 6%, 20%) reduction in casualty crashes at the 164 project sites where they were employed. The estimated effectiveness for the 365 intersection projects was significantly more with a reduction in casualty crashes by 37% (95% CI: 32%, 42%). The difference was found to stem from differences in metropolitan regions, where small insignificant crash reductions were associated with road segment treatments and intersection treatments were associated with a crash reduction of 38% (32%, 43%). The difference between intersection and road segment associated casualty crash reductions was not evident in rural regions.

Both the 311 SRIP3 treatments completed in metropolitan Melbourne and the 242 treatments located in rural areas were associated with reduced casualty and serious casualty crashes ($p<0.0001$). Based on the degree of overlap of that the 95% confidence intervals have for the metropolitan and rural serious casualty crash reduction rate estimates, it was found that there was no statistical evidence for a difference between them. For casualty crashes, the overlap was small providing some weak evidence of a true difference. This difference is evidenced in the road segment program which is significantly lower (by 30% units) in metropolitan regions. A statistically significant difference of 30% units was also observed for road segment treatments between metropolitan and rural regions for serious casualty crashes.

Metropolitan projects were associated with an estimated reduced casualty crash rate of 18% (varying from 14% to 23% with 95% certainty) and rural projects by an estimated 31% (95% CI: 22% to 39%). Metropolitan projects were associated with an estimated reduced serious casualty crash rate of 24% (varying from 15% to 31% with 95% certainty) and rural projects by an estimated 31% (95% CI: 19% to 41%).

Road segment treatments were more effective at reducing run-off road casualty and serious casualty crashes than on-path/overtaking/head-on casualty crashes. Intersection treatments were more effective at reducing opposite and adjacent style (47%) casualty crashes than same direction (16%). There associated effects were similar for serious casualty crashes. Intersection treatments were associated with greater serious crash reductions in the key crash types in metropolitan compared to rural regions. Road segment treatments showed similar crash type reductions in metropolitan and rural regions.

Implications of results on project selection for future infrastructure improvement programs

Where there are finite funds available to make improvements to road infrastructure with the aim of reducing casualty crashes, treatments that are known to be highly effective should be applied at sites where the annual number of crashes is high or where the crashes are most frequently of high severity. Furthermore, treatments involving the lowest possible implementation costs applied to these sites will ensure maximisation of the economic benefits of the program. If future road infrastructure programs are to be evaluated with respect to their contribution to achieving targets defined in terms of reductions in casualty crashes, prioritising sites to be treated in terms of predicted cost effectiveness is an important indicator of which mix of projects will deliver the greatest savings. In order to predict the cost-effectiveness of different projects, it is necessary to: (1) accurately estimate the cost of a potential project; (2) accurately measure the casualty crash problem at potential sites to be treated, and (3) as accurately as possible estimate how the project is likely to reduce serious casualty crashes at the site as a result of the treatment.

This study supports the finding from the previous SRIP evaluations that intersection projects have been more cost-effective than road segment treatments. This evaluation of SRIP 3 has estimated that the average expenditure of $95,973 was required to prevent one serious casualty crash at an intersection site compared with $120,619 at road segment treatments. Intersection projects were estimated to be more cost-effective than road segment projects because of the higher crash densities at intersections compared to road lengths and because the average cost of intersection treatments was less than that of road segment treatments ($448,546 per project compared to $1,899,825). However, this should not be interpreted as meaning that intersection treatments should be applied in preference to road segment treatments. Instead it supports the principles of treatment site selection outlined above where the lowest cost treatments should be implemented at sites with the largest crash problem, whether that problem is one of high frequency or one of high fatalities or serious injuries. In the case of the SRIP treatments, it is intersection treatments that meet this criterion better than road segment treatments. This may not always be the case depending on whether new, lower cost road segment treatments can be developed and whether in the future intersection crash densities continue to be higher than those on the highest risk rural road segments.

Conclusions

Evaluation of the implementation of SRIP3 clearly demonstrated an association between program implementation and reduced casualty and serious casualty crashes and the resulting casualties and serious casualties at treated sites. It also suggests the program has been cost effective producing benefits to the community in terms of reduced road trauma costs that outweigh the costs of implementing and maintaining treatments implemented under the program.

Final evaluation of SRIP 3 is planned once all treatments have been completed. Further evaluation will allow all sites that will ultimately be treated under the SRIP 3 program to be evaluated in terms of crash effects and economic worth rather than just the sites treated under the program that were evaluated in this study.

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Brunei iRAP – Speed Management and Infrastructure Improvements

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Abstract

Brunei have made considerable investment in improving the design and safety of their road transport infrastructure over the last 20 years. Like almost all countries, Brunei (on the island of Borneo) are still not happy with the level of road trauma (fatal and serious injury crashes) on their roads and the impact this has on families and communities. In 2014 they decided to undertake an iRAP assessment of their strategic routes (just over 500km of their network) to determine what else could be done to reduce road trauma. The findings of the iRAP assessment did indicate that Brunei has a relatively safe network, compared with other ASEAN and developed countries. Around 45% of all roads (urban and rural) and 63% of highways (rural/high speed) had a three star rating or better (the rating varies from one star which is poor to five star which is excellent). Two safety road investment program (SRIP) scenarios were developed using the VIDA (iRAP) analysis tool.

Scenario One includes infrastructure upgrades with a cost of at least BND$42M. Scenario One, when fully implemented, is expected to increase the number of 3 star plus roads to 85%. Scenario Two includes both speed management (reducing operating speeds by typically 5 to 10km/h on all highways and main roads) and infrastructure upgrades. The infrastructure upgrades will be at least BND$36M. Scenario Two, when fully implemented, is expected to increase the number of 3 star plus roads to over 95%. Brunei is one country where a minimum three star rating for all highways and strategic main roads is within reach.

Introduction

Deaths and injuries from road vehicle crashes are a major and growing public health epidemic. Each year 1.3 million people die and a further 50 million are injured or permanently disabled in road crashes. Road crashes are now the leading cause of death for children and young people aged between 10 and 24. The burden of road crashes is comparable with malaria and tuberculosis and costs 1-3% of the world's GDP (Geneva, WHO, 2009).

While the number of fatal and serious injury crashes in Brunei (at around 100 per year) are relatively low compared with the global figures, the grief and suffering caused by road crashes still has a major impact on families and communities within this small country of around 400,000 residents. Hence the strong desire by the Government to continue to drive down the number of fatalities and serious injuries (hospitalisations). A key element of this commitment has been the major investment in highway infrastructure over the last twenty years. The other key areas of focus being safer road users and safer vehicles. With a relatively young vehicle fleet Brunei does benefit from improvements in vehicle safety. Driver behaviour still needs further attention, particularly around speeding and seatbelt wearing.

Given the high investment in infrastructure over the last twenty years it is important to understand the level of safety the current highway network provides and what further work could be done to reduce crash rates further. The iRAP road assessment approach is an excellent way of understanding the crash risks along the strategic road network and targeting improvements that address these risks. Of particular interest in Brunei is the high operating speeds on urban roads, given the relatively high speed limits, and many drivers travelling above these speed limits.

The iRAP package of tools includes the development of safer roads investment programme (SRIPs) to lower crash risks further. This normally focuses on infrastructure improvements. In the case of Brunei the investment program also included speed management. Initially it is suggested that a speed management program focuses on getting drivers to travel within the current speed limits, before considering whether the speed limits themselves need to be lowered.

This paper first outlines the iRAP process before presenting details on the 2014 safety performance of just over 500km of both urban and rural single and dual carriageway highways and main roads in Brunei. It then presents two safety improvement upgrade scenarios that are expected to reduce serious and fatal crashes significantly across this strategic road network.

International Road Assessment Programme (iRAP)

The International Road Assessment Programme (iRAP - www.irap.org) has drawn upon the extensive knowledge base of the developed world's Road Assessment Programmes (EuroRAP, AusRAP and usRAP), to develop a road survey methodology for all countries. This Star Rating methodology does not require detailed crash data and works directly from road surveys. The iRAP approach has been applied in over 70 countries.

The iRAP Protocol used internationally has four stages:

1. **Risk Maps**; where detailed crash data is available maps can illustrate the actual number of deaths and injuries on a road network (good quality data is not readily available in Brunei).
2. **Star Ratings** provide a simple and objective measure of the level of safety provided by a road's design.
3. **Safer Roads Investment Plans** draw on approximately 90 proven road improvement options to generate affordable and economically sound infrastructure options for saving lives. Multiple investment plans should be created with different scenarios and goals to highlight the beneficial aspects of each and drive a forwards work programme to improveroad safety.
4. **Performance Tracking** enables the use of Star Ratings and Risk Maps to track road safety performance and establish policy positions.

Star Ratings provide a simple and objective measure of the relative level of risk associated with road infrastructure for an individual road user. 5-star (green) roads are the safest, while 1-star (black) roads are the least safe. Figure 1 shows photo examples of the various star rating levels. Notice that the location and type of road-side hazards and presence of shoulder is important in the 'vehicle' star rating. For the higher standard roads both shoulder and median barriers are provided from extra protection of drivers. Importantly, Star Ratings can be produced without reference to detailed crash data.

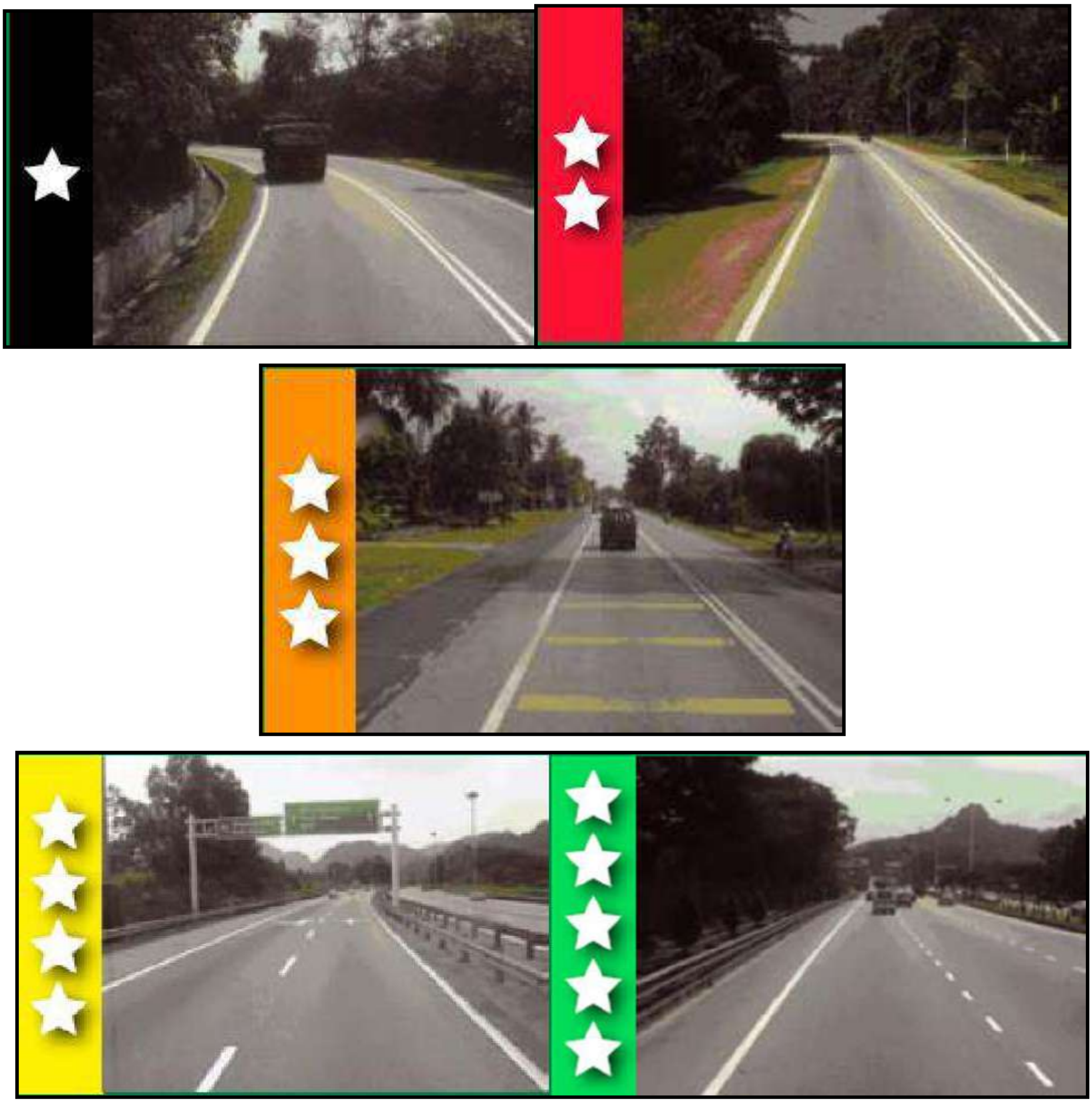

Figure 1 - Examples of different Vehicle Star Rating roads (Malaysia, source iRAP website)

iRAP Star Ratings are based on the engineering features of the road and the degree to which they impact on the likelihood and severity of crashes (see Figure 2). Data on engineering features are coded at 100m intervals along the surveyed roads. The focus is on the features that influence the most common and severe types of road crash for motor vehicles, motorcyclists, pedestrians and bicyclists. The volume and speed of vehicles is also a key factor in crash occurrence.

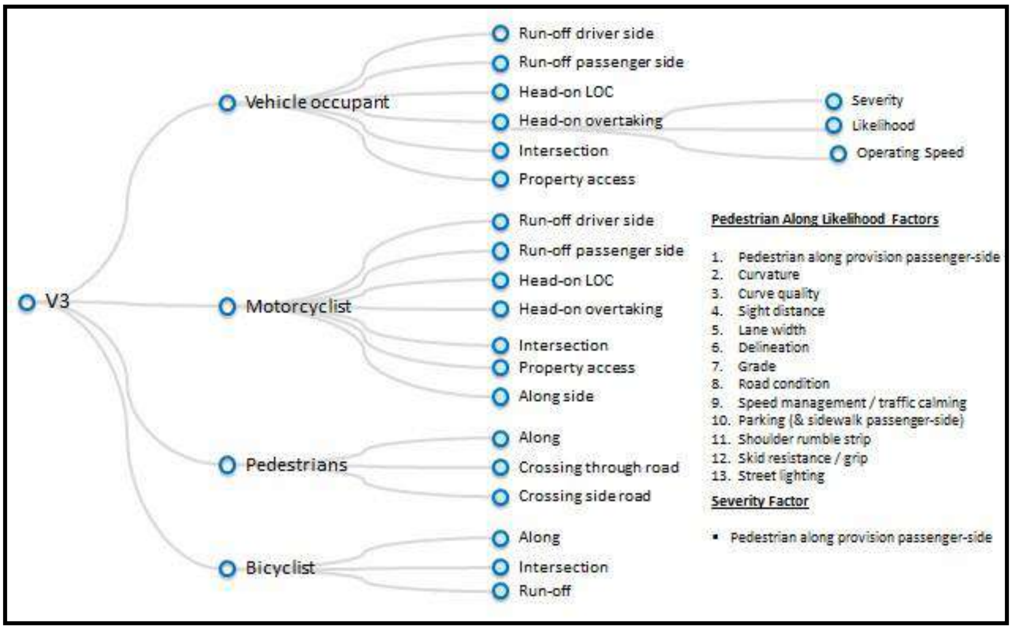

Figure 2 – Main crash types considered for each mode and example of crash variables examined - in this case for pedestrians walking alongside road (source iRAP website)

Brunei iRAP Data Collection

The surveyed network consisted of 535 km of strategic routes and main arterials (single and dual carriageway). These roads were selected by the Brunei Department of Roads and were surveyed between 3rd and 16th of December 2014. The location of roads surveyed in Brunei (which is a small country in the northern part of the island of Borneo) are shown in Figure 4. The main highway /motorway travels along the coast (the bottom left of the diagram to the top right). The separate section of black and red highways is in the Tempurong (popular for eco-tourism) region which is separated from the other regions of Brunei (Muara, Tutong and Belait) by part of the Malaysia state of Sarawak. Access to this area is by boat or car through Sarawak.

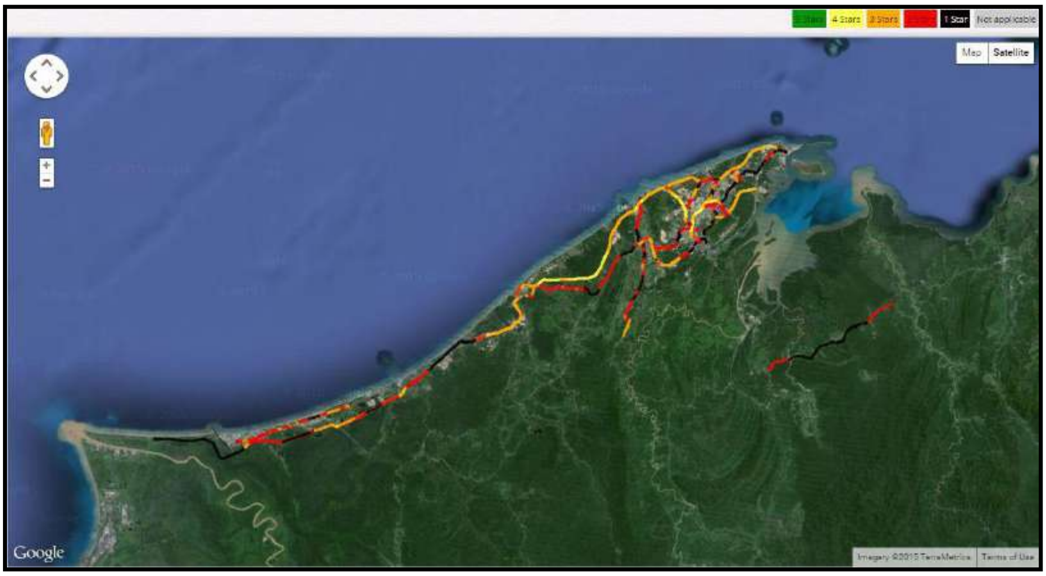

Figure 4 - Strategic Brunei Road Network (surveyed)

Dual carriageway roads have been surveyed in both directions. The surveyed network includes approximately 10% of all roads in Brunei, and the majority of the strategic and high volume urban and high speed routes. All the countries motorways and highways are included.

To calculate the Star Rating of each section of route the entire survey network was videoed, and from this feature data has been coded at 100m intervals. In excess of 60 speed and traffic volume counts were collected (for a representative sample of routes), as this data was not readily available. Countermeasure costs were estimated using Malaysia unit construction costs. The crash saving benefits for each serious and fatal crash were collated (based on willingness to pay for fatalities). Aggregated crash data was also provided for the last two years to calibrate the iRAP model to Brunei conditions.

The predicted distribution of fatal and serious crashes across the Brunei network is expected to decreases by around 60-65% for each improvement in Star Rating band (e.g. upgrading a road from the middle of the 2 star band to the middle of the 3 star band will reduce fatal and serious injury crashes by around 60 to 65%). A four star road is predicted to have between 80% and 90% less fatal and serious injury crashes (per user) than a two star road (full 2 band shift). So an improvement in star ratings of one and two star roads can lead to a major difference in the number of serious injury and fatal crashes.

While motor vehicle occupants are the primary mode of transportation in Brunei, pedestrians, bicyclists, and motorcyclists star ratings were developed so that this can be considered in the design of new roads and safety improvements. The weight being placed on a safer design for each mode should reflect the likely future use of each corridor. Hence routes that may be promoted for bicycle use need a better star rating for bicycles compared with those where cycling is less likely.

The goal being to increase the proportion of trips by each mode that occur on higher star rated roads.

Current Performance of Network

Table 1 shows the star rating table for all four road user types, vehicle occupants, pedestrians, bicyclists, and motorcyclists. Figure 6 and 7 show the star rating maps for vehicle occupants and pedestrians (showing facility ratings only in areas pedestrians were observed). The star rating of the road, both urban and rural, in Brunei compares well with those of other developed countries and generally above that of other ASEAN countries. It shows that 45% of strategic roads have a star rating of three or better for vehicle occupants. Further investigation indicates that 63% of motorways have three star or better.

A review of the star rating scores indicate that the proportion of roads that have three stars for vehicle occupants, and particularly urban roads, would increase markedly if the high operating speeds on Brunei roads could be reduced. The infrastructure for walking, cycling and motor-cycling is fairly poor. Fortunately there are few serious and fatal crashes involving these modes. But some routes are used by these modes, and should have better infrastructure provided.

Pedestrians can be protected through the provision of safe crossing places such as at signalised crossings and overpasses, and protected at mid-point locations through wider and increased separation of footpaths and pedestrian fencing.

Smoothed Star Ratings - Before countermeasure implementation								
	Vehicle Occupant		Motorcyclist		Pedestrian		Bicyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent	Length (kms)	Percent	Length (kms)	Percent
5 Stars	0.00	0%	0.00	0%	0.10	0%	0.00	0%
4 Stars	38.30	7%	0.00	0%	3.30	1%	0.00	0%
3 Stars	205.60	38%	16.70	3%	7.70	1%	3.40	1%
2 Stars	170.00	32%	177.20	33%	40.10	7%	77.60	15%
1 Star	118.10	22%	338.10	63%	187.80	35%	353.20	66%
Not applicable	2.70	1%	2.70	1%	295.70	55%	100.50	19%
Totals	534.70	100%	534.70	100%	534.70	100%	534.70	100%

Table 1 – 2014 Star Ratings Table

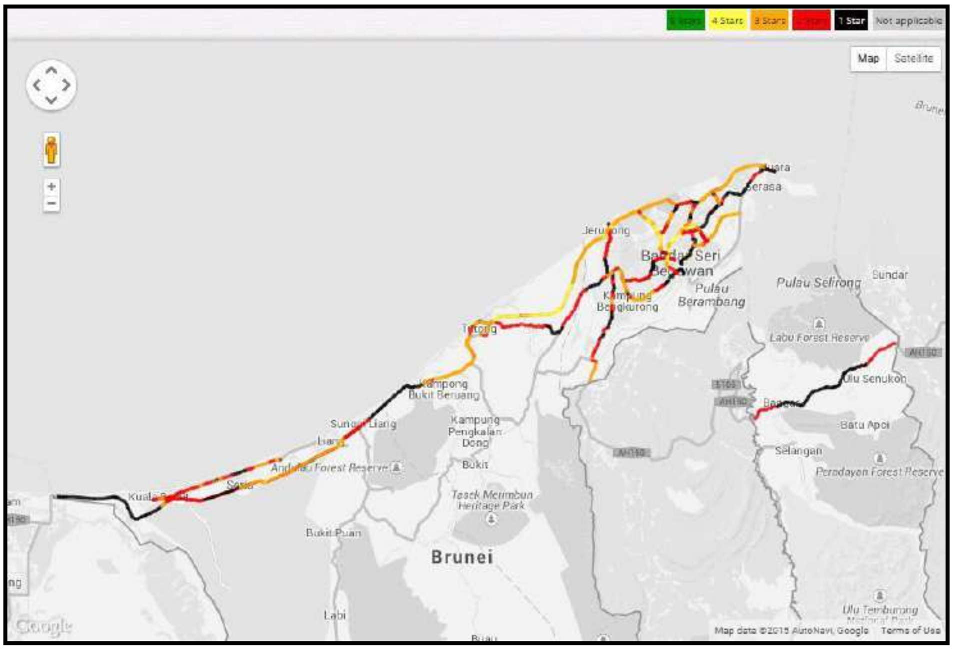

Figure 5 - Vehicle Occupant Star Rating Map (smoothed)

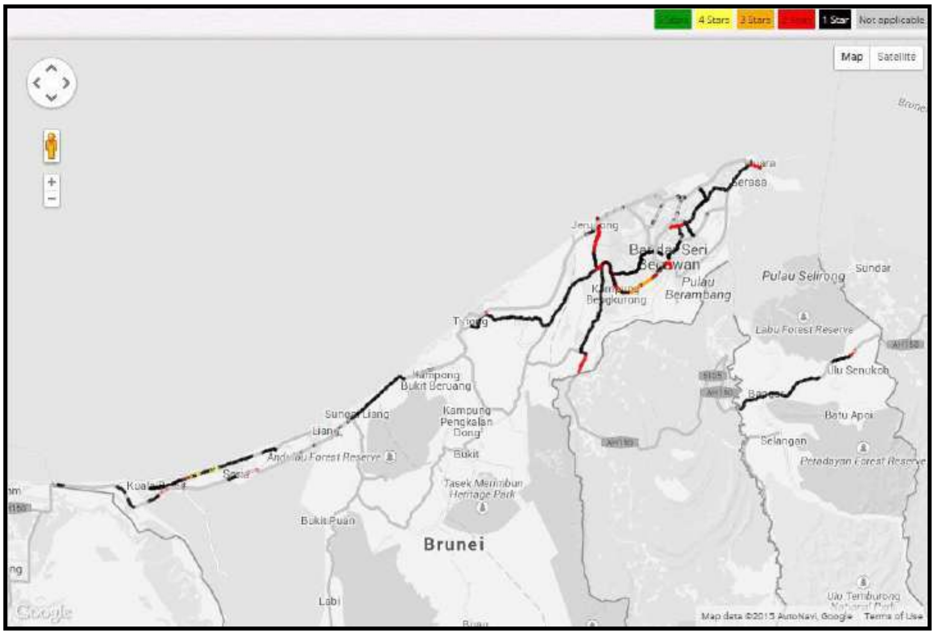

Figure 6 - Pedestrian Star Rating Map (smoothed)

Safer Road Investment Programmes (SRIPs)

A Safer Roads Investment Plan (SRIP) shows a list of affordable and economically sound road safety treatments (or countermeasures), specifically tailored to reduce risk on the surveyed network (see Figure 7 for examples). Each countermeasure proposed in the SRIP is supported by strong evidence that, if implemented, it will prevent deaths and serious injuries in a cost-effective way, i.e. it is suggested that the countermeasures listed will save more in crash costs prevented than it costs to construct and maintain the feature. Nevertheless, each countermeasure should be regarded as a recommendation only for further investigation and must be subject to additional prioritisation, concept planning and detailed design before implementation. Although the results shown here were generated using a cost-benefit ratio (BCR) threshold of 3 (only treatments that return benefits three times their implementation cost or better); this cut-off can be increased in order to produce a smaller and less costly programme of works, or decreased in order to produce a larger and more costly programme of works, to suit the available budget. The countermeasure unit costs are currently based on Malaysian construction costs.

Figure 7 – Examples of proven road safety treatments/countermeasures

Two scenarios have been run to produce two different SRIP, with different costs and outcomes. A scenario involves the application of a series of countermeasures to the surveyed (or baseline) road network. For each scenario the reduction in fatal and serious crashes (for a given cost) is predicted. The crash reduction is the sum of crash reduction benefits of a large number of upgrade treatments.

The unit treatment costs are currently based on Malaysian unit costs for each treatment type converted into Brunei dollars.

Scenario 1 - Infrastructure Improvements Only

The first scenario includes a number of road safety treatments that have at least an initial cost-benefit ratio of 3 or higher and no change in operating speed for each speed limit and road type. The treatments are generated by algorithms in the VIDA tool, which is the platform that the iRAP organisation has produced for storing and analysing iRAP data for each country that has collected this information. The treatment analysis tool (in VIDA) looks at each road deficiency (that leads to a lower star rating) and look at the range of improvement options that could be implemented to address that deficiency. For example shoulder barriers can be implemented to prevent drivers going into hazardous road-sides. It selects those treatments that have a cost-benefit ratio (crash saving benefits divided by treatment costs) that is at or above the cut-off. In this case the BCR cut-off is 3 or more.

The Safer Roads Investment Plan (SRIP) for Scenario One includes various works, the most effective and prolific are:

- 25 km of road duplication and central median barrier mostly on the Rasau Bypass – this cost appears low but has a programme BCR provisionally of six
- 128 km of roadside barrier and 151 km of roadside hazard removal – roadside hazards contribute significantly to crash severity, hazard protection through semi-rigid barrier systems is often more effective than clear-zone work through hazard removal
- 73 km of high fiction surfacing – road surfacing quality was based on a brief visual inspection rather than a measured process and so surfacing condition within iRAP is not necessary representative of actual skid resistance available
- 314 km of shoulder rumble strips – rumble strips provide audio and tactile awareness to vehicle drivers that they are straying from the traffic lanes. Centreline rumble strips are effective low cost short term treatments prior to duplication or a central median barrier
- 73 km of route and curve delineation

Table 2 shows the star rating that are expected when Scenario One is fully implemented. This proposed scenario is estimated to reduce deaths and hospitalisations by 20 annually including approximately 7 fatalities. A total of approximately BND$250M in safety benefits over 20 years for a capital expenditure in excess of BND$43M and an overall cost-benefit ratio of 6.

Under this scenario the length of road with a (vehicle occupant) star rating of three or more improves from 45% to 85% of the surveyed network. This includes 20% of the road length being rated at four or five stars. Approximately 90% of vehicle kilometres travelled would be on three or higher star roads and 25% of vehicle kilometres would be on four and five star roads. The length of roads with one star is very low and two star is less than 20%.

Smoothed Star Ratings - After countermeasure implementation								
	Vehicle Occupant		Motorcyclist		Pedestrian		Bicyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent	Length (kms)	Percent	Length (kms)	Percent
5 Stars	18.60	3%	0.00	0%	0.10	0%	6.80	1%
4 Stars	98.50	18%	1.00	0%	6.40	1%	1.00	0%
3 Stars	346.00	65%	113.60	21%	20.50	4%	10.90	2%
2 Stars	61.10	11%	340.50	64%	121.80	23%	189.40	35%
1 Star	7.80	1%	76.90	14%	90.20	17%	226.10	42%
Not applicable	2.70	1%	2.70	1%	295.70	55%	100.50	19%
Totals	534.70	100%	534.70	100%	534.70	100%	534.70	100%

Table 2 - Scenario One Star Ratings Table

Scenario 2 – Speed Management and Infrastructure Improvements

In Scenario 2 both speed management and infrastructure treatments have been considered. Like many countries in South East Asia speeding is a major issue in Brunei and it does have a big bearing on the number of serious and fatal crashes. Table 3 shows the improvement in operating speed (85th percentile and mean speeds) by speed limit that have been assumed for this scenario. This reduction in operating speeds seems reasonable in the short to medium term. Ideally speeds could be reduced further, especially in urban areas. Further refinement of this scenario (and the assumed speed changes) would be undertaken once a speed management strategy has been developed for Brunei. A speed management strategy needs to consider the level of investment in education and enforcement that might be required to achieve particular operating speed targets.

Table 3. Maximum 85th percentile and mean speeds for various posted speed limits

Posted Speed Limit	**Reported Speed Range**		**Scenario 2 Maximum**		**Scenario 2 Maximum 85th**
	Mean	**85th**	**Mean**	**85th**	**Speed Reduction**
50 km/h	80 km/h – 65 km/h	95 km/h – 75 km/h	55 km/h	65 km/h	30 km/h
65 (70) km/h	70 km/h – 50 km/h	80 km/h – 60 km/h	65 km/h	75 km/h	5 km/h
80 km/h	85 km/h – 80 km/h	95 km/h	80 km/h	90 km/h	5 km/h
100 km/h	95 km/h – 85 km/h	105 km/h – 95 km/h	90 km/h	95 km/h	10 km/h

Once the operating speeds were adjusted, the iRAP tools (in VIDA) have been used to develop the SRIP for the lower speed network based on a cost-benefit cut-off for each treatment of 3.

The SRIP for Scenario 2 includes various works, the most effective and prolific are:

- 25 km of road duplication and central median barrier mostly on the Rasau Bypass – this cost appears low but has a programme BCR provisionally of six
- 104 km of roadside barrier and 220 km of roadside hazard removal – roadside hazards contribute significantly to crash severity, hazard protection through semi-rigid barrier systems is often more effective than clear zone work through hazard removal
- 60 km of high fiction surfacing – road surfacing quality was based on a brief visual inspection rather than a measured process and so surfacing condition within iRAP is not necessary representative of actual skid resistance available
- 167 km of shoulder rumble strips – rumble strips provide audio and tactile awareness to vehicle drivers that they are straying from the traffic lanes. Centreline rumble strips are effective low cost short term treatments prior to duplication or a central median barrier
- 56 km of route and curve delineation

Table 4 shows the overall changes in star rating of this scenario.

Smoothed Star Ratings - After countermeasure implementation								
	Vehicle Occupant		Motorcyclist		Pedestrian		Bicyclist	
Star Ratings	Length (kms)	Percent	Length (kms)	Percent	Length (kms)	Percent	Length (kms)	Percent
5 Stars	27.50	5%	0.00	0%	0.10	0%	0.20	0%
4 Stars	119.80	22%	2.00	0%	6.40	1%	2.50	0%
3 Stars	349.00	65%	187.20	35%	18.10	3%	22.30	4%
2 Stars	33.90	6%	281.70	53%	130.40	24%	193.70	36%
1 Star	1.80	0%	61.10	11%	84.00	16%	215.50	40%
Not applicable	2.70	1%	2.70	1%	295.70	55%	100.50	19%
Totals	534.70	100%	534.70	100%	534.70	100%	534.70	100%

Table 4 - Speed Management with Physical Works Star Rating Table

This proposed SRIP is estimated to reduce deaths and hospitalisations by 22 annually including approximately eight fatalities on the surveyed network. It would have a benefit of approximately BND$190M over 20 years for a capital expenditure of BND$36M. For this scenario the vehicle occupant star rating of three stars or more increases from 45% to 95% by road length. In addition approximately 25% of the road length would be rated as four or five Stars.

Summary and Conclusions

The iRAP assessment of Brunei's strategic road network (in 2014) shows that approximately 45% of strategic roads (and 63% of motorways) have a star rating of three or better for vehicle occupants. The network is performing relatively well compared with other countries in the ASEAN region and many developing countries. However there is plenty that could be done to make the network safer for a relatively low cost (around BND$35M to $50M). Indeed Brunei is well placed to achieve a minimum three star rating on all strategic roads, especially if operating speeds can be reduced.

Two safer road improvement programme (SRIP) scenarios were developed to show how the risk of serious injury and fatal crashes could be reduced on Brunei strategic road network. Scenario One includes infrastructure upgrades with a cost of BND$42M. Scenario One, when fully implemented, is expected to reduce the number of fatal and serious crashes per year by 20 (a saving of 7 to 8 fatalities), and increase the number of 3 star plus roads to 85%.

Scenario Two includes both speed management (reducing operating speeds by typically 5 to 10km/h on all highways and main roads) and infrastructure upgrades. The infrastructure upgrades will be around BND$36M. The speed management costs, which will be ongoing, are yet to be priced. Scenario Two, when fully implemented, is expected to reduce the number of fatal and serious crashes per year by 22 (a saving of 8 to 9 fatalities), and increase the number of 3 star plus roads to 95%.

Further analysis could be undertaken to determine how this remaining 5% of roads could be upgraded to at least three stars. Such an achievement would make Brunei one of the first countries internationally to achieve this goal of all strategic roads being three stars or better.

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Development and use of the Austroads Safe System Assessment Framework

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Abstract

Australia adopted the Safe System approach more than a decade ago. The first action item from the Australian National Road Safety Strategy is to ensure that all new road projects consider Safe System principles. Although the main objectives of this approach are clear, there is limited direct guidance on how this can be implemented, especially in the provision of road infrastructure. Austroads has developed a tool to directly address this issue. A framework is presented that assists in assessing how closely road design and operation align with the Safe System objectives, and in clarifying which elements need to be modified to achieve closer alignment with Safe System objectives. A treatment hierarchy was also developed to identify effective Safe System infrastructure solutions. The development of both the assessment framework and treatment hierarchy are discussed.

Introduction

Road safety has improved dramatically in Australia in the last few decades. From a high of round 3800 deaths per year numbers have fallen to an average 1250 people per year (average between 2010 and 2014; BITRE 2014; Department of Infrastructure and Regional Development, 2015). However, in recent years the numbers have been relatively stable, and even shown slight increases. When compared to the good road safety performers amongst our OECD peers Australia kills twice as many people per head of population (BITRE 2014).

The Safe System approach was adopted in Australia to provide the framework for a step-change in road safety performance (Australian Transport Council 2005). This approach (see Austroads 2013) recognises that road users inevitably make mistakes that may lead to a crash. In addition, the human body can only withstand certain impact forces before death or serious injury results. A shared approach or responsibility is required to prevent these deaths and serious injuries occuring. More specifically, there is the requirement to move away from blaming the victim, to ensuring that different parts of the ’system’ all act together to improve safety, and eventually elimiate death and serious injury. As an example of the shared responsibility, road infrastructure should be forgiving and take into account road user vulnerability to avoid serious injury or death in the event of a crash.

In Australia, the Safe System approach is outlined in a number of Federal and state-based documents. The National Road Safety Strategy 2011–2020 (Australian Transport Council 2011) defines the Safe System key principles as follows:

> “a road safety approach which holds that people will continue to make mistakes and that roads, vehicles and speeds should be designed to reduce the risk of crashes and to protect people in the event of a crash”.

The Safe System comprises four essential components or pillars:

- safe roads and roadsides
- safe speeds
- safe vehicles
- alert and compliant road users (safe road use).

It is noted that there is increasing recognition of a fifth pillar within the system that should also be included. The global action plan for the decade of action in road safety also includes post-crash care as a pillar (WHO 2011).

The Safe System approach was introduced in Australia more than 10 years ago, firstly as part of the 2005/06 Road Safety Action Plan (Australian Transport Council 2005). The vision for this strategy is reasonably clear, as summarised above, but the steps required to reach these objectives are less well understood.

In addition, the first action item from the Australian National Road Safety Strategy (Australian Transport Council 2011) is to ensure that all new road projects consider Safe System principles. Although there has been some progress on this action item in individual jurisdictions, clear practical guidance on embedding Safe System principles into the provision of new infrastructure or the upgrading of existing infrastructure is not available.

The aim of this project was to develop an assessment framework to help road agency practitioners methodically consider Safe System objectives in road infrastructure projects. The framework will be useful in assessing how closely road design and operation align with the Safe System objectives, and in clarifying which elements need to be modified to achieve closer alignment with objectives.

Development of the framework

Development of the framework involved the establishment of a working group, a literature review, engagement with international experts, a stakeholder workshop, framework development, testing and refinement.

The working group was established at the outset of the project and comprised representatives from the Road Safety Task Force, with strong representation from the roads and roadsides sub-group. There was also representation from local government and the research community at various points in the project.

A literature review was conducted (reported in Austroads 2016) to assess current Australian, New Zealand and overseas approaches to Safe System infrastructure implementation and assessment for road infrastructure projects. The review also attempted to identify any existing Safe System infrastructure frameworks as well as material that may inform the development of such a framework. Some key findings from the review are described below.

Different frameworks have been developed and applied within Australia and New Zealand as well as in some overseas jurisdictions. Most notable in Australia were frameworks developed by Marsh (2012) in Western Australia, and by ARRB Group (reported in Austroads 2016) in South Australia. Overseas initiatives included the International Road Assessment Program (iRAP) trigger set and approaches used in Sweden and Canada (reported in Austroads 2016). More recently, McTiernan and Rensen (2016) provided a framework developed specifically for local roads.

In Western Australia the ‘Towards Zero Framework’ was developed to provide a structured approach to assess projects against Safe System objectives (Marsh 2012). The framework focusses on limiting forces to within human tolerances during a crash. It specifically focusses on fatal and serious injuries, particularly run-off-road and head-on crashes, intersection crashes and crashes involving vulnerable road users. Safe System speeds were taken into account for all these crash types (i.e. the speeds beyond which fatal and serious injury becomes more likely**Error! Reference source not found.**). The framework also recognises the limited funds that road authorities often have for these projects, and as a result provides a hierarchy of control for treatments. At the top end, this involves targeting the prevention of death or serious injury (e.g. through road and roadside infrastructure), while still considering other demands such as managing community and road authority expectations (referred to as 'sustainable solutions'). Second-order treatments are those that provide real-time risk reduction or the provision of pre-crash warning (e.g. ITS and audio-tactile road markings). The lowest level of the hierarchy is general risk reduction, including other road and roadside treatments, enforcement and driver/community education.

Work in South Australia built upon the approach developed in Western Australia. However, key differences included the addition of all Safe System pillars. Prompts for the assessment of Safe Vehicles and Safe Road Users were added to those of Safe Roads and Safe Speeds. In addition the 'fifth pillar' of post-crash care was also added. This reflected the UN Decade of Action pillar on this topic (WHO, 2011) and also older appreciation of this issue, including that from the Haddon Matrix (Haddon 1968; 1980) which considered issues following a crash to be of importance in understanding and addressing crash risk.

The South Australian framework comprises a checklist that embeds Safe System principles and core to this understanding are the different biomechanical tolerances of road users in certain situations. This is based on a combination of selecting the desired speed environment (based on road function), the existing or predicted future speed environment, and the infrastructure provided. Key crash types that result in the majority of death and serious injury were included in this framework.

One other key finding from the literature review was the notion that there are different categories of infrastructure treatments, including those that are likely to largely eliminate death and serious injury (termed Primary, Safe System or Transformational treatments) while others made smaller steps to improving safety outcomes (termed supporting treatments) (Turner et al. 2009; Tate and Brodie 2014). Often the Primary treatments are overlooked (typically due to higher cost) in favour of lesser treatments, but these should actually be considered as first choice options even though there application will not always be possible.

The findings from the literature review were presented to a national workshop involving over 30 professionals from industry, government, the research community and advocacy leaders interested in influencing the national agenda relating to road safety infrastructure. The need for an assessment framework was discussed. Some of the key outcomes from the workshop were that the framework:

- should include all pillars of the Safe System (i.e. it was thought that at least for some projects, all pillars were relevant or could be influenced to produce better safety outcomes for infrastructure projects)
- should be scalable, meaning that it can be applied to small projects within local government, and to assessment of major projects or infrastructure types
- needed to cover the full lifespan of the project
- should include documentation of the process that is used and the reasons that decisions have been made
- needs to assess risks for different road users
- should be able to determine changes before and after options or solutions are applied
- needs to include guidance on key concepts, issues and solutions, but information provided should not be too prescriptive (i.e. there must be room for innovation)
- needs to describe what is meant by 'safety performance' in a Safe System context.

In addition, it was considered that the 'Primary' or 'Transformational' treatments should be presented as a first option. If these cannot be used, the reasons need to be documented, and alternative secondary options provided. There would be preference to next consider treatments that might be a stepping stone, with minimal redundancy of investment, to future Safe System implementation

The assessment framework

Based on the literature review and input from the workshop a draft framework was developed. The proposed framework followed an approach fairly typical in the assessment of risk, including that used in road safety (e.g. Austroads 2006), analysing exposure, likelihood and severity for key crash types. This is important, as the approach needs to be intuitive and reasonably familiar to those who use it. The main stages of the framework are as follows:

- identification of assessment objectives
- setting the project context
- applying the Safe System matrix
- if required, applying a treatment hierarchy and selection process.

The first step is to identify and document the objective of the assessment. The framework can be used for a number of different objectives, e.g.:

- to identify whether a project or solution will produce a Safe System outcome
- to identify the degree of a project's alignment with the Safe System objectives
- to document issues that mean the project will not be aligned (i.e. severe injury risks)
- to suggest solutions that would move the project closer towards, or in full alignment with Safe System objectives
- all of the above.

Another objective which needs to be recognised before commencement is the scale of the assessment. For example, the framework could be used to assess an individual location, a route, a major highway upgrade/bypass, an innovative infrastructure design solution, or a generic road type or design (e.g. a staggered T-intersection design). In some cases the assessment may need to be broken down into smaller sections or elements which are more manageable.

It should also be noted that these two objectives may change once an assessment has commenced. For example a limited assessment at an individual location may require further detail or a review of the broader context once the assessment is conducted.

Finally, the desired depth of assessment needs to be identified. The assessment could be conducted at high level at the planning stage (key issues only, broad level of alignment, areas for improvement). It could also be carried out in more detail for individual project components (quantitative level of Safe System alignment, identify specific problems and solutions). Where a high degree of precision is required, the subjective assessment proposed in the framework can be replaced by more detailed quantitative information. For example, such information could be added using the Australian National Risk Assessment Model (ANRAM; Austroads, 2014).

It is important to recognise what final outcome is expected – whether it is an infrastructure solution to a particular crash problem, or the assessment of multiple locations for network-level roll-out – and to keep this in consideration at all steps in the framework process.

Once the objectives of the assessment are identified, the context of the project must be defined. Table 1 provides a template with prompts to help achieve this.

Table 1. Template for setting the project context

Prompts	Comments
What is the reason for the project? Is there a specific crash type risk? Is it addressing specific issues such as poor speed limit compliance, road access, congestion, future traffic growth, freight movement, amenity concerns from the community, maintenance/asset renewal, etc.	
What is the function of the road? Consider location, roadside land use, area type, speed limit, intersection type, presence of parking, public transport services and vehicle flows. What traffic features exist nearby (e.g. upstream and downstream)? What alternative routes exist?	
What is the speed environment? What is the current speed limit? Has it changed recently? Is it similar to other roads of this type? How does it compare to Safe System speeds? What is the acceptability of lowering the speed limit at this location?	
What road users are present? Consider the presence of elderly, school children and cyclists. Also note what facilities are available to vulnerable road users (e.g. signalised crossings, bicycle lanes, school zone speed limits, etc.).	
What is the vehicle composition? Consider the presence of heavy vehicles (and what type), motorcyclists and other vehicles using the roadway.	

They key intention of these prompts is to help ensure that each pillar in the Safe System is considered as part of the assessment. Even though the focus of the framework is to assess infrastructure-related projects, there are many ways that professionals may be able to influence safety outcomes besides infrastructure-specific changes.

In order to ensure that Safe System elements are considered, or to measure how well a given project (e.g. an intersection, road length, area, treatment type etc.) aligns with Safe System principles, a Safe System matrix has been produced. The purpose of the matrix is to assess different major crash types (those identified as the predominant contributors to fatal and serious crash outcomes) against the exposure to that crash risk, the likelihood of it occurring and the severity of the crash should it occur. The basic structure of the framework is provided in Table 2. The content of each cell has been sourced from recent literature reviews and statistical modelling of severe crash risk factors (safety performance functions, crash rate analysis) conducted for Austroads and individual jurisdictions (e.g. Austroads 2010; Austroads 2012; Austroads 2014; Austroads 2015a)

Table 2. Safe System assessment framework for infrastructure projects

	Run-off-road	Head-on	Intersection	Other	Pedestrian	Cyclist	Motorcyclist
Exposure	AADT; length of road segment	AADT; length of road segment	AADT for each approach; intersection size	AADT; length of road segment	AADT; pedestrian numbers; crossing width; length of road segment	AADT; cyclist numbers; pedestrians	AADT; motorcycle numbers; length of road segment
Likelihood	Speed; geometry; shoulders; barriers; hazard offset; guidance and delineation	Geometry; separation; guidance and delineation; speed	Type of control; speed; design, visibility; conflict points,	Speed; sight distance; number of lanes; surface friction	Design of facilities; separation; number of conflicting directions; speed	Design of facilities; separation; speed	Design of facilities; separation; speed
Severity	Speed; roadside features and design (e.g. flexible barriers)	Speed	Impact angles; speed	Speed	Speed	Speed	Speed

Additional Safe System components	
Pillar	**Prompts**
Road user	Are road users likely to be alert and compliant? Are there factors that might influence this? What are the expected compliance and enforcement levels (alcohol/drugs, speed, road rules, and driving hours)? What is the likelihood of driver fatigue? Can enforcement of these issues be conducted safety? Are there special road uses (e.g. entertainment precincts, elderly, children, on-road activities, motorcyclist route), distraction by environmental factors (e.g. commerce, tourism), or risk-taking behaviours?
Vehicle	What level of alignment is there with the ideal of safer vehicles? Are there factors which might attract large numbers of unsafe vehicles? Is the percentage of heavy vehicles too high for the proposed/existing road design? Is this route used by recreational motorcyclists? Are there enforcement resources in the area to detect non-roadworthy, overloaded or unregistered vehicles and thus remove them from the network? Can enforcement of these issues be conducted safety? Has vehicle breakdown been catered for?
Post-crash care	Are there issues that might influence safe and efficient post-crash care in the event of a severe injury (e.g. congestion, access stopping space)? Do emergency and medical services operate as efficiently and rapidly as possible? Are other road users and emergency response teams protected during a crash event? Are drivers provided the correct information to address travelling speeds on the approach and adjacent to the incident? Is there reliable information available via radio, VMS etc. Is there provision for e-safety (i.e. safety systems based on modern information and communication technologies, C-ITS)?

A risk assessment approach has been adopted that includes exposure, likelihood and severity. The Safe System approach has helped practitioners understand that exposure and severity are both important considerations in fatal and serious crash outcomes. However, likelihood (which was perhaps the main issue considered prior to Safe System thinking) has often been overlooked. Yet, preventing crash, or minimising its probability, have been recognized early by the Safe System thinkers (e.g. Wegman and Aarts, 2006). The frameworks highlights how all elements are important. As indicated below, elimination of exposure or likelihood or severity will mean that fatal and serious outcomes will be eliminated.

Exposure, likelihood and severity (the rows of the matrix) are defined as follows:

- Road user exposure: this refers to which road users, in what numbers and for how long are using the road and are thus exposed to a potential crash. The measures of exposure include: AADT, side-road traffic volumes, number of motorcycles, cyclists and pedestrians crossing or walking along the road, length of the road, area and length of time.
- Crash likelihood: groups of road factors affecting the probability of a crash occurring. They can be elements which moderate opportunity for conflict (e.g. number of conflict points, offset to roadside hazards, separation between opposing traffic). They can also include elements of road user behaviour and/or road environment. Typically, these are the elements which moderate road user error rates. This includes issues such as level of intersection control (e.g. priority/signals/movement ban), speed, sight distance, geometric alignment, driver guidance and warning, and road maintenance (change in practice, implications of timing).
- Crash severity: groups of infrastructure or operational factors affecting the probability of severe injury outcomes should a crash occur. Typically, these factors are associated with the amount of kinetic energy and its transfer to those involved in the crash, e.g. impact speeds and angles, severity of roadside hazards.

The matrix columns show the following major crash types:

- run-off-road (also referred to as ‘loss of control’, or ‘off path on curve/straight’)
- head-on (or ‘vehicles from opposing directions’)
- intersection (‘vehicles from adjacent directions’)
- other (this incorporates all same direction, manoeuvring, overtaking, on path and miscellaneous crashes)
- pedestrian
- cyclist
- motorcyclist.

These crash types represent the main crash and road user types that contribute to death and serious injury (see e.g. Austroads 2015b). They are included as an element of the matrix to help concentrate thinking on crash causes and solutions. They are also provided in this way to ensure that vulnerable road users are directly considered.

Pedestrian, cyclist and motorcyclist crashes are separated to highlight the special focus on vulnerable road users. Note that in some circumstances (depending on the purpose of the assessment) other columns may also be added for specific crash types if these are of high importance (e.g. heavy vehicles).

As already discussed, the additional Safe System components have been included to help meet the objective that each Safe System pillar be included. Note that post-crash care has been added as a pillar. This forms a pillar of the global road safety action plan through the United Nations (WHO, 2011). In the infrastructure context there are sometimes measures that can be taken to facilitate quicker emergency response times, including access to the crash scene, thereby improving safety outcomes.

It is suggested that each of the cells relating to the key crash types in Table 2 be given a rating out of four for each of the key risk types (exposure, likelihood and severity). A zero indicates the safest or ‘Safe System’ state, while a four indicates the highest risk. Guidance is provided in Austroads (2016) on this rating process. Scores are then multiplied for each column, with a possible total of 64 for each crash type. Scoring in this manner identifies how close to Safe System outcomes the design is (i.e. how close to zero), and where the remaining crash risk lies. The score can also be used as a baseline to compare alternative project/treatment options.

The treatment hierarchy

An important part of this framework was provision of advice on treatment selection, and to ensure the best solutions are considered to help move towards Safe System objectives. Information on infrastructure treatment options and effectiveness is widespread (e.g. Austroads 2012; Elvik et al; 2009). Turner et al. (2009) present an early framework for Safe System infrastructure solutions based on major crash types. As already discussed, treatments that have the potential to achieve the Safe System objectives of near-zero deaths and serious injuries (termed Primary Treatments) are most desirable. It is intended that if high levels of risk were identified for one or more crash types, the solutions for that crash type should be reviewed (e.g. for run-off-road). The information on effective solutions for each crash type is provided in order of priority based on Safe System effectiveness, i.e. consideration of solutions which eliminate occurrence of fatal and serious injuries first.

In some situations, such options will not be feasible due to project constraints (e.g. budget, conflicting road user needs, environment etc.). If so, the next safest solution needs to be identified. If all possible Safe System solutions are ruled out, the next highest priority are the supporting solutions that might act as stepping stones, with minimal redundancy of investment, to future implementation of Safe System solutions. For example, a wide central painted median with audio-tactile lines may be installed with adequate width to allow future application of wire rope barrier.

Example treatment options are provided in full in Austroads (2016), while those options applicable to run-off-road crashes are provided in Table 3. These options were produced based on a number of recent Austroads projects (e.g. Austroads 2010; Austroads 2012; Austroads 2015a), as well as several Safe System infrastructure national round-table workshops (the first documented in Turner et al. 2009; second as part of the 2013 Australasian Road Safety Research, Policing and Education conference, and the last as part of the Framework development project). The information presented is indicative only, and careful thought should be given to the selection of treatments. Certain specific types of infrastructure, and the way that they are applied might mean that the location within the hierarchy might vary. Also future research may revise effectiveness of some treatments.

Table 3. Run-off-road (to left or right) treatments

Hierarchy	Treatment	Influence (E = exposure L = likelihood S = severity)
Safe System options ('primary' or 'transformational' treatments)	▪ Flexible roadside and median barriers (or equally/better performing future equivalent) ▪ Very high quality compacted roadside surface, very gentle to flat side slopes and exceptionally wide run-off areas ▪ Very low speed environment/speed limit.	S S L, S
Supporting treatments which move towards better Safe System alignment (compatible with future implementation of Safe System options)	▪ Wide run-off areas, with well-maintained shallow drainage and gentle side slopes ▪ Wide sealed shoulders with audio-tactile edgeline ▪ Lower speed limit.	S L L, S
Supporting treatments (does not affect future implementation of Safe System options)	▪ Non-flexible safety barrier ▪ Consistent design along the route (i.e. no out-of-context curves) ▪ Consistent delineation for route ▪ Skid resistance improvement ▪ Improved superelevation ▪ Audio-tactile centreline ▪ Audio-tactile edgeline ▪ Vehicle activated signs.	S L L L L L L L
Other considerations	▪ Speed enforcement ▪ Rest area provision ▪ Lane marking compatible with in-vehicle lane-keeping technology.	L, S L L

For each treatment an indication is provided on how safety is influenced, whether this be by reducing exposure (indicated with an E), likelihood (L) and/or severity (S). This information can be coupled with the outputs from the assessment process to help identify appropriate treatments. For example, if the assessment for likelihood identifies that risks are high, then those treatments that operate through reductions in crash likelihood would be more appropriate.

Where high risks are present for more than one crash type (as is often the case), combinations of one or more of these treatments should be considered. In addition, combinations of supporting treatments, particularly in association with lower speeds, may be adequate to fully address specific crash risks.

Once solutions are identified, the assessment process can be repeated to determine the likely benefits when compared to the original design. Different options can also be compared to help identify the most appropriate solution.

Discussion

An assessment framework will be an important tool to help road agencies methodically consider Safe System objectives in road infrastructure projects. The framework developed has been tested on a variety of projects, and been found to produce results that not only identify compatibility with Safe System objectives, but also assist practitioners in assessing key elements of the Safe System. This includes a focus on the key crash types that result in fatal and serious outcomes and the mechanisms by which these crashes result in serious injury outcomes (i.e. exposure, likelihood and severity). It also ensures that a broader perspective is taken when assessing projects, and that opportunities are sought to address issues relating to road users, vehicles and post-crash care.

The provision of a treatment hierarchy is also an important tool for practitioners. This provides a useful approach whereby the most effective treatment options are considered first. These will not be available for use in all cases, but it is important that a systematic approach be taken to the selection of treatments and that this process be documented. The subjective application of the framework means that comparisons between locations should not be made, and the results cannot be linked to actual crash rates or frequency at this time. Trials using objective assessment (e.g. outputs from ANRAM) should be undertaken and clear guidance produced to demonstrate this process.

The framework and treatment hierarchy are likely to evolve and improve over time. As these tools are applied to projects, more case studies will become available. As more evidence is gathered on effective treatments and risk, the guidance provided will be improved. As with any new approach, it is likely that the tools will undergo a rapid evolution and it will be important to coordinate any new knowledge to ensure that all practitioners have access to this.

Safe System implementation requires a systematic approach to measuring every project’s level of alignment with the vision’s objectives. The Safe System Assessment Framework provides this facility for the practitioners in a form which is easy to apply and scalable with the project size. Application of the framework will be greatly assisted by training of road agency and consulting practitioners.

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Female Pedestrians' Vulnerability due to Different Crash Locations, a Case-Study for IRAN

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Abstract

While pedestrians' fatality stands for 23% of total mortality, the share of pedestrians' fatality distribution for various road areas is totally different from the other road users. Meanwhile female pedestrians assumed to burden more vulnerability according to some factors. This study attempts to test hypotheses related to female pedestrian casualties as per their location of death and other factors like age, day time and visibility (clothing color).

Methods

This is a cross-sectional study using death registry data from 2009 to 2014. Also the actual traffic crash records were used to link roadway function classes and Pedestrian Locations to victims' data. Then female pedestrians' mortality rates were calculated and tests of association between selected variables performed.

Results

The findings revealed that female pedestrians around intercity roadways are less exposed to fatal crashes compared to those crossing on urban roadways. But walking around minor/rural roads leads to higher exposure to death. While crossing urban and intercity roadways increases the vulnerability of female pedestrians who are respectively 65+ and 16-24 years to traffic crashes, walking through minor/rural roads increases the vulnerability of those who are under 15 years. Vulnerability of female pedestrians to crashes showed no significant differences for different day time but wearing dark clothing (mostly veils as common robe in the country) significantly increases their vulnerability.

Conclusions

As proved that female pedestrians are more vulnerable at some specified road areas and due to several factors, the above findings assist the officials to deploy pedestrian crash preventive measures at identified hazardous traffic areas and to plan more relevant awareness campaigns and education for females especially at more prone locations.

Keywords

Female Pedestrians, Vulnerability, Fatal Crash Locations, Iran.

Rural casualty crashes in NSW: A comparison of two major arterial roads and two main highways

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Abstract

This research considers the interaction between road geometry and driver behaviour and its impact on change of crash rates for day/night and different driving directions. An empirical location-specific approach is used to compare the results between two types of rural roads. The crash data is investigated for two major arterial roads (Kings Highway and Waterfall Way) and two main highways (Pacific and Princess Highways) in NSW. The results suggest that the risk of crashing is higher at night and during the day on arterial roads and varies according to travel direction. Driver gender, age and speed are all significantly different between day/night. Higher crash rates at night might be due to speed and fatigue, and more crashes during the day on arterial roads might because of the complexity of the interaction between road geometry and driver behaviour on sinuous sections of the road.

Background

There is widespread agreement that rural casualty crashes are a serious aspect of road safety (Elvik, 2008). It has been argued that they occur as a consequence of driver behaviour (e.g. speed and fatigue), road characteristics (e.g. segment length, horizontal and vertical curves, and lane and shoulder width), environmental features (e.g. time of the day and weather conditions), along with interactions between these issues (Alian, Baker, & Wood, 2015; Elvik, 2006; Shankar, Mannering, & Barfield, 1995; Yu & Abdel-Aty, 2014). Speed, visual field, road curvature, grade, and traffic volume are some of the variables that might increase both crash frequencies and rates, according to driver gender and age (Haynes, Jones, Kennedy, Harvey, & Jewell, 2007), but might have mixed effects on crash incidences depending on environmental conditions (Wang, Quddus, & Ison, 2013). Day/night driving (i.e. different illumination levels) (Fildes, Leening, & Corringan, 1989; Plainis, Murray, & Pallikaris, 2006) and eastbound/westbound or northbound/southbound driving (i.e. different effects of grade on speed in different travel directions) (Hassan, 2003) are two environmental variables that may have different effects on casualty crash rates.

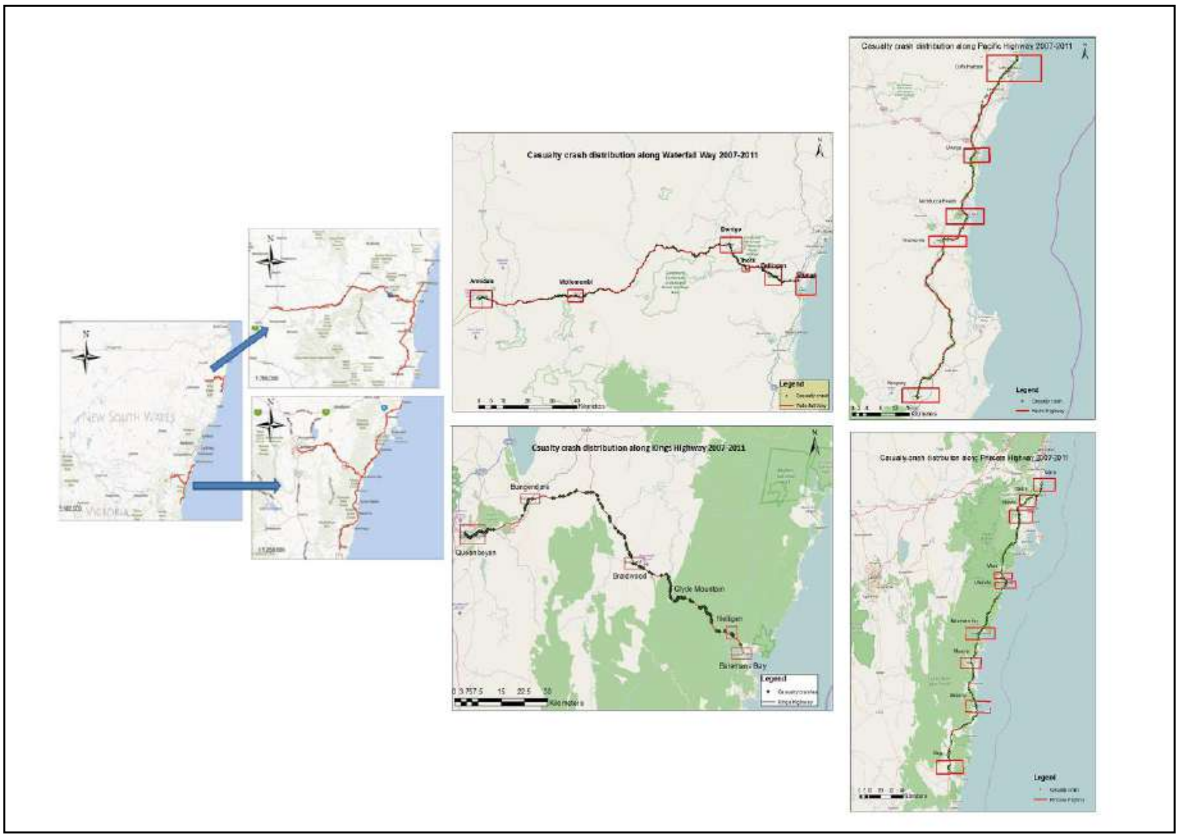
Apart from the role of road and environment, in about 80% of crashes driver errors or violations are the main causes of crashes (Rothengatter, 1997; Sabey & Taylor, 1980). Speeding, fatigue, driver inattention and violation, and drink driving are the main driver behavioural factors that contribute to crash occurances on rural roads in Australia (Siskind, Steinhardt, Sheehan, O'Connor, & Hanks, 2011). The contribution of driver behavioural factors to the risk, rate and distribution of casualty crashes might be different on different types of rural roads with changes of road characteristics and environmental features. Recently, the authors developed a location-specific approach to the study of road safety based on road segmentation using road centerline data. They considered the interaction between physical measures of road curvature (sinuosity index) and behavioural measures of road curvature (critical visual points) and its effect on changes in the rate and distribution of casualty crashes between day/night and eastbound/westbound travel on rural sections of the Kings Highway NSW. They concluded that casualty crashes are not significantly different on straights and curves at night, but the risk of having a crash is higher during the day on curvy sections of the road, traveling eastbound, because of the stronger effect of road geometry on driver visual cues (Alian et al., 2015).

Against this backdrop, the current study aims to apply the above approach to different types of rural roads (i.e. main arterial roads, and main highways), discuss similarities and differences, and generalise previous outcomes. It considers the interaction between road geometry and driver behaviour and its impact on segmental rates of change and distribution of casualty crashes between day/night and eastbound/westbound or southbound/northbound travel in four different study areas in NSW.

Study areas

The current paper explores two major arterial (overpass-mountain) roads, running from inland to the coast (Kings Highway [about 132 Km] and Waterfall Way [about 163 km]), and two sections of coastline highway (Princess Highway, from Kiama to Bega [about 304 km]; and Pacific Highway, from Coffs Harbor to Kempsey [about 116 km]) all of which were mainly two-way, undivided rural roads during the study period (2007-2011). Figure 1 illustrates the casualty crash distribution in the study areas. The study areas were selected because of high casualty crash rates during the study period and mixed geometry characteristics. Since 2011, the Roads and Maritime Services (RMS) introduced a number of road safety reviews, road upgrades, and some long-term plans on the selected routes. The particular focus of this paper is on similarities and differences, if any, between the selected routes in terms of casualty crash rates and distributions, driver behavioural factors and road geometry variables, according to day/night and different travelling directions.

Figure 1. Crash distribution in selected study areas (2007-2011)



Method[i]

In this research three sources of data were used including crash data and traffic count data (from RMS), and road centerline data (from NSW Lands Department); comprehensive road geometry data was not made available to the authors. The method followed Alian et al. (2015), which might be used in circumstances where detailed road geometry data is not available. It is a bottom-up, exploratory data analysis approach that considers the geographical location and time of casualty crashes. In summary, to measure road geometry variables, the road centerline was divided into *n* segments where the straight-line distance for each road segments was equal to 1 km. In each road segment the sinuosity index (ratio of actual road distance to straight-line distance) and grade (ratio of vertical change to horizontal change) were determined to capture key road geometry characteristics, and critical visual points (focal points, or the points in a curved segment where the visual information of the driver changes because of change in the direction) were measured to reflect key aspects of driver behavioural responses to road characteristics. The sinuosity index equals one for straight segments and increases according to increasing road curvature; grade reflects the differences between uphill and downhill travel; and critical visual points are measured by tangent lines to reflect differences between different types of road segments where sinuosity is equal, and to provide a proxy to changes in the visual information of drivers.

The method is an empirical, bottom-up approach that considers the nonlinear interaction between geometrical and behavioural measures of road curvature as a basis for further steps of the analysis. Urban areas were excluded (because of the built-up environment, and different speed limits). For the rural segments, associations between changes of sinuosity index and critical visual points were plotted and analysed using quadratic regression.

To explore the data, crash data was standardised per volume and length, and crash frequency, crash rate, driver age, gender, travel speed, and the frequency of crashes on straight and curved sections of the roads were compared for day/night travel and different travelling directions. To avoid the influence of assumptions concerning normal or random distributions, nonparametric statistical tests (chi-square and Mann-Whitney U tests) were used to test for significant differences between two groups of variables. The results were regarded as significant for *p*-values less than 0.05 (greater than 95% confidence).

To identify and compare how associations between the rate of casualty crashes and the sinuosity index vary according to day/night travel and according to major arterial roads and main highways, routes with similar road geometry and crash rates were combined. The road segments for both arterial roads (Kings Highway and Waterfall Way) and main highways (Princess and Pacific Highways) were divided into three main groups: straight ($SI \leq 1.05$), curved ($1.05 < SI \leq 1.25$), and twisted ($SI > 1.25$) and the crash rates were compared. The nonparametric Kruskal-Wallis test was used to ascertain significance since it considers the equality of more than two population means.

To determine how associations between changes in road geometry variables and crash rates vary according to day/night travel and according to major arterial roads/main highways, the rural road centerlines were divided into equal sections where each section included five segments to reflect the NSW road advisory signs. The quadratic correlation coefficients between road geometry variables and crash rates for day/night were measured and significant results ($p < 0.05$) used for further analysis.

To illustrate and analyse the interplay between road geometry variables (both physical and behavioural) and casualty crashes rates and distributions, during both day and night travel, a responsiveness of curvature index was used. It considered the multiplying effect of the sinuosity index and critical visual points (horizontal change of road curvature) on the segmental change of crash rates on both overpass mountain (arterial) roads and coastline (main) highways for day/night driving conditions.

Finally, the speed- and fatigue-related crashes (sourced from crash database) were compared for day/night and for two different travel directions (eastbound/westbound or southbound/northbound) between the selected study areas.

Results

As discussed above, the urban areas are excluded from these results. For the remaining rural areas, to measure road geometry variables 121.66 km of the Kings Highway is divided into 115 segments; 157.47 km of the Waterfall Way is divided into 148 segments; 264.48 km of the Princes Highway is divided into 252 segments; and 94.90 km of the Pacific Highway is divided into 93 segments.

Associations between the sinuosity index and critical visual points are illustrated in Figure 2. In this figure, the X-axis represents the sinuosity index measure per segment and the Y-axis shows the critical visual point measure per segment. The results are compared between 263 rural segments on overpass mountain roads (Waterfall Way and Kings Highway) in the left graph and 345 rural segments on coastline highways (Princess and Pacific Highways) in the right graph. The graphs suggest that both sinuosity index and critical points measures are about two times greater on overpass mountain arterial roads than coastal highways. The *R*-squared and *p*-values suggest that for both types of roads *R*-squared values are greater for quadratic regression rather than linear regression (0.549 to 0.526 for arterial roads, and 0.189 to 0.169 for main highways). In addition, regression lines/curves suggest that quadratic regression better represents how critical visual points (driver behaviour) change in relation to the sinuosity index (road geometry).

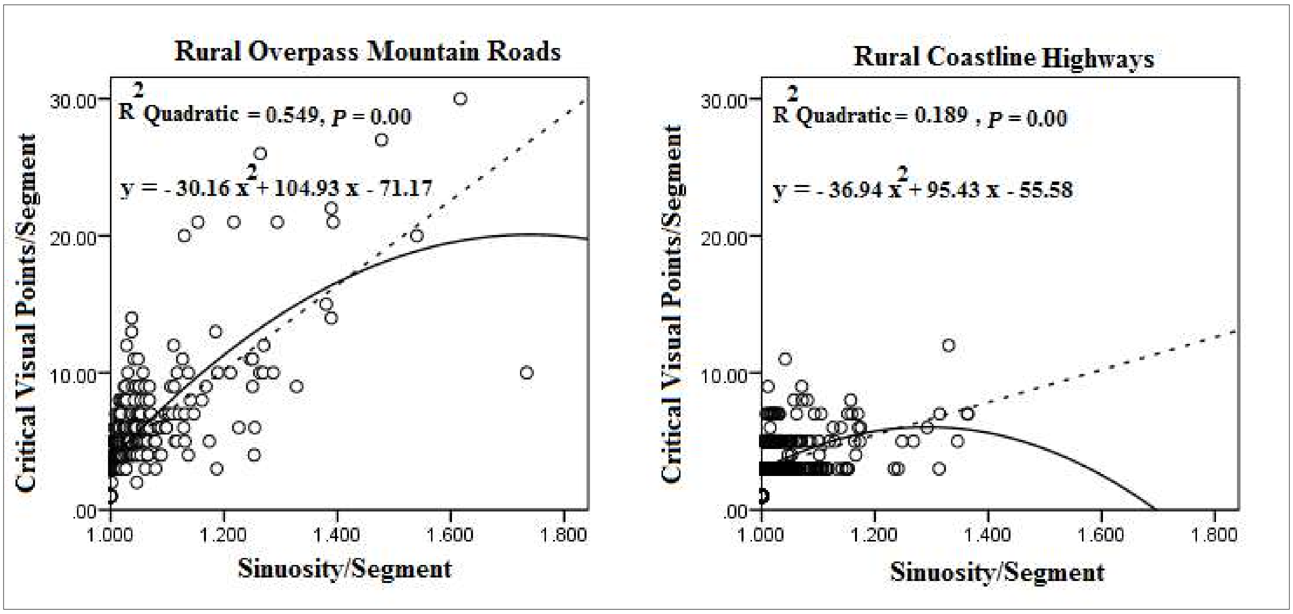
The results of further data exploration are summarised in Table 1. Some of the significant results are highlighted in bold. The crash data results indicate that for all study areas the risk of having a crash at night is greater than day-time. The results are statistically significant for Kings Highway, Waterfall Way and Princess Highway ($p < 0.05$), but not statistically significant for Pacific Highway. Crash frequencies and rates are higher travelling eastbound, during the day, on arterial roads (Kings Highway and Waterfall Way), but no significant difference was found on the main highways (Pacific and Princess Highway) for different travelling directions. For all study areas the mean driver age is higher during the day. In addition, the probability of a crash by male drivers is higher at night time, and the results are statistically significant. For most of the study areas the mean travel speed at night-time is higher than day-time. For arterial roads the risk of having a crash on both straight and curved sections is greater travelling eastbound during the day. The road data results suggest that the mean and standard deviation for the sinuosity index, the mean and standard deviation for critical visual points, the standard deviation of the ratio of negative gradient to positive gradient, and the ratio of curved segments ($SI > 1.05$) to straight segments ($SI \leq 1.05$) are all higher on arterial roads. The greatest variation in road geometry variables is found on Waterfall Way, followed by Kings Highway; the lowest variation is found on Pacific Highway. In summary, the risk of having a crash is higher on arterial overpass mountain roads than on coastline highways. The probability of having a crash is highest on Waterfall Way and lowest on the Pacific Highway.

Figure 3 illustrates how increase in the sinuosity index affects casualty crash rates. The results are compared between three different groups of sinuosity index for day/night between 263 segments on major arterial roads and 345 segments on the main highways. In Figure 3, the X-axis shows the three different sinuosity index groups (straight, curved, and twisted), and the Y-axis illustrates mean crash rates standardised per 100000 moving vehicles and length of segments in each group. The results are compared between day in the left column and night in the right column, and major arterial roads in the first row and main highways in the second row. The graphs suggest that there is a slight increase in crash rates as the sinuosity index increases on main highways, but considerable increase in crash rates when the sinuosity index increases on major arterial roads. The results at night-time are not consistent for main highways and arterial roads. The nonparametric Kruskal-Wallis test results suggest that for both arterial roads and main highways the results are statistically significant for day-time (*p*-values are 0.000 and 0.020). In contrast, the results for night-time are not statistically significant for both arterial roads and main highways (*p*-values are 0.233 to 0.396).

Appendix 1 shows the quadratic correlation coefficients between the mean and standard deviation of the road geometry variables per 5 segments and casualty crash rates according to day/night for all the study areas. The quadratic *R*-squared values are significant for day crashes in relation to the mean sinuosity index, mean critical visual points, standard deviation for critical visual points, and mean grade for Kings Highway and Waterfall Way (major arterial roads). No significant results are found for the mean and standard deviation of road geometry variables at night-time for arterial roads (except for the mean grade on Waterfall Way, which might be random). On the main highways (Princes and Pacific Highway), no significant results are found between road geometry variables and day-time crashes. The results are significant for night-time crashes in relation to the standard deviation of critical visual points, mean grade and standard deviation of grade for Princess Highway; and for night-time crashes and the mean sinuosity for Pacific Highway. Further analysis of these results is required.

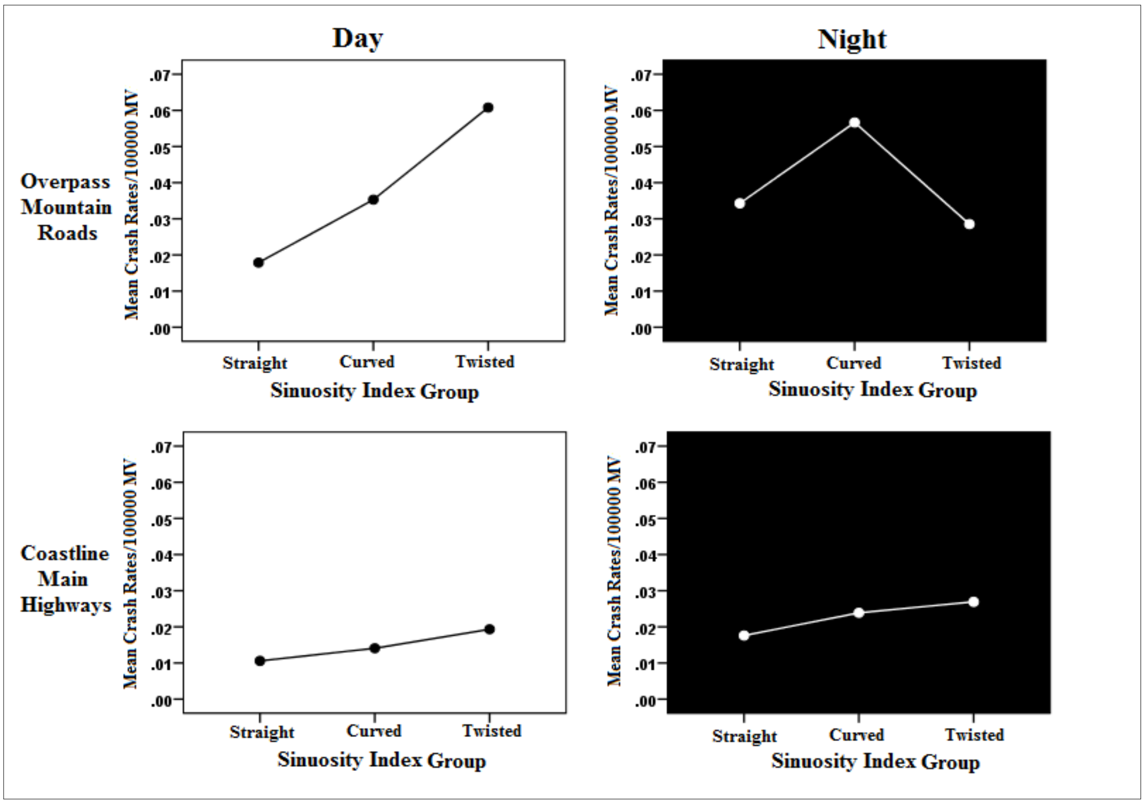
Figure 4 shows the regression analysis results between crash rates and responsiveness to curvature index for day/night driving on overpass mountain arterial roads and coastline highways, respectively. In Figure 3, the X-axis illustrates responsiveness to curvature index (calculated by multiplying the mean sinuosity index by the standard deviation of critical visual points per 5 segments), and the Y-axis illustrates crash rates standardised per 100000 moving vehicles per 5 segments. In this figure the first column shows the results for day-time and the second column shows the results for night-time. Finally, the first row illustrates the relationship on overpass mountain roads, and the second row graphs it for the main highways. The quadratic regression results suggest that *R*-squared values are significant for overpass mountain roads during day-time ($p < 0.05$), but no significant results are found for overpass mountain roads at night-time, or for the coastline highways for either day or night. The quadratic curves suggest that there is a limit to the impact of road curvature on casualty crash rates.

Figure 2. Quadratic regression between sinuosity index and critical visual points



As a further aid to analysis, Table 2 summaries the percentage of speed and fatigue related crashes (sourced from the crash database) between the study areas for day/night and different travel directions (eastbound/westbound and southbound/northbound). The results suggest that the percentage of speed-related crashes is higher on overpass mountain roads (major arterial roads) during the day and on coastline highways (main highways) at night-time. The results also suggest that the percentage of fatigue related crashes for both day and night is higher on the main highways. Except for the significant difference between fatigue-related crashes on Waterfall Way between eastbound and westbound travel at night there are no significant changes between different travelling directions. The comparison between day/night suggests that fatigue-related crashes at night in all the study areas are about two times more than day-time.

Figure 3. Distribution of crash rates for different types of sinuosity for day/night and arterial roads/main highways



Discussion

In this research an empirical approach is used to identify how road curvature might affect the risk and geographical distribution of having a crash according to day/night and different travelling directions (i.e. eastbound/westbound or southbound/northbound). Road centreline data is used to measure road geometry characteristics and the interaction between geometrical and behavioural components of road curvature (sinuosity index and critical visual points) is used for further steps of the analysis. The method is applied to four rural roads: two overpass mountain roads (Kings Highway and Waterfall Way), and two coastline Highways to validate and expand previous findings (Alian et al., 2015). The findings in this research might be used as the preliminary basis for further crash analysis and road safety studies.

The regression analysis between the geometrical measure (sinuosity index) and the behavioural aspects (critical visual points) of road curvature suggest that quadratic regression might better represent the interaction and nonlinear associations between road and driver behaviour than a linear one. As the regression curves show there is a saturation to the impact of sinuosity on driver visual cues. The stronger *R*-squared values for overpass-mountain roads might be due to higher rates of change of both geometrical and behavioural proxies of road curvature in comparison with the less sinuous coastline highways. Range, average, and variation of road geometry variables are all greater on Waterfall Way and Kings Highway in comparison with Princess and Pacific Highways.

The results of data exploration confirm the previous findings in the literature. Higher crash rates at night might be due to a constrained visual field, speed, fatigue, and voluntary risk-taking of young male drivers (Konstantopoulos, Chapman, & Crundall, 2010). It might also happen because of the higher use of alcohol at night driving on rural roads (Siskind et al., 2011). The results for day-time, eastbound travel on arterial roads may be the result of the stronger effect of road geometry on curves, down the hill at day-time (Jurewicza, Chaub, Mihailidisb, & Buic, 2014). Finally, higher crash clusters on curves on arterial overpass mountain roads may be due to the important role that road geometry and environmental conditions play in affecting crash rates and distributions on twisty and mountainous sections of road.

Different crash rates between sinuosity groups for day/night and arterial roads/main highways suggest that road geometry might have different effects on casualty crash distributions and rates according to different environmental conditions and road type. The quick and continuous increase of crash rates from straight to curved and twisted road segments for day-time on arterial roads might be associated with the greater proportion of twisted and curved segments when compared with main highways. The results suggest that road geometry has a stronger effect on crash rates and distributions during the day, probably because more continuous and complex visual cues are provided than at night-time, where the background visual field is absent.

The quadratic correlation coefficients between road geometry variables (mean and standard deviation of sinuosity index, mean and standard deviation of critical visual points, mean and standard deviation of grade) and crash rates per 5 segments for day/night indicate that on arterial roads *R*-squared values are significant between mean road geometry variables and standard deviation of critical visual points and day-time crashes for both Kings Highways and Waterfall Way. No significant and consistent outcomes are found between mean and standard deviation of road geometry variables and night-time crashes on arterial roads, and mean and standard deviation of road geometry variables and day and night-time crashes on main highways. The results confirm the strong effect of road geometry on driver behaviour and crash rates on arterial roads for day-time.

The regression analysis between the responsiveness to curvature index and crash rates support the preceding discussion. As the sinuosity index and standard deviation of driver visual cues increases the crash rates will increase to a certain point and then will decrease for day-time. The results suggest that road curvature has a mixed effect on road safety. At the scale that we examined, the effect of segmental change of road curvature on crash rates, there is no significant change for night-time driving on both arterial and main highways, and for day-time driving on main highways. It suggests that crashes are randomly distributed at night and on quite straight highways.

Finally, a review of speed and fatigue related crashes indicates that the percentage of fatigue related crashes at night are about two times more than day-time. This suggests that fatigue (e.g. driving for a long time or lack of sleep) might be the main cause of higher crash risks at night, especially on main, straight highways with fairly monotonous driving environments (Sagberg, 1999; Ting, Hwang, Doong, & Jeng, 2008). The results also suggest that the percentage of speed related crashes during the day are higher on arterial roads because of the stronger effect of road geometry on driver behaviour (speeding and limited visual cues).

In summary the results suggest that the distribution of crashes on overpass mountain arterial roads is significantly different between day/night and eastbound/westbound, but this is not the case for main highways. The crashes are randomly distributed at night on both types of roads and during the day on main highways, but clusters have been found during the day on overpass mountain roads. The results suggest that during the day on bendy and hilly sections of the road the complex interplay between road curvature, driver visual cues, and background visual field might be the cause of crash clusters; that is not the case for night driving because of the absence of background information and the effect of headlights. The results also suggest that both road geometry and environment might have a positive effect on speeding on curves driving downhill, which might be the cause of runoff road crashes. The method might be used if detailed road geometry data is not available, but as a limitation, it cannot quantify the associations between segmental change of road geometry variables and crash rates at night and on almost straight road segments because crashes are randomly distributed.

The outcomes recommend to national authorities that different policies might be used for road safety public policies between day and night driving on arterial and main highways. Various speed limits, different advisory signs and accelerated upgrades might be required between these two types of roads.

Some of the limitations of this research are: not considering the effect of drug and alcohol, the role of some other road factors such as lane and shoulder width, the effect of animals, type of crash and vehicle, and the role of weather conditions due to data limitations. Further research might be used to expand and generalise the results. It should be noted that the results and discussions of this paper are preliminary outcomes of the research, and analysis is ongoing. In addition, some upgrades have been done in the selected study areas by authorities after the study period, and where data is available, it might be valuable to compare the results in future studies.

Conclusions

In this research an empirical approach compares the change of casualty crash rates between major arterial roads and main highways in NSW. It considers the interaction between road curvature (sinuosity) and driver visual cues (critical visual points) and its effect on the rate and distribution of casualty crashes for day/night driving and eastbound/westbound or southbound/northbound travels.

The results suggest that the risk of crashes is higher at night and on arterial roads during the day and only varies according to travel direction on arterial roads, but not main highways. High crash rates at night might be because of fatigue, speed, or the use of alcohol, and crash clusters during the day on arterial roads might be because of the complexity of the interaction between geometrical and behavioural measures of road curvature.

In summary both the rate and distribution of casualty crashes varies between straight/curves according to lighting conditions, travel directions and type of road. The outcomes of this research suggest that national authorities might use different safety policies for day/night and arterial roads/main highways.

Acknowledgement

We need to acknowledge The NSW Road and Maritime Services for providing crash and traffic data, and The Departments of Lands for providing road centreline data. It was not possible to do this research without their support.

Figure 4. Quadratic regression between responsiveness to curvature index and crash rates

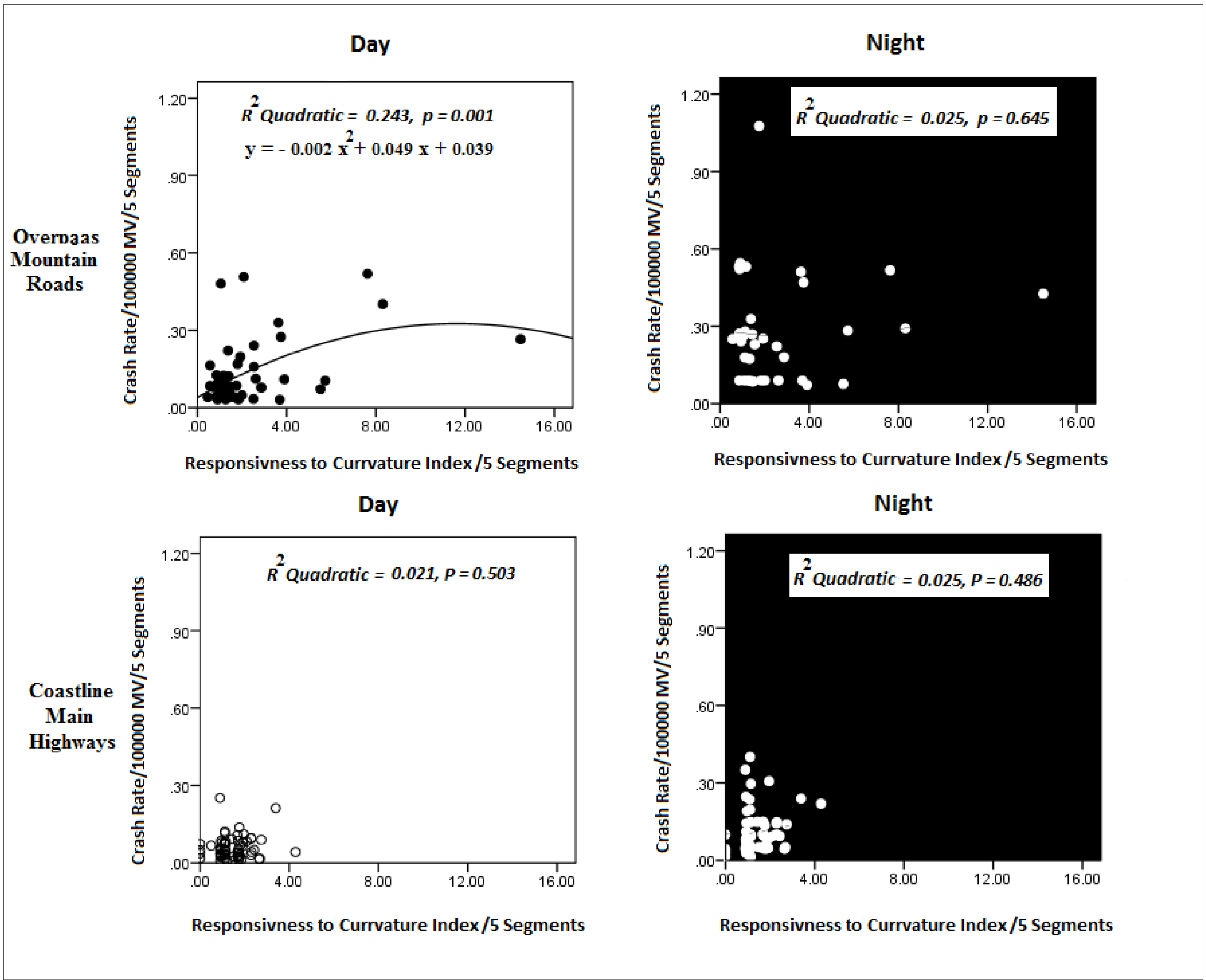


Table1. Summary of crash data, social economic and road geometry variables 2007-2011

		Crash data															**Road data**					
		% Crash freq.			**Crash rate /100,000 (MV)/ (Km)**			**Mean driver age (yrs.)**			**Driver gender crash freq. (M/F)**			**Mean travel speed (Km/h)**			**Mean sinuosity index**	**SD sinuosity index**	**Mean critical visual points**	**SD critical visual points**	**SD N/P gradient**	**% Straight /curves**
		Total	**Day**	**Night**	**Total**	**Day**	**Night**	**Total**	**Day**	**Night**	**Total**	**Day**	**Night**	**Total**	**Day**	**Night**						
Kings Highway	**Total**	100	**80**	**20**	0.020	**0.019**	**0.027**	37	**41**	**33**	1.45	**1.25**	**2.88**	82	*77*	*86*					-	
	East (Q-BB)	**64**	**52**	12	**0.026**	**0.024**	0.030	36	42	31	2.16	**1.82**	2.5	79	74	84	1.058	0.098	6.33	4.60	1.77	2.85
	West (BB-Q)	**36**	**28**	8	**0.014**	**0.013**	0.020	38	41	36	2.86	**0.64**	**3.66**	84	81	88					0.56	
Waterfall Way	**Total**	100	**82**	**18**	0.033	**0.032**	**0.046**	37	40	34	1.47	1.35	2.25	82	*82*	*81*					-	
	East (A-U)	**55**	**47**	8	**0.037**	**0.036**	0.044	36	39	33	1.52	1.36	3	83	80	**87**	1.064	0.102	5.72	4.15	1.65	1.94
	West (U-A)	**45**	**35**	10	**0.029**	**0.026**	0.047	39	42	36	1.42	1.33	1.80	80	84	**76**					0.61	
Princess Highway	**Total**	100	**77**	**33**	0.014	**0.013**	**0.023**	41	**46**	**36**	2.09	1.72	2.47	83	*81*	*85*					-	
	South (K-B)	50	39	11	0.014	0.013	0.020	42	47	37	2.22	1.87	2.56	83	82	85	1.050	0.073	3.91	1.95	1.12	2.45
	North (B-K)	50	38	12	0.014	0.012	0.022	40	45	36	1.97	1.57	2.38	83	80	86					0.09	
Pacific Highway	**Total**	100	67	33	0.010	0.009	0.011	40	**44**	**36**	3.22	2.26	4.18	85	*83*	*87*					-	
	South (C-K)	49	32	17	0.010	0.010	0.013	42	47	38	4.13	**1.87**	**6.40**	86	86	87	1.020	0.030	2.76	1.14	0.07	6.14
	North (K-C)	51	35	16	0.009	0.009	0.010	37	41	34	2.94	2.65	3.23	83	80	87					1.33	

Note. MV: Moving Vehicles, M/F: Male/Female, SD: Standard Deviation, N/P: Negative/Positive. The main significant results are highlighted in bold ($p < 0.05$)

Table2. Summary of crash data, road geometry and social economic variables 2007-2011

		% Speed or fatigue related crashes							
		Day				Night			
		Speed	No /unknown	Fatigue	No /unknown	Speed	No /unknown	Fatigue	No /unknown
Kings Highway	East (Q-BB)	56	44	11	89	41	59	23	77
	West (BB-Q)	57	43	10	90	36	64	21	79
Waterfall Way	East (A-U)	52	48	8	92	42	58	17	83
	West (U-A)	59	41	14	86	36	64	7	93
Princess Highway	South (K-B)	41	59	13	87	42	58	26	74
	North (B-K)	39	61	13	87	39	61	18	82
Pacific Highway	South (C-K)	23	77	17	83	43	57	27	73
	North (K-C)	25	75	21	79	47	53	35	65

Appendix 1. Quadratic correlation coefficients between crash rates and road geometry variables day/night

		Mean SI	Deviation SI	Mean CVP	Deviation CVP	Mean Grade	Deviation Grade
Kings Highway	Day Crashes	**0.291** **0.044**	0.199 0.121	**0.468** **0.003**	**0.512** **0.001**	**0.637** **0.000**	0.152 0.210
	Night Crashes	0.185 0.176	0.042 0.693	0.158 0.232	0.206 0.141	0.164 0.219	0.084 0.474
Waterfall Way	Day Crashes	**0.364** **0.004**	**0.225** **0.041**	**0.491** **0.000**	**0.380** **0.003**	**0.279** **0.017**	0.132 0.170
	Night Crashes	0.133 0.343	0.080 0.534	0.119 0.388	0.046 0.701	**0.580** **0.001**	0.311 0.061
Princess Highway	Day Crashes	0.046 0.327	0.038 0.391	0.000 0.991	0.009 0.807	0.078 0.141	0.034 0.438
	Night Crashes	0.025 0.609	0.054 0.340	0.028 0.578	**0.178** **0.022**	**0.215** **0.009**	**0.205** **0.012**
Pacific Highway	Day Crashes	0.061 0.325	0.005 0.966	0.301 0.068	0.009 0.807	0.046 0.700	0.099 0.459
	Night Crashes	**0.241** **0.039**	0.042 0.724	0.296 0.072	0.037 0.752	0.047 0.697	0.038 0.750

The first value in each box is R-squared and the second value is p-value. The results sre significant for ($p < 0.05$)

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[i] A more detailed description of the methodology is provided in Alian et al (in press).

Roadway Lighting As Countermeasure For Nightitme Collisions: Case Study Of Quebec's Highways And Arthabaska Roads

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Abstract

Compliance with roadway lighting regulations is not sufficient to warrant effective reductions in night-time collisions, lighting levels are disconnected from the crash history. A method to estimate effective lighting levels from locally observed crash history is presented. It uses statistical analyses to estimate the explanatory power of illuminance, luminance, and uniformity ratios. Findings: from Arthabaska region illuminance was not useful on road segments, luminance levels should be increased and uniformity variations reduced. For highways in Quebec, luminance should be increased up to 1.5cd/m2 and illuminance-uniformity reduced to one in order to reduce collision's severity.

Introduction

Worldwide practices in roadway lighting give preference to luminance as a design criterion for highways instead of illuminance (Wanvik 2009). The Japanese guidelines (JAS 1988), the European code (CEN 2004) and the Austroads manual (AS/NZS. 2010), they all recommend the use of luminance from the perspective of the driver. Whenever the design involves high speeds or deals with the driver's ability to perceive objects and dangerous circumstances, luminance seems more adequate (Jackett and Firth 2013).

Methodology

Values recommended by IESNA (2005) are used as initial point (Figure 1). The approach is repeated for average values of illuminance, luminance and uniformities. The first step consist in the selection of a trial level for each lighting explanatory variable, then the data is categorized according to this level and the explanatory capability of the factor is learned from the statistical analysis. If decreasing the lighting variable helps to explain a lower number of collisions then the procedure is repeated by setting up a new trial level. If the variable does not help explain a reduction in the frequency/severity of collisions then the procedure is terminated and the previous level of the lighting variable is set as recommended minimum value (Figure 1). The method must go in this way and do not follow a continuous variable approach, because of the need to identify the minimum or maximum levels for each lighting parameters in their capability to explain less collisions.

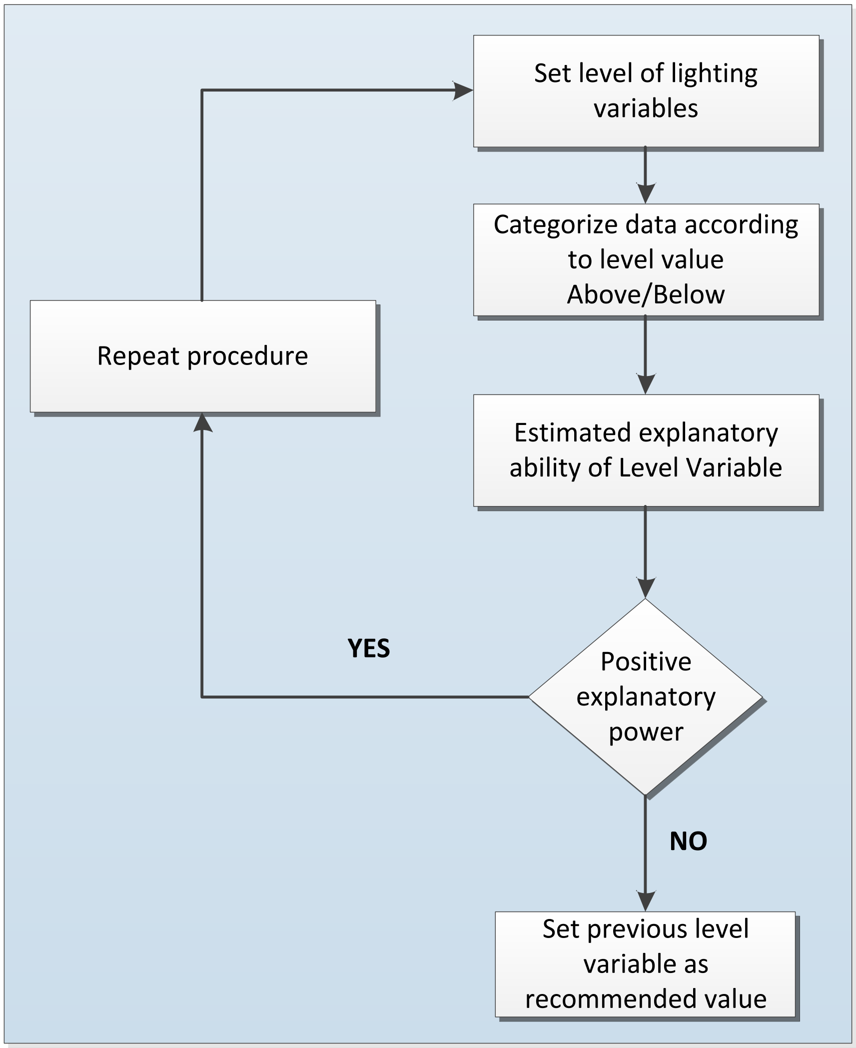

Figure 1 Method for the estimation of recommended level

Case study of the province of Quebec

For example Table 3 shows the results of the statistical analysis for luminance, similar analysis were made for other variables. As seen values of 1.5 (and above) resulted in statistically significant reductions of severity and frequency of night time motorized collisions.

Table 1 Identification of Recommended Levels for Luminance

Luminance-levels analysis of severity								
	Level of Lighting Indicator on Dummy variable							
	0.6 cd/m2		**1.5 cd/m2***		**1.7 cd/m2**		**1.9 cd/m2**	
Variable	**coeff**	**p-value**	**Coeff**	**p-value**	**coeff**	**p-value**	**Coeff**	**p-value**
nd_ratio_one	0.29	0.00	0.25	0.00	0.27	0.00	0.27	0.00
number_lanes	-0.52	0.11	-0.26	0.43	-0.32	0.34	-0.36	0.27
intersections	1.12	0.03	1.74	0.00	1.63	0.00	1.57	0.00
shoulder_width	-0.55	0.00	-0.61	0.00	-0.59	0.00	-0.59	0.00
lnaadt_night	0.78	0.00	0.70	0.00	0.75	0.00	0.76	0.00
speed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
radius	0.00	0.24	0.00	0.33	0.00	0.28	0.00	0.27
DUMMY Var	**0.40**	0.05	**-3.39**	0.01	-4.74	0.18	-15.02	0.98
effect	*negative*	*significant*	*positive*	*significant*	*positive*	*80% CI*	*positive*	*insignificant*
No. of Obs.	450		121		74		67	
Luminance-levels analysis of frequency								
	Level of Lighting Indicator on Dummy variable							
	0.6 cd/m2		**1.5 cd/m2***		**1.7 cd/m2**		**1.9 cd/m2**	
Variable	**coeff**	**p-value**	**Coeff**	**p-value**	**coeff**	**p-value**	**Coeff**	**p-value**
nd_ratio_one	0.67	0.00	0.48	0.00	0.49	0.00	0.48	0.00
number_lanes	-0.33	0.10	-0.09	0.63	-0.01	0.96	-0.18	0.35
intersections	1.65	0.00	2.69	0.00	2.90	0.00	2.57	0.00
shoulder_width	-0.21	0.00	-0.29	0.00	-0.28	0.00	-0.28	0.00
lnaadt_night	0.50	0.00	0.48	0.00	0.52	0.00	0.49	0.00
speed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
radius	0.00	0.00	0.00	0.05	0.00	0.04	0.00	0.02
DUMMY Var	**1.14**	0.00	**-2.08**	0.00	-3.85	0.00	-699.79	Not converge
effect	*negative*	*significant*	*positive*	*significant*	*positive*	*80% CI*	*positive*	*insignificant*
No. of Obs.	450		121		74		67	

Note: * denotes the recommended minimum level of luminance

Conclusions

Luminance for highways in Quebec should be increased to at least 1.5cd/m2. Variation of illuminance-based uniformity (average to minimum) showed that more consistent lighting is beneficial. Non-illuminated roads are preferable than those with significant variations of light on the surface of the road (illuminance uniformity variation). From the perspective of uniformity of luminance the design can tolerate up to 8 times between the brightest and darkest spots. Variations larger than 8 times should be avoided as they will likely result in negative effects from a safety perspective and could represent the fact that one is now under the presence of some degree of glare.

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Effect of Computer-based Cognitive Training on indicators of unsafe driving in older adults: study design

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Abstract

There is insufficient knowledge on effective methods to increase older driver skill. A major contributor to driving safety in older populations is the effect of age-related brain changes on driving skills. These brain changes affect a driver's ability to attend to multiple events, make decisions, and rapidly respond to hazards. A critical question is whether training can reduce the underlying age-related changes that impact on driving. Here, we design an intervention to investigate whether computer-based training of attention and speed will translate to other tests known to predict unsafe driving in older adults.

Background

Previous work that has looked at cognitive training (or 'brain training') in relation to driving, has focused on training the ability to rapidly perceive multiple objects in one's visual field known as "Speed of Processing Training" (SOPT) (Ball et al. 2013). Training on SOPT can improve performance on a variety of similar tasks (Rebok et al. 2013; Wolinsky et al. 2013), and reduce self-restriction of driving frequency (Ross et al. 2015), however, its effect on either on-road driving performance (Roenker et al. 2003), or simulated driving performance (Cassavaugh and Kramer 2014) has been mixed. A range of cognitive and sensory tests have been developed that are shown to predict unsafe driving in older adults, and are commonly used by clinicians when determining an older drivers' risk (e.g., Ball et al. 2013; Horswill et al. 2008; Wood et al. 2008). Our previous research has also led to the development of a screening battery called the Multi-D, which measures cognitive control of fast reactions, motion perception, and postural stability and is strongly associated with older driver risk (Wood et al. 2008). While it is unclear what specific cognitive functions relate to driving difficulties in older adults, a large body of neuroscience data indicates that normal ageing of the brain primarily impacts frontal networks that subserve a set of skills called 'executive functions'(Buckner 2004; DeCarli et al. 2012; Hedden and Gabrieli 2004). If SOPT training improves underlying attention, speed and executive functions in older adults, then these improvements may also be seen in older driver screening tests that tap into these areas.

Aim

We will test whether cognitive training will lead to improved performance on off-road measures associated with driving safety when compared with a matched wait-list control group.

Method

Fifty older drivers (aged ≥65 yrs) will be recruited from the community and be assessed on a range of older driver screening tests: the Trail Making Test B, UFOV, Multi-D, Hazard Perception Test. They will then be given access to a commercial online SOPT training program to be undertaken at home. Participants will complete a log-book of training hours and training levels with the aim of completing 2 hours of training per week for 5 weeks (or a total of 10 hours). A researcher will monitor each participant's training through weekly phone calls. At the end of the training period, all participants will be re-assessed on the older driver screening tests. A control group with participants matched in age, gender and test-retest interval will undergo the same protocol but will not engage in any brain training.

Results

Proximal effects of SOPT training will be assessed by comparing the change in UFOV scores between the control and intervention groups. Distal effects and translation of training will be examined by comparing change in each of the older driver screening tests between the control and intervention groups.

Conclusion

If SOPT training leads to distal effects on non-trained off-road driver screening measures, it will justify its use in future trials as an intervention for improving on-road performance, and whether it can be combined with tailored driver refresher courses to enhance older driver safety and maintain mobility for longer.

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Cost-Effectiveness Of Interventions To Prevent Road Traffic Injuries In Low-And Middle-Income Countries: A Systematic Review

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Abstract

In Low- and Middle-Income Countries (LMICs), cost-effective road safety interventions can save not only lives of vulnerable road users but also save costs to society. The objective of this systematic review was to identify, critically appraise, summarise and synthesise cost-effectiveness evidence of road traffic interventions in LMICs by age group and road users targeted. Thirteen databases were searched between May 2002 and August 2015. The cost-effectiveness of interventions ranged from US$4.14 per DALYs averted for building speed bumps to US$3,403 per DALYs averted for legislation and enforcement of motorcycle helmet use in the sub-Saharan Africa region.

Background

In Low- and Middle-Income Countries (LMICs), an important step in Road Traffic Injuries (RTIs) prevention is to develop and evaluate interventions that work best regarding cost and benefits because cost-effective interventions can save not only lives from RTIs but save costs to society as well (Peden et al., 2004). Considering the huge burden of RTIs in LMICs (WHO, 2015), growth in the implementation of effective interventions (Brown, 2007; de Andrade, Soares, Matsuo, Barrancos Liberatti, & Hiromi Iwakura, 2008; Law, Umar, Zulkaurnain, & Kulanthayan, 2005; Soori, Royanian, Zali, & Movahedinejad, 2009; WHO 2015), evidence of translating effective interventions from high-income countries to LMICs (Esperato, Bishai, & Hyder, 2012; Stevenson et al., 2008), and the absence of evidence on the cost-effectiveness of studies in LMICs as stated by Waters, Hyder, & Phillips (2004) there is a need to review the literature in order to identify the evidence on the cost-effectiveness of interventions to prevent RTIs in the context of LMICs.

Method

MEDLINE, EMBASE, CINAHL Plus, PsycINFO, the Cochrane Central Register of Controlled Trials, the Cochrane Injuries Group's Specialised Register, EconLit, Index Medicus for the South-East Asia Region, World Health Organisation Library Information System, OpenGrey, African Index Medicus, and Index Medicus for the Eastern Mediterranean Region were searched between May 2002 and August 2015 using specifically designed search filters. An English language restriction was applied. Additional studies were identified by contacting authors, searching reference lists of included studies, and grey literature by using Google Scholar. The terms that state the overall strength of the evidence regarding quality, quantity and consistency (i.e. no evidence, weak evidence, moderate evidence, strong evidence, and inconsistent evidence) were adapted from the recent National Institute for Health and Care Excellence (NICE) public health guidance (NICE, 2012).

Results

Out of 1,504 studies, five studies were included in the final review that reported nine interventions. Only two out of nine interventions (drink-drive legislation with enforcement via breath testing campaign, and combined interventions for reducing RTIs) showed a moderate evidence of being cost-effective while the evidence regarding other interventions was weak. Similarly, only two interventions (bicycle and motorcycle helmet use legislation and enforcement) were explicitly targeted to children, young people and vulnerable road users. The cost-effectiveness of interventions ranged from US$4.14 per DALYs averted for building speed bumps at junctions that causes 10% of junction deaths to US$3,403 per DALYs averted for legislation and enforcement of helmet use by motorcyclists in the WHO sub-Saharan Africa region.

Conclusions

There are currently few studies reporting the cost effectiveness of interventions in LMICs to prevent RTIs, particularly for children, young people and vulnerable road users. Further research to build upon this emerging evidence base should include robust methods, with outcomes that measure the impact on children, young people and vulnerable road users. The ability to demonstrate effectiveness and cost-effectiveness would be facilitated by the development of systems to routinely record road traffic incidents and injuries in these countries.

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Undertaking a Safe System Audit

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Abstract

Before the release of the *Austroads Safe System Assessment Framework*, Safe System Solutions Pty Ltd developed a methodology and template to advance road safety praxis by undertaking Safe System Audits.

This paper outlines the principles of Safe System Auditing and uses as a case study - the Safe System Audit for the ACT Government in relation to on-road intersection activities such as windscreen washing, entertaining, collecting, selling and advertising.

The outcomes of the audit were a set of fifteen recommendations grouped into categories; safer road and roadside treatments, for safer vehicles, for safer road users, and for safer speeds.

Background

Safe System principles are an accepted part of road safety strategies. The underpinnings are that fallible humans will inevitably make mistakes when driving, riding, or walking. Nevertheless, road trauma is not inevitable. No one should be killed or seriously injured on our roads. Consequently, to prevent serious trauma, the whole road system must be forgiving, so that collision forces do not exceed limits that the human body can tolerate.

At the tactical level, there is considerable guidance available on the conduct of Road Safety Audits.

Before the release of *Austroads Research Report AP-R509-16 - Safe System Assessment Framework* Safe System Solutions Pty Ltd, a Victorian based road safety consultancy, has developed a methodology and template to advance road safety praxis by undertaking Safe System Audits.

Method

A Safe System Audit examines the four components of the Safe System shown in Figure 1 within a formal safety examination of a road-related program, project, initiative or activity. The Safe System Audit comprehensively assesses the safety of one or more of an existing road, intersection or length; a road investment project; a community road safety program; a roadside or on-road activity; a road transport policy or strategy.

Figure 1. Diagrammatic representation of the components of the Safe System

The audit then categorises identified speeds (Liu et al., 2012; Quimby et al., 1999) road and roadside treatments (Candappa et al., 2008; Moon and Mihailidis, 2013), vehicles and road user (Wierwille et al. 2002) features as:

1. **Primary treatments**: Safe System compliant treatments or features;
2. **Step Towards Safe System compliant** treatments or features;
3. **Safe System supporting** treatments or features; or
4. **Non-Safe System compliant** treatments or features.

The Safe System Audit provides advice on how to raise all road and roadside features into the **primary treatments** category, and suggests measures to implement Safe System principles into the speeds, vehicles and road user categories.

Results

As a case study of a Safe System Audit we will use, as an example, the Safe System Audit for the ACT Government undertaken by Safe System Solutions Pty Ltd in relation to on-road intersection activities such as windscreen washing, entertaining, collecting, selling and advertising.

The Auditors assessed the on-road intersection activities as having poor alignment with Safe System principles. The major reason for this poor alignment is the presence of a vulnerable road user in an environment where, if struck, the forces exceed that tolerable by the human body. Identified issues included the potential for high energy crashes between:

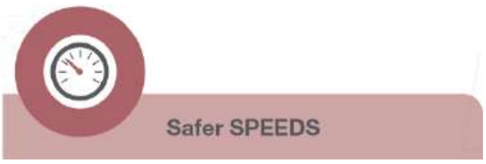
- windscreen washers and cars
- windscreen washers and motorcycles
- windscreen washers and commercial vehicles
- vehicle-to-vehicle crashes

The Auditors acknowledged that road authorities have competing demands, and thus provided a variety of recommendations.

Conclusions

The major recommendation in each category are:

1. Raised intersections or raised safety platforms



1. Raised intersections or raised safety platforms with advisory speed limits

5. Enforce existing restrictions on illegal movements/activities.

15. Ensure compatibility between permitted activities and deployed Autonomous Vehicle systems.

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Engagement of Older Drivers, Families and GP to investigate the safety and mobility needs of an ageing population

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Abstract

Most older people travel by private car and continuing to drive is key to mobility, independence and quality of life. Giving up driving can have serious consequences for their health and well-being. It is also important, however, that older drivers and other road users remain as safe as possible. While older drivers have relatively few crashes, due to frailty they have a high crash fatality rate. The 'Older Driver, Family and GP study' is a multi-faceted approach to address the needs of an ageing population, balancing safety and mobility. This presentation will outline the study rationale, methods, and policy impact.

Research Summary

The maturation of the "baby boom" population, combined with longevity and declining birth rates, is predicted to markedly transform the developed world's demographics [1]. By 2036, it is projected that one in four NZers will be aged 65 years or older. Over this time it is estimated that road related fatalities and injuries among this age group will increase by 71% due to the combination of an ageing population, growth in road traffic, and growth in the number of workers over 65 years [2].

Transport in NZ is largely achieved through private car travel, and driving remains fundamentally important to today's society. It is predicted that driving is likely to remain the main transport option for older NZers, with public transport being used for less than 5% of their trips [3]. This reliance on private vehicle travel is an important safety and health issue for older people, and in many ways is influential in determining their quality of life.

A critical issue for older drivers is the balance between their need for independent mobility, while maintaining their safety, and the safety of other road users. Older drivers have relatively few crashes, but when distance travelled and frailty are factored in they have high rates of serious injury and fatality. This particularly affects those aged 75+, who have the highest crash fatality rate per distance travelled of any age group, except 15-19 year old males [4].

Another critical issue for older drivers is their transition out of licensure and adjustment to life post driving cessation. Ceasing to drive, and the associated loss of independent mobility, can have very serious consequences for older people, including depression, poorer physical functioning and performance, general health decline, social isolation, and early death [5].

Alongside older adults, families have an important role in the driving cessation process and older driver safety is often a difficult issue for both parties. GPs also have an important role in older driver safety. Since 2006, licence renewal in NZ is required at age 75 and involves obtaining a medical certificate from a GP regarding fitness-to-drive. This requirement has placed a greater emphasis on the medical certificate and GPs consultations with their older patients regarding driving issues. It also places greater emphasis on GPs to diagnose medical conditions that may affect the person's ability to drive safely. These legislative changes mean that GPs are key to making decisions about fitness-to-drive and are a pivotal resource for understanding the mobility and safety issues at stake for older drivers.

The Older Driver, Family and GP study will use a mixed methods design to better understand travel patterns, driving behaviours, and fitness-to-drive issues. The findings will help develop evidence-based policy and programmes to address mobility and safety, to 1) maintain independence through driving for as long as safely possible; and 2) identify assistance needed by support networks to manage driving cessation and minimise negative consequences.

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Motivations during the learning to drive process - Case studies of NSW learners and their parents

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Abstract

A comprehensive range of resources are provided to learner drivers and their supervising drivers in NSW. We are examining learners and their parents during the period of learner licensure to assess reasons for the use or non-use of these resources. Semi-structured interviews of learner drivers and their supervisors are being undertaken. Documentary records of driving activity are being examined through the learner driver log book and data from the Licence Ready app, an application developed for smartphones and tablets which provides a digital record of the parameters required for learner driver log books in New South Wales.

Background

In NSW, learner drivers and their parents are provided with resources to assist the learning to drive process, including a comprehensive road users' handbook (NSW Roads & Maritime Services (2015), the learner driver log book (NSW Roads & Maritime Services (2013), a variety of web-based and paper-based resources including information about gaining a drivers licence and preparing for the driving test, and several augmentation programs for learner drivers (Keys2Drive, structured lesson planning, and the Safer Drivers course).

The learner driver log book provides a mechanism for learner drivers to record and keep track of their driving experience (Faulks & Irwin, 2009). There is a regulatory requirement for learner drivers to acheive a minimum of 120 hours of driving practice, although discounts are available through structured lesson planning and the Safer Drivers course. The log book also provides advice of the teaching process for learning to drive, and specifies twenty learning goals based on the GADGET matrix (Hatakka, Keskinen, Hernetoski, Gregersen & Glad, 2003). These goals serve as a guide for both the learner driver and the supervising driver (typically a parent) to enable the structuring of what is being taught, the selection of driving environments to use, and the sequencing of differing types of driving experience during the period of learner licensing (Faulks, 2012; Faulks, Irwin & Morphett, 2010).

It is unclear how well these resources are being used by learner drivers and their supervising drivers (Bates, Watson & King, 2009; Bates, Watson & King, 2014). Our research is designed to provide a detailed, fine-grained assessment of the use or non-use of the resources for learner drivers, and to identify the reasons why learners and their parents to use or ignore the guidance these resources are intended to provide.

Method

Learner drivers from the western and northern suburbs of Sydney who are seeking the assistance of a driving instructor are being recruited. The relationship with the driving instructor follows typical commercial principles. Once agreement to participate has been obtained from the learners and their supervising drivers, the Licence Ready app is provided. This application for smartphones and tablets enables the integration of training, practice and instruction for learner drivers within the framework provided by the learner driver log book. Specifically, the Licence Ready app provides a digital record of the parameters needed to meet the regulatory requirements for recording driving practice in the learner driver log book. The app combines lesson planning, experience-appropriate driving practice, and route selection for learner drivers throughout their period of supervised driving.

Periodically, each learner driver and their supervising driver will be contacted and a semi-structured interview regarding driving practice experiences and expectations is conducted. The use of the log book, the Licence Ready app, and other resources will be assessed. Where relevant, interviews will also be conducted with the driving instructor(s) working with the learner driver.

The study will continue throughout the period of learner licensure for each individual, expected to be for up to three years. It is anticipated that up to thirty learner drivers will be recruited over the period 2015-2018.

Results and Conclusions

Preliminary results for learner drivers who were first licensed in 2015 indicate that there are major shortcomings in the use of the available resources. The focus is on recording driver experience in the log book (the 'hours'). For learner drivers and their supervisors, the use of the guidance for teaching provided in the log book, as well as the systematic structuring of practice driving to reflect the goals for learning, appears to be limited. Interviews with learner drivers have indicated that they have read the learning goals, but their supervising drivers have not, and consideration of the learning goals does not take place before an episode of driving practice. Similarly, use of the Licence Ready app is limited. In contrast, interactions with driving instructors are focused on learning goals: gaining car control skills initially, and then on achieving hours of experience under structured lesson planning; this scheme provides a discount of up to 30 hours on the 120 hour requirement for completion of learner licensure if ten hours of practice under driving instruction are undertaken and learning goals are specified (Faulks et al., 2010).

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Interventions to enhance driving skills in older adults: design of a randomized controlled trial of efficacy

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Abstract

Recent statistics from the National Road Safety Review suggests that with the increasing population of older road users crash rates are also rising, whereas these rates are declining for younger drivers. This is likely due to intensive investment in driver education targeting youth driving issues, with comparative lack of knowledge on effective methods to maintain older driver skills. We designed a randomized controlled trial (RCT) to investigate the efficacy of individually tailored refresher lessons against a group-based refresher course, on on-road driving performance and safety in older adults.

Background

Current road safety strategies for older drivers include mandatory testing, license restriction or removal. License review based on a single test is often unfair and inaccurate, as a proportion of these drivers fail due to increased anxiety and poor performance on the day. There is no clear evidence that mandatory testing lowers crash rates amongst older drivers (Dugan et al. 2013), and driving cessation in older adults is associated with increased rates of depression (Windsor et al. 2007), social isolation (Marottoli et al. 2000), and general health decline (Edwards et al. 2009). A number of different approaches to improve older driver safety have been trialed with varying success. These include: (1) self-screening and self-awareness interventions (Ackerman et al. 2010), (2) class-room based driver education sessions (Jones et al. 2012), and (3) On-road 'behind the wheel' training (Bedard et al. 2008; Marottoli et al. 2007). Of these, only on-road training has been shown to improve on-road driving performance. Most trials have only examined changes over a few weeks, so it is not clear whether tailored on-road interventions result in long-term improvement in driver safety, and under naturalistic conditions.

Aim

To test whether a program of classroom based driver education along with tailored driving lessons will improve older drivers' (1) on-road test performance, and (2) driving performance under naturalistic conditions, when compared to a control group that receives only classroom based driver education.

Method

Sixty drivers aged 65 years and above will be recruited from the community, who are fully licensed, not planning to cease driving, and have not undertaken driver education in the past 6 months. The study will use a two arm stratified (gender: male/female, age: 65-75 years, 76-100 years) parallel-groups design, with balanced random allocation ratio of 1:1 into the intervention and control groups.

Participants will be assessed at baseline for cognitive and sensory function, on-road driving skills, and collect naturalistic driving footage over two-weeks using a DashCam installed in their own car. They will then attend a 2-hour Road Rules refresher course. This constitutes the only intervention for the control group. The Road Rules session is conducted by a qualified driving instructor and include information on the effects of ageing on driver safety, and an update on road rules. Following randomisation, the Tailored Lessons group will receive two one hour lessons with a qualified driving instructor. Following intervention, all participants will have a cognitive and sensory assessment, two-week naturalistic driving footage, and on-road test. Participants will then provide monthly reports on driving incidents for 6 months after the intervention.

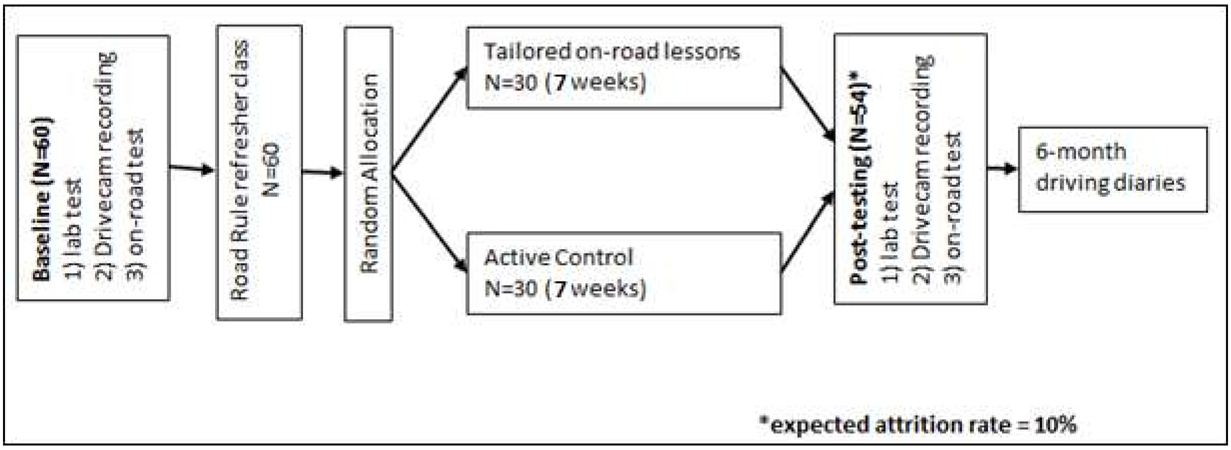

Figure 1. Trial Design Flow Chart.

Results

An occupational therapist (OT) blind to allocation will score all on-road tests and naturalistic footage using a standardised scoring method. Intention to treat analyses will compare changes in on-road scores, DashCam scores and incidents over 6-months for the two groups

Conclusions

The findings will demonstrate the efficacy of tailored lessons over a group refresher course, and whether effects translate to everyday driving and safety over a 6 month period.

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Validation of a virtual driver assessment tool for older drivers

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Abstract

Few studies have developed and validated a driving simulator for use with older drivers. As the population ages and demand for maintaining mobility in late-life increases, so will demand for efficient, safe and cost-effective methods of assessment and training that is suitable for older drivers. We compared simulator-based driving in older drivers against on-road driving with matching route and scoring procedure. We found that errors on the simulator predicted general driving safety. This has implications for the use of simulator technology for identifying at-risk older drivers.

Background

Road safety is an ongoing public concern and recent data indicate a need for further research into injury prevention focusing on the growing population of older drivers (e.g., Betz et al, 2014). Driving simulators provide a safe, economic and repeatable measure for determining safety in at-risk drivers. However, few studies have examined the acceptability and validity of simulator-based assessment in older drivers (e.g., Lee et al, 2003). Most validation studies also tend not to match their simulator measure with their on-road criterion in terms of driving environment and scoring method (Mullen et al., 2011). Furthermore, existing virtual set-ups are costly and require technical expertise – reducing their potential for translation and clinical utility.

Aim

Here, we develop a cost-effective, desktop virtual driving assessment for older adults, and validate it against an on-road assessment using matching environment, route and scoring methodology.

Method

Sixty-three drivers (mean age=75.6 (5.87) years) recruited from the community, were screened for motion sickness susceptibility before completing a simulated driving session. The simulator test comprised four instructor-guided and one self-navigation scenario. Standard scoring criteria were used by the experimenter to identify errors in observation, indication, brake/acceleration, lane position, gap selection and approach. Participants also underwent an on-road assessment with a driver-trained Occupational Therapist (OT) using the same standard criteria for scoring errors as used in the simulator test. The OT rated errors for each section of the on-road route that matched the simulated scenarios, as well as general safety (1(unsafe) to 10(safe)) based on the participants' driving performance over the whole 45-minute route.

Results

Fifty-four of 63 volunteers were screened eligible (85% of volunteers), and seven (13%) withdrew due to simulator sickness. Data from the remaining 47 were analysed. Bivariate correlation indicated that the simulator errors were moderately correlated with OT rated on-road safety: r = -0.398 (95%CI:-0.212 to -0.592), $p<0.01$. Regression analysis indicated that the relationship remained after adjustment for simulator sickness and age (B= -0.063 (SE=0.02), $p<0.01$). Simulator errors also predicted pass/fail on the on-road test - classifying on-road fails with a sensitivity of 69.2% and specificity of 100%.

Discussion and Conclusion

The findings show that around 74% of older adults can tolerate a short simulator-based driving assessment. The simulator set-up is low cost and easy to score, and is a valid predictor of overall driving safety. Further analysis will determine whether the error rate and type of errors made on-road corresponds to those on the simulator. The findings suggest that, for those able to tolerate the simulator, this type of set-up may be useful as an older driver screening tool.

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Promoting Safer Road User Behaviour in a Community Setting More "Bang for our Road Safety Buck"

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Abstract

Educating road users of all ages, experience levels and backgrounds in safer road behavior is crucial in changing attitudes to road safety and to other road users. We are all pedestrians at some point in our journey with many of us also being drivers, riders or motorcyclists. At a community level, there is huge capacity to engage with our local community to encourage improved understanding and compliance of the road rules as well as tolerance of other road users.

Background and Observations

Willoughby City Council has recently introduced several road safety education workshops aimed at improving road user knowledge, understanding and compliance when out and about.

Two of these workshops target drivers. "Drive Safer – Drive Longer" is for senior drivers while "You're the Driver!" is for the general driving population from L platers to experienced drivers. The "You're the Driver" workshop has also been popular with those from other countries who have been driving in Australia but need a refresher, and with learner driver supervisors who require some reassurance that they understand the road rules before teaching their learner driver.

In addition a pedestrian safety workshop, Street Savvy Seniors has been developed and presented in conjunction with NSW Police to target safety as a pedestrian, passenger and public transport user.

Benefits of a workshop setting

Willoughby Council runs public education campaigns across various road safety topics. Whilst there is a need for broad awareness campaigns through media channels there is still an appetite in our local community for face to face workshop style sessions. One benefit of these has been the ability to interact with participants and to answer questions or counter misconceptions. The "Little-Bit-Over" myth related to low level speeding is a good example. Being able to address misconceptions directly makes it more likely that information will be accepted and taken on board. A bonus has been information reportedly passed on to family and friends by participants.

Another benefit of workshop style session has been the opportunity for participants to raise questions. These can either be covered as part of the existing presentation or included ad-lib as the presentation progresses.

Costs and benefits of workshop based delivery over media based delivery

Whilst quantifying the actual behavior changes of a cohort of participants is not viable in the setting in which I operate, the reported learning from participants gives clear indications that behavior change is likely. The costs of holding and running a two session workshop, including advertising the event in the local newspaper, room hire and catering, totals in the order of $900 and reaches up to 25 participants at a time. Each workshop cover a wide variety of road safety topics such as road rules, fatigue, effects of drugs and alcohol on driving, mobile phone use etc.

By comparison, measuring behavior change from a media based campaign is almost impossible. Current methodologies include surveys of how many people recognize the ad/poster, what their understanding of it was and whether they self-report any changes in behavior. In addition the costs associated of a media campaign are high. Graphic design plus the actual advertising costs can easily reach $10000 or much more. The major benefit of media based campaigns is the potential to reach a large number of people however they can only target one issue.

Conclusion

Whilst developing and holding workshops is time-consuming, the benefit in understanding and behavior modification to those road users is well worth the time and commitment.

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This discussion is based on anecdotal evidence and comments received as part of the feedback process folowing each workshop.

Why is there an elephant in the Wheatbelt?

Will Golsby

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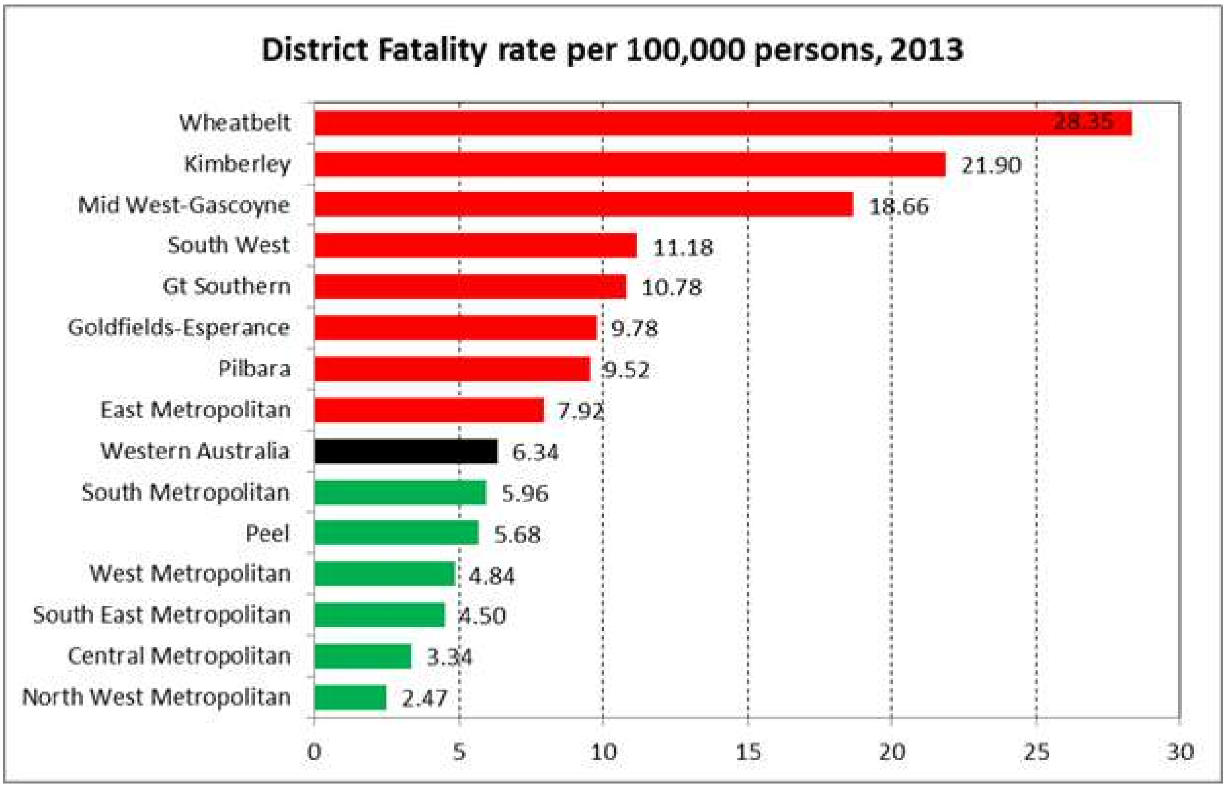
Abstract

The Wheatbelt region in Western Australia has consistently had the highest fatality rate of WA regions. Following an analysis of the characteristics of Wheatbelt fatalities, the Royal Automobile Club of WA (RAC) undertook a novel community awareness and engagement strategy to highlight the issue as the first element. The second stage of the campaign -#ItsMyElephant – launched in April 2016, with the premise that every person in every community can help to improve road safety in the Wheatbelt.

Background

In 2012, the joint RAC - WA Police publication "*Fatal and Serious Injuries of WA Roads*" highlighted the over-representation of fatalities in the Wheatbelt. The Wheatbelt Police District's fatality rate was six times the WA fatality rate and four times the fatality rate in both the nearby South West and Great Southern Police Districts.



The over-representation prompted an analysis of six years of crash data from 2007-2012, comparing what characteristics of fatal crashes are different between Wheatbelt, near neighbours and the whole state. The analysis demonstrated there is no single factor that dramatically differentiates Wheatbelt from its neighbours, although it displayed a number of characteristics which are higher than neighbouring district aggregations; eg Wheatbelt is characterised by high rates of single vehicle, driver only crashes with a relatively high proportion of alcohol and speed related crashes. Wheatbelt fatal crashes are typically on local roads involving local drivers.

Community Attitude Survey

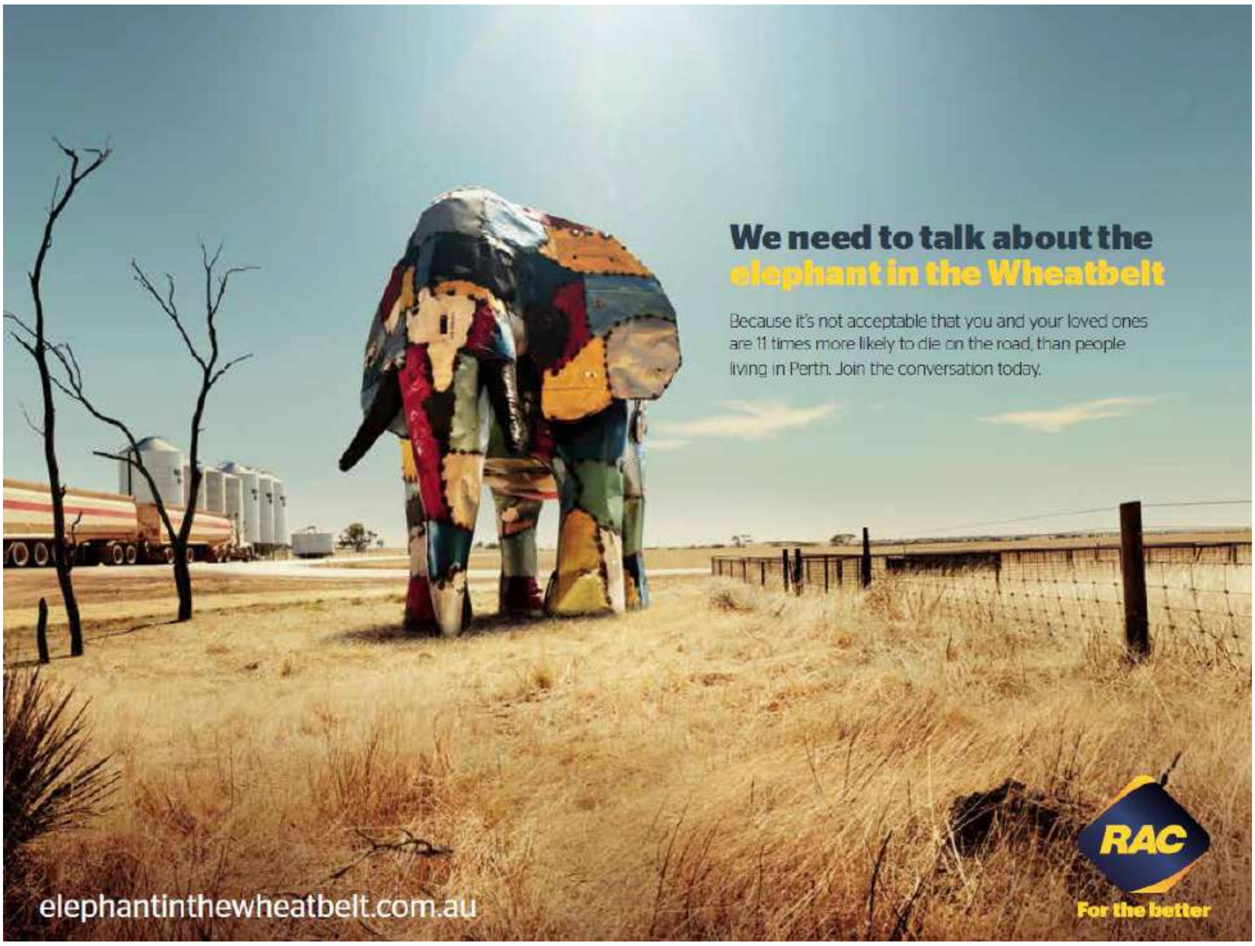
There is limited information on whether community attitudes in the Wheatbelt are different from other regions, why that might be the case, and furthermore, if those attitudes contribute to the higher fatality rate. The hypothesis was if this was true; that features of Wheatbelt life, such as learning to drive on a farm without a seatbelt plus specific beliefs, misconceptions and attitudes all contribute.

In 2014, an online interviewing approach was used and surveyed 1350 respondents from Wheatbelt region, metropolitan region and other regional areas across Western Australia on their attitudes towards road safety, current road behaviours, knowledge regarding penalties and what 'myths' existed (eg the major problem is city-based drivers who don't know how to drive on country roads).

The results showed that road users in the Wheatbelt were not vastly differentiated from other Regional or Metropolitan drivers in terms of their attitudes and reflected social expectations. The disconnect lie in the translation of desirable attitudes into desirable behaviours.

The Elephant in the Wheatbelt Campaign.

The campaign was conceptually developed around the elephant in the room and used a three metre high, four metre long elephant constructed from wrecked cars as the symbol to motivate community awareness and discussion on road safety. The campaign undertook a tour from April – October 2015 to break the silence about road trauma and bust the myths about road safety.



A second survey targeting the Wheatbelt region was conducted in September 2015 and included campaign evaluation questions. A total of 454 interviews were achieved. Overall the campaign had a high awareness and strongly addressed the initial objective of 'getting people talking about road safety' in the Wheatbelt. More than half (54%) spoke to friends/family about road safety, 73% reported to have thought about their behaviour and 40% reported to have changed their driving behaviour as a result of the campaign.

Driver attitudes remained relatively consistent to those seen in 2014. The effects of the campaign are yet to be filtered through into significantly changing driver behaviour, although in many cases, driver attitudes are more positive among those who have seen the campaign indicating a positive influence.

References

The data used in this analysis is sourced from the joint RAC-WA Police publication "Fatal and Serious Injuries on WA roads, 2012" and includes fatal and serious injuries due to road crashes between January 1, 2007, and December 31, 2012. The data is collected by the Attending Officer at the scene and remains subject to change.

Tracking road vehicles in heterogenous vs homogenous colour sets

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Abstract

In order to avoid collisions when driving, it is often necessary to keep track of the positions of multiple moving objects at once. For example, in a highway driving scenario, drivers need to keep track of multiple vehicles in order to safely perform manuvers such as overtaking and merging. The current work extends our basic research on Multiple Vehicle Tracking, to investigate how drivers' ability to attend to multiple moving points in a simulated driving task varies with the composition of the vehicle search set. We demonstrate clearly that tracking set heterogeneity positively affects task performance.

Background

In the basic research on attention, there is an experimental task called multiple-object tracking that measures the ability to keep track positions of multiple moving items at once. Laboratory research into multiple object tracking suggests that young adults can typically track 3-5 items simultaneously, though there are some individual differences. These differences may explain why some drivers are more at risk of collisions than others when required to monitor the positions of multiple moving objects at once, (for example, in elderly or young drivers). Although object tracking has been studied for over 25 years in the experimental literature, there is very little research on the topic in the driving literature. This is possibly because the conditions in the classic laboratory tracking task are very different than those on the road

In this study we follow up our previous work on vehicle tracking (Lochner & Trick, 2014), by investigating how the composition of the target and distractor vehicle set impact tracking performance.

Method

48 Undergraduate students were tested in a Drivesafety DS600-C fixed–base driving simulator. The simulator body was made up a full-body Saturn sedan surrounded by viewing screens (5 screens in front and one in the back) on which a 300 -degree wrap-around virtual driving environment was projected (250 in the front and 50 degrees in the back, respectively). The simulator display operated at 256 colours and operated at 60 Hz. A standard 3-lane freeway style roadway simulation, with no turns, was modified such that the target and distractor vehicles appeared in front of the participant vehicle.

The participant viewed displays in which there were always 8 vehicles. These vehicles were either a homogenous set (i.e., all the same colour), a heterogeneous set (every vehicle had a different colour), or a set in which each target was paird with a distractor of the same colour, when there were four different colours (e.g. red, blue, green and yellow) in replication of the "Paired-4" condition in . Vehicle colours were distributed randomly across all vehicles at the start of each trial, and there were a total of 6 unique colour sets: 2 for each condition. Two possible versions of each condition (so, 2 versions of the homogenous, 2 versions of the heterogenous, and 2 versions of the "paired-4") were available to be presented during the experiment.

Results

Overall tracking accuracy was 80%.

A 3 x 2 x 2 mixed ANOVA was performed. The between-subjects factor Articulatory Suppression was non-significant, $F(1, 47)=2.239$, $p=.141$, $\eta 2= .046$, and as such the conditions were combined. The effect of Tracking Set Composition was significant at $F(2,94)=9.019$, $p<.001$, $\eta 2= .161$, indicating that, as expected, tracking accuracy was higher in the Heterogenous condition, as compared with the Homogenous and Paired-4 conditions. Likewise, the predicted effect of Task Load was significant at $F(1,47)=16.061$, $p<.001$, $\eta 2= .255$, indicating that tracking accuracy was poorer when the participant was required to operate the vehicle. Finally there was a Tracking Set Composition X Task Load interaction, consistent with the prediction, significant at $F(2,94) = 4.142$, $p < .05$, $\eta 2= .081$, indicating that the effects of the Tracking Set Composition differed across levels of the Task Load manipulation

Conclusions

We have shown that, as predicted, the composition of the tracking set does influence the ability of a participant to track multiple vehicles in a simulated roadway environment. Specifically, when the tracking set is made up of a heterogenous selection of colours, tracking accuracy was higher than when the tracking set was either all one colour (Homogenous), or when there was one target and one distrator in each colour (Paired-4). This is interesting because it indicates that, at least in terms of the composition of the stimuli, the classical multiple object tracking task may fail to take into account an important aspect of tracking objects in a realistic environment – namely that such heterogeneity often exists in naturalistic environments, and can be used to benefit performance.

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Agility, Innovation and Impact: Pedestrian Safety Walkway Intervention in Kajang, Malaysia

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Abstract

Child pedestrian as a vulnerable group around the school area needs intervention to address their problem as their risk is high for sharing the roadway with vehicles. The problem here was high traffic volume with speed enough to be dangerous for children whom are exposed in open. Thus to reduce the child pedestrian risk on road, a pedestrian safety walkway intervention was mooted and grant proposals were bided and successfully obtained from donors. This resulted in the birth of a Pedestrian Safety Walkway with the aim of segregating the pedestrian from the vehicles whom are using the same roadway.

Background

Child injuries are a growing global public health problem that requires urgent attention. At least a million children under the age of 18 years die from injury and violence (Peden M et al, 2004). The burden of injury to children decreases significantly in developed countries as compared to developing countries. Malaysia is also of no exception to this global child problem. Malaysian population were 30,073,353 and vehicle population stands at 25,101,192 for the year 2014. This resulted in 476,196 reported road crashes with 6,674 road deaths. Of these road death figures 23.9% (1,598) involved population below age 20 years (mostly school going children) and 7.7%% (515) are pedestrian (Royal Malaysia Police, 2015). The 2nd Global United Nation Road Safety Week launched in 2013 with the theme on pedestrian safety gave birth to the innovation of idea to address the problem diagnosed among school children whom are travelling to school as a pedestrian. The innovation was to segregate the child pedestrian from other vehicle users whom are sharing the same roadway. The agility of building a Pedestrian Safety Walkway helped to eliminate the hazards faced by the school children on the road when interacting with vehicles. This resulted in the impact of reductions in hazards for children on the road around the school and reduced the risk of road crash involvement as a pedestrian around the school.

Methods

A pedestrian safety intervention was initiated to segregate the vulnerable road users (pedestrians) from the traffic by building a Covered Pedestrian Walkway (277 feet long x 7 feet width) for Kajang Tamil School which has a high student population of 1178 and the school located in the CBD of Kajang town with high traffic volume movement. Justification for choosing the location was State of Selangor has the highest number of road crash in the country and whiten the state of Selangor, the District of Hulu Langat is one of the districts with high number of road crashes in Selangor and Kajang is the biggest township within the Hulu Langat District. The busiest part of Kajang Township is the CBD area and there are many schools around here and Kajang Tamil School was chosen for its high student enrolment with two school sessions in a day. It is an initiative by Safe Kids Malaysia Universiti Putra Malaysia with funding from Industries (FedEx and Global Alliance of NGOs on Road Safety and Safe Kids Worldwide USA). This initiative bridged the industries and community. Industries came forward to assist the needs of the school community and Safe Kids Malaysia Universiti Putra Malaysia facilitated the process by connecting them. To sustain this safe practice on road, through the 3rd Global United Nation Road Safety Week in 2015 with the theme Child Safety, a road safety club was launched in the school to run road safety programs for the school children.

Results

The entire school community comprising of 1178 Children, 70 Teachers, 8 Staffs and 870 parents are using the pedestrian walkway which reduces their risk on road by removal of hazard. The way forward here is to make sure they use the walkway always for the benefits to be sustainable. This intervention has built a safe practice culture among this school community. The pedestrian safety walkway took some space of the roadway which resulted in reduction of space for motorway. This resulted in drop of vehicle speed which reduced pedestrian hazards on the road. There were no reported pedestrian crash around the school vicinity after the intervention came into place compared to before where there were reported road crash among school children around the school vicinity (near misses were not accounted for in this comparison). The follow-up initiative of opening up the school road safety club helped to sustain the good road safety practice in calculated. Through the school road safety club, education based activities were organised in the form of road safety talks, quizzes and exhibitions.

Figure 1. The Pedestrian Safety Walkway Intervention: Before and After

Conclusions

The transfer of road safety knowledge from Safe Kids Malaysia, Universiti Putra Malaysia were able to transform the school community towards safer pedestrian. The removal of the road hazards has helped to create a safe walking pathway for pedestrians whom are vulnerable on a mixed traffic road. The limitation of this study was we missed the opportunity to collect primary crash data before the intervention. We can only collect the post intervention and compare by time of all post intervention stage. Alternatively, we explore for secondary data of road crash involvement reported to school and school absenteeism due to road crash involvement before and after intervention.

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School Holiday Road Safety led by the Little Blue Dinosaur

Michelle McLaughlin

Little Blue Dinosaur Foundation Ltd.

Abstract

Our keystone campaign, "It's Holiday Time!" was launched following Tom's coronial inquest that highlighted the environment of Macmasters Beach as a contributing factor to the accident. It is prudent to remind the community of road safety during the 3-4 months of the year children are outside of school zones and often in public, recreational areas.

The campaign enhances safer 'holiday town' road environments through seasonal installation of strikingly colourful, road safety signage to appeal to drivers and pedestrians alike.

The signs target our three key audiences:

- Drivers: 'Slow Down, Kids Around'
- Parent/Carers **&** children: 'Hold my Hand'

Approach

Focusing on the beach hamlets of the Central Coast where Tom's accident occurred, the foundation was able to pilot their 'Holiday Time' campaign in the environment most comparable to that of Tom's accident. In doing so, we were able to collaborate with the local government, Gosford City Council, to create a seasonal campaign suited to the size, style and demands of the busy holiday-maker region.

Seasonal Installation

To increase the campaign's impact, the signage is installed seasonally; put in place during the last week of the school term and taken down as schools return. By only erecting the colourful signage during school holidays, it will ensure the public are not desensitized to its message, especially locals who frequently use these roads.

Campaign expansion

It has since been replicated in Newcastle, Lake Macquarie and Shoalhaven as well as Bemm River in Victoria.

The areas targeted are primarily coastal towns with:

- Aging or non existent infrastructure
- Aesthetically non-metropolitan looking streets (mainly beaches)
    - Lack of curb and guttering
    - Unsealed/unmarked roadways
    - Less frequent traffic lights and pedestrian crossings
- A tendency to attract large amounts of holidaymaking tourists (particularly families) during school holiday periods

Centring on the notion that road safety is a 365-day conversation, our campaign aims to encourage conversations between children and their parents about road safety during holidays while reminding the general community of this increased presence of children in the area.

Restraining a child is a key step in educating children of the dangers associated with roadways while addressing their limited cognitive abilities. Our 'Hold my Hand' signage is addressing children's risk taking behaviour due to their changing hormonal levels (Bjork et al., 2004; Steinberg, 2007; Steinberg et al, 2008) by reminding adult carers to hold hands with children in their care.

Statistical data from Destination NSW was used to see where people are spending their holidays and what activities they are conducting in these locations. For example, last year the Central Coast of NSW received 1.3million domestic overnight visitors, of which 45.8% identified 'Holiday' as their purpose of visit (Destination NSW 2015, para. 4). Likewise, The Hunter area accommodated 3.1million domestic overnight visitors and 41.6% identified 'Holiday' as their central purpose (Destination NSW 2015, para. 4).

Incorporating the media

Local media and radio assisted the campaign by spreading the key messages over their respective platforms. Raising awareness through visual, audio and print allowed more children, their parents/guardians, as well as the general public to be reached at low cost.

Results

While we do not have a direct measure of lives saved through the campaign by avoiding a fatality or severe injury, council has conducted a survey in Shoalhaven and speed detection technologies have been measuring speed reduction in Bemm River, with the results of both due shortly. The results thus far have been based on community response and feedback from the Local Council's where we operate.

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An investigation of bike speed on shared paths in Victoria

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Abstract

The high speed of a minority of bike riders on shared paths is an emerging road safety issue. VicRoads has a number of bike loop counters, most are on shared paths or bike paths. They record the speed of each passing cyclist.

This poster will provide an overview of a project that was run from December 2015 to February 2016 to investigate the issue of bike speed on shared paths and to determine countermeasures to address it. A key focus of the investigation was the interaction between bike riders and pedestrians, and creating a safe shared environment on shared paths.

Background

This *Monash Interdisciplinary Team Initiative* project was a practical project undertaken at VicRoads that involved two students doing an investigation into bike speeds on shared paths, and bike riders interaction with pedestrians.

Injury data related to shared path conflicts is sparse, neither Victoria Police reported crash data or hospital data provide specific data for shared path locations, yet evidence shows that bike speeds can be high and therefore pose a risk to slower bike riders or pedestrians. The investigation involved a number of methods and resulted in a comprehensive set of recommendations for VicRoads to consider.

Methodology

A number of different methods were used. A literature review was undertaken and the VicRoads bike loop counters set up on shared paths and bike paths were interrogated to determine bike speeds in specific locations. Observations were done on five shared path locations, these were determined due to their bike use and issues with fast speed cycling or proximity to a school. The observations focused on the interaction between pedestrians and cyclists, 131 bike/pedestrian interactions were observed. A small number of intercept surveys were undertaken on shared paths at the same five locations, 16 interviews were done in total, 13 with pedestrians and 3 with bike riders. In addition, 27 stakeholders contributed their thoughts either via e-mail, interview (by phone or in person), or attendance at a workshop; with a final workshop held to validate the recommendations that emerged.

Results

Results are available for each of the methodologies implemented. In terms of bike loop counters, looking at the 10 shared paths with the highest 85 percentile bike speeds, the speeds measured ranged from 29.9km/h to 32.78km/h. While the top 10 shared paths showing the highest maximum speeds, showed speeds ranging from 59.6km/h – 60km/h (note 60km/h was the upper limit extracted as so few cyclists exceeded that number).

Council stakeholders raised a number of issues on shared paths including bike speed, narrow path width, lack of bike forewarning of other path users, unpredictable pedestrians, distracted pedestrians, lack of stencils/signage. Other stakeholders reported a number of issues including bike speed, conflicts between users, lack of cyclist etiquette, low perceived pedestrian safety, and inadequate path infrastructure.

The observations revealed that 82% of cyclists did not give a warning to the pedestrian they were overtaking in the same direction. Also 62% of belled and 64% of not belled pedestrians took no action when approached by a bike rider (did not divert from their path of travel).

Conclusion

As a result of this investigation a number of recommendations were proposed to address high bike speeds on shared paths. These included a range of engineering recommendations; some education recommendations, an enforcement recommendation and some miscellaneous recommendations.

This presentation will provide an overview of the project undertaken and discuss some of its findings and recommendations.

Crash Risk Models For A Motorcycle - Dominated Traffic Environment

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Abstract

This paper presents a methodology to estimate the potentials of rear-end and sideswipe crashes for motorcycles moving in a motorcycle-dominated traffic environment on urban roads and examines their integration in the International Road Assessment Programme (iRAP) star rating system. The crash risk models developed are based on discrete choice models and traffic conflict techniques. The proposed methodology was validated using data collected on road segments from the city of Danang in Vietnam. The models' field validation shows that the proposed methodology produces a good estimate of rear-end and sideswipe crash risk for motorcyclists and the enhanced iRAP star rating methodology produces most satisfactory results. It was found that risk factors such as front distance, longitudinal gap, lateral gap, lateral clearance, speed difference, and operating speed have a significant contribution to motorcycle crash risk and therefore they should be considered in the selection of appropriate countermeasures aimed at improving motorcyclist safety.

Introduction

The motorcycle is the predominant mode of urban transport in a number of low-income and middle-income countries worldwide, particularly in most Southeast Asian cities due to its affordability and flexibility in terms of movement and parking. As a result, crashes resulting in deaths and serious injuries involving motorcycles in these countries are significant. In certain countries, motorcycles' crashes may reach about 70% of the total road crashes. For example, in the city of Danang in Vietnam, motorcycles constitute over 80% of total traffic and motorcycles' crashes account for nearly 70% of the total road crashes (DoT, 2013). Similarly, in Indonesia, the number of motorcycles reached 78.3% of the total vehicle population and 75% fatalities of traffic crashes involved motorcyclists (Amelia and Harnen, 2010). In Taiwan, the motorcycles' crashes were about 88% of the total traffic crashes in 2011 (Ming et al, 2013) and in Malaysia in 2009, accident statistic data revealed that the ratio of other road users to motorcyclist fatalities was 1:1.52 (MIROS, 2011).

In motorcycle-dominated traffic conditions, it is found that non-lane based movements of motorcycles are the major contributors to motorcycle crash risk (Minh, 2007; Amelia and Harnen, 2010; Long, 2012; Shiomi et al., 2013). In Danang of Vietnam for example, crash data revealed that "changing lanes improperly" and "failed to keep safe following gap" are two major causes of motorcycle crashes, accounting for 19.3%, 31.9% respectively (DoT, 2013). Those causations were also found to contribute to a large proportion of motorcycles' crashes in Taiwan (Ming et al., 2013).

Although the movement characteristics of motorcycles are found to be a significant factor contributing to motorcycle crashes, it seems that to date there are no models taking into account explicitly these risk factors. To this end and to examine the effect of such manoeuvre behaviour of motorcyclists on crash risk, this study develops models to estimate the potentials of both rear-end and sideswipe crashes between motorcycles in a motorcycle-dominated traffic environment.

Literature Review

Several researchers have examined the risk factors affecting the motorcycles' crash frequency in the traffic environment of low-income and middle-income countries by developing crash prediction models based on historical data and statistical methods. For example, Harnen et al. (2006) developed a model to estimate the frequency of motorcycle crashes at junctions of urban roads in Malaysia. They suggested that the flow of non-motorcycle on a major road, the approach speed of vehicles, the junction geometry, the junction control and the land use are significant factors contributing to the occurrence of motorcycle crashes at junctions. Amelia and Harnen (2010) built a probability model to predict the motorcycle crash occurrence for the city of Malang in Indonesia and they suggested that gender (i.e. male riders), the increase of motorcycle ownership, long travel distances and little riding knowledge are factors that have a significant impact on the occurrence of motorcycle crashes. Manan et al. (2013) developed a safety performance function for fatal motorcycle crashes for primary roads and they suggested that an increase of traffic flow and number of access points per kilometer lead to an increase in motorcycle crash fatalities. However, it appears that to date there are no models developed to assess the effect of non-lane-based movement of motorcycle on crash occurrence. In addition, as most of the above models were built based on historical crash data, they inherit the drawback of poor data quality which is a major issue in most low-income and middle-income countries (Ismail, 2010; Laureshyn, 2010).

Although several researchers focused on investigating the effect of manoeuvre behaviour of motorcyclists on crash risk, they mainly focused on the conventional traffic environment of high-income countries where the passenger cars are the predominant vehicle types. For example, Elliot et al. (2006) using a questionnaire found that traffic errors, speed violations, stunts, safety equipment and control errors are significant factors relating to crash risk for motorcyclists. Pai and Saleh (2008) evaluated factors contributing to the severity level of motorcyclist injuries in sideswipe collisions between motorcycles and other motorised vehicles at T-junctions in the United Kingdom and they suggested that motorcyclist injuries are more severe when an overtaking motorcycle collides with a turning vehicle. Haque et al. (2009) examined the effect of roadway characteristics, environmental factors, motorcycle descriptions, and rider demographics on the fault of motorcyclists involved in crashes at intersections, expressways, and non-intersections and found that the higher the speed of motorcycles the higher likelihood of at-fault crashes on expressways.

Moreover, the International Road Assessment Programme (2009) developed a star rating protocol to assess the safety level for four road user groups including car occupants, motorcyclists, bicyclists and pedestrians. For motorcyclists, the star rating score is calculated for five crash types including run-off, head-on, intersection, property access and along crash. Due to the range of paths that motorcycles can take within traffic streams, those five crash types are likely to capture less of the total motorcycles' crashes (Lynam, 2012). Sideswipe crashes and rear-end crashes away from intersections are found to account for a large proportion of total motorcycles' crashes in urban environments (AASHTO, 2009; Davoodi et al., 2011; DoT, 2013; Ming et al., 2013). However, these two crash types are not taken into account by the existing iRAP star rating score system (iRAP, 2013) which is based on research covering more conventional traffic composition and focusing mainly on inter-urban roads.

Therefore, the literature review seems to suggest that there is a lack of models focusing on evaluating the movement characteristics of motorcycles contributing to the risk of crashes in the traffic environment where the motorcycle is the predominant mode of transport. In addition there is a need therefore to obtain a surrogate measure to address the limitation of historical crash data analysis approach and to develop a methodology to capture crash potentials associated with motorcyclists' manoeuvre behaviour in the above conditions. The preliminary results of the developed models may be used to support traffic engineers in improving urban road safety and developing appropriate countermeasures to mitigate the crash risk for motorcyclists.

Model Development

Model Formulation

Due to their small size and flexible turning radius, motorcycles can manoeuvre relatively freely in the traffic stream. In a motorcycle-dominated traffic environment, motorcycles do not conform to lane disciplines and lane markings as passenger cars do. They tend to swerve to change their directions and speeds frequently. Also, because they occupy a small space when travelling, motorcycles are able to travel alongside other vehicles in the same lane as well as filter through the lateral clearance between vehicles. These movement characteristics are described to be as the non-lane-based movement characteristics of motorcycles (Minh, 2007; Lee, 2007; Long, 2012; Shiomi et al., 2013). Such non-lane-based movement characteristics are found to be the major causes contributing to the crash risk for motorcyclists (Hsu et al, 2003; Minh, 2007; Amelia and Harnen, 2010; Long, 2012; Manan, 2014). The manoeuvre behaviour of motorcyclists in a motorcycle-dominated traffic environment may be illustrated as in Figure 1. The crash risk is defined as a traffic conflict event potentially leading to a crash if there are no evasive actions taken by road users involved. Under this assumption, two types of conflicts may be considered. One is the rear-end conflict occurring due to motorcycles' following manoeuvre that potentially lead to a rear-end crash. The other one is the sideswipe conflict occurring due to motorcycles' swerving manoeuvre that results potentially in a sideswipe crash.

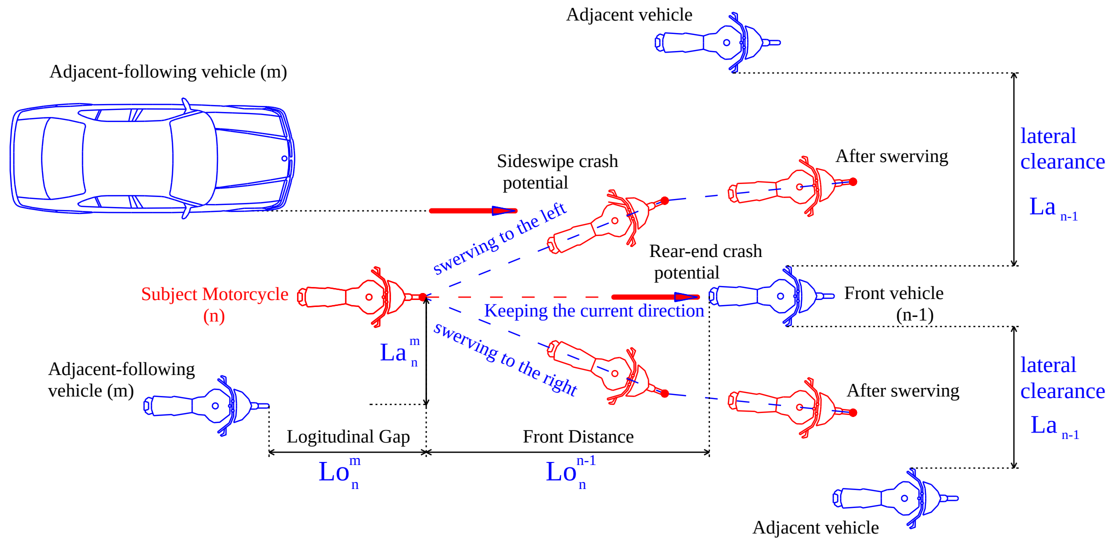

Figure 1. Manouevre behaviour of motorcycles in a motorcycle-dominated traffic situation

Rear-end crash risk model

The potential of a rear-end crash for a motorcycle (n) moving in a motorcycle-dominated traffic situation may be defined as the result of a series of events: (i) the subject motorcycle (n) keeps its current direction to follow the front vehicle (n-1) with a front distance (Lo_n^{n-1}); (ii) the front vehicle suddenly slows down; (iii) the subject motorcycle must decelerate to reduce its speed to avoid a possible rear-end crash with the front vehicle and (iv) a rear-end conflict occurs if the front distance is less than the threshold safety distance (D_{TSD}^{FM}) and it potentially leads to a rear-end crash if no proper evasive actions taken by road users involved. Under the assumption that these events are independent, the probability that a rear-end crash may occur at a point of time t under a given traffic condition may be estimated by the joint probabilities of these events as follows:

$$Pr(RE_{n-1}^{n}) = Pr(FM_n|X) \times Pr(FM_{n-1}|X) \times Pr(C_n^{n-1}|D_{TSD}^{FM}) \quad (1)$$

where,

- $Pr(FM_n|X)$: is the probability that the subject motorcycle (n) will keep its current direction under a given traffic condition X.
- $Pr(FM_{n-1}|X)$: is the probability that the preceding vehicle (n-1) will keep its current direction under a given traffic condition X.
- $Pr(C_n^{n-1}|D_{TSD}^{FM})$: is the probability of occurring a rear-end conflict between the subject motorcycle (n) and the front vehicle (n-1).

Sideswipe crash risk model

The potential of a sideswipe crash for a motorcycle (n) moving in a motorcycle-dominated traffic situation may be defined as the result of a series of events: (i) the subject motorcycle (n) swerves to the left or right to overtake the front vehicle; (ii) the adjacent-following vehicle (m) must decelerate to reduce its speed to avoid a possible sideswipe crash with the subject motorcycle and (iii) a sideswipe conflict occurs if the longitudinal gap (Lo_n^m) is less than the threshold safety distance *(D_{TSD}^{SM})* and it potentially results in a sideswipe crash if no proper evasive actions taken by road users involved. Under the assumption that these events are independent, the possibility that a sideswipe crash may occur at a point of time t under a given traffic condition may be estimated by the joint probabilities of these events as follow:

$$Pr(SW_n^m) = Pr(SM_n|X) \times Pr(FM_m|X) \times Pr(C_n^m \middle| D_{TSD}^{SM}) \quad (2)$$

where,

- $Pr(SM_n|X)$: is the probability that the subject motorcycle (n) will swerve to the left and right under a given traffic condition X.
- $Pr(FM_m|X)$: is probability that the adjacent-following vehicle (m) will keep its current direction under a given traffic condition X.
- $Pr(C_n^m \middle| D_{TSD}^{SM})$: is the probability of occurring a sideswipe conflict between the subject motorcycle and the adjacent-following vehicle (m).

Model components

To fully implement the proposed estimation methodology in Equation (1) and (2), two probabilities should be calculated: (i) the probabilities that the motorcycle chooses either a swerving manoeuvre or a following manoeuvre to perform in a given traffic condition, and (ii) the probabilities of the conflicts to occur.

To capture the probability that the subject motorcycle chooses either swerving manoeuvre or following manoeuvre to perform in a given traffic condition, a manoeuvre choice model is developed based on the discrete choice analysis using the binary logistic regression model. The form of binary logistic regression model represents the probability that a motorcycle choose a swerving manoeuvre behaviour as follows (Ben-Akiva and Lerman, 1985):

$$Pr(SW_n|X) = \frac{e^{g(x_i)}}{1 + e^{g(x_i)}} \quad (3)$$

The probability that a motorcycle chooses a following manoeuvre behaviour is given by:

$$Pr(KS_n|X) = 1 - Pr(SW_n|X) = 1 - \frac{e^{g(x_i)}}{1 + e^{g(x_i)}} = \frac{1}{1 + e^{g(x_i)}} \quad (4)$$

where, g(x) is the logit of the logistic regression model, x_i are independent variables affecting the choice of swerving manoeuvre behaviour of the subject motorcyclist.

It is felt that before deciding to choose a path to travel in a traffic stream, drivers normally evaluate the current driving conditions with respect to the relation with surrounding vehicles. In other words, the presence of neighbouring vehicles on the road directly affects the subject drivers' decisions for their movement choices. It therefore seems reasonable to suggest that the movement behaviour of the subject motorcyclist depends on the relative positions and relative speeds of the subject motorcycle with respect to its surrounding vehicles including: the relative speeds with the front vehicle ($V_{\mathrm{n}}^{\mathrm{n-1}}$), the relative distance with the front vehicle ($Lo_{\mathrm{n}}^{\mathrm{n-1}}$), the lateral clearance beside the front vehicle (La_{n-1}), the relative speeds with the adjacent-following vehicle ($V_{\mathrm{n}}^{\mathrm{m}}$), the longitudinal gaps with the adjacent-following vehicle *(Lo_n^m)*, the type of front vehicle (Te_{n-1}) and the type of adjacent-following vehicle (Te_m). In a motorcycle dominated traffic environment, the type of front vehicle and adjacent-following vehicle may be a motorcycle or a passenger car. Heavier vehicles such as buses or trucks were not considered in this study. These variables are illustrated in Figure 1.

Therefore, the logit of the logistic regression model *g(x_i)* for the seven independent variables x_i = ($Lo_{\mathrm{n}}^{\mathrm{n-1}}$, $V_{\mathrm{n}}^{\mathrm{n-1}}$, Lo_n^m, $V_{\mathrm{n}}^{\mathrm{m}}$, La_{n-1}, Te_{n-1}, Te_m) may be formulated as follows:

$$g(x_i) = \beta_0 + \beta_1 Lo_n^{n-1} + \beta_2 V_n^{n-1} + \beta_3 Lo_n^m + \beta_4 V_n^m + \beta_5 La_{n-1} + \beta_6 Te_{n-1} + \beta_7 Te_m \quad (5)$$

where, β_0, β_1, β_2, β_3, β_4, β_5, β_6, β_7 are unknown coefficients of independent variables to be estimated from the real data.

This paper defines traffic conflict as a condition of two consecutively moving motorcycles having inadequate threshold-safety-distance (TSD) such that the following motorcycle will crash into the preceding motorcycle when it swerves or makes an unexpected stop. The TSD indicators are calculated based on the stopping distance of a vehicle and identified separately for the rear-end conflict scenario (D_{TSD}^{FM}) and the sideswipe conflict scenario (D_{TSD}^{SM}) (see Appendix A). In a real traffic stream, the front distances (Lo_n^{n-1}) and the longitudinal gaps (Lo_n^m) are likely to follow a lognormal distribution (Minh, 2007; Lee, 2009). Therefore, the probability that the rear-end conflicts occur on a road segment may be predicted based on a lognormal distribution function as follows:

$$Pr(C_n^{n-1}|D_{TSD}^{FM}) = Pr(Lo_n^{n-1} \leq D_{TSD}^{FM}) = \Phi\left[\frac{ln(D_{TSD}^{FM}) - \mu^{Lo_n^{n-1}}}{\sigma^{Lo_n^{n-1}}}\right] \quad (6)$$

where, $\Phi[\cdot]$ denotes the cumulative standard normal distribution, $\mu^{Lo_n^{n-1}}$ and $\sigma^{Lo_n^{n-1}}$ are the mean and standard deviation of the logarithm of front distances respectively.

Similarly, the probability that the sideswipe conflicts occur on a road segment is expressed by:

$$Pr(C_n^m|D_{TSD}^{SM}) = \Pr(Lo_n^m \leq D_{TSD}^{SM}) = \Phi\left[\frac{\ln(D_{TSD}^{SM}) - \mu^{Lo_n^m}}{\sigma^{Lo_n^m}}\right] \quad (7)$$

where, $\Phi[\cdot]$ denotes the cumulative standard normal distribution, mean $\mu^{Lo_n^m}$ and $\sigma^{Lo_n^m}$ are the mean and standard deviation of the logarithm of longitudinal gaps respectively.

Model Specification

To specify the proposed model, a traffic survey was conducted on a road segment in the city of Danang in Vietnam. Vehicles' trajectory data was collected using video recording. A representative road segment of length 40 m and of width 7.0 m on the Nguyen Tri Phuong street was chosen that could be captured by the video camera (see Appendix B). The traffic survey was conducted on 20 August, 2014, from 6:00 am to 09:00 am and 3:00 pm to 6:00 pm. The trajectories of vehicles were manually extracted from the recorded video file using the SEV (Speed Estimation from Video Data) computer software (Minh, 2007) which converts video screen coordinates into roadway coordinates. As a result, a data set containing 535 observations of the trajectories of 115 subject motorcycles and 2675 observations of 575 influential vehicles was used to estimate the unknown coefficients of the proposed models. The data set included flow density, relative positions, speeds, accelerations and decelerations of each vehicle.

The statistical software SPSS was used to analyze the vehicle trajectory data and to estimate the unknown coefficients of independent variables. The Wald test revealed that the (Te_{n-1}) variable does not affect significantly on the swerving manoeuvre decision of motorcyclists and thus it was removed from the model. The final estimate results are summarized in Table 1 together with further statistical tests. As a result, the best fitting model capturing the probability that the motorcyclist chooses a swerving manoeuvre is expressed:

$$Pr(SM_n|X) = \frac{e^{-0.524-\ 1.677Lo_n^{n-1}+1.452V_n^{n-1}+0.139Lo_n^m+0.224V_n^m+1.445La_{n-1}-0.642Te_m}}{1+e^{-0.524-\ 1.677Lo_n^{n-1}+1.452V_n^{n-1}+0.139Lo_n^m+0.224V_n^m+1.445La_{n-1}-0.642Te_m}} \quad (8)$$

By considering the statistical tests shown in Table 1, it may be seen that the estimated coefficients of independent variables are statistically significant which means that the proposed model satisfactorily captures the swerving manoeuvre choice behaviour of motorcyclists in a motorcycle-dominated traffic situation.

Table 1. Estimated coefficients for the best fitting manoeuvre choice model

Variables	**Estimated Parameters**	**Standard Error**	**Wald test**	**p-value**
$\boldsymbol{Lo_n^{n-1}}$	-1.677	0.234	51.246	< 0.001
$\boldsymbol{V_n^{n-1}}$	1.452	0.283	26.379	< 0.001
$\boldsymbol{Lo_n^m}$	0.139	0.056	6.161	0.013
$\boldsymbol{V_n^m}$	0.224	0.109	4.196	0.041
$\boldsymbol{La_{n-1}}$	1.445	0.193	56.020	< 0.001
$\boldsymbol{Te_m}$	-0.642	0.096	44.652	< 0.001
constant	-0.524	0.591	0.785	0.376

The statistical characteristics of the longitudinal gaps and the front distances from the data set were investigated and it was found that these distances are correlated with the traffic density condition and may be fitted with a polynomial function as shown in Table 2. The Kolmogorov-Smirnov test (K-S test) measure was also applied to verify the assumption of the distribution for these distances and the results illustrate that they follow a lognormal distribution.

Table 2. The statistical properties of longitudinal gaps and front distances

Factor	**Lognormal distribution**			**K-S test**
	Mean	**R-squared value**	**Standard Deviation**	**Confidence**
Front distance	$7 * 10^{-5}\ Den^2 - 0.019Den + 2.108$	0.75	0.52	0.51
Longitudinal gap	$4 * 10^{-5}\ Den^2 - 0.013Den + 1.823$	0.62	0.30	0.95

where, *Den:* is the traffic density defined as the number of motorcycles travelling on a road segment of length 100 m and width 10 m.

Therefore, Equation (6) and (7) become:

$$Pr(C_n^{n-1}|D_{TSD}^{FM}) = \Phi\left[\frac{ln(D_{TSD}^{FM}) - (7 * 10^{-5}\ Den^2 - 0.019Den + 2.108)}{0.52}\right] \quad (9)$$

$$Pr(C_n^{m}\middle|D_{TSD}^{SM}) = \Phi\left[\frac{ln(D_{TSD}^{SM}) - (4 * 10^{-5}\ Den^2 - 0.013Den + 1.823)}{0.3}\right] \quad (10)$$

Model verification

The main purpose of the field validation task was to verify the performance of the proposed models in the real-world by comparing the predictive conflict frequency produced by the proposed models with the actual conflict frequency observed in the field. This verification task is conducted in two steps. First, rear-end conflict and sideswipe conflict frequencies are observed in the field for different time periods in a day in order to fully capture conflict frequencies for both peak hours and non-peak hours. Second, the frequencies of rear-end and sideswipe conflicts are predicted using the proposed models for those same time periods and then the estimate results are compared with the real observed conflict frequencies in the field by determining the percentage correct of estimate with observed values. The data used for this field verification was collected on a road segment of length 40.0 m and of width 7.5 m on Truong Chinh street. The comparison results for each hour of six hours from 6:00 am to 9:00 am and from 3:00 pm to 6:00 pm are presented in Table 3 and show a good degree of accuracy between predicted and observed conditions. It is appreciated however that a more extensive trial programme could lead to a calibrated model.

Table 3. The comparison results between predicted and observed conflict frequency

Time periods	Predicted conflicts			Observed conflicts			Percentage correct (+/- %)
	Rear-end	Sideswipe	Total	Rear-end	Sideswipe	Total	
6:00am-7:00am	7.4	3.6	11.0	9	5	14	78.5
7:00am-8:00am	32.7	8.1	40.8	27	10	37	89.8
8:00am-9:00am	19.6	11.8	31.4	24	14	38	82.6
3:00pm-4:00pm	4.1	1.7	5.8	5	2	7	83.0
4:00pm-5:00pm	18.6	8.8	27.3	22	12	34	80.4
5:00pm-6:00pm	57.3	12.9	70.2	46	15	61	84.9

Sensitivity Analysis

The effect of input variables on the outputs of the proposed models was tested. To simplify the process, several input variables were assumed to be a constant. The reaction time (τ) of the motorcyclists is 0.5 second (Minh, 2007), the braking deceleration of motorcycles in emergency situation is 6.02 m/s/s (Davoodi and Hamid, 2013), the swerving angle is 12.5 degree (the mean determined from the collected data set). Therefore, the effects of the following input data on the model was tested: Front distance; Longitudinal gap; Speed; Speed difference; Traffic density and Lateral clearance (see Appendix C).

Model Application

The Development of Conflict Modification Factor (CoMF)

To address specific safety concerns of a specific location on road networks, a treatment should be determined and implemented. To estimate the effectiveness of a treatment, Crash Modification Factor (CMF) is used as a tool to support this effort. CMF is used to estimate crash frequency or the change in crashes due to the implementation of a given countermeasure at a specific location by multiplying a CMF with the number of crashes before applying a treatment to estimate the number of crashes after applying a treatment (AASHTO, 2009; Gross et al., 2010).

In low-income and middle-income countries, obtaining reliable crash data to define CMFs is a difficult task due to the under-reporting of accidents and the poor quality of historical crash data (Lynam, 2012). Therefore, this study proposes a concept of Conflict Modification Factor (CoMF) and as potential surrogate measure to CMF in road safety assessment due to the following reasons:

- The causal mechanism for conflicts and crashes are similar (Hyden, 1987; Svensson, 1998; Guo et al., 2010).
- There is a strong relationship between the frequency of conflicts and crashes (Hyden, 1987; Svensson, 1998; Archer, 2004; Guo et al., 2010).
- The contributing factors and risk factors are not significantly different for crashes and near-crashes (Guo et al., 2010).

CoMFs are defined as the ratio of the likelihood of conflicts for a specific location under a specific condition to the likelihood of conflicts for the same location under a base condition. According to this definition, CoMFs of risk factors may be used as the relative risk values presenting the changes in crash potentials due to the change in values of those risk factors.

To this end, CoMFs are developed in this study as follows. The likelihood of the occurrence of an event (e.g. conflict) may be expressed (Guo et al., 2010) as follows:

$$likelyhood\ of\ conflict = \frac{probability\ of\ event\ occurrence}{probability\ of\ event\ nonoccurrence} \quad (11)$$

Subsequently, the CoMFs may be calculated as follows:

$$Conflict\ Modification\ Factor = \frac{likelyhood\ of\ conflict_{certain\ traffic\ conditions}}{likelyhood\ of\ conflict_{baseline\ traffic\ condition}} \quad (12)$$

The baseline traffic condition is defined as the normal driving condition in which motorcyclists can move freely in the traffic stream with a low crash risk level. As a result, for the proposed crash risk models, CoMFs are developed for its variables (i.e. traffic density, operating speed, speed difference, front distance, longitudinal gap, lateral clearance, lateral gap, road surface condition, separate motorcycle lane, presence of heavier vehicles) based on the sensitivity analysis of section 3.4. The relative risk values (CoMFs) of these variables are presented in Appendix D.

Enhancing the existing iRAP star rating system for motorcyclists

Methodology

The International Road Assessment Programme (iRAP) has developed a Star Rating methodology to assess and improve the safety of roads in the low-income and middle-income countries (iRAP methodology, 2013). It is based on the assessment of infrastructure attributes to identify the likelihood of a crash and its severity. For motorcyclists, the star rating score is based on assessing five crash types including run-off crash, head-on crash, intersection crash, property access crash, and along crash. These are likely to capture less of the total motorcycles' crashes in urban environments (Lynam, 2012). The existing star rating score (SRS) is calculated as follows:

$$\text{Motorcyclist SRS} = (\text{Run-off} + \text{Head-on} + \text{Intersection} + \text{Property} + \text{Along}) \text{ Crash Scores}$$

Therefore, to provide an enhanced tool for assessing the motorcyclist safety in a motorcycle-dominated traffic environment, the existing star rating score system may be enhanced by taking into account the risk of rear-end and sideswipe crashes as follows:

$$\begin{aligned}\text{Enhanced Motorcyclist SRS} = (&\text{Run-off} + \text{Head-on} + \text{Intersection} + \text{Property} + \text{Along} \\ &+ \text{Rear-end} + \text{Sideswipe}) \text{ Crash Scores}\end{aligned} \tag{13}$$

The scores of rear-end and sideswipe crashes are calculated as follows:

$$\begin{aligned}(\text{Rear-end / Sideswipe}) \text{ Crash Score} = &\text{ Likelihood} \times \text{Severity} \times \text{Operating speed} \\ &\times \text{External flow influence}\end{aligned} \tag{14}$$

where,

- Likelihood refers to attribute risk factors that account for the chance that a crash will be initiated
- Severity refers to attribute risk factors that account for the severity of a crash
- Operating speed refers to factors that account for the degree to which risk changes with speed
- External flow influence factors account for the degree to which a person's risk of being involved in a crash is a function of another person's use of the road

The risk factors that contribute to the likelihood and severity of rear-end and sideswipe crashes are shown in Table 4.

Table 4. Risk factors of Likelihood and Severity for rear-end and sideswipe crash type

Crash type	Risk factors attribute the Likelihood	Risk factors attribute the Severity
Rear-end	• Front distance • Road surface condition • Separate motorcycle lane	• Speed • Presence of heavier vehicles • Separate motorcycle lane
Sideswipe	• Longitudinal gap • Lateral gap • Road surface condition • Separate motorcycle lane	• Speed • Presence of heavier vehicles • Separate motorcycle lane

In the iRAP methodology, the relative risk values of the above factors are known as Crash Modification Factors (CMFs) (iRAP methodology, 2013). In a similar and simplified manner, the scores of rear-end crash type and sideswipe crashes are associated with the CoMF which are based on potential conflicts instead of actual crashes. In other words, CMF represents the relative change in the crash frequency due to the change in one specific risk factor and CoMF represents the relative change in the conflict frequency due to the change in one specific risk factor.

Comparison

To compare the outputs between the existing iRAP star rating system and the enhanced iRAP star rating system, real data was collected from five homogeneous road sections chosen randomly from five divided roads in the city of Danang in Vietnam and then analyzed (see Appendix E). The results (see Table 5) show that the existing iRAP star rating system produces the same Star Rating Score (SRS) for all locations, implying that all these locations have the same risk. However, the actual historical crash data of these locations are different and they present the same trend with the SRS produced by the enhanced iRAP star rating methodology.

Table 5. Comparison results between existing and enhanced iRAP star rating system

Location	Existing iRAP Star Rating system		Enhanced iRAP Star Rating system	
	SRS	Rating star	SRS	Rating star
1	0.76	5-star	2.9	4-star
2	0.76	5-star	2.2	5-star
3	0.76	5-star	2.6	4-star
4	0.76	5-star	3.3	4-star
5	0.76	5-star	3.5	4-star

The above was tested further first by calculating the average yearly crash frequency for each road segment as proposed by AASHTO's Highway Safety Manual (HSM) (2009). These locations were then ranked based on the predicted average yearly crash frequency in descending order. The same locations were ranked based on the enhanced iRAP star ratings and based on the average yearly actual crash frequency (real crash data collected over the period from 2008 to 2015) and then by using the Spearman rank correlation coefficient the three rankings were compared.

The outputs of methodologies and the corresponding rankings for locations are shown in Table 6 and the Spearman correlation coefficients are shown in Table 7. The comparison results reveal that there is a strong correlation between the outputs of the enhanced iRAP star rating methodology with the actual historical crash data, implying that the enhanced iRAP methodology produce most satisfactory results.

Table 6. Outputs of methodologies and rankings for road segments

Location	Enhance iRAP methodology		HSM methodology		Actual historical crash	
	SRS	Ranking	Crash frequency	Ranking	Crash frequency	Ranking
1	2.9	3	0.6	2	3.3	3
2	2.2	5	0.4	4	1.4	5
3	2.6	4	0.5	3	2.5	4
4	3.3	2	0.6	2	4.2	2
5	3.5	1	0.8	1	5.5	1

Table 7. Spearman rank correlation coefficient

Methodology	Average actual historical crash
Enhanced iRAP SRS	1.00**
HSM methodology	0.97**

** Correlation is significant at the 0.01 level

Conclusion

The paper presented a methodology to estimate the rear-end and sideswipe crash risk for motorcyclists in a motorcycle-dominated traffic environment of urban roads. The innovative feature of the methodology is the non-lane-based movement of motorcycle is captured to evaluate its contribution to the crash risk. In addition, a new concept of Conflict Modification Factor was proposed as a potential surrogate measure to Crash Modification Factor in road safety assessment and a methodology to integrate the developed models with the existing iRAP star rating system was also presented in the paper. Furthermore, the study focused on the contribution of infrastructure factors and traffic conditions to the potential of motorcycle crashes. Other contributing factors that may affect motorcyclists' crash risk may include their knowledge and experience, alcohol or drugs consumption, and motorcycle capabilities but these were not included in the proposed models as in most cases this information cannot be directly measured from vehicles' trajectory data in real time.

In conclusion:

a) The developed methodology provides a good estimate of both the rear-end crash and sideswipe crash risks for motorcyclists in a motorcycle-dominated traffic environment of urban roads.

b) The front distance, the longitudinal gap, the lateral gap, the lateral clearance, speed difference, and the speed of motorcycles were found to be the predominant factors contributing to the rear-end and sideswipe crash risk.

c) The models may estimate the rear-end and sideswipe crash risk for motorcyclists using real time data; this could be an invaluable tool in detecting hazardous roads in traffic conditions were motorcycles is the predominant mode of transport.

d) A Conflict Modification Factor (CoMF) was proposed in this study as a surrogate measure to Crash Modification Factor for road safety assessment in order to overcome the under-reporting or unavailability of historical crash data in low-income and middle-income countries.

e) The proposed methodology to enhance the current iRAP star rating system seems to produce reliable results and subject to more testing, may be considered for full implementation.

f) The proposed models may assist traffic engineers in detecting hazardous locations associated with higher motorcycles' crash risk and developing appropriate countermeasures to improve motorcyclist safety.

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The authors would like to thank the Government of Vietnam, the Danang Department of Transportation and the International Road Assessment Programme for their supports to this study.

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Appendix A

Threshold-safety-distance calculation

With regard to rear-end conflict scenario as illustrated in Figure A1, it is assumed that the front vehicle (n-1) suddenly decelerates to slow down and the subject motorcycle (n) responds to this urgent situation by applying the brake to avoid a possible crash. The threshold-safety-distance of this scenario is defined as the distance that the subject motorcycle needs to stop to avoid a possible crash with the front vehicle. This distance may be calculated as:

$$D_{TSD}^{FM} = v_n \tau_n + \frac{v_n^2}{2a_n} - \frac{v_{n-1}^2}{2a_{n-1}} \quad (A.1)$$

where, D_{TSD}^{FM} is the threshold-safety-distance for rear-end conflict scenario; τ_n, v_n and a_n are the reaction time, initial speed and braking deceleration of the subject motorcycle respectively; v_{n-1} and a_{n-1} are initial speed and braking deceleration of the front vehicle respectively.

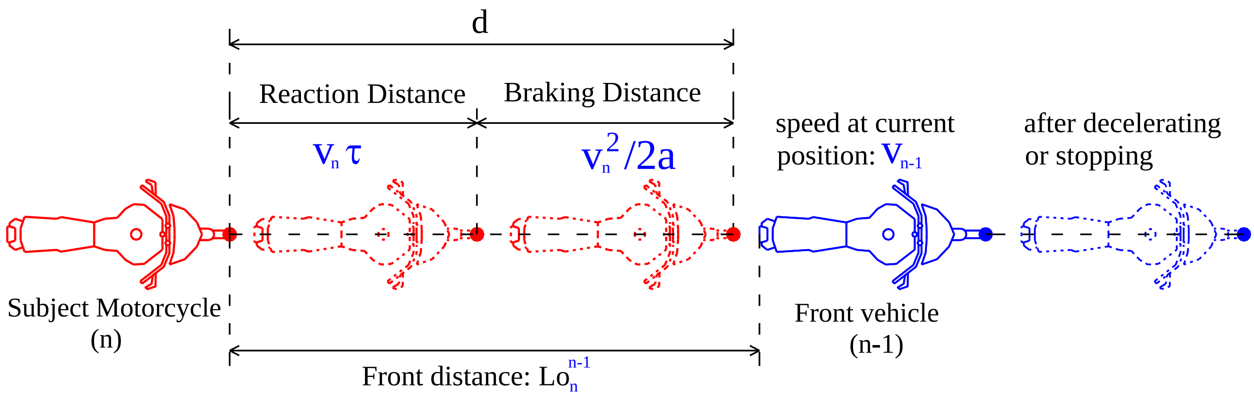


Figure A1. Rear-end conflict scenario

With regard to sideswipe conflict scenario, it is assumed that the trajectory of the subject motorcycle (n) is the hypotenuse of a right triangle as illustrated in Figure A2 and the adjacent-following vehicle (m) starts braking while the subject motorcycle starts swerving. The threshold-safety-distance of this scenario is defined as the distance that the vehicle (m) needs to stop to avoid a possible collision while the motorcycle (n) executes a swerving manoeuvre. This distance may be calculated as:

$$D_{TSD}^{SM} = v_m \tau_m + \frac{v_m^2}{2a_m} - \frac{La_n^m \times cos\alpha_n}{sin\alpha_n} \quad (A.2)$$

where, D_{TSD}^{SM} is the threshold-safety-distance for sideswipe conflict scenario; τ_m, v_m and a_m are the reaction time, initial speed and braking deceleration of vehicle (m) respectively, La_n^m is the initial lateral gap between motorcycle (n) and vehicle (m), and α_n is the swerving angle of motorcycle (n).

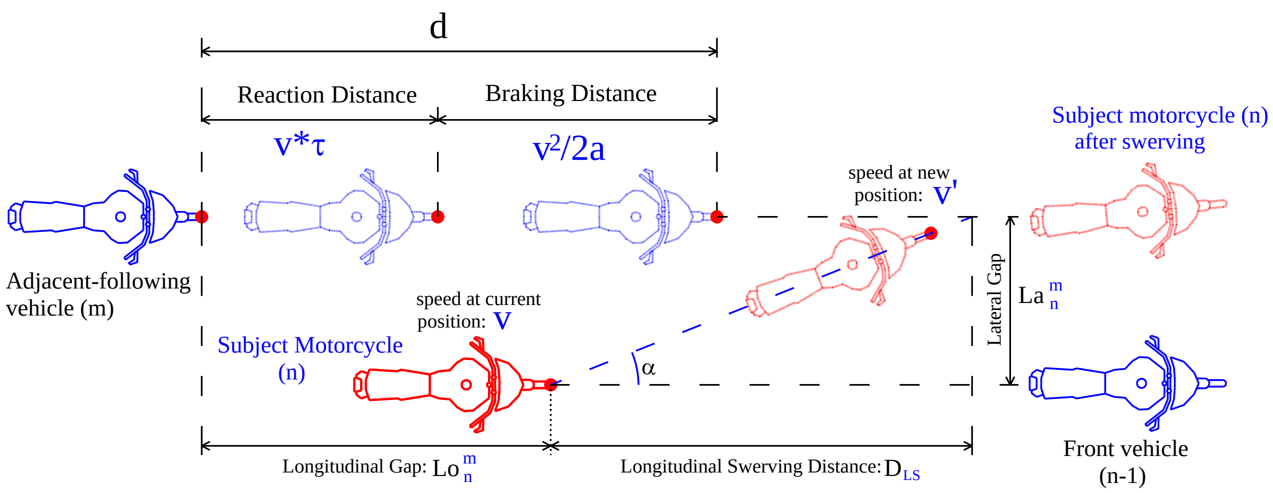


Figure A2. Sideswipe conflict scenario

Appendix B

The selected road segment for traffic survey

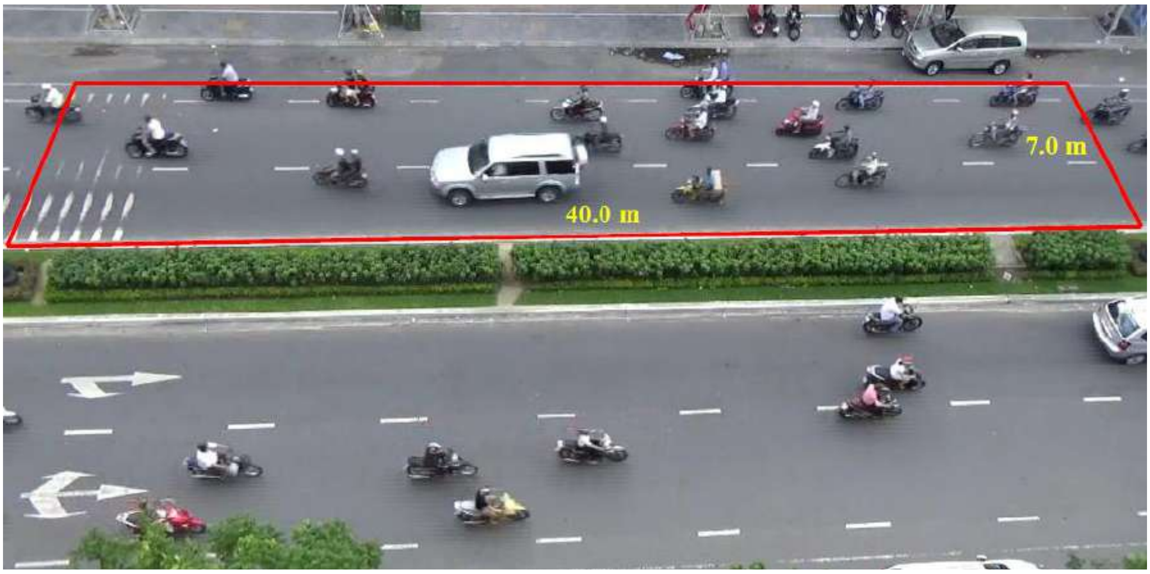


Figure B. The selected road segment for traffic survey

Appendix C

Sensitivity analysis results

Figure C.1. Effect of front distance on crash risk

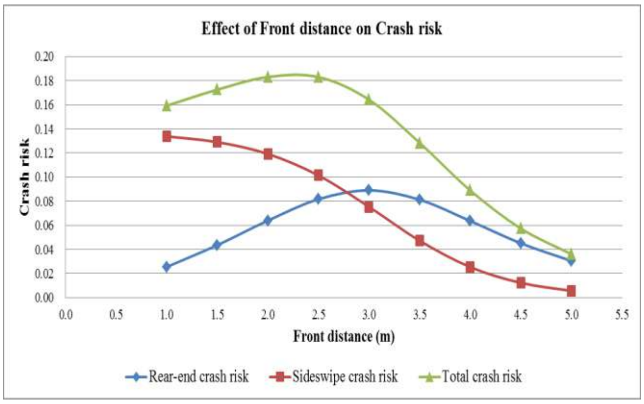


Figure C.2. Effect of longitudinal gap on crash risk

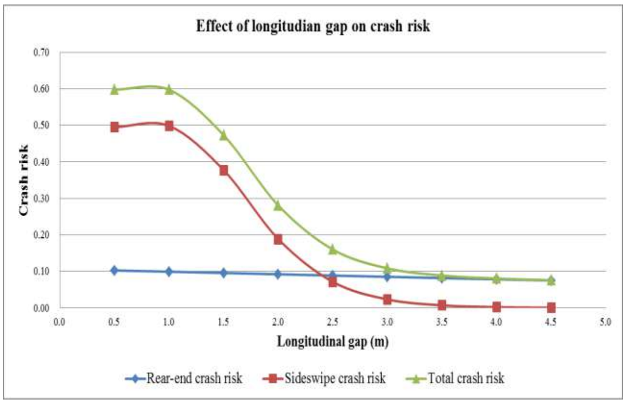


Figure C.3. Effect of speed on crash risk

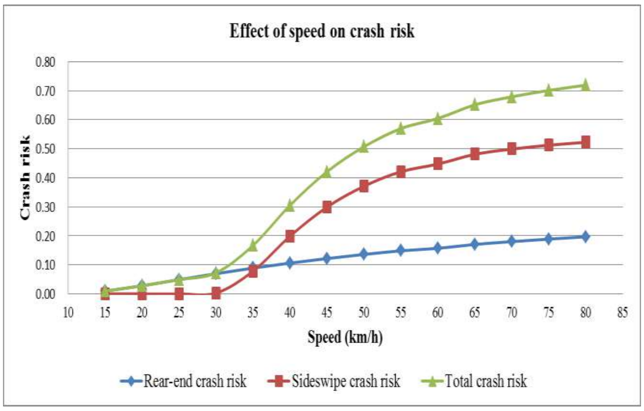


Figure C.4. Effect of speed difference on crash risk

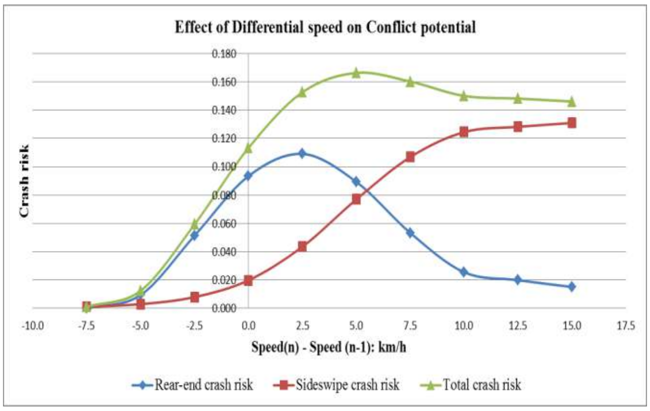


Figure C.5. Effect of traffic density on crash risk

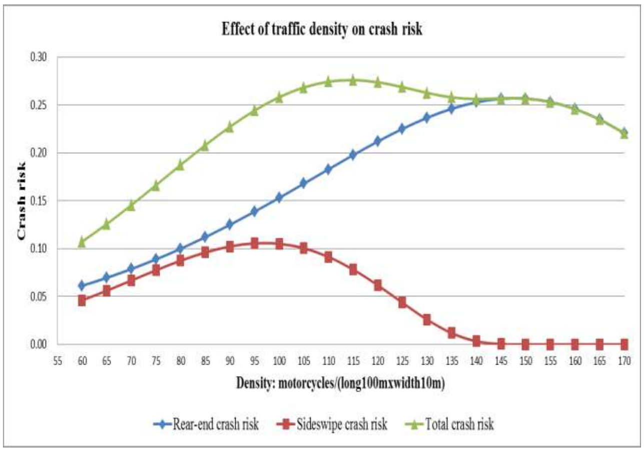
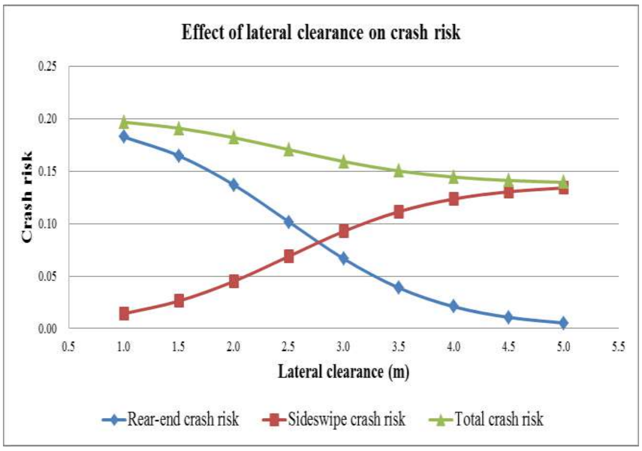


Figure C.6. Effect of lateral clearance on crash risk



Appendix D

Relative risk values of risk factors

Table D1. Relative risk values of front distance factor

Front distance (m)	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Rear-end crash	0.5	0.8	1.0	1.1	1.0	0.8	0.5	0.4
Sideswipe crash	3.0	2.7	2.3	1.6	1.0	0.5	0.2	0.1

Table D2. Relative risk values of speed difference factor

Speed difference (km/h)	-7.5	-5.0	-2.5	0.0	2.5	5.0	7.5	10.0	12.5	15.0
Rear-end crash	0.01	0.1	0.5	1.0	1.2	1.0	0.5	0.3	0.2	0.1
Sideswipe crash	0.1	0.1	0.4	1.0	2.2	4.1	5.9	7.0	7.3	7.4

Table D3. Relative risk values of longitudinal gap factor

Longitudinal gap (m)	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
Rear-end crash	1.1	1.1	1.0	1.0	1.0	0.9	0.9	0.8
Sideswipe crash	12.9	7.9	3.0	1.0	0.3	0.1	0.01	0.01

Table D4. Relative risk values of lateral clearance factor

Lateral clearance (m)	1.5	2.0	2.5	3.0	3.5	4.0	4.5
Rear-end crash	2.8	2.2	1.6	1.0	0.6	0.3	0.2
Sideswipe crash	0.3	0.5	0.7	1.0	1.2	1.4	1.5

Table D5. Relative risk values of speed factor

Speed (km/h)	25	30	35	40	45	50	55	60	65	70
Rear-end crash	0.5	0.8	1.0	1.2	1.4	1.6	1.8	1.9	2.1	2.3
Sideswipe crash	0.0	0.1	1.0	2.9	5.0	7.0	8.6	9.6	10.9	11.8

Table D6. Relative risk values of traffic density factor

Traffic density	Free flow	Few restriction	Low restriction	Moderate restriction	High restriction	Very high restriction
Rear-end crash	0.75	1.0	2.0	3.0	3.5	2.5
Sideswipe crash	0.75	1.25	1.5	0.5	0.25	0.1

Table D7. Relative risk values of lateral gap factor

Lateral gap (m)	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
Rear-end crash	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sideswipe crash	2.4	1.0	0.1	0.0	0.0	0.01	0.01	0.01

Table D8. Relative risk values for road surface condition factor

Road surface condition	Dry Pavement	Wet Pavement

Rear-end crash	1.00	1.1
Sideswipe crash	1.00	1.7

Table D9. Relative risk values of vehicle factor

Vehicle factor	**Motorcycle**	**Heavier vehicle**
Rear-end crash	1.00	1.5
Sideswipe crash	1.00	2.3

Table D10. Relative risk values of motorcycle lane presence

Separate motorcycle lane	**Absence**	**Presence**
Rear-end crash	1.00	0.66
Sideswipe crash	1.00	0.43

Appendix E

Traffic characteristics of road segments and historical crash data

Table E. Traffic characteristics of road segments and historical crash data

Location	**Volume (vehicles/day)**	**Density (vehicles/1000m^2)**	**Average speed (m/s)**	**Crash records (2008-2015)**	
				Rear-end	**Sideswipe**
1	59704	89	9.68	21	5
2	41621	68	9.99	9	2
3	49706	72	9.83	16	4
4	61402	94	9.48	27	7
5	78945	76	9.19	35	9

- Historical crash data collection source: Danang Department of Transport

Appendix F

Non-lane based movement characteristics of motorcycles

Due to their small size and flexible turning radius, motorcycles can manoeuvre relatively freely in the traffic stream. In a motorcycle-dominated traffic environment, motorcycles do not conform to lane disciplines and lane markings as passenger cars do. They tend to swerve to change their directions and speeds frequently. Also, because they occupy a small space when travelling, motorcycles are able to travel alongside with other vehicles in the same lane as well as filter through the lateral clearance between vehicles. These movement characteristics are described to be as the non-lane-based movement characteristics of motorcycles (Minh, 2007; Lee, 2007; Long, 2012; Shiomi et al., 2013). Such non-lane-based movement characteristics (e.g. Alongside manoeuvre, Oblique following manoeuvre, Filtering manoeuvre, Swerving/Weaving manoeuvre) were discussed in a number of previous studies as follows:

Alongside manoeuvre

Due to small size with the average width of 0.75 m which accounts for only 25 per cent of an average car-lane of 3.0 m, motorcycles occupy a small space while moving on roads and they are therefore capable of travelling alongside with other motorcycles in the same car-lane (Hsu et al., 2003; Minh, 2007; Lee, 2007; Long, 2012). Minh (2007) also described this behaviour as a pair-riding manoeuvre of motorcycles and it is commonly observable in a motorcycle-dominated traffic environment.

Oblique following maneuver

Due to a flexible movement characteristic, motorcycles can follow the preceding vehicle at an oblique position (Lee, 2007; Long, 2012). For this manoeuvre behaviour, motorcyclists can achieve a better view in front of and a better chance to overtake the front vehicle.

Filtering maneuver

Due to a small size and a flexible turning radius, motorcycles can move freely in the traffic stream. The filtering manoeuvre refers to the behaviour that a motorcycle moves through the lateral clearance between vehicles to achieve a desired speed and a better condition (Elliott et al., 2003; Minh, 2007; Lee, 2007; Long 2012). Minh (2007) described this behaviour as a zigzag movement of motorcycles and they tend to perform this manoeuvre frequently in a motorcycle-dominated traffic environment.

Swerving/weaving manoeuvre

Due to a small turning radius, motorcycles can make turns easily. The swerving manoeuvre refers to the behaviour that a motorcycle changes its current direction to move to the left or right beside the front vehicle. It may be sometimes followed by an overtaking or filtering movement. This is the typical behaviour that represents the none-lane-based movement characteristic of motorcycles and can be frequently observable in motorcycle-dominated traffic environments (Minh, 2007; Lee, 2007; Long, 2012).

New Zealand's Safer Journeys - Delivering the State Highway Safer Roads and Roadsides Programme

Andrew Scott and Bruce Corben

Safe Roads Alliance

Abstract

This paper describes work underway in New Zealand, commencing mid-2015, on implementing its "Safer Journeys - Delivering the State Highway Safer Roads and Roadsides" programme. The programme is a new, highly ambitious initiative of the national government, targeting the prevention of an aggregate 1400 deaths or serious injuries on New Zealand's rural State Highways in the first ten years of each project's life. This will entail investing $745m in safer infrastructure along the country's highest-risk corridors and intersections. Wherever affordable and fit-for-purpose, having regard to the functional classification of each corridor, infrastructure aligned with Safe System principles will be delivered.

Background and Programme Aims

This paper provides the strategic context for New Zealand's "Safer Journeys - Delivering the State Highway Safer Roads and Roadsides" programme, as well as describing a new national delivery mechanism which has involved the formation of an alliance between government and private sectors. Due to the programme's unprecedented commitment to eliminating death and serious injury from New Zealand's rural highways, a number of our longest-standing conventional approaches to improving safety on state highways are being challenged. Three major crash types characterise the country's rural roads; head-on, run-off-road and intersection collisions. High-impact solutions to these three major sources of road trauma are being sought or developed by drawing upon successful practices from leading countries of the world, as well as adapting them to the conditions that uniquely define New Zealand's state highway system.

Delivering the savings in deaths and serious injuries

The recently formed Safe Roads Alliance has worked strenuously to establish a clear vision and a strong culture of leadership that strives for excellence, seeks affordable solutions to safety problems commonly encountered on rural roads, and is practical and delivery action-oriented. The Alliance aims to leave a lasting legacy of low-risk travel for future generations of New Zealanders.

Defining the path ahead

The principal elements of the Alliance's approach are being progressively documented in a 'Safety Toolkit' to assist project teams, designers and business-case writers to implement the programme, with speed and efficiency, across some 90 individual rural corridors. To support NZ's transition to a new safety paradigm, innovation in program development, project design and project delivery is essential. Accordingly, a range of new processes are being introduced wherever practical. More effective designs, which extend beyond many of the traditional standards, have begun to be introduced and will be closely monitored and evaluated as a means of assuring highly-effective investment and continuous improvement in the years and decades ahead.

The recently developed "Safety Toolkit" encompasses important aspects that impact directly on safety, such as commencing the journey towards Safe System performing roads, holistic route treatment philosophies, metrics and evidence-based methods for identifying and prioritising routes with a high risk of deaths and serious injuries, fit-for-purpose design principles for routes, including intersections, investment prioritisation metrics and methods, and the monitoring and evaluation of programme and project performance. While the stated enhancements in corridor safety are keenly sought, a number of significant practical challenges must first be overcome; for example, the unintended impacts on route maintenance and operation, restrictions on property and emergency services access, route resilience in the event of crashes or vehicle breakdown, and provision for cyclists and motorcyclists along already narrow cross-sections. The Toolkit will be a 'living' document that attempts to implement the 'right designs' from the beginning. It will be continually updated as local and international experiences bring new insights.

Relevance

The programme and approaches described in this paper, and lessons learnt on the journey to these goals, are expected to be of interest to all road and road safety agencies and stakeholders wishing to achieve major savings in deaths and serious injuries on their roads.

Review of Research Methodologies in Investigating Work-Related Driving Behaviour

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Centre for Accident Research and Road Safety – Queensland, Queensland University of Technology

Abstract

This paper reviewed research in work-related driving safety with a particular focus on the current methodologies used to investigate driving behaviours in work settings. Results from this review demonstrated that the majority of past research have utilised questionnaires to measure work-related driving behaviours, but an increasing number of research are utilising in-vehicle monitoring systems as an alternative method. Other methodologies include: interviews, observational studies and crash analysis. Strengths and limitations of each methodology will be discussed as well as the practical implication and benefits of implementing both traditional and innovative measures in work-related driving safety research.

Background

Due to the over representation of work-related road trauma and injury, there is a growing interest in examining work driving safety and recent years have seen an increase of studies in the field of work-related driving research. Yet gaps in the knowledge gaps still exist, in particular, current methodologies utilised to measure work-related driving behaviour poses several limitations and challenges. Some of the issues include: over-reliance on self-report measures and lack of psychometrically validated instruments. For instance, most research on work driving behaviours utilises the Manchester Driving Behaviour Questionnaire (DBQ) (Reason, Manstead, Stradling, Baxter, & Campbell, 1990) that was initially developed to measure general driving behaviours (Newnam, Greenslade, Newton, & Watson, 2011). However, this questionnaire fails to adequately capture other risky behaviours that are specific to the work-related context such as, driving under work pressure, or answering work-related calls and messages while driving (Newnam et al., 2011). This paper will review research on work-related driving safety with a focus on current methods used to measure work-related driving behaviours.

Method and Results

PsycINFO, ScienceDirect, CINAHL and Medline were searched for relevant literature on work-related driving behaviours using the keywords: *driving behaviour*, *work-related*, *organisations*, *fleet* and *commercial*. Inclusion criteria for the review were: (1) papers written in English; (2) peer-reviewed; (3) articles published within the last 30 years (from 1986 to present); (4) studies that assessed work-related driving behaviours. Papers that specifically focus on heavy vehicles (e.g., trucks and buses) were excluded as driving heavy vehicles require additional skills from driving light vehicle fleets (Roads and Maritime Services, 2014). Over 30 studies met the criteria. Results showed that research on work driving behaviours typically utilises questionnaires to measure driving behaviours in work settings, which often lack psychometric validity. The Manchester DBQ and variations of it were typically used to measure work driving behaviours. However, this questionnaire often fails to fully capture the risks that are specific to work drivers. Recently, increasing number of research are utilising in-vehicle monitoring system to measure work driving behaviours. While this methodology offers a more objective approach to measuring driving behavior, it also has its challenges and limitations (e.g., costs, data collection and analysis, expertise of use). Other methodologies include: interviews, crash data analysis and observational methods.

Conclusions

Research on work driving safety have mostly utilised self-report measures to investigate work driving behaviours. With the advent of new technologies and increased accessibility of in-vehicle monitoring systems, innovative methodologies could be combined with traditional research methodologies to improve the measurement of work-related driving behaviour and consequently, advance the current knowledge of work-related driving safety. For instance, self-report questionnaires could provide subjective data on work driving behaviours, while in-vehicle monitoring systems could provide objective measures of driving behaviours along with an opportunity to collect and analyse data that may relate to critical events (e.g., crashes, harsh braking and excessing speeding) (Horrey, Lesch, Dainoff, Robertson, & Noy, 2012; Newnam, Lewis, & Warmerdam, 2014).

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Comparing the Characteristics of the Target and Bullet Vehicle for Injury Severity in Two Vehicle Crashes

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Abstract

This paper undertakes an in-depth analyses of the driver reaction and crash severity of the target and bullet vehicles in two vehicle crashes. Previous driver reaction and crash predictive modelling are reviewed. Statistical analysis (Cross tabulation, Chi-Square test and T- test) are conducted to identify the relationship between injury severity human; vehicle; road geometric; environmental; and crash or dynamic factors for the target and bullet vehicle. The 2009 – 2014 National Automotive Sampling System-Crashworthiness Data System (NASS-CDS) is used in the analysis. The results indicates that struck and striking drivers are differentiated in terms of the human factors, age, gender, and delta V. For instance, high percentage of severe or fatalities is related to:

a) male drivers over female (Figure 1).

b) struck over striking vehicles at delta V more than 20 km/hr (Figure 3).

c) risky segments; non interchange and non-junction or intersection. Right angle crashes are the most risky for driver among other crashes types.

Future work could investigated the differences between single and two vehicle crashes related to crash severity and driver avoidance manoeuvers.

Background

Road traffic injuries are amongst the most important health, societal, and economical issues in the world. Worldwide there are an estimated more than 1.2 million people killed in road accidents each year and approximately between 20 and 50 million non-fatal injuries (Peden, 2008). Thus, various studies have investigated injury severity from five point of views depending on the influencing factors. These factors are categories into the following five groups: 1) human characteristics; 2) vehicle characteristics; 3) road geometric characteristics; 4) environmental characteristics; 5) crash or dynamic factors. There is a lack in literature in terms of analyzing the characteristics of each vehicle individually in the dynamic point of view

Method

A Chi-Square Goodness of Fit test and T-test are conducted to distinguish between target and bullet vehicles in related to crash severities. Three groups of analysis of real-world crash classified into "Serious Injuries, Minor Injuries, and Property Damage Only (PDO)". Each group is also explored through the use of associated paramters.

Results

Before answering the research question. The associated factors is outlined, as well as a detailed explanations of the anlaysis that is under gone. The summary of each part of the analysis are presented (See Figure 1, 2 and Table 1), and finally some recommendations as to future used for the data are suggested.

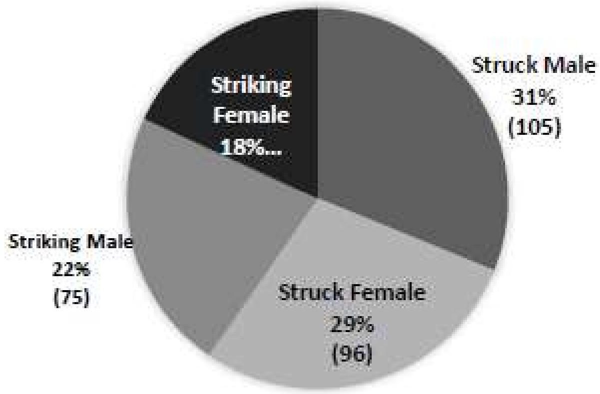

Figure 1. Severe and Fatal Percentage of Severe and Fatal Collisions related to gender for Struck and Striking Vehicles

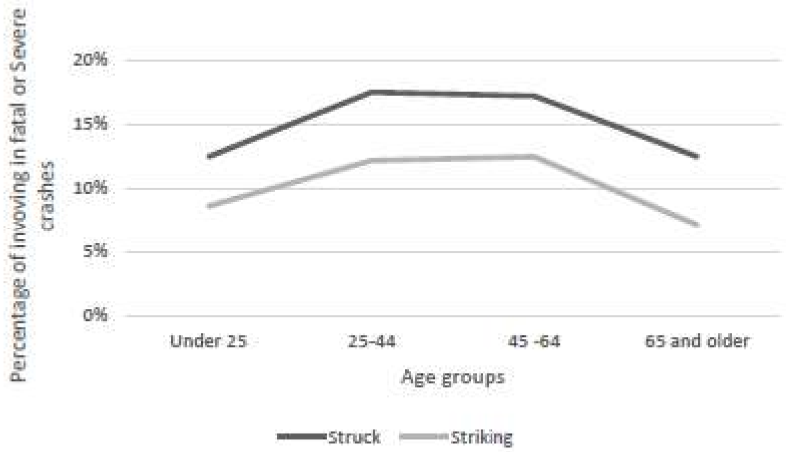

Figure 2. Severe and Fatal Percentage of Severe and Fatal Collisions related to age for Struck and Striking Vehicles

Table 1. Relationship between delta V and the severity of crashes

Struck								
Change in velocity KM/HR.	**PDO**		**Severe or Fatal**		**Minor**		**Total**	
0 - 19	1263	69%	13	10%	779	45%	2055	56%
20 - 39	511	28%	50	40%	765	44%	1326	36%
40 - 59	62	3%	34	27%	152	9%	248	7%
60 and over	6	0%	27	22%	33	2%	66	2%
Sub. Total	1842	100%	124	100%	1729	100%	3695	100%
Total	1842	50%	124	3%	1729	47%	3695	100%

Striking								
Change in velocity KM/HR.	**PDO**		**Severe or Fatal**		**Minor**		**Total**	
0 - 19	1282	67%	17	20%	786	43%	2085	54%
20 - 39	550	29%	24	29%	878	48%	1452	38%
40 - 59	68	4%	18	21%	146	8%	232	6%

60 and over	14	1%	25	30%	25	1%	64	2%
Sub. Total	1914	100%	84	100%	1835	100%	3833	100%
Total	1914	50%	84	2%	1835	48%	3833	100%
P value for Chi-Square of Struck	<0.0001							
P value for Chi-Square of Striking	<0.0001							

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Crash Reduction in Wet Weather on M1 with Intelligent Transport Systems

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Roads & Maritime Services

Abstract

In 2006 the speed limit on the northbound carriageway on the M1 (between the Hawkesbury River and Mount White) was increased to 100km/h for dry conditions and designed to drop to 90km/h in wet weather using Intelligent Transport Systems (ITS). This study analyses variation in crashes before and after the implementation of the system for both northbound B and southbound carriageways. The crash data includes fatal crashes, injury crashes and non-injury crashes for both dry and wet conditions. The analysis portrays what worked and what didn’t work with the implementation of an ITS based variable speed system in a motorway environment.

Background

Over the past twenty years, a high number of crashes on the M1 between the Hawkesbury River and Mount White resulted in the reduction of the speed limit for the area. However, in 2006, following public demand for higher speed the Roads and Maritime Services implemented a variable speed limit scheme that increased the speed for the northbound carriageway to 100km/h for dry weather condition only and lowered it to 90km/h during wet weather.

Method

In order to assess the effect of the variable speed limit scheme, Roads and Maritime compared crash data for dry and wet conditions for the seven years before and after the scheme was introduced. Roads and Maritime also assessed vehicle volumes as part of this study. The data revealed that there were no changes in road conditions such as road surface improvements, signs, delineation, speed limits or road widening post installation of the system that could affect the results (Ozroads, 2014). Changes in vehicle technologies over the period were not considered.

Intelligent Transport System

The ITS system utilizes Variable Speed Limit Signs (VSLS) to vary legal speed in wet weather on the northbound carriageway and includes a speed camera for enforcement. The VSLS are switched to a lower speed when wet weather is encountered by the wetness sensors. See Figure 1 for location of ITS on the M1.

Figure 1.ITS Location

Findings and Results

Of the three main crash categories assessed, there was a marked improvement of overall crash numbers on the northbound carriageway after the introduction of the ITS system in 2006, however the increase of injury crashes indicated an opportunity for further improvement. After comparing the northbound versus southbound data, Roads and Maritime identified higher crash levels on the northbound as a result of the steep and curvaceous road, and increased northbound traffic volumes (on average five per cent). The scheme implemented a higher speed of 100km/h for northbound in dry condition rather than a lower speed limit e.g. of 80km/h in wet conditions. In accordance with Nilsson's Power Model, higher speeds attract higher crashes (Nilsson, 2004). The increased number of crashes at higher speeds results in more injuries.

What's more, because the speed camera is located at the top of the hill, there is a natural tendency for motorists to increase speed after passing the speed camera. The steep slope at the end of the variable speed limit allows motorists to increase their speed to 110km/h on this slope with sharp turns and in presence of heavy vehicles.

The southbound speed limit remains at 90km/h for all weather conditions. While the speed camera is on the northbound it is detected on the southbound due to proximity. Also, the southbound has more regular police patrols that have become more intense over the years. The results are summarized in Table 1.

Table 1. Summary of Crashes 1999 to 2013

Direction of Travel	Injury		Non-Injury		Fatal	
	Dry	WET	Dry	Wet	Dry	Wet
Summary 1999 to 2006						
Northbound	19	33	59	93	2	1
Southbound	15	34	28	68	0	1
Total	101		248		4	
Summary 2007 to 2013						
Northbound	29	37	28	61	0	0
Southbound	14	21	24	45	0	2
Total	101		158		2	

Conclusion

A variable speed limit on the M1 using ITS reduces the overall number of crashes on the northbound even while the speed is increased from 90km/h to 100km/h during dry conditions.

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Motorcyclist, Make Yourself Visible

David Wright[a] and George Formentin[b]

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Abstract

The Motorcycle Riders Association of Western Australia through their involvement with the Western Australian Motorcycle Safety Advisory Group recognized a rider hazard that we believed was not fully covered by any on line or hard copy publication that we could find. We therefore set about working with Main Roads Dept. of Western Australia on the dangerous position that some motorcycle riders find themselves in, with the intention of educating them to recognize and when possible avoid these situations. We therefore produced the booklet Make Yourself Visible.

Make Yourself Visible Booklet

As part of our commitment to motorcycle safety, members of the W.A. Motorcycle Safety Advisory Group review the motorcycle and scooter fatality and serious injury major crash investigation undertaken by Main Roads Department of W.A. this includes information from the W.A. Police, major crash investigation. We have been conducting these reviews over the past 3 years and it was apparent that in a large proportion of these fatal and serious injury crashes were as a result of bad decisions by riders in their road positioning, or not recognizing road hazards by the rider. After an extensive search we could not find any information to inform riders of the dangers and too educate then as to correct road positioning. Through collaboration by Main Roads Department of W.A. and the Motorcycle Riders Association of W.A. Inc. we were able to build a series of examples of dangerous road positioning by motorcycle riders based on actual fatal motorcycle crashes investigations. With this information the Motorcycle Riders Association of W.A. Inc. produced a series of simple graphic sketches and some photographs of dangerous situation that riders can encounter on our roads. We than employed a graphic artist to put the final touches to these sketches and produce a print and on line version of the finished booklet. We kept the text to a minimum in the booklet as we wanted the riders to simply look at the examples and quickly understand the danger without an unnecessary overload of text. We believed that we as motorcycle riders understand better than most what a rider will look at and absorb. We attempted to keep this booklet relatively simple to read and understand with just a few examples of the dangers in an attempt to raise their awareness of the dangers of not being seen by other road users. This booklet was launched in November 2015during the W.A. Motorcycle Safety Week by the Minister for Road Safety. The booklet is available on our website www.mrawa.org

The Real Cost of Serious Injury

Lyn Journeaux

Trauma Department, Royal Australasian College of Surgeons

Background

Trauma is a significant public health problem and a major cause of death and disability in Australia, with young persons being the most affected. The 'costs' of trauma are extensive and intrusive, including human, social and financial costs. The health costs are also considerable, especially road transport related trauma, which accounts for more than half of the trauma surgery undertaken in Australia.

Purpose of Symposium

The symposium will explore the cost of patient care and the provision of adequate resources from the cost to the patient, their families and the community as well as hospitals, health providers and third party insurers. Topics will include the need for leadership in areas of trauma prevention (especially for youth, quad bike users and all road users), decision-making in the operation theatre and effective and meaningful data collection.

Justification

Annually there are 32,000 hospitalisations for serious injury and 1400 deaths. The financial cost each year is $27 billion. Injuries in the workplace cost the Australian economy more than $60 billion each year. The impact of injuries is far-reaching and more can be done to ensure the best, most cost-effective, care is delivered at all times.

Presenters, Title of Presentation & Brief Description

Dr Ailene Fitzgerald, Ms Rebekah Ogilvie, PA.R.T.Y. Program at Canberra Hospital

The international P.A.R.T.Y. (Prevent Alcohol and Risk-Related Trauma in Youth) program has been running in Australia for over 15 years. It is an effective way to raise awareness to the 15-25 age group of the dangers of alcohol with particular attention to road trauma. Injury is the leading cause of death and hospitalization among young Australians and can result in long-term disability.

Dr Warwick Teague, Quad bike injuries in the young

Quad bike trauma represents a concerning and increasing burden of injury across Australia, with children accounting for 1 in 5 serious quad bike related injuries or deaths. On average, 15 Australians die each year from quad bike related injuries. Legislative changes may play an important in future efforts to reduce quad bike injuries and deaths in Australian children.

Dr Valerie Malka, Distracted young driver

The use of mobile phones is a contributing factor in one in five car crashes and two in three truck crashes. It is difficult to estimate the size of the problem in terms of distracted communicating because these statistics are not collected in hospitals. However more than 90% of Australian drivers own a mobile phone, and 60% report using their mobile phone while driving.

Dr John Crozier, Australian Trauma Registry - Serious injuries, rehabilitation and costs

The Australian Trauma Registry collates data from patients with an Injury Severity Score greater than 12 from 25 major trauma centres. The registry can track actions of the National Road Safety Strategy and provide relevant information on serious injuries from road crashes. The registry is a key to measuring trauma performance and cost, which can lead to improved understanding of variability in trauma care and encourage practices of the best performing services.

Road Safety's Family Feud

Marilyn Johnson[a,b,c], Melinda Spiteri[a,d], David Healy [a,e], Kenn Beer [a,f], Jessica Truong [a,g]

[a]Australasian College of Road Safety (Victorian Chapter); [b]Institute of Transport Studies, Monash University, Clayton Vic 3800; [c]Amy Gillett Foundation, Melbourne Vic 3004; [d]Royal Automobile Club of Victoria (RACV), Noble Park Vic 3174; [e]Road Safety consultant, Melbourne Vic 3000; [f]Safe System Solutions, Brunswick Vic 3056; [g]Jessica Truong, Global NCAP, London, UK

Background

This interactive symposium is based on the format from the television program Family Feud and engages delegates of the 2016 Australasian Road Safety conference. The host (KB) will lead two teams consisting of volunteer conference delegates through a series of questions where the team members suggest an answer. Questions in the symposium will directly address the conference themes of: agility, innovation, impact. The responses to the survey will be collated and presented as the 'survey responses' in the symposium. In the weeks leading up to the conference, the authors will forward to conference delegates a short online survey asking them to answer questions on the following themes:

- What action has made the biggest impact on making roads safe in Australasia?
- What is the next big issue that we need to tackle to reduce road trauma?
- How do we ensure that road safety is a priority for Governments?
- How do we encourage innovative thinking in road safety?

This format builds on a session held by the Australasian College of Road Safety, Victorian Chapter in 2015. While the format is entertaining, the questions address some of the big issues road safety in an innovative and interactive session for participants. Further, greater audience participation sparked discussions and engagement amongst participants. The session will also demonstrate the value of ACRS membership and the collegial environment of the state chapters.

Purpose of symposium

The purpose of the symposium is to create a fun and engaging session that will spark discussion about some of the 'big picture' questions in road safety. It also provides an opportunity for Family Feud participants and audience members to start conversations about some of the answers provided in the survey.

Justification

This session is a structured opportunity to achieve two key outcomes:

- Explore the conference themes in a fun format
- Create the opportunity for people to start conversations and make new connections

Presenters, title of presentation and brief descriptions

The questions to be used in the symposium will be developed by the Victorian chapter and prior to the conference, all delegates will be invited to respond to the questions in an online survey which will be used in the symposium. Responses will be collated by the Victorian chapter and prepared in the Family Feud format.

Embracing Safety – Road Safe: Worker Safe

Michael Caltabiano

Australian Asphalt Pavement Association

Background

The safety at "Road Work Sites" initiative commenced in Queensland in a partnership between DTMR and AAPA in 2013 where the issue was explored as part of a strategic alliance project. AAPA then undertook its first National Workshop Series (NWS) in 2014 "Safety at Road Works" articulating a new way of addressing the problems being experienced on worksites around the country which has evolved into a national Austroads project with industry wide outcomes.

Purpose of Symposium

This symposium will present the outcomes from the Austroads process and the impacts these will have on the harmonized national delivery of safety around road works sites. It will also serve to present practical measures being implemented on the road network across Australia now and what other measures are being utilized across the World that have direct application in Australia.

Justification

This symposium will inform attendees of the current state of progress in the reform of the road work signage, layout, implementation and training. Information on the changes that will be delivered nationally that will impact on all road users and road builders alike will be discussed and information provided on the impacts of these changes.

Presenters, Title of Presentation & Brief Description

Mr Michael Caltabiano, CEO Australian Asphalt Pavement Association.

Overview of the symposium, what we will hear, learn and take away. Why is industry leading the way and what cooperative arrangements are in place for rapid implementation of change?

Mr Craig Moran, Roads and Maritime Services, NSW – Chair of the Austroads sub committee Safety at Road Work Sites.

Austroads is paving the way for great change in the way in which traffic management is delivered on road work sites and the training and how the accreditation of traffic management companies and personnel is delivered. Based on the international research outcomes there are five key focal points for change which will deliver safer road work sites for workers and motorists alike.

Name, Surname & Affiliation (TBD)

Industry representative from the traffic management or construction sector focusing on innovation in the safety at road work sites area. What are the implementable technologies not yet being used on Australian roads and what has already been done that sits outside the prescriptive specifications that is working? Why is industry taking the lead in this space?

Dr Eric Denneman, Director Technology and Leadership, Australia Asphalt Pavement Association.

An international perspective on road work site safety based on the recent 2016 International Knowledge Transfer (IKT) tour to Europe undertaken by AAPA. What is different and why? What is directly transferable to Australian conditions and the gains that will fall out from the adoption of new processes, methods and devices?

Developing a Practical Guide to Achieve Safe System Outcomes for Pedestrians

Hafez Alavi[a] and Bruce Corben[b]

[a]Transport Accident Commission (TAC), [b]Corben Consulting

Abstract

The Safe System Approach states that no pedestrian should be killed or injured using the transport system. While the key underlying principles of the Safe System Approach are generally well-understood, the translation of its premises into practice is not yet fully realized. Using the Kinetic Energy Management Model, we developed a framework to study pedestrian crash and injury risks. We developed a practical guide, consisting of pedestrian safety infrastructural measures, to address pedestrian crash and injury risk. We believe the guide will provide the necessary tool to address pedestrian safety issues, in an effective and Safe System compliant manner.

Background

The Safe System Approach states that nobody should be killed or seriously injured when using the transport system. The main underlying principles of the Safe System, relevant to road design and speed management for pedestrians are: a) *moral demand*, b) *human frailty*, c) *human fallibility*, and d) *shared responsibility*.

The key underlying principles and the intended outcomes (no deaths or serious injuries on the roads) of the Safe System Approach are generally well-understood. However, the translation of its theoretical and philosophical premises into practice is not yet fully realised, due, in part, to a lack of practical guiding principles. Such practical principles do not necessarily prescribe definitive solutions for road safety issues at hand, but provide a platform to assess the Safe System compliance of existing safety measures and to develop new measures to achieve Safe System outcomes.

Conceptual platform: Kinetic Energy Management Model

The concept of human frailty is the centrepiece of developing practical guides to realising the Safe System. Any practical realisation of the Safe System should ensure that the human body's tolerance of external forces is not exceeded. The Kinetic Energy Management Model (KEMM), developed by researchers at the Monash University Accident Research Centre (Corben, Cameron, Senserrick & Rechnitzer, 2004; Corben, van Nes, Candappa, Logan & Archer, 2010), is a conceptual model to study the risks of transferring of kinetic (motion) energy to the human. Five layers of protection are assumed to either prevent the crash (by 'deflecting' energy) or mitigate its effects (by absorbing energy). Figure 1 shows these layers.

It should be noted that the Safe System Approach does not require the elimination of crashes, if that proves to be impractical or too cost-prohibitive, but, mandates the elimination of deaths and serious injuries. Therefore, a greater emphasis should be put into the management of injury risk when applying the KEMM designing Safe System compliant measures.

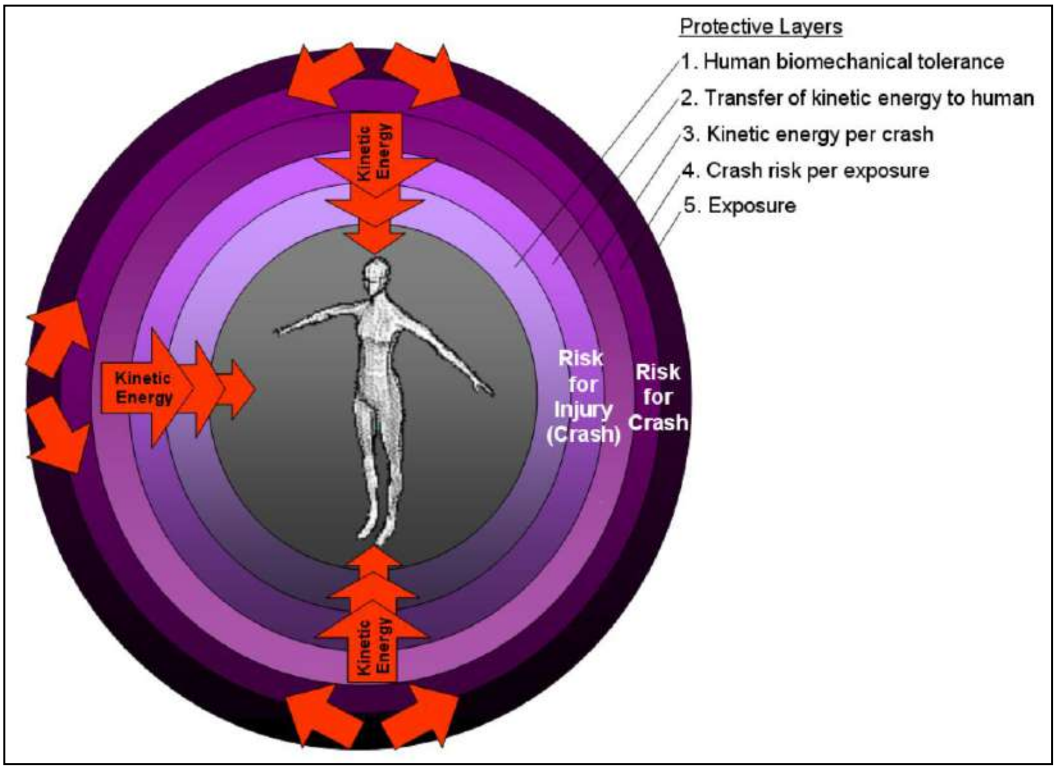

Figure 1. The five layers of protection of the KEMM (adopted from Corben et al., 2010)

Results: Practical guides to achieve Safe System outcomes for pedestrians

The KEMM provides the necessary conceptual framework to develop a set of practical guides to achieve Safe System outcomes for pedestrians. These guides are presented under the five layers of the KEMM, below.

It should be noted that speed and road infrastructure were the focus of this guide; therefore, all the practical guidelines are related to these pillars. However, it is acknowledged that vehicle safety and human behaviour play important roles to achieve Safe System outcomes for pedestrians. These were out of the scope in this research.

Furthermore, fatal/serious injury prevention is the focus of the Safe System Approach. Therefore, a greater emphasis should be put into measures that manage injury risk than those that just manage crash risk.

Exposure management

1. Re-think road function: Depending on the type and frequency of road use, re-consider the function of the road to manage exposure.
2. Manage traffic flows: Redirecting traffic to low-risk, alternative routes to provide a safer environment for pedestrians and cyclists.
3. Reduce travel speeds

Reduce crash risk

1. Reduce travel speeds
2. Eliminate/manage conflicts at intersections
3. Eliminate/manage conflicts at road lengths

4. Increase readability of road environment
5. Provide appropriate number and position of crossings:
6. Eliminate or moderate crash risk factors

Limit crashes' kinetic energy levels

1. Reduce travel/impact speeds
2. Increase homogeneity of mass

Limit crashes' kinetic energy levels

Increase the energy absorption of pavements, roadside and road furniture.

Enhance human biomechanical tolerance

No practical infrastructural solution is identified to enhance human biomechanical tolerance.

Conclusions

The Safe System Approach aspires to eliminate deaths and serious injuries for those using the transport system. Based on a set of elegantly simple theoretical and philosophical principles, its application can be a challenge to the general practitioner when translating it into practice. This document has applied the KEMM conceptual model to develop a set of practical guides to achieve Safe System for pedestrians. It is envisaged that these guides will be an aid to the general practitioner in the journey towards achieving Safe System outcomes through identifying and/or developing Safe System compliant measures.

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Safe System Transformation for Pedestrians

Hafez Alavi

Transport Accident Commission

Background

Walking has been being promoted in Victoria, as a green mode of transport with proven public health benefits. It is shown that lack of safety, both perceived and actual, is a major barrier against take up of walking. Moreover, the anticipated increase in walking levels will result in even more pedestrian deaths and serious injuries if pedestrian risk is not addressed. The Victorian Government has pledged itself to fund pedestrian safety measures in Victoria.

Purpose of Symposium

The main purpose is to investigate how the Safe System principles can be translated into practical applications for pedestrians. A practical guide developed in Victoria will be presented and discussed. Furthermore, a few common challenges that pedestrian safety practitioners encounter, namely: identifying highly effective pedestrian measures, studying spatial distribution of pedestrian severe casualties and developing comprehensive, Safe System complaint pedestrian safety programs, are discussed through presenting relevant case studies from Victoria.

Justification

Although elegant, the Safe System principles may challenge practitioners to be translated into practice. Providing a practical guide to achieve Safe System outcomes for pedestrians is timely. There is a need to focus the limited funds available to areas where pedestrian road trauma concentrates and to utilise the most effective measures to treat pedestrian safety issues. It is useful to demonstrate how these can be used to develop a Safe System compliant pedestrian safety program.

Presenters, Title of Presentation & Brief Description

Pedestrian safety in Australia and New Zealand – risk factors and emerging issues

Shane Turner, MWH Global

Walking has been being promoted in Victoria, as a green mode of transport with proven public health benefits. It is shown that lack of safety, both perceived and actual, is a major barrier against take up of walking. Understanding risk factors that contribute to pedestrian crash and injury severity risks will help us paint a more precise picture of pedestrian safety landscape in Victoria. What is more, there are a few emerging issues such as distracted pedestrians and the ageing population that deserve more detailed discussions.

Developing a practical guide to achieve Safe System outcomes for pedestrians

Bruce Corben, Corben Cosulting; Hafez Alavi, Transport Accident Commission

Although elegant, the Safe System principles may challenge the general practitioner to be translated into practice. Using the Kinetic Energy Management Model (KEMM), a hierarchical practical guide was developed to a) manage pedestrian crash risk (conflict and crash risk management), and b) manage pedestrian injury severity (energy, transfer, body tolerance).

Evaluating the effectiveness of pedestrian safety measures in Victoria

Amir Sobhani, ARRB Group; Hafez Alavi, Transport Accident Commission

There is a paucity of research into the effectiveness of pedestrian safety measures in Victoria. Also, it is important to identify measures that are likely to treat a greater part of pedestrian severe road trauma. Studying pedestrian road trauma in Victoria, four major pedestrian measures were identified and evaluated.

Identifying high pedestrian serious casualty areas in Victoria - a geospatial analysis

Deepak Gupta, VicRoads; Hafez Alavi, Transport Accident Commission

Considering the limited funds available to enhance pedestrian safety across Victoria, it is important to identify high pedestrian serious casualty areas to focus infrastructural investments. Using the Kernel Density technique, the spatial distribution of pedestrian serious casualties across Victoria is investigated. The high ranking areas are suggested for developing pedestrian safety programs.

A Geospatial Analysis to Identify and Rank High Pedestrian Serious Casualty Areas across Victoria

Deepak Gupta[a], Hafez Alavi[b], Warren Blandy[a]

[a]VicRoads; [b]Transport Accident Commission (TAC)

Abstract

Identifying and ranking high pedestrian serious casualty (PSC) areas enable practitioners to develop more targeted and efficient pedestrian safety programs. We employed the Kernel Density method to study the spatial distribution pattern of PSC's and formulated PSC density criteria to rank the identified areas. We used police-reported injury data for the 8 year period to 2013, where the reported injury levels were validated using the TAC hospitalisation data. We produced concentration maps, identified numerous high PSC concentration areas across Victoria, and ranked them using the land area and estimated traffic volumes of each area. We introduced the top 87 areas for pedestrian safety program development under the Safe System Road Infrastructure Program (SSRIP).

Background:

Pedestrians are among the most vulnerable road users and the Safe System Approach mandates the provision of specifically-designed road environments to ensure their safety. Pedestrian serious casualties (PSC) are usually concentrated across dense urban environments. However, considering the expanse of the Melbourne Metro and the regional urban areas in Victoria and the limited pedestrian safety funds, it is necessary to identify and rank high PSC areas. Such knowledge is vital to guide the investments under the Safe System Road Infrastructure Program (SSRIP) to develop more efficient and targeted pedestrian safety programs.

Data and method:

Police-reported crash data for the 8 year period to 2013, where the reported injury levels were validated using the TAC hospitalisation data, indicate that more than 12,000 pedestrian injuries occurred in Victoria, almost half of which (5,388) were classified as fatal or serious injuries. This represents 1,500 pedestrian injuries each year, of which approximately 670 will be fatal or serious injury. Whilst pedestrian fatal and serious injury numbers are reducing, serious injuries as a proportion of all other road user serious injuries have increased, indicating that the pedestrian safety issue is not reducing in line with other road users.

PSC's are scattered across a road network of 150,000 km roads. Geo-spatial mapping has become a valuable technique for visualising the geographic incidence of socio-economic data and therefore is well suited to studying the spatial distribution of PSC's (Pulugurtha, Krishnakumar, & Nambisan, 2007). One of the most widely used techniques for generating heat maps is kernel density estimation (KDE) combined with Geographical Information Systems (GIS) (Pulugurtha, & Sambhara, 2011). The geo-spatial mapping concept is based on the evident spatial interaction existing between contiguous PSC locations, and KDE is a non-parametric way to estimate the probability density function of a random variable (Pulugurtha, & Repaka, 2008).

The geospatial analysis process involved four steps:

Step 1 - Identify pedestrian serious casualty data: The source of data was taken from VicRoads Road Crash Information System and cross checked against TAC claims information to verify crash severity.

Step 2 – Geo-code pedestrian serious casualty data: The TAC Validated data was coded into a GIS data set and plotted onto a map of Victoria. This task allows the creation of PSC concentration maps. The user can view serious casualties across Victoria and has the ability to zoom into individual crash locations (Figure 1). However whilst geo-coded crashes show the degree of spatial clustering and dispersion, it does not clearly identify the level of concentration.

Figure 1. Pedestrian serious casualties in the Melbourne CBD

Step 3 - Create a crash concentration map (heatmap).

GIS mapping software was used to map the crash density, i.e. the magnitude of serious casualties per area unit, with the application of KDE. Using KDE, we calculated a density value for each area. These values are represented with colour (Figure 2).

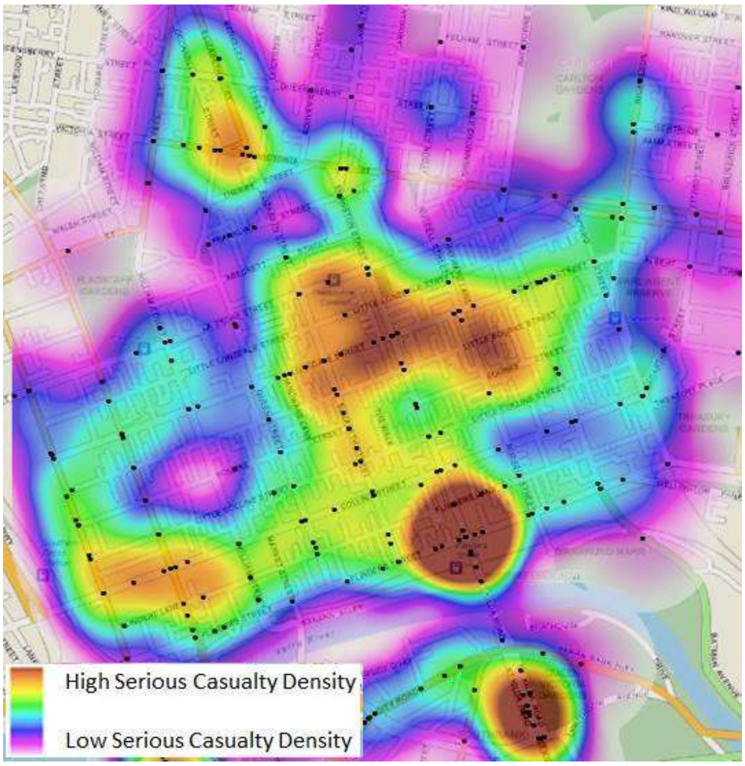

Figure 2. Concentration of pedestrian serious casualties in the Melbourne CBD

Step 4 - Identify areas, their shapes and sizes.

Once having created the heatmap the user can objectively focus on the high density locations. The heatmaps may indicate that the area is circular or linear. VicRoads Spatial Services team examined all the high density areas in heatmaps across Victoria, and identified and ranked highly concentrated areas. This has resulted in a list of 87 high PSC areas across Victoria.

Conclusions:

We studied the spatial distribution of pedestrian serious casualties across Victoria. Using an 8-year worth police-reported pedestrian injury data, validated against TAC hospitalization data, we employed geospatial methods combined with Kernel Density Estimation technique to identify and rank high pedestrian serious casualty areas in Victoria. We identified a total of 87 top priority areas to be funded under the Safe System Road Infrastructure Program. We believe targeting these areas will yield significantly higher road safety gains for pedestrians as well as increasing the efficiency of the program.

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Pedestrian Serious Casualty Risk in Victoria, Australia: A Logistic Regression Analysis of Road, Environmental and Human Demographic Factors

Amir Sobhani[a], Chris Jurewicz[a], Hafez Alavi[b], Michael Nieuwesteeg[b]

[a]ARRB Group Ltd; [b]Transport Accident Commission

Abstract

Pedestrian safety is securing more and more support from the Victorian Government. This paper investigated the effect of road, environmental and human demographic characteristics on the likelihood of pedestrian fatal and serious injuries in Victoria, Australia. Pedestrian injury data was obtained from Transport Accident Commission (TAC) dataset, where the injury data are validated using TAC hospitalization data. A binary logistic regression model was developed to identify factors influencing the likelihood of pedestrian serious casualty. This study will assist TAC and VicRoads in formulation of pedestrian programs and selection of treatments which effectively target pedestrian serious casualty risk factors.

Background:

Pedestrian injury and mortality are a global issue, with more than 270,000 pedestrians killed worldwide each year (World Health Organization 2013a), and this represents approximately 22% of all global road trauma. In Victoria, 249 road fatalities were reported in 2014 from which 18% were pedestrian fatalities. These statistics convinced the Victorian Road Safety Partners to develop a number of major programs to reduce number and severity of pedestrian serious casualties.

Although research were conducted to understand crash attributes contributing to pedestrian casualty crashes in Victoria (Corben et al. 1996; Oxely et al. 2013; Senserrick et al. 2014), these studies were limited and did not adequately concentrate on pedestrian serious casualties. This article outlines the effect of road, environmental and human factors on pedestrian serious injuries and fatalities.

Method:

This study performed a comprehensive literature review of past studies conducted in Victoria to investigate crash attributes affecting pedestrian serious injury problem. Chi-square test was conducted to identify the crash parameters which have a statistically significant effect on pedestrian injury severity. Then, the identified variables entered into a binary logistic regression model to understand the relative importance of the factors. Change in the value of the model likelihood function was used to indicate the relative effect of each variable on the model outcome. The relative importance of levels of variables was indicated using the value of odds ratio.

Results:

The literature review of factors influencing the pedestrian serious injury problem in Victoria highlighted the following gaps in knowledge:

- Most of the studies used simple statistical analysis to understand factors affecting the number and severity of pedestrian fatalities and serious injuries. Very few studies utilised multivariate statistical analysis method to better understand the relative importance of these factors (Alavi, 2013; Senserrick et al. 2014).

- Different types of databases were used to conduct pedestrian injury/crash analyses. The majority of studies used Road Crash Information System (RCIS) data to conduct their analysis. Alavi (2013) revealed that the relative importance of different parameters was different if the same analysis was carried out using police and hospital data. Therefore, more accurate understanding could be achieved using a combined database.

- Limited studies focused on understanding the effect of crash factors on pedestrian fatality and serious injuries.

The results showed that:

- 'speed zone', 'age', 'crash time', 'location type', 'pedestrian movement', 'atmospheric condition' and 'gender' were the significant parameters affecting pedestrian injury severity level.

- Higher speed limit was associated with higher possibility of being involved in a pedestrian FSI. This possibility was substantially increased if the speed limit was 70 km/h or more.

- Age of the pedestrian significantly influenced the likelihood of being involved in a pedestrian fatal and serious injury. Pedestrians aged more than 65 years old were associated with higher possibility of being involved in pedestrian serious casualties. This possibility is almost equal for other age groups.

- Crash time was also found to be a significant factor affecting the number of pedestrian fatal and serious injuries. 'Dark AM off-peak' and 'PM off-peak', which are dark times of the day, significantly increased the likelihood.

- Mid-blocks were associated with more pedestrian serious casualties than intersections

- Pedestrian movement defined by DCA was the other significant factor affecting injury severity. 'Crossing carriageway', 'working/playing/lying or standing on carriageway' and 'not on carriageway' were the most problematic movements in fatal and serious injury pedestrian crashes.

- In terms of gender, males were more likely to die or be seriously injured than females. However, this difference was very marginal.

The model also revealed that three variables, which had the most effect on the model results, are 'age', 'speed zone' and 'pedestrian movement'.

Conclusions:

This study confirmed and improved the current understanding of pedestrian serious injury problem in Victoria, Australia. The findings pointed to the need to focus future programs and treatments on road crossings.

In future studies, it is recommended to use random parameter logistic regression modelling technique for this analysis. This method improves understanding of the factors influencing pedestrian injury severity since it accounts for unobserved heterogeneity in the data.

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Building Capacity for Road Safety and Taking Responsibility

Lauchlan McIntosh

ACRS

Background

Improving road safety results requires multi-disciplinary actions, which are often poorly coordinated. There tends to be an overemphasis on blaming the road user, and the responsibility of research, infrastructure, vehicles, technology and trauma care as well as the total cost to the community is not well recognized nor given equal or even a higher priority within the system. The role of management of the total system, or the interactions within the system, and hence the allocation of responsibility is clouded. Who should, or who can build the capacity necessary for that interaction and how will we allocate reduction responsibility targets?

Purpose of Symposium

At the 2015 ARSC a Symposium "Who is Responsible for Road Safety" mostly concluded that road safety should be included within a much broader community safety agenda, a collaborative leadership model between all the participants in a safe system was needed, we should promote and advocate the benefits of successful programs and determine "who should or could take responsibility?" The last question remained unanswered. This symposium will seek to identify the capacity of the various pillars within the Safe System to specific areas of responsibility and accountability in discussion to consider how to join the pillars to gain synergy, and hence more reductions in road trauma by collaboration with many governments, business and the community.

Justification

The Safe Systems model for improving road safety sets out opportunities and actions in five pillars; Road Safety Management, Safer Roads and Roadsides, Safer Vehicles, Safer Drivers, and Post-Crash Care. The coordination of these five appears to be left with governments who have some responsibility for areas such as infrastructure design and most funding, vehicle standards and behavior enforcement; but not always for ideas, research, technological change, market power, or the user. Are there too many free riders who expect others to improve road safety?

Presenters, Title of Presentation & Brief Description

Austroads Program Manager for Safety, David Bobberman

How is the Australian Road Safety Strategy and Action Plan allocating responsibility within the five pillars and what are the coordination mechanisms?

Mr Eric Howard, Global Road Safety Advisor at the Monash Accident Research Centre.

Building capacity with road safety leadership and management training

Dr Richard Tooth Director sapere research group limited.

The use of the insurance market has potential to result in a massive step-change and cost-effective improvement in road-safety.

Lauchlan McIntosh President ACRS

How can or should a professional organization such as ACRS contribute to building capacity and encourage coordination?

Gruen Transfer: The Road Safety Pitch

Jacinta Cubis[ab], Phoebe Dunn[a], Marilyn Johnson[ac], and Kate Mckevitt[a]

[a] Amy Gillett Foundation; [b]QBis: Engagement and Partnering for Social Impact; [c]Monash University Institute of Transport Studies

Introduction

During this symposium students will present pitches for road safety communication solutions in answer to the question 'how do we tackle the sense of entitlement on the roads in Australia and New Zealand?'

Students will tackle the issue of how to help people start to move from the attitude of, 'to get where I want' to 'everyone getting to where they want safely'. The ABC television program the Gruen Transfer is the model for this symposium, which will also include a facilitated discussion on the content of the student pitches with an expert panel. One team will be selected as the winner, and there will also be a people's choice award. This session will provide valuable industry feedback for the students who are involved, and facilitate important discussion surrounding road safety.

Although the students are given creative license in creating their clip (e.g. can be emotive, humorous etc) they must address the question 'how do we tackle the sense of entitlement on the roads in Australia and New Zealand?' All video clips will be thoroughly vetted in the shortlisting process, and must adhere to the Commercial TV Code of Practice. All clips will also contain the ARSC2016 logo.

Symposium format

The intro:

- The host welcomes the attendees, and gives an outline of format for the session (host)
- The host briefly introduces each expert panel member (host)

- *The presentation session:*
    - Team #1 is introduced by the host
    - Team #1 student representative give a "pitch" intro on their entry – describes the approach to brief.
    - Team #1 video clip is shown
    - The expert judging panel briefly discusses Team #1 entry and provides feedback.

  The above structure is repeated for all 4 -5 shortlisted student teams.
- The host wraps up the presentation section

The discussion:

- The expert judging panel discusses and reviews all entries
- The conference audience are given the opportunity for comment / facilitated questions

The Awards

- The host announces the winner of the AGF Road Safety Award, invites the winning team to speak.
    - The winning team student/s representative speaks/thanks.
- The host announces the winner of the People's choice award (previously voted for)
    - The People's Choice student/s representative speaks/thanks.

Close

- The host closes the session, thanks etc.
- A sample of 'local' road safety advertisements are shown as the last slide to inspire students and participants.

Participants involved

- **Host:** Kenn Beer (Safe System Solutions).
- **Student teams:** The students will be confirmed once teams are shortlisted.
- **The expert judging panel will be comprised of:**
    - A road safety expert from the Amy Gillett Foundation;
    - A representative from the Australian College of Road Safety (Lauchlan McIntosh tbc)
    - A road safety expert from sponsor 3M; and
    - An advertising and media expert from award winning Advertising Agency McCann.

Intended impact of the symposium

This symposium intends to spark discussions about how advertising and creative approaches can be harnessed to challenge established narratives about road safety in stimulating and innovative ways. Importantly, this symposium will encouraged new minds to consider road safety, as typically undergraduate university students do not engage in the road safety space. This symposium will create space for new approaches, new ideas and new collaborations to begin.

After the symposium

The winning video clip and people's choice video clip will be launched by the Amy Gillett Foundation and AGF partners via social media.

Engaging organisations to develop an effective policy around the use of mobile phones in vehicles

Jerome Carslake

ARRB Group Ltd

Background

The mobile phone has revolutionised the way we communicate. It has not only permeated every facet of our lives – work, personal and social – but has brought them together into the one space. And because our mobiles are always at arm's reach, they have the potential to impact on everything we do, including driving a car. Using a mobile phone while driving is a growing and concerning behaviour for businesses, organisations and the community at large.

Purpose of Symposium

Businesses have a responsibility to provide a safe working environment and the car and phone are often crucial tools. This symposium presents the policies, procedures and research to promote employer and worker compliance with Australia's driving laws based on education and awareness and providing practical advice to drivers on how to minimise distraction risks. The National Road Safety Partnership Program (NRSPP) established a Working Group to guide organisations and the wider public on the safe use of mobile phones in vehicles.

Justification

The symposium would outline the various stages of the Working Group's activities and seek feedback from participants on them.

Presenters, Title of Presentation & Brief Description

Research evidence that supports the policy development

Mitchell Cunningham and Professor Michael Regan, ARRB

There is a large body of road safety research that shows mobile phones are one of many distractions that drivers face on a daily basis. Presented will be a review of existing literature and the key risks identified by drawing on naturalistic driving studies and other relevant data

Agreed principles and their successful implementation in an organization

Jerome Carslake, ARRB Group

Present the Working Group's agreed principles based on the research and common sense that will empower the driver around understanding the risk and changing behavior through empowerment. The principles are underpinned by a guide on how organisations should develop and implement a phone policy.

Communications to influence businesses to adopt the policy

Andrew Hardwick Hard Edge Media

Will outline the development of an education campaign that provides:

- Business-to-business communications whereby leaders are engaging their peers seeking them to adopt good practice mobile phone policy among their workers and advocate to the community
- Middle management.
- Workers.
- Social network to recognise organisations that have adopted policy

Facilitated discussion with the audience on identifying measures to evaluate the Working Group's effectiveness and on the engagement process.

Autonomous, semi-autonomous and existing vehicles What will be the impact on road safety results and when?

Lauchlan McIntosh

ACRS

Background

A recent Infrastructure Australia Plan (February 2016) states; "Over coming decades, the greater automation of vehicles is likely to require a growing network of devices and sensors in and around roadways. The automation of vehicles is well-underway, with many new vehicles including various technologies to assist drivers or override controls when an accident or loss of traction is detected…The technology can enable drivers to use their time more productively, prevent accidents, save fuel, reduce emissions, raise average speeds and expand the capacity of roads and parking facilities through assisted driving and self-parking.

Purpose of Symposium

The Infrastructure Plan fails to outline any specific actions, any quantifiable benefits, or any timetable for the "prevention of accidents" by the introduction of the automation of vehicles. The Plan does state; "that increasingly complex vehicle and data collection systems increase barriers for consumers to fully understand the benefits and costs of adopting new technologies. Governments should ensure developments provide benefits for all road users, and mandate manufacturers provide objective information on vehicle technologies and their use of consumer-generated data." The Symposium will discuss these issues to encourage commitment to the introduction of automation actions to obtain tangible reduction in road crash trauma.

Justification

The development and implementation of vehicle "automation" technologies is already providing significant reductions in crash rates as evidenced from many sources including research, insurance and real world crash results. (eg Electronic Stability Control crash reduction at least by 25%; low-speed Autonomous Emergency Braking technology shows a 38% reduction in real-world rear-end crashes. These and other technologies in vehicles, in infrastructure and management /delivery of mobility are disrupting existing models and plans. Recognition of the impacts of disruption with the associated disintermediation is vital for infrastructure planning.

Presenters, Title of Presentation & Brief Description

Hiep Bui Chief Engineer Subaru Australia

Subaru is a leader in preventative safety innovations with "Eyesight®" driver assist as well being the first manufacturer in Australia to offer 5 star ANCAP rating for every car sold

Gerard Waldron ARRB Group and Leader of the Australian Driverless Vehicle Initiative

The Initiative's vision is "To accelerate the safe and successful introduction of driverless vehicles onto Australian roads"

Wendy Machin Chair ANCAP Australasia

ANCAP's role is to test and assess the relative safety of new vehicles for new car consumers. How will consumers react to and trust "automation"?

Professor Mike Lenné, Chief Scientific Officer, Human Factors at Seeing Machines

Seeing Machines' driver fatigue and distraction monitoring technology, initially developed for the mining industry, has evolved into a driver monitoring solution that is being implemented by the global automotive industry to help manage safety during automated driving.

The MUARC TAC Enhanced Crash Investigation Study: Early findings from the case and control data

Michael Fitzharris

Monash University Accident Research Centre

Background

The MUARC-TAC Enhanced Crash Investigation Study (ECIS) is a multidisciplinary case-control in-depth crash investigation study that seeks to understand the factors associated with serious injury crashes in Victoria. Over a three-year period, ECIS will investigate 400 serious injury crashes and obtain data from over1500 drivers who are observed driving through known crash sites without incident. These data will provide invaluable insights into factors that contribute to the occurrence of serious injury crashes.

Purpose of Symposium

In this symposium, we present early findings from the ECIS case and control data. In particular, the findings from the first 200 serious injury cases are summarised, focusing on crash types and contributing factors. We also highlight the value of the ECIS methodology in using real-world crash and speed data to evaluate the safety performance of roundabout design using a case study method. Further, control data are presented highlighting the range of activities drivers report while driving and examining the relationships these share with factors such as driver fatigue and observed free travel speed.

Justification

ECIS represents a large-scale multi-component program that forms an important part of Victoria's road safety strategy. The ECIS program includes state of the art reviews of crash and injury risk factors, analysis of mass data – including cost of injury analysis, and a case-control element. Insights will be used to provide the basis for robust policy and evidence-based action plans. The case and control datasets provide valuable information about contributing factors, common crash types as well as self-reported behaviours drivers engage in whilst driving. The symposium offers the opportunity to disseminate the early finding to road safety professionals.

Presenters, Title of Presentation & Brief Description

The MUARC-TAC Enhanced Crash Investigation Study: Study Update, analysis of crash types and contributing factors

A/Prof Michael Fitzharris, Monash University Accident Research Centre

An analysis of early findings from the first 200 serious injury cases is reported. This analysis focuses on key crash types and contributing factors for the occurrence of those crashes.

Injury reduction benefits of roundabouts evaluated using real-world data and simulation software

Ms Sujanie Peiris, Monash University Accident Research Centre

Real-world crash and speed data are presented which highlight the safety performance of an existing roundabout design. Contemporary design issues are discussed in this context.

What drivers do while speeding: Examining the associations between speeding and driver distraction through the Enhanced Crash Investigation Study protocol

Dr Amanda Stephens Monash University Accident Research Centre

Potential relationships between observed driver speeds and activities undergone while driving are presented. Results suggest that these activities may differ for drivers recorded above the speed limit in comparison to those recorded on or below.

Associations between sleep quality and distracted driving. Exploratory results from the Enhanced Crash Investigation Study (ECIS) control data

Dr Amanda Stephens Monash University Accident Research Centre

The associations between sleep quality and activities reported while driving are examined. The results suggest that drivers engage in a range of activities while driving and these may differ according to the quality of a driver’s sleep and whether other passengers are in the vehicle.

The MUARC-TAC Enhanced Crash Investigation Study: Study Update, analysis of crash types and contributing factors

Michael Fitzharris[a,b], C. Raymond Bingham[c], Di Bowman[d], Samantha Buckis[a], Samantha Cockfield[e], Bruce Corben[f], Hampton C. Gabler[g], Jane Holden[a], Mike Lenné[a], Andrew Morris[h], Michael Nieuwesteeg[e], Sujanie Peiris[a], Amanda Stephens[a], ECIS Study Team[a]

[a]Accident Research Centre, Monash University; [b]National Trauma Research Institute, The Alfred; [c]University of Michigan Transportation Research Institute, University of Michigan; [d]Sandra Day O'Connor College of Law and the School for the Future of Innovation in Society, Arizona State University, USA; [e]Transport Accident Commission; [f]Corben Consulting; [g]Department of Biomedical Engineering and Sciences, Virginia Tech; [h]Loughborough Design School, Loughborough University.

Abstract

This paper presents an update of the Monash University Accident Research Centre (MUARC) – Transport Accident Commission (TAC) *Enhanced Crash Investigation Study (ECIS)* as well as an exploration of the characteristics of injured drivers, crash types and factors implicated in crash occurrence. Three configurations are of particularly high frequency and severity, whilst crashes involving young and older drivers are different in nature and have different contributing factors. Fatigue, driver error, and pre-crash driver blackouts due to medical conditions were prominent contributing factors. Injury severity would be significantly lower in 32% of cases if either front or side airbags were fitted. The findings point to key risk factors that can be addressed in road safety strategies.

Background

Crashes resulting in serious injuries are approximately 25 times more common than fatality crashes and are associated with significant impairment in quality of life (Fitzharris et al., 2007, 2010, 2015). While the personal and social impact of these crashes is significant, so too is the economic cost to the broader community (Collins, Lenné & Fitzharris, 2015).

It is thus important to understand the factors associated with the occurrence of serious injury crashes as this understanding can be used to guide road safety policy. Equally important is understanding the nature of injuries sustained, how they occurred, and how they can be mitigated in the event of a crash. The MUARC-TAC ECIS was purposefully designed to identify key road safety issues in Victoria and to create a robust evidence-base upon which road safety strategies can be based. The aim of this paper is to document common crash types that result in serious injury, and to document contributing factors for both crash occurrence and high injury severity.

Methods

The ECIS is a multidisciplinary case-control study that aims to examine the causes and consequences of 400 serious road crashes in Victoria across a three-year period. A complete description of the ECIS study is provided elsewhere (Fitzharris et al., 2015).

Relevant to this paper is the process of case completion and identification of contributing factors for drivers involved in the 'case arm' of ECIS. In short, injured drivers 18 years and older consent to participation in the study and are interviewed whilst in hospital. For those seriously injured, a next-of-kin may provide consent and details of the crash. Following this, each ECIS case is subjected to a comprehensive investigation with information collected from the injured driver supplemented with ambulance, police and medical history information, as well as a physical inspection of the vehicle and the crash location. This information is used to assess the factors that contributed to the crash, which is done first by each member of the 'case team', and following this, the case is subjected to a review by the entire ECIS team. Multiple information sources are used for this determination with each *Case* subject to a series of comprehensive reviews and panel discussions. Contributing factors are those where documented evidence exists that the particular 'factor' was not only present, but that it played a role in the occurrence of the crash or influenced the injury severity; for each factor deemed to have contributed in these ways, a 'confidence measure' of high, medium and low is awarded. More than one factor can be present at the time, although in the analysis presented here, the proportion of crashes where each was present and deemed a factor is reported.

Results

As at February 2016, 237 drivers aged 18 years and older admitted at least overnight agreed to participate in the study. Two-thirds of eligible drivers approached by the ECIS Research Nurses consented to the study. The sample consists of 135 males (57%) and 102 (43%) females, and 20% are aged 18-25 years, 19% were 26-39 years, 27% were 50-59 years, 20% were 60-75 years and 14% are 76 + years. One-third of crashes occurred in regional Victoria. The sample had a similar age and sex profile to all injured drivers admitted to The Alfred as well as those declining consent.

Crash types - Based on the information collected thus far, there appear to be five characteristic types defined by vehicle movement and location, and driver age, these being:

1. Crashes at un-signalised intersections in regional Victoria
2. Lane-departure crashes (run-off-road, head-on) in regional Victoria
3. Crashes at busy metropolitan intersections
4. Young driver crashes
5. Older driver crashes

These five characteristic crash types, noting overlap with the age-based categories, form the basis of identifying vehicle, infrastructure, technological and behavioural measures with the goal of reducing the likelihood of crash occurrence as well as mitigating the severity of injuries should these crashes occur.

As ECIS is an on-going program, to date 107 cases had been submitted to full internal MUARC panel review. Table 1 presents the most common factors directly associated with the crash occurring, and includes drivers involved in all five crash types noted above. Fatigue, driver error (e.g., failed to see other road user, misjudged road layout), medical condition-related 'blackouts' and driver emotional state were key contributing factors. Whilst not in the 'top-10' factors, current drug use (e.g., ice, THC, GHB) was a known factor in 7.6% of crashes which was only marginally lower than alcohol affected drivers (9.5%). Based on impact configuration, the absence of either a frontal or side airbag system adversely affected injury outcomes for 32% of drivers, as did excessive vehicle intrusion which was largely observed in vehicles that performed poorly in NCAP tests (13%) and lack of seat belt use (8.6%). Error on the part of another driver was the core contributing factor in 10% of crashes. In producing this table, no distinction was made between contributing factors of single vehicle and multi-vehicle crashes, which comprised 28% and 72% respectively of the sample.

Table 1. Contributing factor for serious injury crashes

Contributing factor category / factor description	Percent	Rank
Factors affecting driver ability: driver fatigue (stated fell asleep at wheel, so tired, crash evidence)	27.1%	1
Driver error: failed to see other road user (stated by driver)	24.8%	2
Factors affecting driver ability: blackout pre-crash due to medical conditions (seizure, diabetes, cardiac conditions)	17.8%	3

Factors affecting driver ability: emotional state (high levels stress, mental health)	13.1%	4
Driver error: misjudged road layout	12.4%	5
Factors affecting driver ability: inexperience	11.2%	6
Other driver factor: driver error	10.9%	7
Driver behaviour: inappropriate speed for conditions	9.5%	8
Factors affecting driver ability: alcohol / BAC (case driver)	9.5%	9
Driver error: counteractive avoidance action	7.6%	10

Conclusions

This early look at the data highlights the immense value of in-depth data in understanding serious injury crashes. This level of detail and its holistic nature about crash causation has not been seen before in the analysis of road crashes in Victoria. Of particular concern is the scale of medical conditions and other driver impairments as contributing factors for crash occurrence. The data also demonstrates that there is significant opportunity to achieve reductions in injury severity through a safer vehicle fleet. Whilst the data collection program is continuing, these emerging insights can be used to explore opportunities to drive the development of innovative road safety measures.

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Injury Reduction Benefits of Roundabouts Evaluated Using Real-world Data and Simulation Software

Sujanie Peiris[a], Michael Fitzharris[a], Bruce Corben[b], Robin Jackel[a], ECIS Study Team[a]

[a]Monash University Accident Research Centre; [b]Corben Consulting

Abstract

Roundabout geometry inherently promotes favorable impact angles and reduced travel speeds, with casualty crash reductions of around 75% being found (Newstead et al., 2001). Using real-world crash and speed data, the benefits of a traditional roundabout were examined. We present a crash case-study and free-speed measurements from a conventional roundabout to highlight the safety performance of this design. While the conventional roundabout is a Safe System compliant intersection treatment, not all designs promote travel speeds that meet acceptable injury risk levels. Contemporary design issues are discussed briefly in this context.

Background:

Crashes that occur at cross-intersections can have major consequences, given they typically occur at high speeds and at 90-degree impact angles. This is exemplified by 45% of serious casualty crashes and 20-30% of road fatalities in Victoria occurring at intersections (Candappa et al., 2015).

Roundabouts are regarded as an intersection design solution that offers major safety benefits whilst achieving efficient traffic flow. An optimally designed roundabout, via the radii of its approach alignment achieves speed reductions, such that vehicles enter the roundabout at 50 km/h or lower before they reach the conflict area (Austroads, 2015). The horizontal deflection associated with the circular island achieves further speed reductions and the tangential approach optimises intersection performance by managing conflict angles and sight lines.

Given the importance of roundabouts as a Safe System solution for intersection-based road trauma, this study examines the impact speed and injury severity of a specific crash at a conventionally-designed roundabout, and presents vehicle speeds at entry and through the roundabout.

Methodology:

A crash case study was examined from the MUARC Enhanced Crash Investigation Study (ECIS), (refer to Fitzharris et al., 2015 for a detailed description of ECIS). ECIS includes a 'control component' where the ‘free speed’ (i.e., first vehicle in traffic) of drivers passing through the crash site without incident is recorded, on the same day of the week and within a 30 minute window either side of the known time of crash.

The case study crash occurred in a roundabout at the intersection of a high volume highway (100 km/h) and a regionally-significant road (100 km/h), in a semi-urban environment (Figure 1). The site was represented in Rhino V5 and imported into Human Vehicle Environment (Figure 1). Two simulation vehicles representing the real-world case-vehicle (a 2005 SUV, ANCAP 5) and the real-world B-vehicle (a large sedan, ANCAP 5) were used to simulate crash. The crash was validated against objective crash measures. The point of impact (POI) was the left front door of the A-vehicle (the struck vehicle) and the front right corner of the B-vehicle (the striking vehicle). The driver of the B-vehicle failed to yield. Airbags did not deploy in either vehicle. The case (A) vehicle driver first presented to a local GP and was then transferred to hospital by ambulance with cervical spine (neck) pain, lower back pain, and concussion (AIS1, minor injury). Both vehicles were towed from the scene with minor damage.

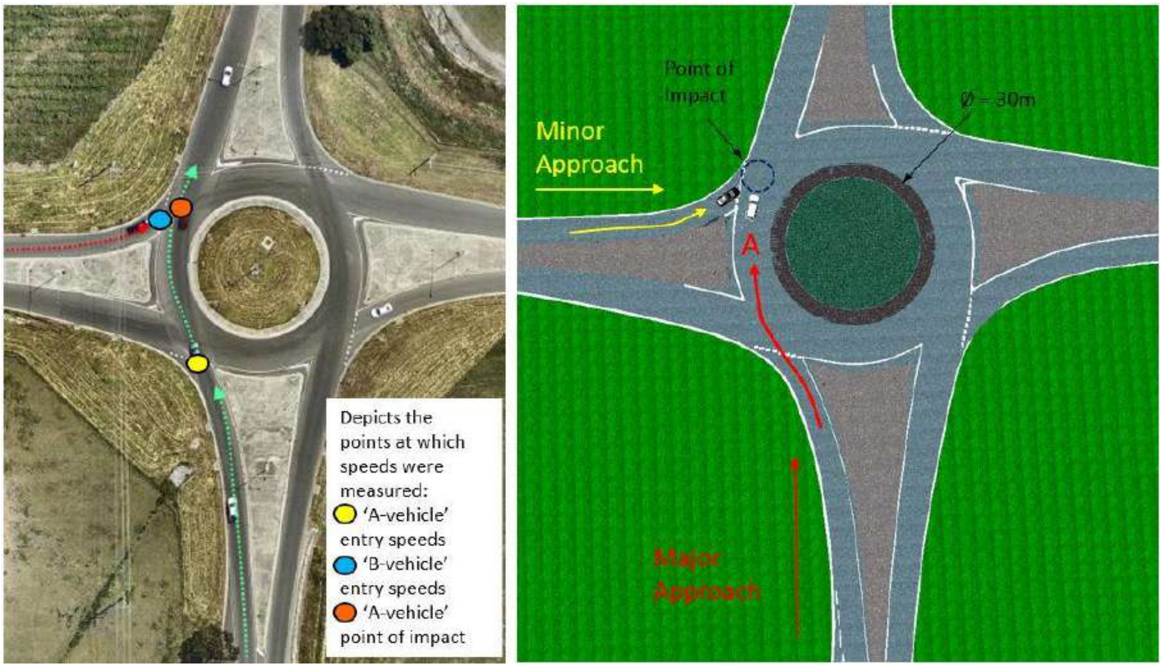

Figure 1. A graphic showing the actual site (Left) and that modelled in HVE (Right), showing the intended paths of the vehicles.

Results:

Simulation Outcomes: Simulation estimates suggest that the case-vehicle travelling on the major approach, entered the roundabout at 41 km/h and after braking, impacted at 35 km/h. The B-vehicle, travelling on the minor approach, entered the roundabout at 38 km/h and impacted the A-vehicle at approximately 29 km/h. Crash forces were estimated to be 24 kN. The angle between impacting vehicles was approximately 20 degrees. That the case (A) vehicle driver required hospitalisation for further assessment of their injuries is of concern, however, it is notable that the type of injury was classified a 'minor' using the Abbreviated Injury Scale (i.e., AIS1, AAAM 2005).

Free Speed Measures (Control): Speed for 27 vehicles travelling from the major approach at the entry to the roundabout and at the POI, and 30 vehicles on the minor approach, were measured using a laser camera (Table 1, see Figure 1 for measurement points). The speeds of all but one vehicle (96%) on the major approach at the POI were below 50 km/h (mean speed reduction: 8.8 km/h, p<0.01).

Table 1. Control Vehicle Free Speed (km/h) Measurements Statistical Summary

	Major Road, 100 km/h		Minor Road, 100 km/h
	Entry point	Point of Impact	Entry point
Mean Speed (km/h) (SD, km/h)	49 (13)	40 (6)	33 (8)
Median (km/h)	51	41	34
Lowest / Highest speed (km/h)	16 - 69	28 – 53	16 - 48
Traffic volume* (cars/min)	3	3	3

*Measurements obtained between 12.21pm and 1.35pm

Conclusion:

The study of this roundabout was precipitated by a crash where the driver was hospitalised but with low severity injury after being struck by another vehicle at an estimated 29 km/h. Based on the lower impact speed and commensurate low crash forces, the roundabout performed well and within Safe System design boundaries (i.e. lower impact speeds, more favorable geometry and both drivers were in ANCAP 5-star rated vehicles).

Examination of free-speeds requires a thorough assessment of roundabout geometry and other factors such as traffic volume, road function, the presence of other vehicles within the roundabout and sight lines. A thorough discussion of this will follow in a full length paper

Further work examining roundabouts with different design features including the effects of single or dual circulating lanes, across different times of the day using multiple speed measurement points, will be the subject of future research. In doing this, a comparison of the performance of traditional roundabout designs with innovative designs, including those featuring 'reverse curve' approach lanes, will be undertaken.

Acknowledgements

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Associations between sleep quality and distracted driving. Exploratory results from the Enhanced Crash Investigation Study (ECIS) control data

Amanda Stephens, Michael Fitzharris, Mike Lenné, ECIS Study Team

Monash University Accident Research Centre

Abstract

The ECIS is an ongoing multi-disciplinary case-control in-depth crash investigation study that seeks to understand the factors associated with serious injury crashes in Victoria. Data are collected from injured drivers and later from uninjured (control) drivers passing through crash locations. Sleeping patterns and engagement in activities whilst driving are captured. Results from 233 drivers suggest that the most common potentially distracting activities reported by drivers are talking with passengers (20% of the sample) and adjusting the radio (12% of the sample). However, the tasks drivers engage in differ according to the quality of a driver's sleep and whether other passengers are in the vehicle.

Background

Fatigued driving is a major road safety concern and accounts for approximately 20-30% of all fatal and 8% of all serious injury crashes on Australian roads (Australian Transport Council, 2011). Although many factors can contribute to driver fatigue, the most common include deficits in duration and quality of recent sleep. A fatigued state can be as, if not more, impairing for drivers than drink-driving. The crash-risk for a driver who has been awake for 17 hours is equivalent to that for a driver with a blood alcohol content of .05 g/ML, and the comparable BAC triples (.15) for those who have been awake for 21 hours (Williamson & Feyer, 2000).

While impairment from fatigue is widely recognised, the relationship between fatigue and driver distraction is less researched. However, relationships have been found between restricted sleep and increased distraction-related driving incidents (Anderson & Horne, 2013). This paper explores the associations between sleep quality and distracted driving.

Method

Data presented here are part of the Enhanced Crash Investigation Study (ECIS). The ECIS is a case-control study that will collect and analyse data from 400 serious road crashes in Victoria occurring across a three-year period (see Fitzharris et al., 2015 for a full description of the study protocol). Control participants are those who, within a few weeks of a case-vehicle crash, have safely driven through that crash site, at which time an ECIS investigator using a laser speed camera covertly recorded their speed. Recordings are taken within a 30-minute window each side of the crash time. For privacy reasons, the Transport Accident Commission sends the questionnaire on behalf of the ECIS researchers. Drivers receive a $50 gift voucher as reimbursement for their time. The response rate is 34%.

The survey seeks information about the observed trip, vehicle details and driver demographics. Drivers rate the quality of sleep they had the night before the trip (excellent, good, okay, poor) and report whether a passenger/s were present in the vehicle and whether or not they the driver was engaged in any potentially distracting activities during that drive (i.e., talking to a passenger, interacting with a smart device).

Results

Data from 233 control study drivers (male: 50%) are presented, which relates to 19 sites where a crash had occurred. Table 1 shows the frequency of reported distracting activities, separated across drivers who reported the quality of their previous night's sleep as 'good' (excellent or good) or 'not good' (okay, poor). Overall, talking to a passenger inside the vehicle (20%) and interacting with the radio (12%) were the most commonly reported activities, although differences were evident in the frequency of distracting activities according to sleep quality and the presence of passengers.

Table 1. Ranking of activities and behaviours across sleep quality and presence of passengers

Activities and behaviours	**Overall**	**Good quality sleep (n = 152)**		**OK/Poor quality sleep (n = 72)**	
		No passengers (n = 98)	**Passengers present (n = 54)**	**No passengers (n = 44)**	**Passengers present (n = 28)**
Talking to a passenger inside the vehicle	20.1%	N/A	44.4%	N/A	75.0%
I changed the radio station / adjusted the volume	11.6%	11.2%	9.3%	15.9%	10.7%
I felt stressed or worried about something	8.0%	7.1%	3.7%	13.6%	10.7%
I found the road layout to be confusing	6.7%	8.2%	5.6%	9.0%	Nil
I was running late for something	6.2%	6.1%	1.8%	2.3%	21.4%
I felt 'lost' in personal thoughts	5.8%	6.1%	1.8%	13.6%	0.0%
I thought the road signs were poorly positioned	5.8%	6.1%	11.1%	2.3%	0.0%
I thought the traffic was driving too fast	4.9%	3.1%	5.6%	9.1%	3.6%
I was distracted by something outside of the vehicle	4.9%	3.1%	9.3%	4.5%	3.6%
I felt tired from a lack of sleep	3.6%	1.0%	Nil	6.8%	14.3%
I was viewing a map / route on a navigation device (or smartphone)	3.6%	1.0%	5.6%	6.8%	3.6%
I was trying to pass a slow moving vehicle	3.6%	3.1%	1.8%	4.5%	7.1%
My cars wheels touched or crossed the centre line on the road	3.1%	2.0%	3.7%	6.8%	Nil
Eating or taking a drink	3.1%	2.0%	3.7%	6.8%	Nil
I felt physically exhausted	2.7%	2.0%	1.8%	6.8%	Nil
I felt pressure from another driver	2.7%	2.0%	1.8%	4.5%	3.6%
I was talking on hands-free phone (Bluetooth)	2.7%	3.1%	1.8%	4.5%	Nil
I was adjusting the heater / air-con or demister	2.7%	3.1%	1.8%	4.5%	Nil
I was looking for a street sign	2.7%	1.1%	5.6%	2.3%	3.6%
The bend in the road was shaper than I thought	2.7%	4.1%	1.8%	2.3%	Nil
My attention was caught by a disturbance in my vehicle (passengers, child, animal)	2.7%	0.0%	3.7%	0.0%	14.3%

Conclusions

The exploratory results suggest a relationship may exist between quality of sleep and engagement in distracting activities. The data indicate that a higher proportion of drivers who reported 'okay' or 'poor' sleep quality on the day prior to their drive engaged in a range of different tasks to a greater extent than did drivers who reported 'good' or 'excellent' sleep quality. This might reflect attempts by drivers to keep engaged given their acknowledgement of increased exhaustion and poorer driving performance after poor quality sleep. Data collection is ongoing and more formal analyses of these relationships will be undertaken once data collection has been completed. This will allow incorporation of hours of sleep in addition to sleep quality, as well other subjective measures of drowsiness. Nonetheless, this analysis provides a snapshot of the range of activities drivers performed by drivers.

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What drivers do while speeding: Examining the associations between speeding and driver distraction through the Enhanced Crash Investigation Study protocol

Amanda Stephens[a], Michael Fitzharris[a,b], C. Raymond Bingham[c], Di Bowman[d], Samantha Buckis[a], Samantha Cockfield[e], Bruce Corben[f], Hampton. C. Gabler[g], Jane Holden[a], Mike Lenné[a], Andrew Morris[h], Michael Nieuwesteeg[e], Sujanie Peiris[a], ECIS Study Team[a]

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Abstract

This paper represents an exploratory analysis to assess the feasibility of assessing the relationship between driver speed and engagement in potentially distracting behaviours. Control data from the ECIS project are examined. These data include both objective speed measurements recorded via laser camera positioned at ECIS case-vehicle crash locations as well as retrospective self-reported driving behaviours from drivers recorded at these sites. Exploratory analysis suggests that the activities reported by drivers with recorded speeds above the limit may differ from the activities reported by those recorded on or below the limit.

Background

Violations of the posted speed limit contribute to the number and severity of road crashes (Elvik, 2012). While a direct relationship between speed and crashes is undisputed, there may be indirect relationships arising from associations between driver speed and other activities that compete for the driver's attention. The ECIS allows this relationship to be explored by capturing observed speed data and subsequent self-reported behaviours from drivers about what they were doing at the time their speed was measured. This paper presents an exploratory analysis of potential relationships between observed speeds and activities reported by drivers at the time of speed capture.

Methods

The ECIS is a case-control study that will collect and analyse data from 400 serious road crashes in Victoria occurring across a three-year period (see Fitzharris et al., 2015 for a full description of the study protocol). Control participants are those who, within a few weeks of a case-vehicle crash, have safely driven through a crash-site, and had their 'free speed' and vehicle details covertly recorded by a laser speed camera. Recordings are taken within a 30-minute window each side of the crash time. A retro-reflective sign (60cm x 60cm) is placed after the crash-site and down-stream from the speed measurement point advising drivers they had passed through a Monash University study site; this serves as a later memory cue and is assessed in a questionnaire subsequently sent to drivers. For privacy reasons, the Transport Accident Commission sends the questionnaire on behalf of the ECIS researchers. The response rate is 34%.

Included in the control questionnaire are details of the location and the date and time of when the driver was recorded, as well as a photograph of the location. A number of questions seek information relating directly to the trip in question, including presence of passengers and activities undertaken by drivers at the time their speed was recorded. Drivers are not informed of their recorded speed. Less than 1% did not remember driving through the specified location on the day their trip was recorded.

Results

Control data were available for 233 drivers (Male: 50%), which relates to 19 different sites where a crash had occurred. Analysis of ‘free speed’ showed that 81% complied with the posted speed limit and 19% exceeded the speed limit. Of those above the speed limit, 61% (12% overall) exceeded the speed limit by up to 5km/h over, 33% (4% overall) were 6-10 km/h over the speed limit and 16% (3% overall) by 11 km/h or more. Table 1 shows the frequency of potential distracting activities compared for drivers on or below the speed limit and those above. Whilst there are indications that some distraction-type behaviors occur more frequently among those exceeding the posted speed limit, none of the differences were statistically significant. The data also show the type and range of distractions that drivers engage in. These may be through external events, driver tiredness or a result of passengers in the vehicle.

Table 1. Activities reported by drivers who were exceeding the speed limit, compared with drivers who were not

	On or below the speed limit (n =189)	Above the speed limit (n = 44)	OR_{MH} (95% CI)
I was distracted by something outside of the vehicle	3.70%	9.09%	2.6 (0.7-9.3)
I felt tired from a lack of sleep	2.65%	6.82%	2.7 (0.6-11.7)
I was smoking a cigarette or pipe	1.06%	4.55%	4.4 (0.6-32.5)
I was talking to a passenger	19.58%	22.73%	1.2 (0.5-2.6)
My vision was affected or obstructed whilst driving by a parked vehicle	3.70%	6.82%	1.9 (0.4-7.7)
My attention was caught by a disturbance in my vehicle (passengers, child, animal)	2.12%	4.55%	2.2 (0.4-12.4)
I was talking on hands-free phone (Bluetooth)	2.12%	4.55%	2.2 (0.4-12.4)
I was coughing / sneezing / blowing nose	0.00%	2.27%	NA
I was using hand-held phone on speaker or headphones	0.00%	2.27%	NA
I was looking at AND talking to a passenger	1.06%	2.27%	2.1 (0.2-24.5)
I changed a CD / DVD	1.06%	2.27%	2.1 (0.2-24.5)
My vision was affected or obstructed by road-works	1.06%	2.27%	2.2 (0.2-24.5)
I felt stressed or worried about something	7.94%	9.09%	1.2 (0.4-3.7)
I was running late for something	5.82%	6.82%	1.2 (0.3-4.4)
A driver pulled out and turned across my path	1.59%	2.27%	1.4 (0.2-14.2)

Conclusions

The analysis presented here demonstrates the value of the approach used in the ECIS control arm. The method is robust as it uses objective speed measures that were recoded covertly, and driver responses were independent of this measured speed. Issues of recollection bias are recognised and discussed fully in Fitzharris et al. (2015). Nonetheless, this exploratory analysis shows the types of activities and behaviours that drivers engage in whilst driving. While the future ECIS dataset will permit a more comprehensive analysis, the results here provide some evidence for an indicative relationship between driver distraction and exceeding the speed limit.

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Driver licensing for Aboriginal and Torres Strait Islander People; challenges and opportunities

Rebecca Ivers

The George Institute for Global Health

Background

For many Australians, obtaining a driver's licence is a relatively straightforward process, however Aboriginal people can face significant barriers. These include lack of formal identification documents, the high cost of driving lessons, and lack of suitable supervisory drivers for learners. These issues can be compounded in regional and remote areas by limited access to licensing services in these locations. Consequently, many Aboriginal communities have few licensed drivers, which places undue burden on licensed drivers to provide transportation for other community members and impedes access to employment and healthcare services.

Purpose of Symposium

This symposium will discuss challenges in delivery of licensing support programs for Aboriginal and Torres Strait Islander people, and solutions to overcome these. There are multiple grass-root community programs as well as Government programs emerging across Australia and this symposium will provide an opportunity to highlight both program strengths and best practice.

Justification

It is critical that those delivering such programs have an opportunity to come together and exchange best practice in terms of program delivery and research. With few opportunities for sharing knowledge, this symposium provides an ideal opportunity for researchers, practitioners and community members to share experiences and learn from each other.

Presenters, Title of Presentation & Brief Description

Rebecca Ivers, The George Institute for Global Health

Overview of the Driving Change program, a trial of an end-to-end community based driver licensing support program in NSW, the model of delivery, implementation challenges and outcomes.

Alex Niki and Eliza Fleming: Driving Change coordinators, Wagga and Taree

Alex and Eliza will talk through their experience working with Aboriginal clients, the complex challenges, opportunities and positive outcomes.

Debbie Maguire and Brett Naden, Birrang Aboriginal Corporation

Birrang delivers licensing services to Aboriginal people across NSW. This presentation will highlight the unique service delivery model and outcomes.

Wayne Buckley, DriveSafe NT Remote, NT Government

DriveSafe NT Remote is a holistic Government funded program that delivers services to over 62 remote communities and outstations across the Northern Territory. Program outcomes and evaluation will be discussed and the flexible delivery model.

Angela Webb, Centre for Road Safety, Transport for NSW

TfNSW in partnership with the Australian Football League (AFL) NSW/ACT supports the Adam Goodes Talent Program. The program delivery and road safety outcomes will be presented.

Australasian Road Safety Applied in Low and Middle-Income Countries

Lori Mooren

Transport and Road Safety Research Centre, UNSW

Background

The UN Global Goals for Sustainable Development have set the target to halve road deaths and injuries by 2020. We must work as a global community to quickly learn and apply the success from one country with the need in another. The workshop will bring together experts from low, middle and high-income countries to share their experience and ideas on how to accelerate action worldwide and save lives.

Purpose of Symposium

The purpose of this symposium is to provide a session for Conference delegates to explore the possibilities, challenges and benefits of applying Australian road safety practices in low and middle-income countries. The specific topics will explore the science of Australian road safety, institutional strengthening and interagency collaboration, and safe system applications. Key learning points for Australian and non-Australian participants are:

- Success factors in transferring good practices to other physical and socio-cultural environments;
- Importance of evidence-based road safety measures; and
- How to collaborate with others to optimise road safety benefits.

Justification

The Conference is offering scholarships to encourage delegates from low and middle-income countries in the Asia Pacific Region to register from the conference. It is expected that there will be a substantial number of delegates from other countries. The International Sub-committee has been advised that some of their international colleagues had the impression that this Conference is Australia-centric, so we want to provide at least one session that focuses on international road safety. Moreover, a number of Australian consultants working internationally would benefit for understanding more about how best to introduce Australia road safety in different environments.

Presenters, Title of Presentation & Brief Description

Jonathon Passmore, World Health Organisation (Western Pacific Region)

Regional overview in road safety and comparing Australasia's standing to other countries.

Dr Soames Job, World Bank

The importance of evidence-based laws and law enforcement is an important way to reduce trauma dramatically in the short term.

Socheata Sann, Centre for Accident Research and Road Safety, QUT

Exploring Disabilities and implications for the UN Decade of Action for Road Safety, a case study of Cambodia

Rob McInerney, international Road Assessment Program

Raising the star rating performance of road infrastructure with safe system interventions in LMICs

Exploring Disabilities and Implications for the UN Decade of Action for Road Safety, a Case Study of Cambodia

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Abstract

The Global Plan for the UN Decade of Action for Road Safety (GPDoA) has five pillars to reduce the road crash burden, especially in low and middle income (LMI) countries (WHO, 2011). Previously we have reported on crashes in Cambodia resulting in disability and have conducted further research on crash characteristics and their impact. This paper is a case study of the degree to which GPDoA addresses crashes that result in disability. The findings highlight gaps under all pillars of GPDoA and a need for greater consideration of the impacts of road crashes during the remainder of the Decade of Action and beyond.

Background

Road crashes and injuries have become a growing issue worldwide, and the GPDoA is the first comprehensive global plan of action to address it, particularly in low and middle income countries. However, the long term disability resulting from some road crashes contributes a disproportionate burden that is not fully addressed in the five pillars of the GPDoA. The first author, with her supervisory team, has conducted qualitative and quantitative research in Cambodia, on both primary and secondary data, that explores the extent and nature of this burden. The data collected in the research provides an opportunity to assess the degree to which the GPDoA addresses crashes resulting in long term disability.

Method

The Cambodian research consisted of qualitative interviews with policy makers, persons with disabilities due to road crashes and their family members. The main findings were objectively reviewed alongside the actions identified under the five pillars of the GPDoA, and included consideration of the Cambodian plan developed to address the GPDoA.

Results

The GPDoA highlights the need to establish feasible national targets and indicators for each pillar, without specifying what the national targets should be. Although this gives flexibility for countries based on their local context, it could lead to the absence of necessary targets, especially for long term impairments, intermediate outcomes and indicators. This can be seen in each pillar of the Cambodian plan (National Road Safety Committee, 2014). At the same time, the long lists of actions in the GPDoA make it hard for countries like Cambodia to follow due their limited resources.

As an implication for Pillar 1: Road Safety Management, the research highlighted the need for better data collection systems, not only for fatalities but to measure serious road injuries which might lead to persistent disabilities. Another gap in the GPDoA is the absence of measures of human resource capacity in road safety institutions.

Pillar 2: Safer Roads and Mobility does not include any infrastructure and transportation system interventions for persons with disabilities, pointing to a lack of integration of persons with disabilities into the transport and road networks.

Moreover, Pillar 3: Safer Vehicles tends to concentrate on safety standards for cars, while most of the crashes leading to long term impairment involved motorcycles and local transport modes, which are not included in the GPDoA. There is also no mention of vehicle modification for persons with disabilities.

In addition, both Pillars 3 and 4 (Safer Road User Behaviors) do not pay sufficient attention to disability inclusion in term of safer vehicles and promotion of public transport accessibility for persons with disabilities. The indicators for Pillar 4 tend to focus more on setting regulations, not on the quality and effectiveness of traffic law enforcement, particularly crash investigation systems and ways of reducing “hit and run” cases.

An obvious gap was evident in relation to maintaining an adequate emergency system and delivering post-crash care to prevent long term impairments. This reflected the limitation in Pillars 1 and 5 (Post-Crash Reponses) that focus on only the lead agency (National Road Safety Committee) without full participation of the Ministry of Health and its national health strategy.

Conclusion

The Cambodian research demonstrates that there are gaps under all five pillars of the GPDoA where crashes resulting in long term disability are concerned. The findings illustrate and highlight the need for greater consideration of the long term impacts of road crashes during the remainder of the Decade of Action and beyond. A further consideration is the potential for building disability inclusiveness into the processes of problem identification and intervention implementation for road safety in low and middle income countries.

References

National Road Safety Committee. (2014). *National Road Safety Policy 2011-2020*. WHO. (2011). Global Plan for the Decade of Action for Road Safety 2011-2020: WHO.