Vol 28 No 4, 2017

Journal of the Australasian College of Road Safety

Formerly RoadWise – Australia's First Road Safety Journal

Peer-reviewed papers

Original Road Safety Research

- A Crash Testing Evaluation of Motorcyclist Protection Systems for use on Steel W-Beam Safety Barriers
- Multi-stage Road Safety Auditing to Maximise Development Impact
- Applying a context-informed approach to evaluation of a licensing support program with Aboriginal communities: a study protocol
- Speeding among Jordanian Drivers
- Investigation of Quad bike handling characteristics and their implications for on road use

Contributed articles

Road Safety Policy & Practice

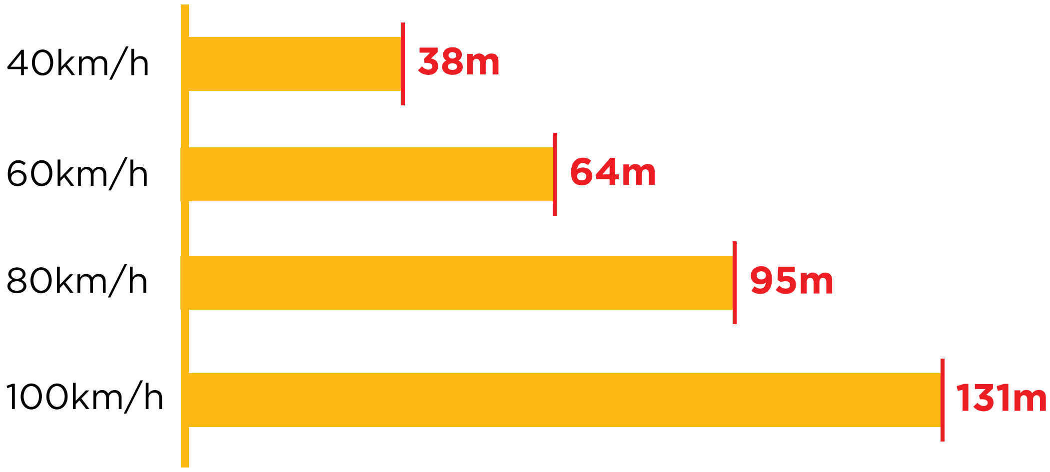
- Truck Rear Underrun Dynamic Crash Test in AS/NZS 3845.2:2017 Standard – a World's First for Heavy Vehicle Crashworthiness

Perspective/Commentary on Road Safety

- It is time to consider a presumed liability law that protects cyclists and other vulnerable road users

Your speed matters.

The faster you go, the longer it takes to stop.



*Average stopping distances for a car on a reasonable road surface, Centre for Road Safety 2014

Even a small difference in your speed can make a big difference to the likelihood and severity of a crash.

Lives lost to speeding. Our goal is zero.

Find out more at towardszero.nsw.gov.au

TOWARDS ZERO

NSW GOVERNMENT | Transport for NSW

Thank you

to the Sponsors of the ACRS2017 Conference.
Your support is appreciated.

2017 AUSTRALASIAN ROAD SAFETY CONFERENCE

Austroads

GOVERNMENT OF WESTERN AUSTRALIA

ROAD SAFETY COMMISSION

RAC For the better

3M

TOLL

TAC TRANSPORT ACCIDENT COMMISSION

Australian Government Department of Infrastructure and Regional Development

AUSTRALASIAN COLLEGE OF ROAD SAFETY

TRANSPORT FOR VICTORIA

mainroads WESTERN AUSTRALIA

C-MARC CURTIN-MONASH ACCIDENT RESEARCH CENTRE

andatech safety

SUNCORP

AAMC

SMART START

RoadWise | WALGA

RoadWise is funded by the State Government and supported by Local Governments. www.roadwise.asn.au

textstopper act smart, drive safe

CARRS

GUARDIAN INTERLOCK

MONASH University | ACCIDENT RESEARCH CENTRE

Pathtech First Choice in Science

Alere

Alcolizer technology TRUSTED ALWAYS

VITRONIC the machine vision people

MetroCount Traffic Data Specialists

Road Trauma Support WA

DPS PROMOTION DPSPROMO.COM.AU

blackmoth VISION IN MOTION

Dräger

ELSEVIER

INFRASTRUCTURE

STALKER Power to Enforce.

serco

CENTRE FOR AUTOMOTIVE SAFETY RESEARCH | THE UNIVERSITY of ADELAIDE

PERTH CONVENTION BUREAU

KSI Global Australia Pty Ltd

3M Roadside

arrb AUSTRALIAN ROAD RESEARCH BOARD

TARS Research UNSW

iame INSTITUTE OF AUTOMOTIVE MECHANICAL ENGINEERS

hea HIGHWAY ENGINEERING AUSTRALIA SINCE 1968

ROADS & CIVIL WORKS AUSTRALIA

CROWN EVENTS & CONFERENCES PERTH

Tourism WESTERN AUSTRALIA

safety an open access journal by MDPI

MARK YOUR DIARY WITH THESE KEY DATES:

Abstract Submissions Open: **16 October 2017**
Registration Opens: **16 October 2017**
Abstract Submission Deadline: **16 February 2018**
Early Bird Registration Deadline: **1 June 2018**

2018 AUSTRALASIAN ROAD SAFETY CONFERENCE

International Convention Centre Sydney 3–5 October 2018

FOUNDING PARTNERS

Australasian College of Road Safety · Austroads

PLATINUM SPONSOR

NSW Government

The Australasian College of Road Safety (ACRS) and Austroads invite you to attend the largest road safety-dedicated conference in the Southern Hemisphere. The 2018 Australasian Road Safety Conference (ARSC2018) will be held in Sydney at the International Convention Centre from Wednesday 3 to Friday 5 October 2018.

ARSC2018 will showcase the region's outstanding researchers, practitioners, policy-makers and industry spanning the plethora of road safety issues identified in the United Nations Decade of Action for Road Safety: Road Safety Management, Infrastructure, Safe Vehicles, User Behaviour, and Post-Crash Care. ARSC2018 will bring with it a special focus on engaging all levels of government and community, from the city to the bush, to move *"Towards Zero – Making it Happen!"* The comprehensive 3-day scientific program will showcase the latest research; education and policing programs; policies and management strategies; and technological developments in the field, together with national and international keynote speakers, oral and poster presentations, workshops and interactive symposia.

To register your expression of interest as a delegate, speaker, sponsor or trade exhibitor, or for further information about the Conference, please visit **www.australasianroadsafetyconference.com.au.**
Additional enquiries should be directed to the Conference Secretariat, Encanta Event Management on +61 3 9863 7608 or **ARSC@encanta.com.au**.

WHO SHOULD ATTEND?

ARSC2018 is expected to attract 500-700 delegates including researchers, policing and enforcement agencies, practitioners, policymakers, industry representatives, educators, and students working in the fields of behavioural science, education and training, emergency services, engineering and technology, health and rehabilitation, policing, justice and law enforcement, local, state and federal government, traffic management, and vehicle safety.

YOUR HOST CITY: SYDNEY

Situated on a breathtaking harbour, Sydney is one of the world's most attractive and exciting cities. With its rich mix of colonial and indigenous history, multicultural cuisines and festivals, museums, exhibitions and theatres, Sydney is an experience waiting to happen. Enjoy the mild sunny climate and miles of golden beaches. Stroll along Darling Harbour, The Rocks and Circular Quay enjoying the sights of the world famous Opera House, or climb the Sydney Harbour Bridge. The new ICC Sydney is Australia's first fully-integrated convention, events, exhibition and entertainment centre, and is located at the heart of its very own Sydney harbour waterfront precinct, set amongst restaurants, retail and a vibrant public domain on Darling Harbour.

www.australasianroadsafetyconference.com.au

Contents

Cover image

Motorcyclists have a significantly greater risk of being fatally and seriously injured than car occupants and safety barriers are a critical countermeasure to protect vehicle occupants from roadside hazards. Crash tests show Motorcyclist Protection Systems can reduce the risk of fatality and serious injury to sliding motorcyclists, without compromising the safety of other road users as demonstrated in the Original Road Safety Research article (Baker, J., Eveleigh, M., and Burrows A. (2017). A Crash Testing Evaluation of Motorcyclist Protection Systems for use on Steel W-Beam Safety Barriers. *Journal of the Australasian College of Road Safety*, 28(4), pages 12-21).

The Journal of the Australasian College of Road Safety
(formerly **RoadWise** between 1988 and 2004) ISSN 1832-9497.
Published quarterly by the *Australasian College of Road Safety*.

Managing Editor: Dr Chika Sakashita
Australasian College of Road Safety & Global Road Safety Solutions
1080 Wisconsin Ave NW #3009, Washington DC, 20007, USA
journaleditor@acrs.org.au

Editor-in-Chief: Prof Raphael Grzebieta (FACRS)
Professor of Road Safety, Transport and Road Safety (TARS) Research Centre, UNSW
West Wing, 1st Floor, Old Main Building (K15), Sydney NSW 2052
+61 (0)2 9385 4479 r.grzebieta@unsw.edu.au

Subscriptions
All issues of this Journal are mailed to personal members or corporate delegates of the Australasian College of Road Safety. Organisations and persons who are not members of the College may subscribe to the Journal on payment of an annual subscription.

Advertising and sponsorship
Advertising rates and, specifications are on the College website at http://acrs.org.au/publications/journals/advertising/ or available by email from faa@acrs.com.au. Discounts are available for prepaid advertising booked to run for more than one issue. The College also welcomes sponsorship of the Journal. For more information about becoming a Journal sponsor, please contact the Managing Editor.

Editorial Policy
The *Journal of the Australasian College of Road Safety* aims to publish high quality papers and provides a means of communication for the considerable amount of evidence being built for the delivery of road safety, to inform researchers, policymakers, advocates, government and non-government organisations, post-crash carers, engineers, economists, educators, psychologists/ behavioural scientists, communication experts, insurance agencies, private companies, funding agencies, and interested members of the public. The Journal accepts papers from any country or region and has an international readership.

All papers submitted for publication undergo a peer-review process, unless the paper is submitted as a *Perspective/ Commentary on Road Safety* or *Correspondence* or the authors specifically request the paper not to be peer-reviewed at the time of original submission. Submissions under the peer-review stream are refereed on the basis of quality and importance for advancing road safety, and decisions on the publication of the paper are based on the value of the contribution the paper makes in road safety. Papers that pass the initial screening process by the Managing Editor and Peer-Review Editor will be sent out to peer reviewers selected on the basis of expertise and prior work in the area. The names of the reviewers are not disclosed to the authors. Based on the recommendations from the reviewers, authors are informed of the decision on the suitability of the manuscript for publication.

When papers are submitted and the authors specifically request the paper not to be peer-reviewed at the time of original submission, the papers will be published under the non peer-review stream. Submissions under the non peer-review stream, *Perspective/ Commentary on Road Safety* and *Correspondence* are reviewed initially by the Managing Editor, who makes a decision, in consultation with the Peer-Review Editor and/or Editorial Board when needed, to accept or reject a manuscript, or to request revisions from the author/s in response to the comments from the editor/s.

As a rule of thumb, all manuscripts can undergo only one major revision. Any editorial decisions regarding manuscript acceptance by the Managing Editor and Peer-Review Editor are final and further discussions or communications will not be entered into in the case of a submission being rejected.

For all articles which make claims that refute established scientific facts and/or established research findings, the paper will have to undergo peer-review. The Editor will notify the author if peer-review is required and at the same time the author will be given the opportunity to either withdraw the submission or proceed with peer-review. The Journal is not in the business of preventing the advancement or refinement of our current knowledge in regards to road safety. A paper that provides scientific evidence that refutes prevailing knowledge is of course acceptable. This provision is to protect the Journal from publishing papers that present opinions or claims without substantive evidence.

All article types must be submitted online via the Editorial Manager: http://www.editorialmanager.com/jacrs/default.aspx. Online submission instructions can be downloaded from: http://acrs.org.au/contact-us/em-journal-conference-contacts/.

Important information for authors
It is essential that authors writing for the Journal obtain and follow the ***Instructions for authors***. These are updated regularly and can be downloaded from the College website at http://acrs.org.au/contact-us/em-journal-conference-contacts/

Authors are responsible for complying with all the requirements (including Article types, Article structure, References, Ethics in publishing, Originality & plagiarism, Author declaration) before submitting their papers. The College has adopted guidelines developed by the Committee on Publication Ethics, which are available at http://acrs.org.au/publications/journals/ethics-and-malpractice-statement/.

ACRS office contact details
Ms Claire Howe, Executive Officer, eo@acrs.org.au: For inquiries regarding membership and College activities.

Dr Chika Sakashita, Managing Editor, journaleditor@acrs.org.au: For inquiries regarding submissions, current and back issues, advertising and sponsorship for the Journal.

Ms Kim Day, Office Manager, faa@acrs.org.au: For inquiries regarding Journal subscriptions and changes of postal address.

Mailing address: PO Box 198, Mawson, ACT 2607 Australia
Phone: (02) 6290 2509
Head office: Pearce Centre, Collett Place, Pearce ACT Australia

Editorial Board

From the President

Dear ACRS members,

Congratulations are due to Professor Raphael Grzebieta and Dr Chika Sakashita for their leadership in restructuring the Editorial Board. Welcome to the new members and thank you to past Board Members for your assistance and guidance. The Journal is a key component of the College, and its review and renewal are necessary as we grow.

The College is growing, as we "expand our horizons", the theme of the recent Australasian Road Safety Conference in Perth. Early feedback from delegates has been very positive.

The key note speaker—the former US National Highway Traffic Safety Administrator—Dr Mark Rosekind, who now heads safety innovation at autonomous vehicle start-up Zoox Inc challenged the over 650 delegates to consider if they were to work "Towards Zero" road deaths, then we all would have to be doing something different to what we are doing now. While recognising the achievement in reducing road trauma in so many areas, he encouraged delegates to act to implement not only new technologies but to review and implement new policies and practices relevant to today's environment.

The State and Federal Ministers responsible for road safety thanked the delegates for their ongoing work and supported their continued research and action in improving road safety.

From my perspective, the most important outcome was that there are so many well researched and well recognised safety programs and technologies which could be implemented today but are held back by some unidentified invisible hand.

An independent review of the process of the Australian Road Safety Strategy has been commissioned by the Federal Minister, and it will be co-chaired by Associate Professor Jeremy Woolley and Dr John Crozier, with Rob McInerney and I as Principal Advisors. I am hoping it may uncover that invisible hand.

The papers in this Issue address a range of factors in the road safety pillars—vehicles, roads, behaviours, and speed. As always, we welcome your comments and feedback.

Lauchlan McIntosh AM FACRS FAICD
ACRS President

From the Editors

The *Journal of the Australasian College of Road Safety* has a new Editorial Board and Editor-in-Chief

As announced at the ARSC2017, we have a new Editorial Board and Editor-in-Chief for the *Journal of the Australasian College of Road Safety*:

Editor-in-Chief	**Affiliation**	**Country/State**
Prof Raphael Grzebieta (FACRS)	Professor of Road Safety, Transport and Road Safety (TARS) Research Centre, UNSW	New South Wales, Australia
Managing Editor	**Affiliation**	**Country/State**
Dr Chika Sakashita	Australasian College of Road Safety Global Road Safety Solutions	Washington DC, USA
Editorial Board	**Affiliation**	**Country/State**
Dr Rebecca Brookland	Research Fellow, Department Preventive and Social Medicine, Dunedin School of Medicine, University of Otago	New Zealand
Prof Judith Charlton	Director, Monash University Accident Research Centre	Victoria, Australia
Dr Judy Fleiter	Global Manager, Global Road Safety Partnership, International Federation of Red Cross & Red Crescent Societies Visiting Fellow, School of Psychology and Counselling, Queensland University of Technology	Switzerland
Prof Clay Gabler	Samuel Herrick Professor of Engineering, Virginia Tech	Virginia, USA
Prof Rebecca Ivers	Director, The George Institute for Global Health	New South Wales, Australia
Prof Soames Job (FACRS)	Global Lead Road Safety, World Bank Head, Global Road Safety Facility	Washington DC, USA
A/Prof Michael Keall	Research Associate Professor, Department of Public Health, University of Otago Medical School	New Zealand
Dr Nadine Levick	Director, Objective Safety LLC	New York, USA
Prof Andrew McIntosh	Director, McIntosh Consultancy & Research Adjunct Professor, ACRSIP FedUni Adjunct Associate Professor, Monash University Accident Research Centre	Victoria, Australia
Prof Lynn Meuleners	Director, C-MARC, Curtin University	Western Australia, Australia
A/Prof Jake Olivier	Associate Professor, School of Mathematics and Statistics, UNSW	New South Wales, Australia
A/Prof George Rechnitzer	Adjunct Associate Professor, Transport and Road Safety (TARS) Research Centre, UNSW	New South Wales, Australia
Prof Michael Regan	Chief Scientist, Human Factors, Australian Road Research Board Adjunct Professor, UNSW	New South Wales, Australia
Prof Gordon Smith	Stuart M. and Joyce N. Robbins Distinguished Professor, School of Public Health, West Virginia University Adjunct Professor, University of Maryland School of Medicine	West Virginia & Maryland, USA
A/Prof Richard Tay	VC Senior Research Fellow, RMIT University	Victoria, Australia
Prof Barry Watson (FACRS)	Adjunct Professor, CARRS-Q, Queensland University of Technology	Queensland, Australia
Prof Fred Wegman	Emritus Professor of Traffic Safety, Delft University of Technology	The Netherlands
Prof Ann Williamson (FACRS)	Director, Transport and Road Safety (TARS) Research Centre, UNSW	New South Wales, Australia

A special thank you to the seven members who are continuing to be on the Editorial Board for their longstanding support of the JACRS. A special warm welcome to the 11 new members of the Editorial Board.

As part of this reinvigoration of the Editorial Board and to strengthen recognition of the JACRS as a scientific peer-reviewed journal, we believe it is important to also have an Editor-in-Chief for the JACRS. Therefore, Prof Raphael Grzebieta will be our new Editor-in-Chief to replace the Peer-Review Editor role Raph has fulfilled for many years.

As noted in the FEB2017 Issue, we are endeavoring to raise the standard of the JACRS to become one of the highest caliber scientific journals in road safety, which in turn will help us secure listing in the impact factor databases, and we have made many improvements to the JACRS this year. We together with the new Editorial Board are working very hard, and welcome your continued support as authors, peer-reviewers, readers of the JACRS and use of information published in the JACRS in your research and other publications.

This NOV2017 Issue marks the last issue for 2017 and we would like to take this opportunity to thank all the authors and peer-reviewers who contributed to the four issues of the JACRS this year. We sincerely appreciate your valuable time and the depth of expertise and experience you bring to the JACRS. Without your support, we will not have the JACRS.

We will continue to focus on expanding the JACRS's readership and the pool of authors and peer-reviewers so that the readers of the JACRS can continue to enjoy reading and learn about the considerable amount of evidence being built for the delivery of road safety as well as the College activities.

We always welcome and appreciate your feedback. If you have questions or feedback, please contact the Managing Editor journaleditor@acrs.org.au.

Dr Chika Sakashita, PhD
Managing Editor

Prof Raphael Grzebieta, PhD
Editor-in-Chief

ACRS Chapter reports

Chapter reports were sought from all Chapter Representatives. We greatly appreciate the reports we received from ACT and NSW.

Australian Capital Territory (ACT) and Region

The Chapter held a very successful seminar on **Driving and Health in Ageing – What we need to know** on 4 October 2017.The objective of the seminar was to provide updated information to assist older drivers and their families with a better understanding of issues related to health that would help them adapt to the changes to their health and cognitive abilities.

The exercise was a collaborative venture between the Chapter; the Centre for Research on Ageing, Health and Wellbeing, Australian National University; and the Council of the Ageing ACT (COTA ACT).

Around 100 people attended (mostly older drivers or their carers). The speakers were:

- Prof Joanne Wood, School of Optometry & Vision Science, Queensland University of Technology; Prof Kaarin Anstey, Director, Centre for Research on Ageing, Health and Wellbeing, Australian National University; Simon Carroll, Professional Services Co-ordinator, Capital Chemists; Associate Professor Vanita Parekh, Director Clinical Forensic Medical Services, Canberra Hospital & Fitness to Drive Centre, Canberra Hospital; Emeritus Professor Don Aitkin, previous Chair, NRMA-ACT Road Safety Trust, Patron, and Alzheimer's ACT; Ewan Brown, President, COTA ACT; and Brian McKinlay & Susan Humphries, ACT Driver Assessment and Rehabilitation Centre (DARS).

The structure worked well. In particular, Joanne and Kaarin's input worked very well as they work together on a number of projects and their presentations complemented each other. The connection to both the ANU and COTA produced a harmonious working relationship in the development and presentation of the seminar. Feedback from the attendees was very positive.

Among the interesting conclusions to come from presentations were:

- the complexity of assessing the effects of particular illnesses on safe driving;
- the growing awareness of taking a multi-functional approach in assessing the impact on individual drivers (the combination of cognition & vision are important);
- even with specific diseases, there can be a variation of safety impacts on individual drivers, with some drivers being safe and others unsafe at particular stage;
- the importance of better understanding these variations so that more definite decisions can be made when a person should withdraw from or restrict their driving;
- drivers should be more aware and honest about their ability to drive safely and be prepared to discuss with their GPs;
- medical practitioners have difficulty picking who is safe to drive and who is not; the gold standard is an on-road test by a trained driving instructor and occupational therapist.
- The ACT has established a Fitness to Drive Clinic to examine drivers referred to it by
- the police, licensing authorities and medical practitioners. Examinations are usually 1.5 hours in duration and take account of driving and adjunct licensing history as well as medical histories. Recommendations can be made by the Drive Clinic or drivers referred to DARS for on road testing;
- Therapeutic drugs can influence older drivers ability to drive safely, especially when a number of drugs are being used and in the early stages of new drug use when the body is being conditioned to the new prescription. Drivers should speak to doctors or

pharmacists, examine labels on packets, not increase doses without agreement of GP, and should be aware of the substantial risk of drinking alcohol and driving while on medications.

- COTA ACT recognises the importance of mobility for older people for themselves, within their families and as a community member. It is attempting to place the onus on older people to make the correct decisions on their driving and to provide them with sufficient information to help them make these decisions. COTA outlined the range of material it makes available to Canberra citizens about the alternatives available to meet their transport needs, and the advocacy role it takes on their behalf with government and other organisations.

Future Activities
The current stages of planning for the three other projects for the 2017-18 year are:

- **The Annual ACT Road Safety Forum – 29 November 2017**
  The Chapter is developing and managing this Forum in conjunction with the ACT Road Safety Office in JACS.

  The Forum will concentrate on the implementation of Vision Zero and Safe Systems in the ACT and in particular the conflicts some organisations perceive between the principles of Vision Zero and other requirements they believe they need to meet. The adoption of Vision Zero is a critical part of the ACT Road Safety Strategy & Action Plan. It is important that maximum benefits can be obtained in future.

  Associate Professor Jeremy Wooley, Centre for Automotive Safety Research, University of Adelaide has agreed to participate.

- **ACT Aboriginal & Torres Islander Driver Licensing Pilot Project Forum - Q1 2018**
  This Forum will be organised and conducted in conjunction with The Aboriginal Legal Services NSW/ACT & is associated with a major initiative by those organisations. The Chapter was represented at a meeting with Professor Rebecca Ivers and a number of ACT departmental staff. She provided a briefing on her experience in developing similar programs in the Northern Territory and New South Wales. A decision on whether this project will be funded by the ACT Road Safety Fund is pending; .and

- **Wildlife Crash Program Forum – Q2 2018**
  This project will be undertaken in conjunction with ACT Health and the Royal Australasian College of Surgeons. The Forum will focus on achieving a better understanding of the extent of injuries to drivers and passengers involved in wildlife crashes. A decision on whether this project will be funded by the ACT Road Safety Fund is pending.

ACT Chapter Chair and Secretary
Mr Eric Chalmers & Mr Keith Wheatley

New South Wales (NSW)

The NSW Chapter meets on the fourth Tuesday of each month, alternating between face-to-face and webinar/teleconferencing. Since our last update, the Committee has facilitated and supported two seminars to members and others interested in road safety.

In August, a free seminar titled **How Do Young Drivers Learn to Drive Safely? Latest research from the United States, with NSW statistics and countermeasure updates** was held at UNSW, with Johnathon Ehsani, PhD, from Johns Hopkins Bloomberg School of Public Health speaking about The Teen Driver Dilemma: Reconciling the Need for Experience with Adolescent Vulnerability. Andy Graham, from Transport for NSW presented analysis of young driver data and Oleksandra Krasnova, PhD candidate at UNSW presented an overview of research relating to her PhD thesis.

A second free seminar titled **Motorcycle crashes and road infrastructure issues** was held in November, with presentations from James V. Ouellet, Principal, Motorcycle Accident Analysis in the USA providing a case study review based on motorcycle crash investigations. James was complemented by presentations from Chief Inpsector Phil Brooks of the NSW Police Force and David Milling of the Australian Road Research Board who was lead author of the recently published Austroads Research Report **Elements of Safer Road Infrastructure for Motorcyclists**.

Both these seminars were made available to Chapter members via a live webinar, facilitating access to members across NSW.

The Chapter looks forward to continuing to host overseas and Australian experts to present topics of interest to our members.

The next 12 months promises to be a busy one, with preparations being made for the Australasian Road Safety Conference 2018, which will be held at the Sydney International Convention Centre at Darling Harbour, in 2- 5 October 2018.

NSW Chapter Representative
Mr David McTiernan

ACRS News

ACT Child Safety Program Takes Out Top Road Safety Prize

A program building strong and enduring safety-focused relationships with families has taken out Australasia's premier road safety award, the 3M-ACRS Diamond Road Safety Award, recognising exemplary innovation and effectiveness to save lives and injuries on roads. The Kidsafe ACT project, led by Team Leader Eric Chalmers, is being delivered by the Not-for-Profit organisation to underpin the zero deaths and injuries target in the Australian Capital Territory for children under 7.

The award was presented at the Gala Dinner & Awards Ceremony of ARSC2017 by the Hon Darren Chester MP,

Clockwise from middle photo:
Federal Minister for Infrastructure and Transport, Hon Darren Chester MP with Grand Prize winner Eric Chalmers (Kidsafe ACT), Chris Leblanc (3M) and ACRS President Lauchlan McIntosh AM.
Highly Commended winners:
Ms Jacqueline Anderson (NSW Roads and Maritime Services, Western Region);
Mr Tony Fuller (for Christine Thiel - Motor Accident Compensation Commission NT);
Mr Tony Evans (RAC President, RAC Automated Vehicle Trial)

Minister for Infrastructure and Transport, Mr Lauchlan McIntosh AM, President of the Australasian College of Road Safety, and Mr Chris Leblanc representing 3M Australasia.

Minister Chester congratulated this year's award winners, including 3 Highly Commended awardees, on their contribution to improving road safety around the nation. "Road safety is an issue that impacts on all Australians, including families, and it's great to see Kidsafe ACT taking out the top award at this year's conference," Mr Chester said.

"Governments cannot do it alone in reducing fatalities and serious injuries on our roads, which costs the Australian economy an estimated $30 billion per year, and seeing such high-quality work get recognised in these awards will pay dividends for all road users.

"The work of Kidsafe ACT, which is focusing on reducing deaths and injuries for the under-7 age group, is just one part of the complex road safety picture. It is up to all of us to work toward a safer road system and I look forward to working with organisations like Kidsafe ACT and the Australasian College of Road Safety to reduce fatalities and serious injuries on our roads."

ACRS President, Mr Lauchlan McIntosh AM, said "Our 2017 winner, represented by Eric Chalmers from Kidsafe ACT, demonstrates a program bringing about zero road deaths and few injuries in the critical under 7 age group."

"The program is a proven, continually developing and integrated road safety Program in the ACT Region focused on children and built around a unique permanent free child car restraint checking service. It is achieving Zero road deaths of children under seven years old in the ACT, but also utilizes relationships with families to go well beyond the core objective and more broadly support injury prevention and improved safety education for families of young children."

Mr Chalmers said "This is the only example we are aware of where this zero injury outcome has been achieved, at least in the 30+ member countries in the Safe Kids Worldwide network. Recent independent research projects for example, have confirmed the high rate of misuse of child car restraints in many states and territories, with the consequential continuing associated road trauma, both serious injury and deaths."

Judges considered the specific features of the many projects submitted, particularly in terms of innovation in thinking and technology, problem-solving as well as the real benefits in reducing trauma. Cost-effectiveness and transferability to other areas were other key criteria.

Finalists for this hotly-contested award came from many areas. These included new ideas and actions from local and state government groups, collaborative programs led by local and regional police groups, individuals passionately pursuing specific projects to reduce risk, industry associations and transport companies implementing programs with targets to ensure safe operations, news programs, and specific education for specialist groups. These are just a few examples of the successful projects awarded as Finalists (26 in total) and Highly Commended (3) winners this year.

Highly Commended winners for 2017 include:

- **Ms Jacqueline Anderson - NSW Roads and Maritime Services** - Towards Zero TAFE Road Safety Partnership - Western Region
- **Mr Tony Fuller & Ms Christine Thiel - Motor Accidents (Compensation) Commission, Northern Territory** - Buckle Up Borroloola - Pilot Indigenous child restraints program
- **Mr Tony Evans & Ms Anne Still - RAC WA** - RAC Automated vehicle trial

"In 2010, 3M took the pledge of the Decade of Action for Road Safety, and it was clear that we could do more", said Chris Leblanc, Sales & Marketing Manager, 3M Australia.

"Our commitment to improving, protecting and saving lives extends far beyond our products and technologies. We are a company driven by the passion to improve every life through our unique approach to innovation."

"This award is modelled on that process - creating an environment where innovative ideas can come together, be shared, collaborated, celebrated, and most importantly, replicated in other regions or capacities to make a much bigger impact on road safety."

As the winning team leader, Eric Chalmers will travel to the USA to attend the 48th ATSSA Annual Convention & Traffic Expo in 2018, and will also visit 3M Global Headquarters in Minnesota.

TAC's Samantha Cockfield recognised with prestigious Australasian Road Safety Award

Congratulations to leading road safety advocate, Samantha Cockfield, Manager, Road Safety Technical and Policy, Transport Accident Commission, who was presented with the prestigious 2017 ACRS Fellowship at last night's glittering ACRS Award Ceremony at Perth Crown Resort. The ceremony took place in front of 600 of Australasia's foremost road safety professionals and advocates, and is deserved recognition of Ms Cockfield's profound commitment to the reduction of road trauma.

The award was presented by Hon Darren Chester, Federal Minister for Infrastructure and Transport, and ACRS President Mr Lauchlan McIntosh AM, during the 2017 Australasian Road Safety Conference (ARSC2017).

Minister Chester said the important contributions made by people like Ms Cockfield are vital to reducing fatalities and serious injuries on the national road network. "Improving road safety is a responsibility of all Australians, but it is advocates like Samantha who bring the community along with them in the road safety journey through their passion, leadership, and technical nous," Mr Chester said.

From left:
Hon Darren Chester MP (Federal Minister for Infrastructure and Transport)
Ms Samantha Cockfield FACRS (2017 ACRS Fellow)
Mr Lauhlan McIntosh AM FACRS (ACRS President)

"For the best part of 25 years Samantha has worked on some of the most important road safety initiatives undertaken in this country, but equally, she has mentored many of the nation's leading road safety experts. Infrastructure investment, policy reform, improving vehicle safety, and other key initiatives are vital in reducing road deaths and serious injuries – and the Australian Government is working hard on all of these aspects.

"But governments cannot do it alone, and it is those recognised here tonight, as well as your associates and your colleagues, who develop and implement these ideas, all of who should be commended for their work in improving road safety for all Australians."

In detailing the award, ACRS President Mr Lauchlan McIntosh AM said "Samantha Cockfield continues to be an outstanding advocate for road safety both in our region and internationally. Sam has contributed enormously to excellence in road safety strategy development across all road safety pillars, and in particular in being a strong leader and mentor in promoting best practice at a national and international level."

Samantha has been involved in the road safety field since 1992, beginning her career as an economist working on the development and evaluation of accident blackspot programs. Over the past 24 years, Samantha has led the development and delivery of numerous key initiatives that have contributed to reduced road trauma in Victoria. Some of Samantha's key achievements over the years include:

- Leading the public education campaign, communications and road safety initiatives to educate parents and the community of the importance of 120 hours practice on the road for learner drivers. The education program acted as a key enabler, allowing for the eventual regulation of 120 hours of mandatory practice for learner drivers and improving the safety outcome for novice drivers.
- Leading the public education campaign and communications to increase consumer awareness and demand of Electronic Stability Control, with an eventual mandate of the technology in Victoria and increasing the safety of the Victorian fleet.
- Evolving the previous Accident Blackspot Program to the current Safe System Road Infrastructure Program (SSRIP). SSRIP is a ten-year $1 billion dollar investment to transform the Victorian road network in accordance with *Towards Zero* principles to increase the safety of road infrastructure in Victoria. SSRIP is one of the largest programs of its kind in the world.
- Securing support and assisting with the development of the Enhanced Crash Investigation Study (ECIS), an $8 million research program designed to examine more than 400 serious injury crashes in detail to provide an understanding of how crashes and injuries occur.

With Victoria moving to implement the *Towards Zero* approach and build a safe road system for Victoria, Samantha has shown excellence in leadership to assist Victoria to achieve the goal of zero deaths and serious injuries through:

- The delivery of an annual Towards Zero Road Safety Leadership Symposium to garner the support of leaders in government, local government and the public sector to brainstorm and implement actions that can help reduce road trauma in Victoria.
- Commissioning and leading the development of a Safe System Road Map to help guide the investment and implementation required to build a safe road system in Victoria.
- Leading the development of a Safety Culture in Victoria through the development of a new communications strategy designed to foster safety as the key priority and to bring the Victorian community on the *Towards Zero* journey.

Samantha has worked tireless over the past 24 years and her leadership, dedication and hard work in the road safety field has no doubt contributed significantly to improved road trauma outcomes in Victoria.

With the 2017 award, Ms Cockfield joins an elite group of eminent road safety professionals who have all been bestowed the honour of an ACRS Fellowship. The College first instituted the award of Fellow in 1991 to enable colleagues to nominate a person recognised by their peers as outstanding in terms of their contributions to road safety.

Congratulations to all the ARSC2017 Award winners

Peter Vulcan Award for Best Research Paper $1000.00
Mr Giulio Ponte, Research Engineer, Centre for Automotive Safety Research Awards

Best Paper by a New Researcher Award $1000.00
Ms Nilindu Muthubandara, Research & Policy Analyst, Centre for Road Safety, Transport for NSW

Road Safety Practitioners Award $1000.00
Dr Catherine Wilkins, Senior Sergeant Victoria Police

Best Paper by a New Practitioner Award $1000.00
Dr Fritha Argus, Research & Data Coordinator Main Roads WA

Best Paper with Implications for Improving Workplace Road Safety Award $1000.00
Dr Lori Mooren, Research Consultant, Transport and Road Safety (TARS) Awards Research Centre

Conference Theme Award $500.00
Dr Kyle Chow, Research Fellow, Curtin-Monash Accident Research Centre

Road Safety Poster Award $500.00
Dr Lyndel Bates, Senior Lecturer, School of Criminology and Criminal Justice, Griffith University

Diary

2017

November 2-4
International Seminar on Road Safety Audit
Tunis, Tunisia
https://www.piarc.org/en/2017-03-20,International-Seminar-on-Road-Safety-Audit-2017.htm

November 9-10
11th Uruguayan Winter Road Congress
Montevideo, Uruguay
http://www.auc.com.uy/index.php?option=com_content&view=article&id=266&Itemid=122

November 14-15
The National Road Safety Conference 2017
Radisson Blu Manchester Airport
http://nationalroadsafetyconference.org.uk/

November 14-17
18th IRF World Meeting
New Delhi, India
https://wrm2017.org/message/

November 15-17
Intertraffic Mexico
Mexico City, Mexico
http://www.intertraffic.com/en/mexico/

November 19
World Day of Remembrance for Road Traffic Victims
http://worlddayofremembrance.org/

November 25-27
International seminar "Safe System Approach to Enhance Traffic Safety in Iran: Recent Activities and Future Directions"
Tehran, Iran
https://www.piarc.org/ressources/documents/INTERNATIONALS-SEMINARS-PROCEEDINGS/International-Seminar-Teheran-November-2017/26536,International-Seminar-First-Announcement-CT-1-Safe-System-Approach-to-Enfance-Traffic-Safety-Tehran-Iran-November-2017.pdf

December 24-25
ICTTP 2017: 19th International Conference on Traffic and Transportation Psychology
Dubai, UAE
https://www.waset.org/conference/2017/12/dubai/ICTTP

Erratum
Figures 1 & 2 (p.34 & p.39) and Appendix (p.42) had poor legibility in the print version of the article: Pedruzzi R., Swinbourne A. and Quirk F. (2017). Investigating perceived control over negative road outcomes: Implications for theory and risk communication. *Journal of the Australasian College of Road Safety*, 28(3), 30-42. The error has since been corrected in the PDF version that is available on http://acrs.org.au/publications/journals/current-and-back-issues/

Peer-reviewed Papers

Original Road Safety Research

A Crash Testing Evaluation of Motorcyclist Protection Systems for use on Steel W-Beam Safety Barriers

Joanne Baker[1], Melvin Eveleigh[2] and Amy Burrows[3]

[1] Centre for Road Safety, Transport for NSW, Sydney, Australia. Joanne.Baker@transport.nsw.gov.au

[2] Centre for Road Safety, Transport for NSW, Sydney, Australia. Melvin.Eveleigh@transport.nsw.gov.au

[3]Transport for NSW, Sydney, Australia

Corresponding Author: Joanne Baker, L4, 18 Lee St, Chippendale, NSW 2008 Joanne.Baker@transport.nsw.gov.au and 02 8265 7553

.

Key Findings

- Motorcyclist Protection Systems can reduce the risk of fatality and serious injury to sliding motorcyclists, without compromising the safety of other road users
- Two products – the Ingal MPR and the HIASA – demonstrated an acceptable level of injury risk to a sliding motorcyclist impacting at 60 km/h
- A third public domain product and the W-Beam alone did not demonstrate an acceptable level of injury risk to a sliding motorcyclist impacting at 60km/h

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 three currently available Motorcyclist Protection Systems (MPS) to investigate 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. Two of the MPS tested demonstrated an acceptable level of injury risk to a sliding motorcyclist impacting at 60 km/h, and a greatly reduced injury risk, compared with the W-beam alone, where impact was likely to be fatal. None of the MPS demonstrated any adverse impact on the injury risk to vehicle occupants, or the vehicle's trajectory.

Keywords

Motorcyclist, Injury risk, Road safety barriers, Motorcycle under run, rub rail, Crash test

Introduction

This study 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.

Background to the study

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 (Transport for NSW, 2016). Motorcyclists are overrepresented in road trauma, representing 16 percent of fatalities and 18 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; Transport for NSW, 2016). 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).

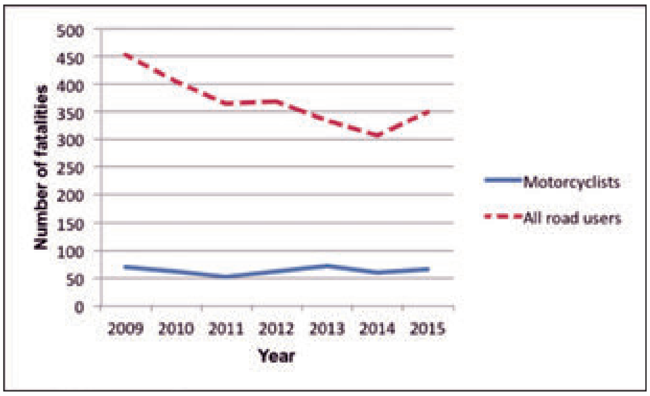


Figure 1. Number of fatalities on NSW roads, 2009-2015

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 was 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 car occupants (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 crash 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

Figure 2. Ingal MPR

Figure 3. HIASA MPS

Figure 4. Public domain MP

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.

Methods

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. These MPS are able to be fitted to a standard W-beam barrier which is used widely across the NSW road network. They were available on the Australian market at the time of the study and had been submitted to NSW Roads and Maritime Services (RMS) for assessment and approval for use on NSW roads. Additional crash tests were carried out to examine whether the MPS had any adverse impact on vehicle occupants. A standard G4 W-Beam barrier alone served as a comparison and was used for informative purposes only. All testing was carried out at Crashlab, a commercial business unit of RMS.

Motorcyclist crash tests

Twelve crash tests were undertaken between November 2014 and February 2015 to evaluate the injury risks posed to an impacting motorcyclist by each of the MPS and to compare these with the injury risk of impacting a W-Beam alone. Testing was undertaken in accordance with the European test specification CEN/TS 1317-8:2012, which was seen as current industry best practice for evaluating MPS at the time testing was undertaken.This test specification has subsequently been recommended in the new Australian and New Zealand standard for barrier testing and installation AS/NZS3845:2015, which was released after this study was completed.

The 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). These modifications enable the ATD to behave more like a sliding motorcyclist rather than a seated vehicle occupant. The modifications are described in CEN/TS 1317-8:2012, and include a "standing" pelvis, to enable the ATD to lie flat, a frangible shoulder assembly to better simulate motorcyclist trajectory and injuries when impacting the MPS, a foam neck shield to ensure the helmet's chin strap could be securely fastened and an alternate lumbar spine to allow for the inclusion of the internal data acquisition system.

Testing is carried out at 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).

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

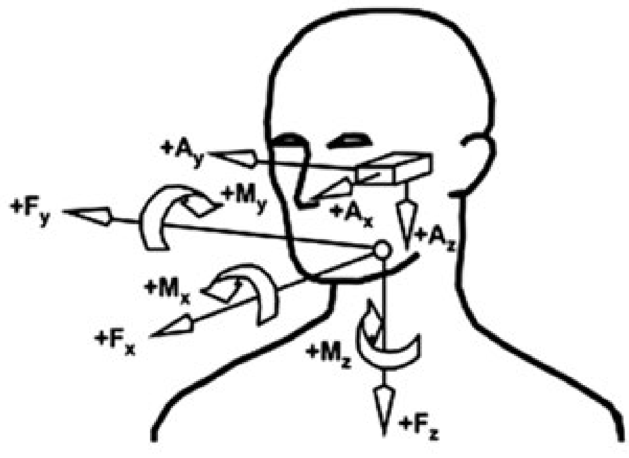
Figure 5. Set up used in the motorcyclist crash tests

Figure 6. The public domain MPS attached to the W-Beam barrier

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.

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), likely 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.



Fx - anterior-posterior shear force, Fy - lateral shear force. Fz - tension-compression force, Mx- lateral bending moment on the neck, My - flexion/extension moment on the neck, Mz - torsion moment (Mz).

Figure 7. Directions for forces, accelerations, and moments in the ATD (CEN/TS 1317 8:2012 P8)

Passenger car occupant crash tests

Three crash tests examined the injury risks posed to passenger car occupants by each of the MPS and a further crash test was carried out with the W-beam alone for comparison. Passenger car tests were carried out in accordance with the Australian and New Zealand standard for barrier testing and installation AS/NZS 3845:1999, which was current at the time of the study. 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, was used. 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 a 1600 kg sedan, which is permitted under AS/NZS 3845:1999, was used. The W-beam barrier fitted with each of the three MPS was assessed against standard criteria relating to structural adequacy of the barrier, occupant injury risk and the vehicle trajectory after the collision. The W-beam only was also assessed against these criteria, for comparison.

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 located at the center of gravity of 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 50th 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. This was varied for the Ingal MPR which was installed on a slightly shorter barrier, 60m

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 (HIC_{36})	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		

Table 2. HIASA - motorcyclist test results

	Mid-span 60 km/h	**Post-centred 60 km/h**	**Mid-span 70 km/h**	***Severity Level I criteria***	***Severity Level II criteria***
Head Injury Criterion (HIC_{36})	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		

in length, with 31 steel posts, spaced 2 m apart and the top edge of the rail 720 mm high. This was due to the conditions at the test site at the time of the test, and was expected to have minimal effect on the test results.

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 CRS (Crashlab, unpublished).

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. Figure 7 shows the direction for forces, accelerations, and moments in the ATD to assist with the interpretation of the test results.

Motorcyclist crash tests

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 shows the HIASA met all performance requirements at 60 km/h for both the mid-span and post-centred impact

Table 3. Public domain – motorcyclist test results

	Mid-span 60 km/h	**Post-centred 60 km/h**	**Mid-span 70 km/h**	***Severity Level I criteria***	***Severity Level II criteria***
Head Injury Criterion (HIC_{36})	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	Met	Met	Not met		

Table 4. W-beam – motorcyclist test results

	Post-centred 60 km/h	**Mid-span 70 km/h**	***Severity Level I Criteria***	***Severity Level II criteria***
Head Injury Criterion (HIC_{36})	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		

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.

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.

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

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
Impact Severity (kJ)	116.2	105.3	112.7	108.9

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***

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

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 deflection of end terminals, x (m)	0.00	0.00	0.03	0.03

discussed by Grzebiata, Bamabach and McIntosh (2013) is clearly supported by the findings of this study. The new standard AS/NZS 3845:2015, which was published after this study, and now references CEN/TS 1317-8:2012, includes measures of thorax compression, based on some of this work.

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, which were conducted to assess whether the MPS were likely to have an adverse impact on the injury risk to vehicle occupants. Tolerances for impact speed and impact angle were met in all four tests. Impact severity measures were all within the maximum allowable value. Note that the negative exit angle of the vehicle following impact with the HIASA MPS indicates that the vehicle rotated towards the barrier upon exit.

There are two key values of interest for the simulated injury risk, which are set out as mandatory testing requirements in NCHRP Report 350. The first is the Occupant Impact Velocity in the longitudinal (x) direction, 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 (x) direction which is the vehicle acceleration transferred to the vehicle occupant after interior impact is made. These values are computed from the vehicle's trajectory, using the flail space model (see Gabauer & Gabler, 2008). The model assumes the occupant is unrestrained in the vehicle and 'flails' within set bounds. The values are calculated from the point when the occupant moves outside the 'flail' space, and ignore the vehicle's pitch (around the y-axis) and yaw (around the z-axis) motions for ease of computation. The other values, while not mandatory requirements under NCHRP Report 350, are reported for comprehensiveness and to enable comparison with other testing.

It can be seen that for each of the MPS, as well as the W-beam alone, the injury risk to passenger car occupants were within acceptable levels. In each test 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.

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 W-beam fitted with each of the MPS demonstrated acceptable levels of structural adequacy, occupant risk and vehicle trajectory. The W-beam fitted with 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 of the barrier into the occupant compartment and vehicles remained upright during, and following the impact.

Table 8 shows the degree of barrier deflection for each of the four tests. Whilst this is not an evaluative criterion of the testing, the findings are reported for comprehensiveness and comparison. It can be seen that the W-Beam alone tended to have the highest degree of barrier deflection.

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, and a greatly reduced injury risk compared with a W-beam barrier with no MPS installed, where impact was likely to result in fatality. These two MPS met all test requirements for injury risk, MPS and ATD behaviour for both mid-span and post-centred impacts at this test speed. The Severity I (lesser) injury criteria were met in all cases. The other MPS tested – the public domain product, however, did not meet the testing requirements for injury risk to a sliding motorcyclist impacting at 60 km/h. None of the MPS demonstrated any adverse impact on the injury risk to vehicle occupants, and the vehicle's trajectory.

The crash tests suggest that the addition of MPS to a standard W-beam may reduce the risk of fatality and serious injury to sliding motorcyclists, without compromising the safety of other road users. Further research, however, is required to understand the injury risks that MPS pose to motorcyclists impacting in an upright or alternative position and how the MPS perform in real world conditions. Given that motorcycle impacts with roadside barriers are more prevalent on curves, it makes sense to start targeting the installation of MPS toward the outside of curved alignments on popular motorcycle recreational routes or where there is a history of motorcycle crashes.

Acknowledgements

The authors would like to thank the team at Crashlab for undertaking the crash tests and for their efforts and support throughout the project.

References

Australian Bureau of Statistics, (2009). *Motor Vehicle Census Australia, 31 January 2009*, cat. no. 9309.0, Canberra, Australia, ABS

Australian Bureau of Statistics, (2010). *Motor Vehicle Census Australia, 31 January 2010*, cat. no. 9309.0, Canberra, Australia, ABS

Australian Bureau of Statistics, (2011). *Motor Vehicle Census Australia, 31 January 2011*, cat. no. 9309.0, Canberra, Australia., ABS

Australian Bureau of Statistics, (2012). *Motor Vehicle Census Australia, 31 January 2012*. cat. no. 9309.0, Canberra, Australia, ABS

Australian Bureau of Statistics. (2013). *Motor Vehicle Census Australia, 31 Jan 2013*, cat no. 9309.0, Canberra, Australia, ABS

Bambach, M. R., Grzebieta, R. H., Olivier, J., & McIntosh, A, (2011). Fatality risk for motorcyclists in fixed object collisions, *Journal of Transportation Safety and Security*, 3(3), 222-235.

Bambach, M., Grzebieta, R., and McIntosh, A., (2010). *Motorcycle crashes into roadside barriers stage 2: Crash mechanics and injury causation,* Sydney, Australia. NSW Injury Risk Management Research Centre

Bambach, M., Grzebieta, R., Tebecis, R., and Friswell, R., (2012, October). *Crash characteristics and causal factors of motorcycle fatalities in Australia*. Paper presented at the Australasian Road Safety Research, Policing and Education Conference, Wellington, New Zealand.

Bambach, M., Mitchell, R., and Grzebieta, R., (2013). The protective effect of roadside barriers for motorcyclists, *Traffic Injury Prevention*, 14, 756-765

Berg, A., Rücker, P., Gärtner, M., König J., Grzebieta, R. and Zou R. (2005, June). *Motorcycle impacts to roadside barriers - Real World Accident Studies and Crash Tests Carried out in Germany and Australia.* Paper presented at the 19th International Technical Conference on the Enhanced Safety of Vehicles, Washington, USA

Crashlab, Test report BR2014/045 Ingal MPR on G4 W-beam motorcycle ATD crash test mid-span 60 km/h, unpublished test report

Crashlab, Test report BR2014/044 Ingal MPR on G4 W-beam motorcycle ATD crash test mid span 70 km/h, unpublished test report

Crashlab, Test report BR2015/006 Ingal MPR on G4 W-beam motorcycle ATD crash test post centred 60 km/h, unpublished test report

Crashlab, Test report BR2014/050 Ingal MPR on G4 W-beam motorcycle ATD crash test post centred 70 km/h, unpublished test report

Crashlab, Test report BR2014/047 HIASA on G4 W-beam motorcycle ATD crash test mid span 60 km/h, unpublished test report

Crashlab, Test report BR2014/041 HIASA on G4 W-beam motorcycle ATD crash test mid span 70 km/h, unpublished test report

Crashlab, Test report BR2015/007 HIASA MPS on G4 W-beam motorcycle ATD crash test - post centred impact 60 km/h, unpublished test report

Crashlab, Test report BR2014/046 Public domain on G4 W-beam motorcycle ATD crash test mid span impact 60 km/h, unpublished test report

Crashlab, Test report BR2014/042 Public domain on G4 W-beam motorcycle ATD crash test mid span impact 70 km/h, unpublished test report

Crashlab, Test report BR2015/010 Public domain on G4 W-beam motorcycle ATD crash test post centred 60 km/h, unpublished test report

Crashlab, Test report BR2014/043 G4 W-beam motorcycle ATD crash test mid span 60 km/h, unpublished test report

Crashlab, Test report BR2015/011 G4 W-beam motorcycle ATD crash test post centred 60 km/h, unpublished test report

Crashlab, Test report BR2013/033 (Ingal MPR MPS on G4 W-beam VT Commodore crash test, unpublished test report

Crashlab, Test report BR2014/024 HIASA MPS on G4 W-beam VT Commodore crash test, unpublished test report

Crashlab, Test report BR2014/026 Public domain MPS on G4 W-beam VT Commodore crash test, unpublished test report

Crashlab, Test report BR2014/025 G4 W-beam VT Commodore crash test, unpublished test report

Department of Infrastructure Transport Regional Development and Local Government, (2008). *Fatal and serious road crashes involving motorcyclists*, Canberra, Australia, Monograph 20

Elvik, R. (1995). The safety value of guardrails and crash cushions: A meta-analysis of evidence from evaluation studies. *Accident Analysis and Prevention*, 27 (4), 523-549

European Committee for Standardization, (2012). *CEN/ TS EN1317-8:2012. Road restraint systems - Part 8: Motorcycle road restraint systems which reduce the impact severity of motorcyclist collisions with safety barriers,* ed. London, UK: BSI.

EuroRAP, (2008). *Barriers to change: designing safe roads for motorcyclists*. Basingstoke, Hampshire, UK. EuroRAP

Gabauer, D., and Gabler, H., (2008) Comparison of roadside crash injury metrics using event data recorders, *Accident Analysis & Prevention,* 40, 548-558

Gabler, C. (2007, June). *The emerging risk of fatal motorcycle crashes with guardrails*. Paper presented at the 20th International Conference on Enhanced Safety of Vehicles, June, Lyon, France

Gibson, T., and Benetatos, E., (2000). *Motorcycles and crash barriers*, Paper prepared for the NSW Motorcycle Council, Balmain, NSW, Australia.

Grzebiata, R., Bambach, M., and McIntosh, A. (2013), Motorcyclist impacts into roadside barriers: Is the European crash test standard comprehensive enough? *Journal of the Transportation Research Board*, 2377, 84-91

Jama, R., Grzebieta, R., Friswell, R., and McIntosh, A. (2011), Characteristics of fatal motorcycle crashes into roadside safety barriers in Australia and New Zealand, *Accident Analysis and Prevention*, 43, 652-660

Peldschus, S., Schuller, E., Koenig, J., Gaertner, M., Ruiz, D., and Mansilla, A., (2007, June). *Technical bases for the development of a test standard for impacts of powered two-wheelers on roadside barriers*. Paper presented at the 20th International Conference on Enhanced Safety of Vehicles, Lyons, France

Ross, H., Sicking, Jr., D., Zimmer, R., & Michie, J., (1993). NCHRP Report 350 - Recommended Procedures for the Safety Performance Evaluation of Highway Features, Washington D.C. Transportation Research Board

Ruiz, D. G., Magallón, B. P., Peldschus, S., Schuller, E., Gallo, A. M., & Bidal, S. (2010). Overview on the development of a test standard for the evaluation of motorcyclists' impacts on road infrastructure elements. *International Journal of Crashworthiness,* 15(1), 1-15

Standards Australia, (1999), *AS/NZS 3845:1999 - Road safety barrier systems*, ed. Homebush, NSW, Australia.

Standards Australia, (2015), *AS/NZS 3845:2015 - Road safety barrier systems and devices*, ed. Homebush, NSW, Australia

Transport for NSW, (2016). *Road traffic crashes in New South Wales: statistical statement for the year ended 31 December 2015*, Sydney, Australia. Transport for NSW

Multi-stage Road Safety Auditing to Maximise Development Impact

Oliver Whalley[1]

[1]*The World Bank, Sydney, Australia*

Corresponding Author: Oliver Whalley, Level 19, 14 Martin Place, Sydney, NSW 2000, Australia, owhalley@worldbank.org, +61 2 9235 6411

Key Findings

- Road safety auditors should be involved early for best outcomes
- Commitment to road safety is required from all stakeholders
- High risk projects should include multi-stage audits
- Infrastructure is only a part of a safe road system

Abstract

Development institutions including the World Bank recognise that road safety is a critical issue for investments in low and middle-income countries (LMICs). Inadequate consideration of safety disproportionately affects the poor; the very group which Governments and development institutions strive to lift from poverty. Road safety audits (RSA) are an effective way of addressing safety, however, their systematic use is often lacking. RSAs are also often completed too late for their full potential to be fully realised. To address this, the World Bank with support from the Global Road Safety Facility (GRSF) trialled the systematic application of multi-stage RSAs. The goal was to integrate road safety into the project design, with RSAs undertaken at feasibility, detailed design and post-construction stages. This approach is innovative for a project in a LMIC, and aimed to overcome the design inertia often observed when RSAs are undertaken later in projects. The results of a case study from the Kiribati Road Rehabilitation Project (KRRP) are presented. The approach resulted in a road design with extensive and well detailed safety features including a narrow carriageway, footpaths, speed humps, street lighting and gateway treatments. For the KRRP, pedestrians were the key vulnerable road user and the risk to them was expected to increase as a result of speed increases due to improved road condition. However, it was found that by applying a multi-stage RSA approach, improvements in road condition were made in parallel with features which decreased the safety risk to Kiribati's most vulnerable road users.

Keywords

Auditing, poverty, development, design, vulnerable, investment

Introduction

International development institutions have set an ambitious target as part of the United Nations (UN) Decade of Action for Road Safety, to stabilise then reduce global traffic fatalities by 2020 (UN, 2010). This is a particularly challenging target for low and middle-income countries (LMICs), where rapid urbanisation and motorisation of their populations is creating large populations of vehicle users which increase the risk of accident trauma. These risks also disproportionately affect the vulnerable users who are typically poorer, such as pedestrians, cyclists and motorcyclists. Development organisations are conscious of these risks, and often use road safety tools to ensure investments are as safe as possible, minimising the harm caused by their investments.

One powerful but underutilised tool to address these issues are road safety audits (RSAs). They consist of a formal qualitative examination of the safety performance of an existing or future road, providing recommendations which help to ensure infrastructure is as safe as possible (AUSTROADS, 2009).

RSAs can be conducted at various stages in the project life including feasibility, preliminary design, detailed design and pre-opening or post-construction stages. It is recognized that the earlier a road is audited within the design and development process, the better as it allows for adjustments to be made in the design with minimal risk of redesign or physical rework. Despite this, it is typical in development projects for RSAs to be conducted only at the detailed design stage, if at all.

The challenge with auditing only at the detailed design stage is that road safety features which fundamentally affect the design solution can only be fully considered if there is a standard audit approach. This is often missing, particularly for road projects in LMICs. As a result, the opportunity to introduce innovative road safety solutions is missed, with designs often developed to such an extent that modifications for road safety may significantly delay the project, and/or increase the costs. For design teams working on lump sum contracts there is also reticence to do anything that could be considered rework.

An approach which has not been widely used on development projects is to conduct auditing at multiple stages throughout the life of the project. Adopting a comprehensive approach with audits at feasibility, detailed design and post-construction stages leads to a road which is much safer, particularly for vulnerable users. Through documenting the benefits of this multi-stage RSA approach which is novel for a development project, a case is made for the wider use of this methodology on road rehabilitation projects which pose a high risk of user trauma, particularly those in LMICs.

Background

Country Context

With an estimated population of 110,000, Kiribati is a small, remote country on the equator comprised of 33 atolls and reef islands, of which 21 are permanently inhabited. The total land area is only 726 square kilometres spanning approximately 3.5 million square kilometres of ocean (Central Intelligence Agency, 2016). The location of Kiribati is shown in Figure 1.

Approximately 60,000 of Kiribati's population reside in the capital of South Tarawa which is a magnet for internal migration from outer islands, with population growth of 4.4 percent a year (Office of Te Beretitenti, 2012). South Tarawa provides employment opportunities, as well as access to education and social services not available elsewhere in Kiribati. The United Nations Development Program (UNDP) noted that South Tarawa has a high incidence of basic needs poverty which affects one quarter of the population (UNDP, 2010).

Existing Road

In South Tarawa, the community is linked by a single main two-lane sealed road and four causeways that run east to west (Figure 1). For the majority of its length, the road passes through ribbon development comprising residences, businesses, schools and hospitals, all located within the confines of the atoll, which is less than three meters above sea level and has an average width of only 450 meters (World Bank, 2011). Virtually the entire population lives close to, and is affected by, the road's condition.

In 2010 the road system consisted of 36 km of bituminous sealed main roads (including causeways); 20 km of secondary roads (half of which are sealed and half unsealed); and 40 km of unsealed feeder roads. Road use on South Tarawa was growing rapidly: in central Bairiki, traffic volume on the main road reached 6,000 vehicles per day, growing at an average rate of four percent per year (PRIF, 2009). The estimated pedestrian traffic was 60,000 per day, so this vulnerable group was by far the largest road user.

While approximately 7 km of main road in Betio in the west of South Tarawa was rehabilitated in 2008 with finance from Japan, some 29 km of paved roads had received no major maintenance for over twenty years. The high traffic levels on the road combined with heavy rainfall during wet seasons caused extensive damage, with long sections of the road losing surfacing completely and reverting to an unpaved surface.

The state and condition of the roads in Kiribati had significant economic and social repercussions; particularly with regard to the health and safety of the population. The traffic speed was reduced in places to 20 km/h or less as a

Figure 1. Kiribati location and KRRP road layout (World Bank, 2011)

Figure 2. Poor condition of South Tarawa Road prior to the KRRP

result of the pavement condition. While lower speeds were advantageous from a road safety perspective, the driving conditions were hazardous particularly after rain (Figure 2). Further, during the dry season the dust from unpaved sections of the road contributed to widespread upper respiratory problems amongst local residents.

Project Objective

Recognising that the poor condition of the South Tarawa road was a key contributor to poverty in Kiribati, the World Bank together with the Asian Development Bank and the Australian Agency for International Development (now the Department of Foreign Affairs and Trade), hereafter referred to as 'donors', prepared the Kiribati Road Rehabilitation Project (KRRP). With the development objective of improving the condition of South Tarawa's main road network and helping to strengthen road financing and maintenance capacity (World Bank, 2011), a comprehensive investment and reform project was prepared. Funding for the project was approximately US$76 million including both the physical works and associated activities for road maintenance and safety (Asian Development Bank, 2016). Physical works started in July 2013, and were completed in December 2016.

Case Study Findings

Phase 1: Feasibility Stage RSA

During the early stages of project preparations, prior to design commencing, donors sought the expertise of a specialist road safety auditor. This was made possible with funding from the Global Road Safety Facility (GRSF), a global partnership program administered by the World Bank with a mission to help address the growing crisis of road traffic deaths and injuries in LMICs. The auditor selected conducted an existing condition RSA of the South Tarawa road corridor, for which the feasibility of rehabilitation was being considered. Typically, a feasibility stage RSA involves a review of broad design decisions such as route selection, an approach consistent with guidelines that suggest auditing the design brief for safety (AUSTROADS, 2009). However, the approach used for KRRP instead focused on existing issues which fed into the design brief. This was similar to the approach documented by Harris (2015) for a 1,500 km of highway in Tanzania, albeit with more detail due to the short length being considered under KRRP. The RSA conducted included several day-time and night-time site inspections with findings compiled in a report. This included a table of issues and recommendations for action by the designer (Road Safety International, 2010). An example of a safety issue raised regarding the hazard clear zone, and the subsequent recommendation is provided in Figure 3. This report was then provided to the engineering designers to ensure that the road safety issues were fully addressed from the commencement of the design stage.

Summary of feasibility stage RSA findings

This feasibility stage RSA found the following major issues with the existing road which required action in the design:

- Provision of footpaths in densely populated villages to reduce risk to pedestrians;
- Provision of bus-stops for better traffic management and to promote safer bus driving;
- Provision of pedestrian crossings at schools and other busy areas;
- Provision of proper signage and pavement markings;
- Improved intersection designs;

SAFETY CONCERN	RISK	RECOMMENDATION
There are numerous trees and houses, shops and other fixed objects within the clear zone along this road. There are too many to individually highlight, and it is expected that removal of the trees will not be a favoured option. The installation of crash barriers is not recommended – such barriers will nto fit in some parts because of inadequate widths for offsets and deflection. They will also cause 'innocent hits' when buses/cars pull too close.	High	• Design the road with suitable line marking and associated delineation to minimise the risk of a vehicle leaving the road. • Take into account especially the locations at each end of the causeways (where speeds will be highest) and ensure that delineation of the curves is excellent. • At selected locations install 2-3 chevron alignment markers (CAMs) to delineate a sharp curve. • Consider developing a program of tree removal to remove only those trees that are closest to the road in high risk locations (blackspots) at the end of the causeways.
		
The bridge on the Betio causeway is narrower than the road cross section. The footpath and the bridge railing are road side hazards. The design proposes a cantilevered footpath to serve pedestrians and to maintain the road width.		The Betio port road runs beside the sea – a safety barrier is now proposed to prevent a vehicle from dropping 4m into the sea here.

Figure 3. Example of feasibility RSA findings showing safety concerns and recommendations (Road Safety International, 2010)

- Provision of street lighting to improve safety at night in busy pedestrian areas;
- Speed control measures such as speed humps to mitigate the likely increased risk of speeding as a result of improved road conditions;
- Speed limits of 30 km/h through villages and 60 km/h through un-developed areas.

In addition to this, the donors supported the auditor's recommendation to reduce the combined traffic lane width from seven to six metres so as not only to create sufficient space for footpaths and shoulders, but also to increase vehicle 'friction' and reduce speeds.

The designers considered these recommendations during the detailed design, and conscious of the importance of road safety to both their client the Government of Kiribati, and the donors, they made commendable efforts to address as many of the recommendations as possible.

Phase 2: Detailed Design Stage RSA

In Phase 2, a RSA was conducted on the draft detailed design of the KRRP civil works. The auditor was the same individual who undertook the feasibility RSA, with an updated issue table prepared to assist the designers with refining the design (Road Safety International, 2011) – Figure 4 for an example on signage. Using the same auditor for feasibility and detailed design stage RSAs resulted in a consistency of input and made use of the relationship that had been established with stakeholders.

In the case of KRRP, this second audit continued a dialogue between designer and auditor to facilitate the process of agreeing details, with comments and responses tracked and

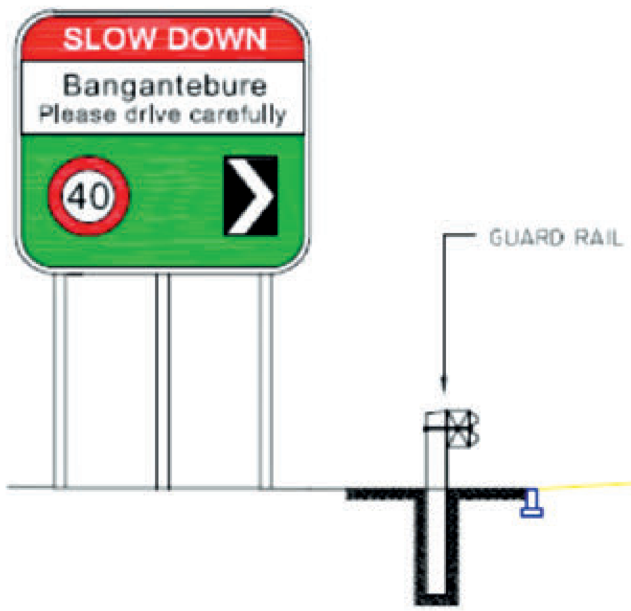
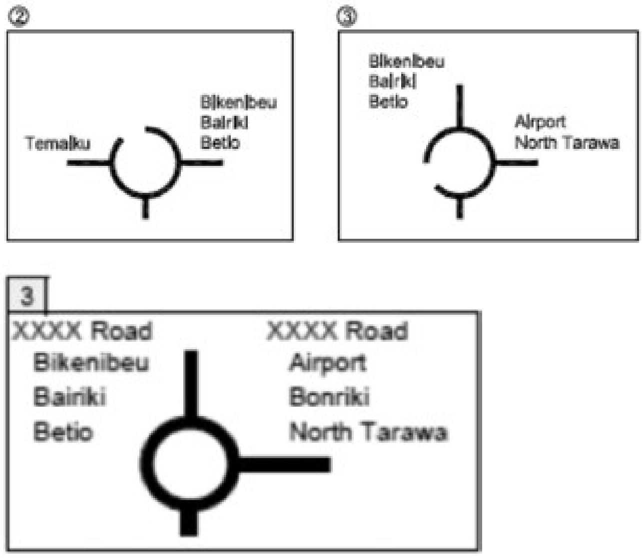
SAFETY CONCERN	RECOMMEDNATION
	
The proposed gateway sign is a good concept but the design is not as useful for safety as it could be. The hazard marker is incorrect and may confuse drivers. The term SLOW DOWN implies people are speeding and yet the speed limit in advance of this sign will be the same as after the sign (40km/h). Drivers should be told why they need to be careful – usually because they are entering an area with more pedestrians than elsewhere.	These signs shown for the roundabout proposed at the T junction of the Airport Road/main Road are incorrect. The "gap" in the circulating carriageway should always be just to the right of the entering road (ie just to the right of the road on the bottom of the sign). Sign No 3 is from Figure 17 in the draft design report. It needs to be reviewed and corrected together with the other diagrammatic directions signs shown there.

Figure 4. Example of detailed design RSA findings (Road Safety International, 2011)

reviewed by Government and donors. This feedback loop reduced the likelihood that recommendations would be ignored, addressing a common weakness of the audit process and developing greater ownership of road safety by project stakeholders.

Often designers and even some governments are reluctant to add safety features when only detailed design RSAs are conducted, with a desire to avoid rework fuelling this. However, because the design for KRRP included extensive safety features from the concept stage, the risk of rework to add safety features was reduced.

After modifying the design based on the RSA, highlights of the road safety detailing included paved footpath for the length of the main road (on both sides) - Figure 5. In addition, the designer went beyond the recommendations of the auditor to specify roundabouts at two key intersections (Figure 6). This indicates a strong commitment to safety which was fostered by providing the designer with a feasibility stage RSA. These and other features contributed to an overall safer design for the road rehabilitation, particularly for pedestrians who were the most numerous but also most vulnerable road users.

Summary of detailed design stage RSA findings

The detailed design RSA focused on refining the details for features recommended in the feasibility RSA. These included:

- Details for signage and line markings including chevrons for delineation, direction, warning and speed restriction signage;
- Provision of crash barriers including end terminal details;
- Details of street lighting including frangible poles;
- Intersection details including splitter islands at roundabouts, centrally placed lighting and channelisation of intersections.

It also separately raised new recommendations for inclusion in the final design including:

- Road cross section including raised kerbs and sealed shoulders;
- Pavement for bus stopping areas;
- Sealing of side roads back from junctions;

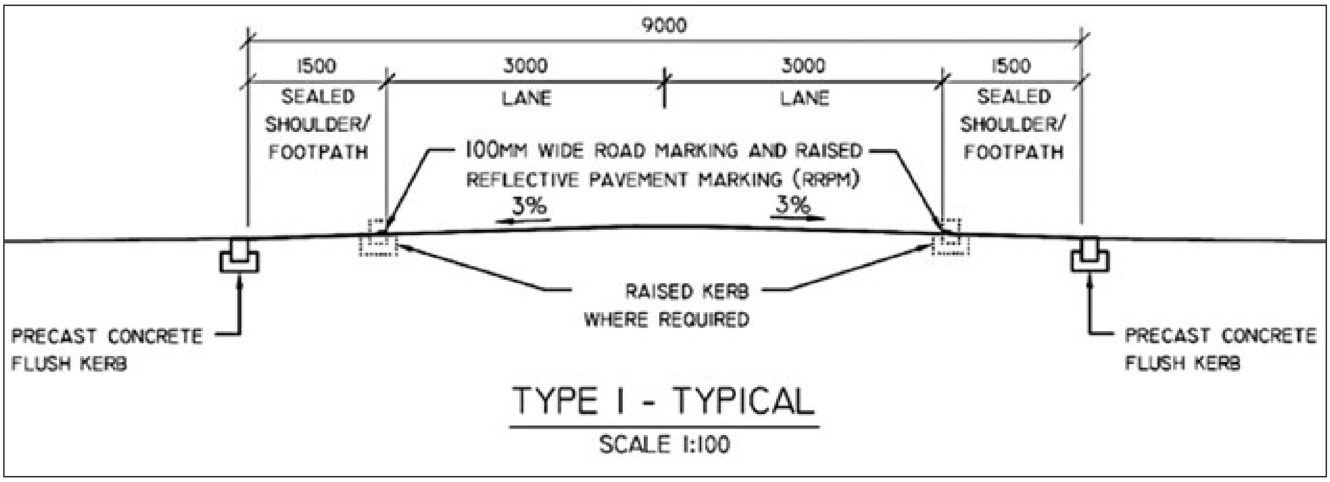


Figure 5. Typical road cross section for KRRP - Betio to Bikenibeu (Roughton International, 2011a)

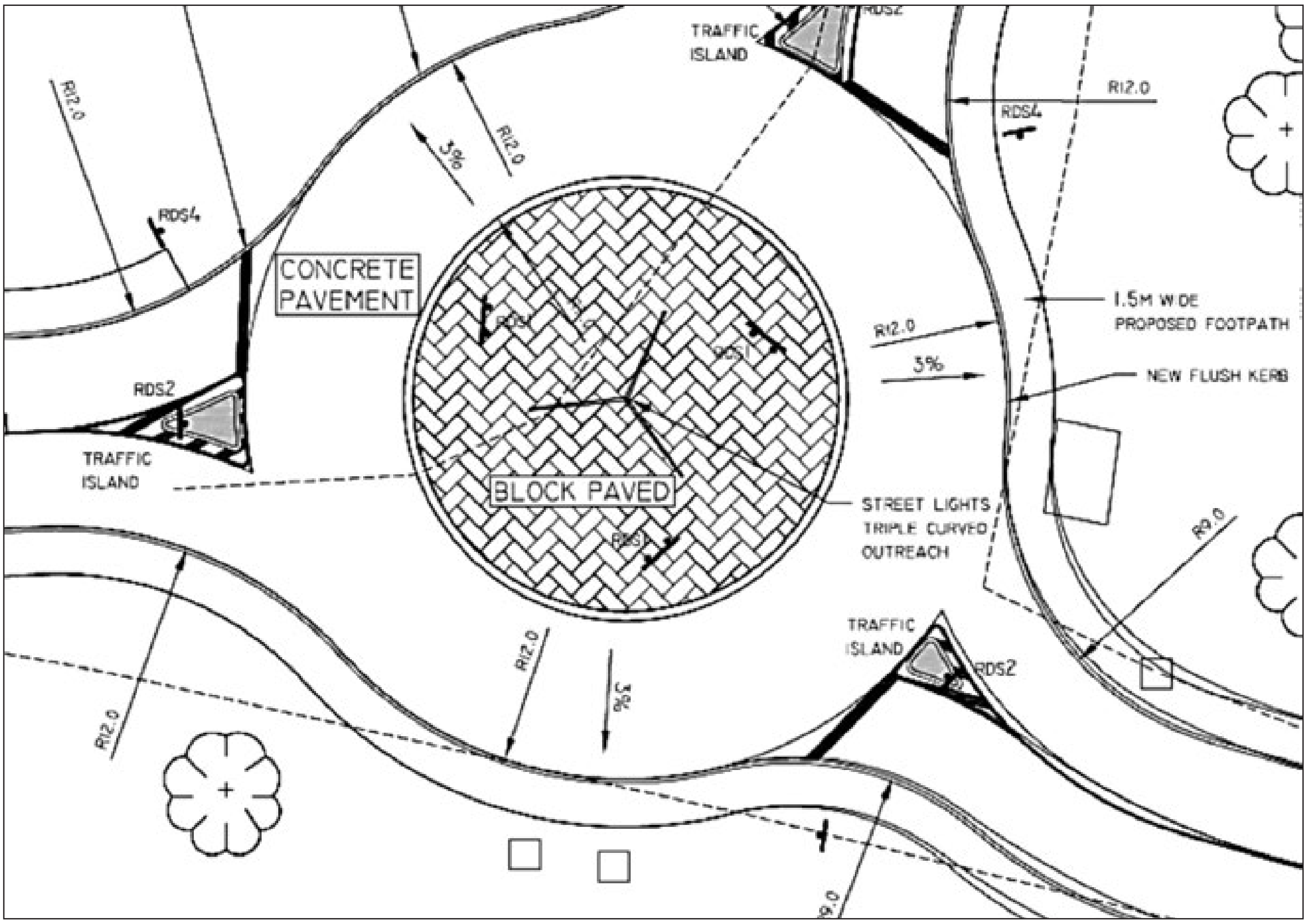


Figure 6. Temaiku roundabout (Roughton International, 2011b)

- Using crash barrier for shielding culverts and bridge abutments only;
- Consistent specification of speed humps (flat top type);
- Gateway treatment details at entrances to villages;
- Location of stopping areas.

Recommendations were provided to the designer with the requirement that they address them wherever possible. Given the design was based on the feasibility RSA, it already included many safety features such as speed humps, a narrow carriageway and gateway treatments.

Phase 3: Post-Construction Stage RSA

With the design finalised, it was tendered and awarded to an Australasian civil construction contractor McConnell Dowell who mobilised to Tarawa in July 2013. During construction, the supervising engineer provided clarifications to the contractor in the form of contract instructions, including many to ensure road safety features were correctly constructed. Close to completion of the works, a post-construction RSA was undertaken. This time, the auditor was a staff member of the World Bank who had experience with KRRP having visited regularly since the commencement of construction. The auditor was independent as required, but due to the constraints of timing, their RSAs were conducted over two visits spanning six months, prior to the completion, and again once outstanding works including line marking and signage installation were complete.

Summary of post-construction stage RSA findings

The post-construction RSA had a range of findings relating to issues with the design and construction as well as road user behaviour which could only be identified once the latter had been completed. It found that all the key issues identified in the Phase 1 feasibility RSA had been adequately addressed. While a number of hazards were identified, the majority were considered low risk. Hazards were classified as relating to signage, roadside hazards, intersections, lighting and other. The most common issues related to signage, which the feasibility RSA noted was almost completely absent from the road prior to rehabilitation. A common issue was the obstruction of newly installed signage by vegetation (Figure 7) which could be resolved by ongoing trimming of vegetation as part of routine maintenance (Whalley, 2017). Vandalism of signage was also evident, and while the contractor was subsequently instructed to replace affected signage, the limited ability of the Government to continually replace these remains a risk. High risk issues related to roadside hazards (including uncompleted elevated manhole risers) were raised. Also, the lack of a physical barrier for the traffic lane at speed humps meant some vehicles could drive around them in several locations. Swerving from the lane to pass clear of the speed hump was a risky manoeuvre which could be prevented by the installation of raised kerbs, which the audit recommended.

In terms of user behaviour, the audit observed that the key vulnerable pedestrians were in general using the footpath and shoulders, which was a safe behaviour. One dangerous behaviour observed was the use of raised kerbs as balance beams by children, where a fall could result in them entering the traffic lane. In terms of driver behaviour, while some were observed to be travelling considerably faster due to the improved road condition, others were travelling significantly below the speed limit. This speed discrepancy had the potential to be a source of user conflict, with faster traveling vehicles choosing to take risks to pass slower moving traffic, increasing the risk of head on and pedestrian crashes. These and other behavioural issues were raised with the Government, who undertook to address them through

Figure 7. Example of obscured signage (left) and completed road showing safety features including signage, line marking, lighting, speed humps, footpaths and drainage (Whalley, 2017)

an integrated information, education and enforcement campaign which was planned as part of their Road Safety Strategy Action Plan.

Recommendations were made for addressing all physical hazards for works that had been constructed, however at the request of donor and Government stakeholders the RSA also undertook a comparison with the existing conditions described in the feasibility audit, finding a significant improvement. This is beyond the typical scope of a post-construction RSA, but satisfied the request of stakeholders for a comparison of prior and post construction conditions.

In general, the auditor observed the general standard of both design and construction of road safety features to be good (Figure 7). The RSAs at feasibility and detailed design stages had clearly resulted in a very safe design, leaving mostly minor construction issues which were relatively simple to address in line with the recommendations of the post-construction RSA. The road safety features resulted in a much safer design, and if recommendations from the post-construction RSA were actioned, they would lift safety to an even higher level.

Road Safety Strategy and Action Plan

Recognising that infrastructure makes up only a part of a safe road system, the KRRP also assisted the Government of Kiribati with the development and implementation of a multi-sectoral road safety strategy and action plan, as well as updating legislation related to road safety.

The strategy and action plan were completed in January 2015 and adopted by the Government soon after (Selby, 2015). The Kiribati Road Safety Task Force committee were tasked with implementing the prioritised actions in the areas of:

- Leadership and coordination/capacity building;
- Speed management;
- Bus passenger safety;
- Road safety education and awareness;
- Driver testing/licencing;
- Vehicle testing/registration;
- Crash data system; and,
- Drink driving.

The Government has since made significant strides in implementing this plan, particularly in the areas of driver licencing, vehicle testing and enforcement of speeding and drunk driving. To improve enforcement in the key risk areas of speeding and drunk driving, the project has supported the Kiribati Police Service (KPS) with new equipment including radar speed detectors and breathalysers, calibration support and training by police counterparts from New Zealand and Australia. The revised legislation and regulations prepared will allow more effective enforcement in these areas, with the Government adopting both.

One of the priority actions under the plan was the implementation of a crash data system as the current traffic accident statistics for Kiribati are unreliable. An improved data collection and management system will allow for better monitoring of the impact of any road safety interventions, allowing for informed decision making to address risks. One option is for Kiribati to consider using the World Bank's open source software platform DRIVER (Data for Road Incident Visualisation, Evaluation, and Reporting) which was developed in the Philippines and adopted successfully elsewhere (World Bank, 2016).

Conclusions

From this case study there are several lessons which hold value for the preparation of new road rehabilitation projects. The RSAs at feasibility, detailed design and post-construction stages captured knowledge which can be used by the stakeholders involved in KRRP on other projects including those in Kiribati as well as other LMICs. Beyond this, the following lessons learnt are useful, particularly for situations where there is a large proportion of vulnerable users as in Kiribati:

Road safety auditors should be involved early for best outcomes

One of the great benefits of the project's approach was the fact that the feasibility stage RSA provided a clear set of recommendations as an input to the design, before the designer had even commenced. This early involvement of auditors had a high impact on the safety of the design, placing it at the forefront of the designer's consciousness. Safety appeared to be given similar importance as for technical aspects such as pavement and geometric design. While it required a larger upfront commitment from donors to organise and fund an audit, this cost is considered small compared with the overall investment and indeed the benefits which can be realised from reduced road trauma. Therefore, it is recommended that existing conditions RSAs be conducted at feasibility stage on all major road rehabilitation projects—particularly where vulnerable users may be a major consideration.

Commitment is required from all stakeholders

From the onset of the KRRP, all parties involved displayed an excellent commitment to making the road in Kiribati safer. While the early involvement of auditors required donor support and funding from the Global Road Safety Facility (GRSF), the Government of Kiribati were also committed after the road safety issues were highlighted. They too showed foresight and were willing to accept the likely higher cost of a road design with extensive safety features, knowing that this would have long term benefits from reduced road trauma. The designer also showed commitment to making the road as safe as possible within the constraints, and while having the feasibility RSA provided to them steered them in this direction, in some cases they went beyond the recommendations of the auditor.

The successful outcome seen on the KRRP only came about due to the commitment of donors, Government, contractor and the design and supervision consultant.

High risk projects should include multi-stage RSAs

The typical approach on development projects is to conduct audits only at detailed design stage, if at all. Unfortunately, this approach often comes up against design inertia, with designers and Government unwilling to revisit designs and specifications to include safety features for fear of re-work or increasing the cost beyond the available funding envelope. In high risk situations such as Kiribati where vulnerable pedestrians were by far the biggest road user, the best practice approach is to conduct RSAs at feasibility, detailed design and post-construction stages. This approach minimises the risk of rework and results in early estimates being developed with full cognisance of the cost implications of road safety. Following this, the detailed design RSA is required to ensure any features are correctly detailed. Finally, the post-construction RSA serves as an independent check of whether the previous RSA stages have performed well, and as for KRRP should typically only result in minor remedial work to enhance safety.

Infrastructure is only a part of a safe road system

The multi-stage RSA approach resulted in a road with comprehensive road safety features, particularly to protect vulnerable pedestrians. However, this is only part of creating a safer road system. In line with the UN's decade of action (UN, 2010), enforcement, education, post-crash care and management should all be addressed in order to minimise trauma resulting from any road improvements. The KRRP recognised this by preparing a road safety strategy and action plan for the road improvements. The Government, with support of the project has made progress towards addressing priority actions in this plan.

Acknowledgements

The author acknowledges the work of his World Bank colleagues Christopher R. Bennett, Lead Transport Specialist, who saw the opportunity to apply the multi-stage RSA approach as well as Tawia Addo-Ashong and Mark Shotten from the GRSF who supported the efforts.

Funding: The feasibility and detailed design audits were carried out with funding support from the GRSF, whose staff were involved in review of this paper.

References

Asian Development Bank. (2016, November). *Project Administration Manual*. Retrieved from Republic of Kiribati: Road Rehabilitation Project: https://www.adb.org/projects/documents/kir-road-rehabilitation-af-pam

AUSTROADS. (2009). *Guide to Road Safety Part 6: Road Safety Audit (AGRS06-09).* Sydney.

Central Intelligence Agency. (2016, October 20). *Kiribati*. Retrieved from The World Factbook: https://www.cia.gov/library/publications/the-world-factbook/geos/kr.html

Harris, P. (2015). *Application of safe system (safe soads) to existing highways in developing countries*. Roadside safety design and devices. Transport Research Circular EC-215. Retrieved from http://onlinepubs.trb.org/Onlinepubs/circulars/ec215.pdf

Office of Te Beretitenti. (2012, January 6). *Republic of Kiribati island report series: South Tarawa*. Retrieved from http://www.climate.gov.ki/wp-content/uploads/2013/01/6_SOUTH-TARAWA-revised-2012.pdf

PRIF. (2009). *Kiribati: Infrastructure Sector Review.* Sydney: Pacific Regional Infrasrtucture Facility.

Road Safety International. (2010). *Report of the road safety audit of roads on Tarawa Island, Republic of Kiribati.* Melbourne: Road Safety International.

Road Safety International. (2011). *Detailed design stage road safety audit for Main Road, Tarawa.* Melbourne: Road Safety International.

Roughton International. (2011a). *Standard road cross section drawing: KRRP.* Hampshire, UK: Republic of Kiribati.

Roughton International. (2011b). *Detailed intersection and signage drawings KRRP.* Hampshire, UK: Republic of Kiribati.

Selby, T. (2015). *KRRP Road Safety Action Plan.* Perth: Opus International Consultants.

UNDP. (2010). *Kiribati: Crisis Poverty and Social Impact Analysis (PSIA).* Suva: United Nations Development Program.

United Nations. (2010, March 2). *General Assembly*. Retrieved from Resolution adopted by the General Assembly - A/RES/64/255: https://documents-dds-ny.un.org/doc/UNDOC/GEN/N09/477/13/PDF/N0947713.pdf?OpenElement

United Nations. (2015, September 25). Retrieved from Sustainable development goals: http://www.un.org/sustainabledevelopment/sustainable-development-goals/

Whalley, O. (2017). *Post-Construction Road Safety Audit KRRP.* Sydney: The World Bank.

World Bank. (2011). *Project Appraisal Document: Kiribati Road Rehabilitation project.* Washington DC.

World Bank. (2016, April 5). *Philippines: Real-Time Data Can Improve Traffic Management in Major Cities*. Retrieved from News: http://www.worldbank.org/en/news/press-release/2016/04/05/philippines-real-time-data-can-improve-traffic-management-in

Applying a context-informed approach to evaluation of a licensing support program with Aboriginal communities: a study protocol

Ms Patricia Cullen [1], Professor Kathleen Clapham [2], Dr Kate Hunter [1,3], Dr Kris Rogers [1], Professor Rebecca Ivers [1,4]

[1] *The George Institute for Global Health, The University of New South Wales, Sydney, Australia*
[2] *Australian Health Services Research Institute, The University of Wollongong, Wollongong, Australia*
[3] *The Poche Centre for Indigenous Health, University of Sydney, Sydney, Australia*
[4] *Flinders University, South Australia, Adelaide, Australia*

Corresponding Author: Patricia Cullen, PO Box M201 Missenden Road NSW 2050, pcullen@georgeinstitute.org and +61 2 8052 4780.

Key Findings

- Culturally responsive programs are critical to address Aboriginal licensing rates
- Urgent need for robust evaluation of community licensing support programs
- Evaluation of community licensing support programs must consider program context
- A context-informed approach can underpin all stages of evaluation

Abstract

Aboriginal and Torres Strait Islander people in Australia are more likely to experience transport disadvantage, which contributes to observed health disparities. Transport disadvantage has been attributed to low rates of licensed drivers in Aboriginal communities; to address this the *Driving Change* program was developed to support Aboriginal communities in New South Wales (NSW) to facilitate equitable access to licensing. This article presents the protocol for the *Driving Change* process evaluation and outlines the application of a context-informed approach. The process evaluation triangulates program data, stakeholder interviews and discussion groups. Descriptive and regression analyses of quantitative data (demographics, interaction with the program, service delivery and outcomes) will review reach, fidelity and dosage. Framework analysis of qualitative data will seek to uncover a richer understanding of context including barriers and facilitators to implementation. Community engagement and acceptability will be explored to determine the program's responsiveness to community and cultural needs. Understanding community and cultural context is crucial to evaluation in complex multi-site interventions. Using a context-informed approach, the *Driving Change* process evaluation will provide valuable insight into implementation and evaluation of multi-site programs in Aboriginal communities. We encourage evaluators to consider context at all stages of evaluation, particularly for complex and multi-site community interventions.

Keywords

Evaluation, Community, Driver licensing, Aboriginal, Indigenous, Transport disadvantage

Introduction

Ongoing difficulties accessing transport (*'transport disadvantage'*) can include lack of access to safe and reliable public transport, inability to maintain private transport and difficulties meeting the costs associated with transport (Rosier & McDonald, 2011). Access to safe, reliable and legal transport is central to social inclusion and economic participation. Further, the health and well-being of individuals and families are impacted by the ability to access transport to maintain employment, attend school, access essential health services, socialise and meet cultural obligations.

Compared to other Australians, Aboriginal and Torres Strait Islander people are more likely to experience transport disadvantage, and this has been implicated in reduced health outcomes for Aboriginal people in Australia (Currie & Senbergs, 2007). In part this relates to the higher proportion of Aboriginal people living in regional/remote and urban fringe areas, as travel in these areas can be problematic for people without access to a private car. Moreover, the impact of transport disadvantage has also been recognised by the New South Wales (NSW) government as a contributor to transport-related injury and fatality (Transport for NSW, 2014). Aboriginal people are two to three times as likely to have a transport-related fatal injury (25% of all Aboriginal injury deaths) and 30% more likely to have a transport-related serious injury (8% of all Aboriginal injury hospitalisations) compared to non-Aboriginal Australians (Harrison & Berry, 2008; Henley & Harrison, 2013; Styles & Edmonston, 2006). The relationship between higher rates of transport-related injury and transport disadvantage centres on the premise that people with limited transport options are more likely to make unsafe choices or engage in illegal driving practices (Transport for NSW, 2014). This association is reinforced by known risk factors for transport-related injury in Aboriginal communities; remoteness, non-use of seatbelts, alcohol use, vehicle overcrowding and unlicensed driving (Clapham, Senserrick, Ivers, Lyford, & Stevenson, 2008; Helps et al., 2008; Henley & Harrison, 2013).

Unlicensed driving in Aboriginal communities is associated with transport-related injury, infringements and incarceration (Clapham et al., 2008; Styles & Edmonston, 2006). Indeed 19% of Aboriginal transport fatalities involved an unlicensed driver or rider (Transport for NSW, 2014). It is widely reported that unlicensed driving is likely related to low rates of licence participation, with Aboriginal people estimated to be significantly under-represented among licence holders (Helps et al., 2008; Transport for NSW, 2014). Low rates of licence participation reflect significant barriers to attaining and maintaining a licence for Aboriginal people. These include lack of formal identification documents (e.g. birth certificate, different names on documentation), high cost of driving lessons, lack of suitable supervisory drivers for learners and feelings of intimidation (Elliot and Shananhan Research, 2008). 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 impedes access to employment and healthcare services and places undue burden on licensed drivers to provide transportation for other community members (Elliot and Shananhan Research, 2008).

In NSW, 120 hours of supervised driving practice be completed by people under 25 years of age to be eligible for the on road practical driving test to attain a provisional P1 licence and drive independently without supervision. The provisional P1 licence must be held for 12 months before progressing to a provisional P2 licence, which requires completion of a computerised hazard perception test. The P2 licence must then be held for 24 months before automatically progressing to a full unrestricted car licence. The NSW government has committed to supporting evidence-based initiatives to address Aboriginal transport injury and increasing legal and safe driving in Aboriginal communities (Transport for NSW, 2014). Integral to assisting Aboriginal people to access the NSW licensing system is robust evaluation of licensing programs to ensure that they are effective and acceptable to Aboriginal communities.

Intervention

The *Driving Change* program was developed to facilitate access to licensing in Aboriginal communities in NSW (Cullen, Clapham, Byrne, Hunter, Rogers, et al., 2016). The program aims to strengthen licensing services in participating communities to provide a more coordinated and culturally responsive approach that will better address community identified shortcomings.

Since February 2013 the program has partnered with 12 Aboriginal communities across NSW that have identified licensing as an issue to implement the program. *Driving Change* supports clients to obtain their learner, provisional and unrestricted licences including reinstated licences after resolving licensing and debt related sanctions. The program aims to build community capacity and strengthen connections between existing service providers, and the program is hosted in each location by a community organisation that is accessible to community members and key stakeholders.

The program is overseen by a central support team and is delivered at each site by an Aboriginal youth worker from the local community. The program is targeted at young people aged 16-24 years and is delivered via case management and mentoring for young people through the licensing system. Additionally, *Driving Change* addresses the issue of licensing sanctions and unpaid fines by supporting participants to liaise with appropriate government agencies to manage fines and have licensing sanctions lifted. The central project team conducted community consultations with the participating sites prior to implementation of the program. This involved engaging with a broad cross-section of government and community stakeholders to determine need and capacity to engage with the *Driving Change* program.

The process evaluation will review program implementation to explore whether *Driving Change* is being implemented as intended and is addressing the needs of the communities. The process evaluation will answer critical questions about the acceptability of the program and explore the contextual factors that may impact delivery.

Context-Informed Evaluation

Process evaluations are increasingly used alongside large scale interventions to explore the barriers and facilitators to implementation, receipt and acceptability of the intervention and potentially to gain insight into factors that may have impacted upon outcomes (Aarestrup, Jørgensen, Due, & Krølner, 2014; Jan et al., 2011; Salam et al., 2013; Saunders, Evans, & Joshi, 2005). Saunders et al (2005) outline steps for developing a process evaluation plan, which includes considering the impact of the context in which the program operates. In considering context, evaluators should seek to understand aspects of the social, political or organisational environment that may impact program implementation (Saunders et al., 2005).

Understanding the program context is fundamental for programs that are based within Aboriginal communities. In 2013-2014 a formative evaluation of the *Driving Change* program was conducted to construct a logic model that articulates the program theory of change (Cullen, Clapham, Byrne, Hunter, Senserrick, et al., 2016). Logic models are frequently used in program evaluation to identify program resources and activities and links these with anticipated program outcomes, which assists in developing a framework for the evaluation (Funnell & Rogers, 2011; Gugiu & Rodríguez-Campos, 2007; McLaughlin & Jordan, 1999; Stetler et al., 2006). To construct the logic model, qualitative methods were used to explore contextual factors and better understand the problem definition. This process led to a richer understanding of how the program would work with multiple communities. It was evident that the program would need to address common systemic barriers to licensing, however due to inherent differences between communities the program needed to be adaptable to changing needs and variable community capacity.

While there is considerable diversity within and between Aboriginal communities, the evaluation of contextual factors provides valuable insight into community need, adversities and strengths. The formative evaluation of *Driving Change* at the three pilot sites provided significant insight into the program context, which subsequently informed the evaluation framework and development of the methodology for the *Driving Change* process evaluation. Accordingly, the process evaluation will consider community diversity and seek to further explore the impact of contextual factors on program implementation.

Theoretical approach: Social ecology

The process evaluation of *Driving Change* is informed by a model of social ecology, which has been employed in health promotion interventions targeting the social and environmental inequalities that underlie health disparities (Edberg et al., 2016; Kok, Gottlieb, Commers, & Smerecnik, 2008; Richard, Potvin, Kishchuk, Prlic, & Green, 1996). The model depicts health as a function of the interrelationship between individual, interpersonal, community, socio-political and environmental influences (Richard et al., 1996). This model is suited to evaluating multi-component community interventions like *Driving Change* as it supports the connectivity between activities at each level. The influence of the social ecological approach can be seen in the *Driving Change* program logic model, which outlines the sequential relationship between the program resources, activities and outcomes (Cullen, Clapham, Byrne, Hunter, Senserrick, et al., 2016). The logic model provides a framework for the evaluation and graphically depicts the program theory of change. Using a context-informed approach to logic model construction and evaluation is suited to multi-site community interventions that must be responsive to community specifications. Overall, the logic model construction revealed that change should be targeted at four levels: 1) Clients and their families; 2) Organisation; 3) Communities; 4) Policy. Thereby, the *Driving Change* process evaluation will seek to have input from stakeholders at each of these levels of change.

There is a fraught history of research and programs being imposed upon Aboriginal communities with insufficient consultation, resultant poor uptake and lack of community support (Thomas, Bainbridge, & Tsey, 2014). Conversely, programs that are culturally responsive seek to work with Aboriginal communities by prioritising sustainable partnerships through capacity building and respectful communication (Clapham et al., 2008; Cullen, Clapham, Byrne, Hunter, Senserrick, et al., 2016; Ivers, Clapham, Senserrick, Lyford, & Stevenson, 2008; Martiniuk, Ivers, Senserrick, Boufous, & Clapham, 2010). This requires in-depth understanding of the context in which the program operates, with input from stakeholders into the evaluation. Drawing from participatory approaches can be a valuable way of involving stakeholders who are impacted by the program at all levels of change (Guijt, 2014; Makhoul, Nakkash, Harpham, & Qutteina, 2014). Further, community trust and respect is critical to ensure that evaluators have an in-depth understanding of community capacity, interest and willingness to participate.

Community partnerships are prioritised in the implementation and evaluation of *Driving Change*. Client feedback and community input is continually sought from local community youth workers and host organisations to ensure that communities have ownership over the solutions developed to address the issues identified by each community. Similarly, input and participation from policy makers and service providers has been sought through a project steering committee that was established to guide implementation and evaluation. This project steering committee convenes quarterly and includes representatives from the communities, and key stakeholders, including Aboriginal policy officers from a range of Government agencies including Transport for NSW, Roads and Maritime Services, the Attorney General's Department, and the Office of State Revenue, as well as representatives from program sites. Additionally, each community has connected with an existing local working party to facilitate input of community members and local stakeholders into the development of the program at each site. Representatives from each local community were invited to join the project steering committee. The research team conducting the evaluation reports to this steering committee, thus the local community representatives have input into the evaluation and dissemination of results. The members of the project steering committee are depicted in Figure 1.

Methods

Design

The process evaluation will use a mixed methods approach, with triangulation of program data, semi-structured interviews and program participant discussion groups. The process evaluation plan is outlined in Table 1.

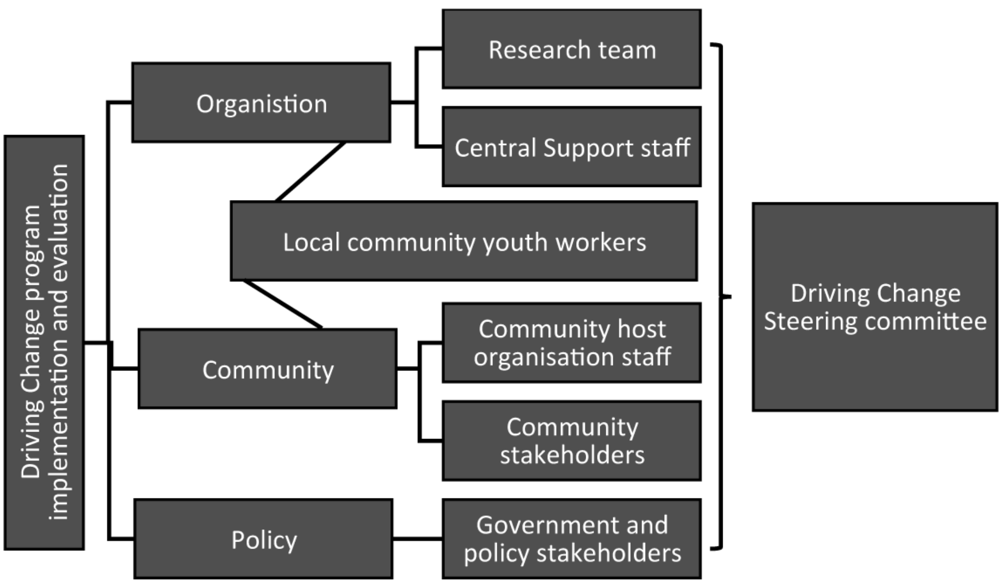


Figure 1. Driving Change Steering Committee membership comprising program staff, research team, community and policy stakeholders

Table 1. Process Evaluation Plan

Process evaluation measure	Process evaluation questions	Data source	Data collection	Data analysis
Reach	1. Were the intended participants with a high level of need being reached?	Program participant data: demographics and intake form	Completed by youth workers at initial participant registration	Descriptive analysis
Fidelity*	2. To what extent was the program implemented as intended?	Semi-structured interviews	In person and telephone interviews with youth workers and central program staff and stakeholders	Thematic analysis
	3. Are the program sites delivering all aspects of the program as intended?	Program participant data: service delivery	Completed by youth workers throughout program delivery	Descriptive analysis
Dosage	4. Is the program delivering sufficient contact and services to meet the needs of Aboriginal people seeking a licence at the program sites?	Program participant data: service delivery, participant contact, licensing outcomes Program participant discussion groups	Completed by youth workers throughout program delivery 2-3 conducted in at least 2 program sites	Regression analysis of service delivery, participant contact and licensing outcomes Thematic analysis
Engagement and acceptability	5. Has the program been effective in engaging communities? 6. Does the program offer licensing support in an acceptable way to communities?	Program stakeholder data Semi-structured interviews Program participant discussion groups	Completed by youth workers and central program staff throughout program delivery In person and telephone interviews with youth workers, central program staff and community stakeholders 2-3 conducted in at least 2 program sites	Descriptive analysis of stakeholder data and content review of stakeholder records Thematic analysis Thematic analysis
Context	7. What factors facilitated/ inhibited successful implementation of the program?	Semi-structured interviews Program participant discussion groups	In person and telephone interviews with youth workers, central program staff and community stakeholders 2-3 conducted in at least 2 program sites	Thematic analysis Thematic analysis

*Fidelity will be measured as high, medium or low based upon how many of the following program elements are implemented: Birth Certificates assistance; Fines assistance; Literacy assistance; Learner driver mentor program (clients receive supervised driving practice with a community mentor); Financial assistance; Professional driving lessons

Quantitative Data

The *Driving Change* program data (demographic information, program participant interaction, service delivery and licensing outcomes) are collected and managed using REDCap electronic data capture tools hosted at The George Institute for Global Health (Harris et al., 2009). The data collection instruments were developed jointly with the research team, central program staff and program field staff. Continual feedback is sought and provided by staff and consequently the instruments have been refined over time.

Stakeholder data

At the community level of the social ecology model engagement and stakeholder interaction with the program will be measured by reviewing site records that detail the number of stakeholders, the reach of stakeholders to secondary contacts, and the number and type of interactions with community organisations (meetings, committee memberships, collaborations). Similary, at the policy level of the social ecology, engagement with policy and government stakeholders will be reviewed to determine the reach and nature of these interactions. This data is collected by all program staff (youth workers and central support) at each interaction with stakeholders and community organisations throughout program delivery.

Program participant data

At the individual level of the social ecology, program participant information is collected at baseline and at each interaction with the program. This data is collected by program staff at each site and is accessible to the research team in de-identified format. Participant follow-up data is obtained by central program staff over the telephone using a standardised questionnaire. Attempts will be made to contact all participants by phone for follow-up to review assistance received from the program, licensing, employment and educational outcomes; the follow-up data is collected 6 months after participants' enrolment in the program.

Qualitative Data

Interviews with program staff

At the organisational level of the social ecology model, semi-structured interviews will be conducted with field workers and central program staff during program development and implementation. Staff interviews will focus on the staff experience of developing the program model, engaging with communities, acquiring resources for the program, implementation barriers and facilitators, overcoming challenges to implementation, important outcomes and program sustainability.

Interviews with stakeholders

At both the community and policy level of the social ecology model, stakeholder participants will be sought throughout program implementation from government agencies, community organisations and the *Driving Change* Steering Committee; purposive sampling will be used to identify key informants to participate in semi-structured interviews (Patton, 1990). Additionally, snowball sampling will be employed with all interviewees asked to recommend other potential interviewees with useful insights or unique perspectives (Liamputtong & Ezzy, 2005). Potential stakeholder participants from government and community organisations will be invited to participate by telephone and email; these interviews will be conducted throughout the implementation of the program. Stakeholder interviews will focus on the program context, the need for the program, experiences and expectations of the program, community and stakeholder engagement, implementation barriers and facilitators, important outcomes and program sustainability. Stakeholder interviews will be conducted until data saturation is reached.

Program participant discussion groups

The process evaluation will seek to capture program participant experiences by conducting discussion groups at two or more program sites. Each discussion group will consist of three to five participants and will be conducted in community host organisations throughout program implementation. Discussion groups with program participants will explore experiences with *Driving Change* and obtaining a license, the acceptability of the program model, access to current services as well as service gaps and the impact of existing licensing policy. Further, discussion groups will allow for exploration of both participant and community factors that may facilitate or impair delivery of the program, which will also explore the interaction between the individual, organisational and community levels of the social ecology model. There will be a semi-structured format but there will be flexibility to explore emergent themes and participants will be encouraged put forward issues that they consider important. The question guide for the discussion groups has been developed jointly by a member of the research team and project field staff.

This format has been selected as it facilitates access to a wide cross-section of program participants, and by keeping the groups relatively small a high level of engagement and contribution is expected. Discussion group participants will be recruited via program staff who will inform potential participants about the evaluation; program staff will then facilitate contact with the research team. Additionally, notices requesting participants to take part in the evaluation will also be displayed in community meeting places. The number of discussion groups will be determined by data saturation.

Data Analysis

The quantitative and qualitative data will be simultaneously collected, analysed and then drawn together to provide an integrated understanding of implementation barriers and facilitators. Data collected from program records will allow the research team to determine program specific outcomes (e.g. community engagement, services delivered, completion rates, licensing outcomes). Descriptive analysis (counts and percentages) will be conducted for this data. Regression analyses will examine the relationship between licensing outcomes, site specific factors and participant factors (including demographics and contact with the program).

Interviews and discussion groups will be voice recorded and transcribed; analysis of the transcribed interview data will be assisted by using Nvivo 10 software (QSR International Pty Ltd, 2012). The data analysis will occur simultaneously with data collection to facilitate an iterative process. Accordingly, there will be some analysis and emergence of preliminary concepts during early data collection and transcription, which can then be explored and developed in subsequent interviews. A framework method of analysis will be used to generate categories and codes and will incorporate both deductive (pre-determined) and inductive (emergent) thematic analysis. This approach allows for the exploration of specific themes (e.g. barriers and facilitators of implementation) while not restricting the emergence of unanticipated themes (Gale, Heath, Cameron, Rashid, & Redwood, 2013). Further, this type of analysis will involve within and cross-case analysis to explore themes and interpret meaning across each level of the social ecology model. The research team will consult regularly with co-authors and seek feedback from program staff and the program steering committee.

Ethics

This project has been approved by the Aboriginal Health and Medical Research Council (AH & MRC) of NSW. The program data will be collected by the program staff and provided to the research team in de-identified form only. Only the research team will have access to the de-identified program data. No other identifying information about study participants will be made available in any reports, presentations or other formats. Data at the community level will be presented but will be aggregated to ensure that no individual data is made available.

An information sheet will be provided to qualitative study participants who will be asked for written consent to participate. It will be emphasised to participants that the data collected will be confidential and de-identified. Further, they will be advised that participation is voluntary and they can opt out at any point during the interview or discussion group.

Discussion

Driver licensing inequality has been recognised as a contributor to transport disadvantage and reduced health outcomes in Aboriginal communities. While the need for culturally responsive licensing support programs has been identified, there is minimal information about the effectiveness or acceptability of such programs for Aboriginal people as few programs have been formally evaluated. This context-informed process evaluation, underpinned by a social ecological framework, seeks to evaluate the implementation of a community-based driver licensing support program. Reach, fidelity and dosage will be examined to ensure a robust program implementation that is targeting high level of need with sufficient level of service delivery. Evaluation of multi-site and complex community interventions must take into account context in which the program operates (Funnell & Rogers, 2011; Makhoul et al., 2014). Accordingly this process evaluation will draw on multiple data sources to produce a cohesive understanding of contextual factors that facilitate and impede implementation.

Understanding the impact of context, and in particular cultural context is crucial to programs that are based within Aboriginal communities. Programs that neglect to seek feedback from communities and consider the impact of cultural values can experience poor uptake and lack of community engagement. The formative evaluation of *Driving Change* revealed that change should be targeted at multiple levels of change beyond the individual client and must consider the impact of the organisation, communities and authorising environment. Further, the exploration of contextual factors identified that level of need and community response to the program was variable. Thereby, this process evaluation seeks to understand the program's responsiveness to cultural and community needs, and will hence explore the acceptability of the program and engagement with communities. This is essential to ensure that the program is working with communities, benefiting from the input of cultural values and sharing ownership of local solutions rather than imposing a rigid model of delivery upon Aboriginal communities.

While it is not uncommon for process evaluations to take context into account this is generally at the final stages of evaluation rather than in the development of the evaluation framework. The process of exploring context early in the implementation and evaluation of the program was crucial to understanding the variable impact on communities and establishing an appropriate evaluation framework (Cullen, Clapham, Byrne, Hunter, Senserrick, et al., 2016). It is critical that evaluators, particularly those working with complex community interventions consider the impact of context at all stages of the evaluation.

Conclusions

This process evaluation will be important to informing sustainable delivery models and success of the *Driving Change* program but it also contributes to better understanding of the needs of Aboriginal communities around licensing support. This context-informed evaluation will contribute to establishing best practice guidelines for implementing community licensing programs and for delivering equitable access to the licensing system for Aboriginal communities in Australia. Further, it is anticipated that this context-informed approach will provide impetus for evaluators to explore context at the early stages of implementation and evaluation so that it may direct the evaluation framework. This pragmatic approach can be used by evaluators of complex and multi-site community interventions to incorporate contextual variables into the evaluation framework to comprehensively address all areas of need.

Acknowledgements

The *Driving Change* program, was developed by The George Institute for Global Health with the support of founding partner, the AstraZeneca Young Health Programme, and principal partners Transport for NSW, and NSW Health. The authors acknowledge the immense contribution of the Driving Change Steering Committee, the Driving Change Investigative Committee and the Driving Change Youth Workers and communities. The authors declare that they have no competing interests. Rebecca Ivers was funded by a research fellowship from the National Health and Medical Research Council of Australia; Kate Hunter by a postdoctoral research fellowship from the Poche Centre for Indigenous Health, University of Sydney; Patricia Cullen by an Australian Post-graduate Award from the University of Sydney and the AstraZeneca Young Health Programme.

References

Aarestrup, A. K., Jørgensen, T. S., Due, P., & Krølner, R. (2014). A six-step protocol to systematic process evaluation of multicomponent cluster-randomised health promoting interventions illustrated by the Boost study. *Evaluation and Program Planning, 46*(0), 58-71. doi: http://dx.doi.org/10.1016/j.evalprogplan.2014.05.004

Clapham, K., Senserrick, T., Ivers, R., Lyford, M., & Stevenson, M. (2008). Understanding the extent and impact of Indigenous road trauma. *Injury, 39*(Supplement 5), S19-S23. doi: http://dx.doi.org/10.1016/S0020-1383(08)70025-1

Cullen, P., Clapham, K., Byrne, J., Hunter, K., Rogers, K., Senserrick, T., . . . Ivers, R. (2016). Implementation of a driver licensing support program in three Aboriginal communities: A brief report from a pilot program *Health Promotion Journal Of Australia, 27*(2), 167-169. doi: 10.1071/HE15089

Cullen, P., Clapham, K., Byrne, J., Hunter, K., Senserrick, T., Keay, L., & Ivers, R. (2016). The importance of context in logic model construction for a multi-site community-based Aboriginal driver licensing program. *Evaluation and Program Planning, 57*, 8-15. doi: http://dx.doi.org/10.1016/j.evalprogplan.2016.03.011

Currie, G., & Senbergs, Z. (2007). Indigenous communities: Transport disadvantage and Aboriginal communities. In G. Currie, J. Stanley, & J. Stanely (Eds.), *No Way To Go: Transport and Social Disadvantage in Australian Communities*. Clayton, Victoria: Monash University ePress.

Edberg, M. C., Cleary, S. D., Andrade, E. L., Evans, W. D., Simmons, L. K., & Cubilla-Batista, I. (2016). Applying ecological positive youth development theory to address co-occurring health disparities among immigrant latino youth. *Health Promotion Practice*. doi: 10.1177/1524839916638302

Elliot and Shananhan Research. (2008). An investigation of Aboriginal driver licensing issues *Aboriginal Licensing Final Report* Sydney: NSW Roads and Traffic Authority.

Funnell, S. C., & Rogers, P. J. (2011). *Purposeful Program Theory: Effective Use of Theories of Change and Logic Models*. San Francisco: Josey-Bass.

Gale, N. K., Heath, G., Cameron, E., Rashid, S., & Redwood, S. (2013). Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BioMed Central Medical Research Methodology, 13*(117). doi: doi:10.1186/1471-2288-13-117

Gugiu, P. C., & Rodríguez-Campos, L. (2007). Semi-structured interview protocol for constructing logic models. *Evaluation and Program Planning, 30*(4), 339-350. doi: http://dx.doi.org/10.1016/j.evalprogplan.2007.08.004

Guijt, I. (Ed.) (2014). Florence: UNICEF Office of Research.

Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research electronic data capture (REDCap) - A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics, 42*(2), 377-381.

Harrison, J. E., & Berry, J. G. (2008). Injury of Aboriginal and Torres Strait Islander people due to transport, 2001–02 to 2005–06. In Australian Institute of Health and Welfare (Ed.), *Injury research and statistics series number 46. Cat. no. INJCAT 120*. Adelaide, SA: AIHW.

Helps, Y. L. M., Moller, J., Kowanko, I., Harrison, J. E., O'Donnell, K., & de Crespigny, C. (2008). Aboriginal people travelling well: Issues of safety, transport and health. Canberra, ACT: Department of Infrastructure, Transport, Regional Development and Local Government.

Henley, G., & Harrison, J. E. (2013). Injury of Aboriginal and Torres Strait Islander people due to transport: 2005-06 to 2009-10 *Injury research and statistics series 85. Cat. no. INJCAT 161*. Canberra: AIHW.

Ivers, R., Clapham, K., Senserrick, T., Lyford, M., & Stevenson, M. (2008). Injury prevention in Australian Indigenous communities. *Injury, 39, Supplement 5*(0), S61-S67. doi: http://dx.doi.org/10.1016/S0020-1383(08)70030-5

Jan, S., Usherwood, T., Brien, J. A., Peiris, D., Rose, J., Hayman, N., . . . Patel, A. (2011). What determines adherence to treatment in cardiovascular disease prevention? Protocol for a mixed methods preference study. *British Medical Journal, 1*(2).

Kok, G., Gottlieb, N. H., Commers, M., & Smerecnik, C. (2008). The ecological approach in health promotion programs: A decade later. *American Journal of Health Promotion, 22*(6), 437-442.

Liamputtong, P., & Ezzy, D. (2005). *Qualitative Research Methods*. Mebourne: Oxford University Press.

Makhoul, J., Nakkash, R., Harpham, T., & Qutteina, Y. (2014). Community-based participatory research in complex settings: clean mind–dirty hands. *Health Promotion International, 29*(3), 510-517. doi: 10.1093/heapro/dat049

Martiniuk, A., Ivers, R., Senserrick, T., Boufous, S., & Clapham, K. (2010). Effective and inclusive intervention research with Aboriginal populations: an Evidence Check rapid review brokered by the Sax Institute for NSW Health.

McLaughlin, J. A., & Jordan, G. B. (1999). Logic models: a tool for telling your programs performance story. *Evaluation and Program Planning, 22*(1), 65-72. doi: http://dx.doi.org/10.1016/S0149-7189(98)00042-1

Patton, M. (1990). *Qualititive Evaluation and Research Methods* (2nd ed.). Newbury Park: Sage.

QSR International Pty Ltd. (2012). NVivo qualitative data analysis software (Version 10).

Richard, L., Potvin, L., Kishchuk, N., Prlic, H., & Green, L. W. (1996). Assessment of the integration of the ecological approach in health promotion programs. *American Journal of Health Promotion, 10*(4), 318-328.

Rosier, K., & McDonald, M. (2011). The relationship between transport and disadvantage in Australia. Melbourne: Australian Institute of Family Studies.

Salam, A., Stewart, F., Singh, K., Thom, S., Williams, H. J., Patel, A., . . . Ward, H. (2013). INterpreting the Processes of the UMPIRE Trial (INPUT): protocol for a qualitative process evaluation study of a fixed-dose combination (FDC) strategy to improve adherence to cardiovascular medications. *British Medical Journal, 3*(5).

Saunders, R. P., Evans, M. H., & Joshi, P. (2005). Developing a process-evaluation plan for assessing health promotion program implementation: a how-to guide. *Health Promotion and Practice, 6*(2), 134-147. doi: 10.1177/1524839904273387

Stetler, C., Legro, M., Rycroft-Malone, J., Curran, G., Guihan, M., Hagedorn, H., . . . Wallace, C. (2006). Role of external facilitation in the implementation of research findings : a qualitative evaluation of facilitation experiences in the Veterans Health Administration. *Implementation Science, 1*, 23.

Styles, T., & Edmonston, C. J. (2006). Australian Indigenous Road Safety – 2005 Update. In Australian Transport Safety Bureau (Ed.). Canberra, ACT: Australian Transport Safety Bureau.

Thomas, D. P., Bainbridge, R., & Tsey, K. (2014). Changing discourses in Aboriginal and Torres Strait Islander health research, 1914-2014. *The Medical journal of Australia, 201*(1 Suppl), S15-18. doi: 10.5694/mja14.00114

Transport for NSW. (2014). *NSW Aboriginal Road Safety Action Plan 2014-2017*. (978-1-922030-43-6). Sydney: Transport for NSW Retrieved from http://roadsafety.transport.nsw.gov.au/downloads/aboriginal-road-safety-plan.pdf [Verified 3 March 2016].

Speeding among Jordanian Drivers

Faisal Magableh[1], Raphael Grzebieta[1], Soufiane Boufous[1] and Soames Job[2]

[1] *Transport and Road Safety Research (TARS), UNSW, Australia*

[2] *Global Road Safety, World Bank & Head, Global Road Safety Facility*

Corresponding Author: Faisal Magableh, 2 Dunn Way Blacktown, NSW 2148, magableh@gmail.com, +61 415 264 440

This peer-reviewed paper was first presented at the 2016 Australasian Road Safety Conference (ARSC2016) held in Canberra, ACT, Australia and first published in the ARSC2016 Proceedings as a 'Full Paper'. It underwent the full peer-review process by independent experts in the field. It is being reproduced here with the kind permission of the authors and is now only available in this edition of the JACRS.

Key Findings

- Jordanian male and female drivers reported speeding fines more than any other type of fines.
- Receiving speeding fines for males was found to be significantly associated with receiving other fines in general.
- Jordanian drivers chose to reduce their driving speed for safety reasons, yet they violate speed limits frequently and receive speeding fines

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. The most common reason for drivers deciding to reduce their speed was for safety. 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.

Keywords

Jordanian Drivers, Speeding, Driver Behaviour, Road Safety in Jordan, Traffic Law Enforcement, Gender and Road Safety.

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.

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.

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

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

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. More details about mean of some of male and female drivers characteristics are shown in Table 2.

The proportions of male and female licensed drivers in Jordan are 72% and 28% respectively while the sample proportions in the study were 84% (393) male and 16% (74) female. The lack of detailed demographic information about each area covered makes it hard to find out whether the recruited volunteers were representative of the demographic that live in the area.

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. Such places where chosen due to the cultural and religious sensitivity (Magableh, Grzebieta, & Job, 2013; Miller, 2012). 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 responses 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 et al., 2013). Many of the DBQ questions used in this study were re-worded or re-phrased to suit 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

Table 2. Mean of some of male and female drivers characteristics

	Males	Females
Age	35	32
Years of driving experience	12	6.3
Daily driven distance (km)	107	54
Fines in the past year	2.4	3.9
Crashes in the past five years	0.8	0.9
Speeding fines in the past year	0.7	1.1
Red light running fines in the past year	0.3	0.7
Seatbelt fines in the past year	0.4	0.9
Distraction fines in the last year	0.4	0.7
Hazardous lane deviation fines in the last year	0.3	0.6
Parking fines in the last year	0.4	0.6
Other fines in the last year	0.2	0.4

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 (SAS, 2012)

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

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.

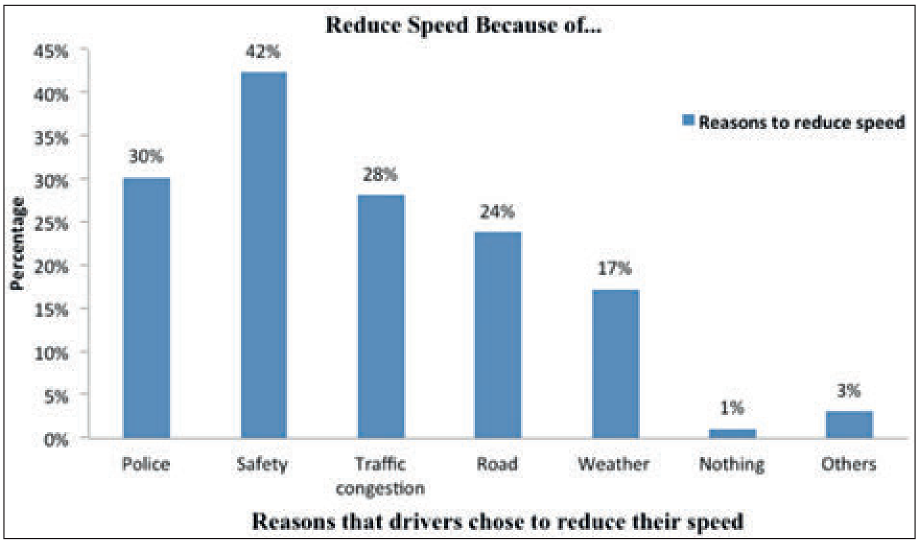


Figure 1 Reasons that drivers chose to reduce their speed

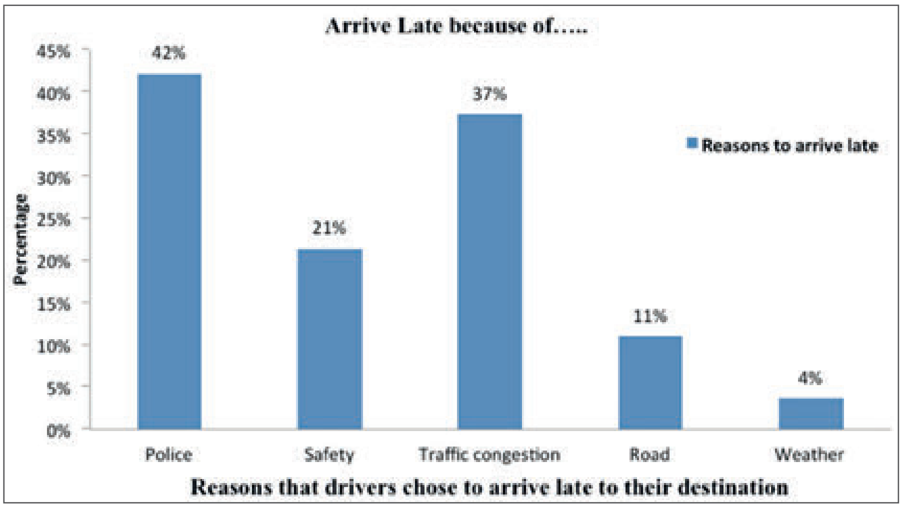


Figure 2 Reasons that drivers chose to arrive late to their destination

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 speed when approaching Police or speeding cameras. Slightly less than two-thirds (64%) of drivers reported changing their reducing their speed when approaching Police or speed cameras. A majority (76%) of respondents supported the use of automated speed cameras.

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 congestion, the existence of Police or cameras on the road, for safety reasons, were delayed for other reasons (e.g. fuelling their cars) or for other reasons (e.g., vehicle breakdown). Responses are shown in Figure 2. Traffic congestion 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.

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 chose to 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; Sjöberg, 2000; Sjöberg, Rundmo, & Moen, 2004) or when they try to use networking (nepotism) 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 almost 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 effects 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 congestion 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 limit decisions. However, increasing speed limits might not be always the answer to traffic congestion 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 congestion 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 significant 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). These include social desirability bias and recall bias which might reduce the reliability of the self-reporting questionnaires (af Wahlberg, 2010; Lajunen & Summala, 2003; Nordfjærn et al., 2011). 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, French, Kemp, & Elander, 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

Respondents in this study were found to be inclined to speeding and to report more speeding fines than any other type of fines. 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. 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 deceleration the human body can tolerate in relation to collision speed as adopted in the Safe System Approach. Advertising and awareness campaigns that target psychological gender related determinants of traffic violations could be adopted by Jordanian authorities to reduce speeding among male drivers. 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. Strict laws and severe sanctions along with the utilisation of religious teachings and cultural values, particularly in relation to family safety, could be implemented to address driver behaviours on Jordanian roads.

References

Åberg, L., Larsen, L., Glad, A., & Beilinsson, L. (1997). Observed Vehicle Speed and Drivers› Perceived Speed of Others. *Applied Psychology, 46*(3), 287-302.

Abojaradeh, M., & Jrew, B. (2013). Development of Statistical Prediction Models to Reduce Fatal and Injury Traffic Accidents. *Journal of Environment and Earth Science, 3*(11), 54-65.

af Wahlberg, A. E. (2010). Social desirability effects in driver behavior inventories. *Journal of Safety Research, 41*(2), 99-106.

Al-Balbissi, A. H. (2003). Role of gender in road accidents. *Traffic injury prevention., 4*, 64-73.

Al-Madani, H. (2004). Drivers' Speed Citation Involvement in Five Arabian Gulf Countries. *Journal of King Abdulaziz University-Engineering Sciences, 15*(1), 49-62.

Al-Omari, B. H. (2013). Analysis of Pedestrian Accidents in Irbid City, Jordan. *The Open Transportation Journal, 7*(1), 1-6.

AL-Omari; Bashar, Ghuzlan, K., & Hasan, H. (2013). Traffic Accidents Trends and Characteristics in Jordan *International Journal of Civil & Environmental Engineering, 13*(5), 9-16.

Al-Rukaibi, F., Ali, M., & Aljassar, A. (2006a). *Investigating the Driving Behavior and Traffic Safety Attitudes of University Students in Kuwait*. Paper presented at the Third Gulf Conference on Roads Muscat, Sultanate of Oman.

Al-Rukaibi, F., Ali, M., & Aljassar, A. (2006b). Traffic Safety Attitudes and Driving Behavior of University Students: Case Study in Kuwait. *Journal of the Transportation Research Board, 1969*(1), 65-71.

Al Reesi, H., Al Maniri, A., Plankermann, K., Al Hinai, M., Al Adawi, S., Davey, J., & Freeman, J. (2013). Risky driving behavior among university students and staff in the Sultanate of Oman. *Accident Analysis & Prevention, 58*(2), 1-9.

Aljassar, A. H., Ali, M. A., & Al-Anzi, M. S. (2004). *An investigation on the Effect of Traffic Cameras on Road Safety in Kuwait.* Paper presented at the 2nd Gulf Conference on Roads, Abu Dhabi, UAE,.

Anastasopoulos, P. C., & Mannering, F. L. (2016). The effect of speed limits on drivers' choice of speed: A random parameters seemingly unrelated equations approach. *Analytic Methods in Accident Research, 10*, 1-11. doi:http://dx.doi.org/10.1016/j.amar.2016.03.001

Anderson, R. (2000). *Introducing Speed Cameras In The ACT-How To Win Friends And Influence People.* Paper presented at the Road safety Research, Policing and Education Conference, Brisbane, Queensland, Autsralia

Austroads. (2013). *Driver Attitudes to Speed Enforcement*. Retrieved from Sydney, Australia:

Bener, A., & Alwash, R. (2002). A perspective on motor vehicle crash injuries and speeding in the United Arab Emirates. *Traffic Injury Prevention, 3*(1), 61-64.

Blais, E., & Dupont, B. (2005). Assessing the Capability of Intensive Police Programmes to Prevent Severe Road Accidents A Systematic Review. *The British Journal of Criminology, 45*(6), 914-937.

Bursac, Z., Gauss, C. H., Williams, D. K., & Hosmer, D. W. (2008). Purposeful selection of variables in logistic regression. *Source Code Biol Med, 3*(17).

Chua, F., & Job, R. F. S. (1999). Event-Specific Versus Unitary Causal Accounts of Optimism Bias. *Journal of Behavioral Medicine, 22*(5), 457-491. doi:10.1023/A:1018657407684

Davey, J., Freeman, J., & Wishart, D. (2008). Predicting high risk behaviours in a fleet setting : implications and difficulties utilising behaviour measurement tools. *Driver behaviour and training. Volume III.*

El-Sadig, M., Nelson Norman, J., Lloyd, O. L., Romilly, P., & Bener, A. (2002). Road traffic accidents in the United Arab Emirates: trends of morbidity and mortality during 1977–1998. *Accident Analysis & Prevention, 34*(4), 465-476. doi:10.1016/s0001-4575(01)00044-6

Elliott, M. A., & Broughton, J. (2005). *How methods and levels of policing affect road casualty rates*. Crowthorne, Berkshire, England: Transport Research Laboratory.

Elvik, R. (2009). *The handbook of road safety measures* (2 ed.). Bingley, UK: Emerald Group

Fernandes, R., Job, R., & Hatfield, J. (2007). A challenge to the assumed generalizability of prediction and countermeasure for risky driving: Different factors predict different risky driving behaviors. *Journal of Safety Research, 38*(1), 59-70.

Fleiter, J. J., Watson, B. C., Lennon, A. J., King, M. J., & Shi, K. (2009). *Speeding in Australia and China : a comparison of the influence of legal sanctions and enforcement practices on car drivers*. Paper presented at the Australasian Road Safety Research Policing Education Conference, Sydney.

Fleiter, J. J., Watson, B. C., Lennon, A. J., King, M. J., & Shi, K. (2011). Social influences on drivers in China. *Journal of the Australasian College of Road Safety, 22*(2), 29-36.

Gaygisiz, E. (2010). Cultural values and governance quality as correlates of road traffic fatalities a nation level analysis. *Accident Analysis & Prevention, 42*, 1894-1901.

GRSP. (2008). Speed management a road safety manual for decision-makers and practitiioners. Geneva: Global Road Safety Partnership.

Haglund, M., & Lars, Å. (2000). Speed choice in relation to speed limit and influences from other drivers. *Transportation research. Part F Traffic psychology and behaviour., 3*(1), 39-51.

Hassan, H. M., & Abdel-Aty, M. A. (2013). Exploring the safety implications of young drivers' behavior, attitudes and perceptions. *Accident Analysis & Prevention, 50*(0), 361-370.

Hössinger, R., & Berger, W. J. (2012). Stated response to increased enforcement density and penalty size for speeding and driving unbelted. *Accident Analysis & Prevention, 49*, 501-511. doi:http://dx.doi.org/10.1016/j.aap.2012.03.023

Iversen, H., & Rundmo, T. (2004). Attitudes towards traffic safety, driving behaviour and accident involvement among the Norwegian public. *Ergonomics, 47*(5), 555-572. doi:10.1080/00140130410001658709

Jordan Traffic Institute. (2014). *Traffic Accidents in Jordan 2013*. Retrieved from http://www.jti.jo/. Amman, Jordan:

Lahausse, J. A., van Nes, N., Fildes, B. N., & Keall, M. D. (2010). Attitudes towards current and lowered speed limits in Australia. *Accident; analysis and prevention, 42*(6), 2108-2116.

Lajunen, T. (1997). *Personality factors, driving style and traffic safety.* (Doctoral thesis), University of Helsinki, Traffic Research Unit, Helsinki. Available from http://worldcat.org /z-wcorg/ database.

Lajunen, T., Corry, A., Summala, H., & Hartley, L. (1998). Cross-cultural differences in Drivers' self-assessments of their perceptual-motor and safety skills: Australians and Finns. *Personality and Individual Differences, 24*(4), 539-550.

Lajunen, T., & Summala, H. (2003). Can we trust self-reports of driving? : effects of impression management on driver behaviour questionnaire responses. *Transportation research. Part F Traffic psychology and behaviour, 6*(2), 97-107.

Lawton, R., Parker, D., Stradling, S. G., & Manstead, A. S. R. (1997). Predicting road traffic accidents: The role of social deviance and violations. *British Journal of Psychology, 88*(2), 249-262. doi:10.1111/j.2044-8295.1997.tb02633.x

Lee, S. H. V., Prabhakar, T., & Job, R. F. S. (1993). *Optimism bias, risk utility and risk taking on the road* Retrieved from Canberra:

Magableh, F., Grzebieta, R., & Job, R. F. S. (2013, 28-30 August). *The Impact of Culture on Road Safety in Jordan.* Paper presented at the Australasian Road Safety Research Policing Education Conference, Brisbane, Queensland, Australia

Magableh, F., Grzebieta, R., & Job, R. F. S. (2015, 12-13 May). *Views of Drivers and Traffic Police on some Road Safety Issues in Jordan.* Paper presented at the The 7th Traffic Safety Conference, Amman, Jordan.

Magableh, F., Grzebieta, R., Job, R. F. S., & Boufous, S. (2015, 14-16 October). *The Role of Gender in Road Safety in Jordan.* Paper presented at the Australasian Road Safety Conference (ARSC2015), Gold Coast, Queensland

Mannering, F. (2009). An empirical analysis of driver perceptions of the relationship between speed limits and safety. *Transportation Research Part F: Traffic Psychology and Behaviour, 12*(2), 99-106. doi:http://dx.doi.org/10.1016/j.trf.2008.08.004

Martinussen, L. M. (2013). *Implicit attitudes towards risky and safe driving in a Danish sample*. Paper presented at the Young Researchers Seminar, Lyon, France. http://orbit.dtu.dk/en/publications/implicit-attitudes-towards-risky-and-safe-driving-in-a-danish-sample(d09d5c5a-5358-4156-8739-3195c726d513).html

Miller, M. (2012). *Transforming spaces: women's use of communication technology in the Middle East and North Africa* (Honour), University of Utah University of Utah

Mooren, L., & Grzebieta, R. (2010). Road manslaughter-or just the cost of progress? *Emerging health threats journal, 3*(e4).

NHTSA. (2004). *Aggressive driving enforcement evaluations of two demonstration programs. (Report No. DOT HS 809 707)*. Retrieved from [Washington, D.C.]: http://purl.access.gpo.gov/GPO/LPS50440

Nielsen, G. (2007). *Traffic integration or segregation for the sustainable city - A review of current debate and literature*. Retrieved from Oslo, Norway:

Nordfjærn, T., Jørgensen, S., & Rundmo, T. (2011). A cross-cultural comparison of road traffic risk perceptions, attitudes towards traffic safety and driver behaviour. *Journal of Risk Research, 14*(6), 657-684.

OECD. (2006). *Speed management*. Retrieved from Paris: http://www.oecdbookshop.org/en/browse/title-detail/?k=5L9M156NLS9W

OECD. (2008). *Towards zero ambitious road safety targets and the safe system approach*. Retrieved from Paris: http://public.eblib.com/choice/publicfullrecord.aspx?p=370311

Özkan, T., & Lajunen, T. (2006). What causes the differences in driving between young men and women? : the effects of gender roles and sex on young drivers› driving behaviour and self-assessment of skills. *Transportation research. Part F Traffic psychology and behaviour., 9*(4), 269-277.

Parker, D., Reason, J. T., Manstead, A. S. R., & Stradling, S. G. (1995). Driving errors, driving violations and accident involvement. *Ergonomics, 38*(5), 1036-1048.

Pilkington, P., & Kinra, S. (2005). Effectiveness of speed cameras in preventing road traffic collisions and related casualties: Systematic review. *British Medical Journal, 330*(7487), 331.

Porter, B. E. (2011). Chapter 31 - Enforcement. In E. P. Bryan (Ed.), *Handbook of Traffic Psychology* (pp. 441-453). San Diego: Academic Press.

Prabhakar, T., Lee, S., & Job, R. (1996). *Risk Taking, optimism bias and risk utility in young drivers.* Paper presented at the The Road Safety Research and Enforcement Conference., Sydney, NSW.

Reason, J., Campbell, K., Baxter, J., Stradling, S., & Manstead, A. (1990). Errors and violations on the roads: a real distinction? *Ergonomics, 33*(10-11), 1315-1332.

Ryeng, E. O. (2012). The effect of sanctions and police enforcement on drivers' choice of speed. *Accident Analysis & Prevention, 45*, 446-454. doi:http://dx.doi.org/10.1016/j.aap.2011.08.010

SAS. (2012). SAS® 9.3 Software: http://support.sas.com/software/93/.

Sjöberg, L. (2000). Factors in Risk Perception. *Risk Analysis, 20*(1), 1-12. doi:10.1111/0272-4332.00001

Sjöberg, L., Rundmo, T., & Moen, B. E. (2004). *Explaining Risk Perception: An Evaluation of the Psychometric Paradigm in Risk Perception Research*: Rotunde.

Soole, D. W., Watson, B. C., & Fleiter, J. J. (2013). Effects of average speed enforcement on speed compliance and crashes: A review of the literature. *Accident Analysis & Prevention, 54*(0), 46-56. doi:http://dx.doi.org/10.1016/j.aap.2013.01.018

Stanojevic, P., Jovanovic, D., & Lajunen, T. (2013). Influence of traffic enforcement on the attitudes and behavior of drivers. *Accident Analaysis & Prevention, 53*, 29-38.

Suliman, M. R., & Awad, W. H. (2003). *Aggressive driving is a major cause of traffic accidents and road rage in Jordan.* Paper presented at the The Second International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design, Utah, USA.

Sümer, N., Lajunen, T., & Özkan, T. (2005). Big five personality traits as the distal predictors of road accident involvement. *Traffic and transport psychology : theory and application : proceedings of the ICTTP 2004.*, 215-227.

Tasca, L. (2002). *A review of the Literature on Aggressive Driving Research*. Retrieved from Ontario, Canada:

Ulleberg, P. (2002). *Influencing subgroups of young drivers and their passengers : motivational influences of personality traits on risk-taking attitudes and driving behaviour*. Institute of Transport Economics, Norwegian Centre for Transport Research, Oslo. Available from http://worldcat.org /z-wcorg/ database.

Walter, L., Broughton, J., & Knowles, J. (2011). The effects of increased police enforcement along a route in London. *Accident Analysis & Prevention, 43*(3), 1219-1227. doi:http://dx.doi.org/10.1016/j.aap.2011.01.003

Walton, D. (1999). Examining the self-enhancement bias: professional truck drivers' perceptions of speed, safety, skill and consideration. *Transportation Research Part Traffic psychology and behaviour, 2*(2), 91-114.

West, R. J., French, D., Kemp, R., & Elander, J. (1993). Direct observation of driving, self reports of driver behaviour and accident involvement. *Ergonomics, 36*, 557-567.

Zaidel, D. (2002). *The impact of enforcement on accidents. Deliverable 3 (Work Package 2) of the ESCAPE project. Contract N: RO-98-RS.3047.* Retrieved from Finland: virtual.vtt.fi/escape/escape_d3.pdf

Appendix A

The driver questionnaire (English translation of the Arabic version)

Section 1: Driving Habits

Please tick as many as applicable

Road safety is the responsibility of

1. ❑ Police
2. ❑ Drivers
3. ❑ Pedestrians
4. ❑ Government
5. ❑ Road designers and keepers
6. ❑ Passengers (seatbelt use)

I learned about traffic violations from

7. ❑ Friends
8. ❑ Driving training and tests
9. ❑ Awareness campaigns
10. ❑ When I get fines
11. ❑ Others (Please specify) ________

Current speed limits should be

12. ❑ Increased
13. ❑ Decreased
14. ❑ Reviewed
15. ❑ Stay the same
16. ❑ Don't know

Would you pay more for a car that has

17. ❑ Airbags or ABS system
18. ❑ Good sound system
19. ❑ Modern
20. ❑ Extra options
21. ❑ Better style

The best sanction for frequent traffic violators would be:

22. ❑ Verbal alert
23. ❑ Fines
24. ❑ License suspension
25. ❑ Imprisonment
26. ❑ License re-testing
27. ❑ Demerit points
28. ❑ Others (Please specify) ________

What makes you reduce your speed?

29. ❑ The existence of Police or cameras
30. ❑ To make the trip safer
31. ❑ The traffic movement
32. ❑ The road condition
33. ❑ The weather
34. ❑ None
35. ❑ Others (Please specify) ________

When I arrive late it is normally because

36. ❑ Of the traffic
37. ❑ Of the Police patrols and cameras
38. ❑ I drive slowly for safety
39. ❑ Someone or something made me late
40. ❑ Others (Please specify) _______________

Drivers violate traffic law because they

41. ❑ Have Peer pressure
42. ❑ Just follow others
43. ❑ Are stubborn

44. ❑ Are not aware of the law
45. ❑ Forget to obey the law
46. ❑ Didn't see the signs
47. ❑ Were distracted (phone, music…ect)
48. ❑ Want to show their manhood
49. ❑ Want to get there sooner
50. ❑ Impaired by medicine, fatigue or tiredness
51. ❑ Are drunk
52. ❑ May get away with it
53. ❑ Others (please specify) _________

When violating traffic law, the main thing I am thinking of is:

54. ❑ My own convenience
55. ❑ Being caught/fined
56. ❑ Being afraid of potential danger
57. ❑ The disapproval of other drivers
58. ❑ To impress others
59. ❑ Being late or on time
60. ❑ Others (please specify)_______

Compared with the average driver, I am:

61. ❑ Much better than average
62. ❑ Better than average
63. ❑ Slightly better than average
64. ❑ Equal to average
65. ❑ Slightly worse than average
66. ❑ Worse than average
67. ❑ Much worse than average.

What do you think affects a Police officer's decision to fine a violating driver?

68. ❑ Driver's/owner's social hierarchy/authority
69. Driver's/owner's personal network
70. Driver's/owner's work organization
71. ❑ Driver's way of treating the Police officer
72. ❑ Mood of the Police officer
73. ❑ Risk level of the violation
74. ❑ The existence of other people (witnesses)
75. ❑ Others (please specify)

____

Section 2: Driver's Self-assessment

How do you feel about the following people in regard to YOUR PERSONAL SAFETY on the road? , please tick **ONE** answer only

Note: four-Point Scale used (Very serious risk hazard, Serious risk hazard, A minor risk hazard and Not a risk hazard). Scale not shown below for clarity

Item
76. Drivers not paying attention
77. Drivers talking on cell phones
78. Drivers driving when sleepy or drowsy
79. Drivers driving aggressively
80. Drivers driving well over the speed limit
81. Pedestrians crossing from any place on road
82. Drivers who driver their cars on the wrong lane
83. Drivers who do not obey traffic signs
84. Drivers who tailgate and intimidate others

Section 3: Driver's attitude, behaviours and traffic enforcement

For the following questions, please provide answer based on your best judgment, please tick **ONE** answer only

Note: Six-Point Likert Scale used (Never, Hardly ever, Occasionally, Quite often, Frequently and Nearly all the time). Scale not shown below for clarity

Question	
85.	Police are selective in enforcing the law
86.	Police are fair when dealing with different drivers
87.	Police favour some drivers
88.	Police explain why they stop me and give me a fine
89.	Police talk to me nicely and treat me respectfully
90.	I treat Police officer harshly when they fine me
91.	I will try to make a deal with Police officer to avoid hefty fines
92.	I drive at speeds a little above the speed limit (less than 10km/h above)
93.	I speed well above (10km/h or more) the speed limit
94.	I ensure that children are properly restrained in the backseat
95.	When driving I wear a safety seat belt
96.	I ensure that all occupants travelling wear seat belt
97.	While driving I talk on mobile phone
98.	While driving I send and read text messages
99.	While driving I eat, smoke, or drink
100.	I use driving as a way to release some of my anger

101. I find excuse for my own bad driving
102. I sound my horn to indicate my annoyance to another road user
103. I become angered by another driver and give chase or use signals and hands with the intention of giving him/her a piece of my mind
104. I use the right lane when driving or overtaking
105. I drive so close to the car in front that it would be difficult to stop in an emergency
106. I pull out of a junction so far that the driver with right of way has to stop and let me out
107. I drive with more passengers than allowed in my vehicle
108. Intending to drive to destination A, I "wake up" to find myself on the road to destination B or getting into the wrong lane
109. I try to race traffic lights
110. I concern of being caught and fined when violating
111. I do not watch for pedestrians
112. Get involved in unofficial 'races' with other drivers.

For the following questions, please provide answer based on your best judgment; please tick **ONE** answer only.

Note: five-Point Likert Scale used (Strongly agree, Agree, Neutral, Disagree, and Strongly disagree). Scale not shown below for clarity

Question
113. There should be a sanction for Police who abuse their authority
114. The current enforcement practices of traffic laws improve drivers' behaviours
115. Traffic fines make driving safer
116. Improving licensing system will improve road safety
117. I would favour more speeding and traffic cameras
118. I would prefer cameras over Police patrols
119. Building and maintaining roads should be financed by traffic fines
120. I prefer a little longer trip that is safe over a short one that is risky
121. I would pay some little extra taxes for better roads and road signs
122. Pedestrians behaviours contribute to road crashes
123. I favour installing cameras in Police cars to record their activities
124. Social hierarchy and personal relations play a role in getting away with fines
125. Road signs are adequate and clear
126. Road surface is smooth with no bumps or potholes and easy to drive on
127. Religious and cultural forgiveness and tolerance values encourage reckless driving and crashes
128. Thinking about my family while driving makes me safer driver
129. Having my family with me in the vehicle makes me safer driver
130. Life and work pressures negatively affect my driving
131. Traffic jams are an acceptable reason to violate traffic laws
132. Family plays role in road safety
133. Traffic violations are against the religious teachings (i.e., haram)
134. Elimination of nepotism improves road safety
135. Only those have no influence get sanctioned
136. Traffic laws do not apply to people in authority
137. Having traffic tickets withdrawn is possible
138. I ignore impolite driving behaviours
139. Nepotism plays a role in getting a license
140. I drive differently if I know Police or cameras in this are
141. I think traffic law should be obeyed
142. I have aversion of certain type of drivers (Taxi, Females, old people, trucks, pickups, minibuses, etc.) I
143. forget to check my rear mirror before changing lanes
144. Over all, driving feels safer than it did five years ago
145. Severe fines are effective countermeasure to improve road safety

Section 4: Traffic fines and violations

Please answer the following table in regard to violations **(whether been fined or not)** and traffic fines

Question
146. How many times were you stopped by Police last year?
147. Times you have violated a U-turn, stop sign or give way in the past year
148. How many times in the past year have you driven on the wrong side of the road
149. How many times have you been intimidated by other drivers in the last month?
150. How many times were you fined last year?
151. The number of crashes you had in the last five years whether you were a driver or passenger (the crash is any event that cause fatality, injury or property damage)

How many of the fines below have you had in the past year:

Fine Type
Speeding fines
Red light fines
Seatbelt fines
Distraction fines (using mobile phone, eating, ..etc)
Driving on the wrong side of the road
Parking fines
Others (please specify)________________

Section 5: Demographic Information

152.	Age
153.	Gender ❑ Male ❑ Female
154.	Marital status ❑ Single ❑ Married ❑ Widow ❑ Divorce
155.	Education Level
156.	Years of driving experience
157.	How many kilometres do you drive per day? Km
158.	Would you like to add anything?

Investigation of Quad bike handling characteristics and their implications for on road use

David Hicks[1], Raphael Grzebieta[1], Keith Simmons[1,2], George Rechnitzer[1,3] and Mario Mongiardini[1]

[1]*Transport and Road Safety (TARS) Research Centre, UNSW Australia*
[2]*KND Consulting Pty Ltd*
[3]*George Rechnitzer & Associates Pty Ltd*

Corresponding Author: David Hicks, Level 1, Old Main Building, UNSW Sydney, 2052, NSW, Australia, david.hicks@unsw.edu.au, 61 2 9385 5242.

This peer-reviewed paper was first presented at the 2016 Australasian Road Safety Conference (ARSC2016) held in Canberra, ACT, Australia and first published in the ARSC2016 Proceedings as a 'Full Paper'. It underwent the full peer-review process by independent experts in the field. It is being reproduced here with the kind permission of the authors and is now only available in this edition of the JACRS.

Key Findings

- Quad bikes have a critical speed between 26 km/h and 35 km/h.
- Roadside structures such as traffic islands and kerbs can displace a seated rider from the quad bike and in one instance, resulted in the quad bike rolling over.

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 injury incidents related to quad bike use on-roads. Results from the University of New South Wales (UNSW) Quad Bike Performance Project identified that most commercial quad bikes tested, demonstrated an oversteer steady-state handling characteristic. A mathematical relationship exists between a vehicle's oversteer characteristic and a 'critical speed' at which the quad bike is at risk of suddenly losing control. Theoretical analyses indicated that the critical speed for the tested quad bikes ranges between 26 km/h and 35 km/h. Computer simulations were also performed to determine whether quad bikes can safely interact with speed humps and roadside structures such as kerbs and traffic islands. The simulations indicated that quad bikes could traverse on-road speed humps without displacing the rider off the seat. However, traversing roadside structures such as a kerb or a pedestrian island, resulted in the displacement of the rider off the seat and in one instance a rollover. The results suggest that quad bikes are unsafe for on-road use where speed limits have been set to 50 km/h or more and where there are road features such as kerbs and traffic islands that need to be negotiated by the rider. In summary, quad bikes are vulnerable to the speeds and roadside structures found in the on-road environment.

Keywords

Quad bike, road, handling, oversteer, understeer, kerb, traffic island

Introduction

Quad bikes, referred to in other countries as All-Terrain Vehicles (ATVs), are claimed to be high-mobility off-road vehicles characterised by a straddle-type seat and a handlebar for throttle and steering control. They also have 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). In particular, quad bikes have a low stability threshold equivalent to a fully loaded semi-trailer heavy truck, which means they are particularly prone to rollover whilst negotiating turns and riding on slopes (Grzebieta et al, 2015a; Milosavljevic et al., 2011; Grzebieta, Rechnitzer, Simmons and McIntosh, 2015b). Consequently, it is recommended that quad bike riders actively change their position on the vehicle to increase the vehicle's rollover threshold when turning as well as when going over irregular terrain, bumps and other obstacles (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'. This can involve a wide range of body movements including; leaning from a sitting position, sliding the pelvis across the saddle and adopting a crouched or standing position.

Aspects of a quad bike's design for use on low-traction off-road surfaces, such as low pressure tyres and locked rear axle, means their use on sealed road surfaces can be dangerous and is warned against by quad bike manufacturers (SVIA, 2013). In addition, similar to motorcycles, quad bikes 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.

Quad bike deaths and serious injuries related to quad bike use on public roads have been observed all over the world including in the USA, Sweden and Australia. Moreover, a statistically significant increase in the odds of injury associated with sealed roads has been identified (Shulruf and Balemi, 2010; Grzebieta et al., 2017). In the USA and Sweden, public road quad bike fatalities (65%) accounted for a higher percentage of the overall fatalities than off-road fatalities (58%) (Persson, 2013; Williams, Oesch, McCartt, Teoh, & Sims, 2014). In the USA, single-vehicle crashes accounted for up to three-quarters of on-road quad bike fatalities and injuries, with rollover also often occurring (NHTSA, 2015; Williams, Oesch, McCartt, Teoh, & Sims, 2014; Denning, Jennisson, Harland, Ellis, Buresh, 2012; Denning, Harland, Ellis, Jennissen, 2013). Similarly, the quad bike was the only vehicle involved in approximately 90 percent of quad bike crashes in Sweden, with rollover being the most prevalent injury mechanism associated with fatalities (70%) (Persson, 2013). Collisions with other road vehicles are also common amongst quad bike crashes (Persson, 2013; Denning, Harland, Ellis, Jennissen, 2013 & Grzebieta et al., 2014a). In a recent study of 141 Australian quad bike related fatalities, 11 percent were noted as occurring on public roads. These fatal events often involved collisions with other vehicles or objects (Grzebieta et al., 2014a; McIntosh, Patton, Rechnitzer and Grzebieta, 2016).

There is unanimous agreement between quad bike manufacturers and safety stakeholders that quad bikes should not be used on-roads (Weintraub and Best, 2014). Despite this, many countries continue to allow quad bike access to 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-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 sealed 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, on-road fatality rates have continued to rise to the extent that on-roads deaths are now higher than off road deaths in the USA, suggesting that the state laws and/or their enforcement 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 tightly restricted with some states allowing conditional registration (Roads & Maritime Services, 2015; Vicroads, 2014). In NSW, conditional registration is only available in situations where the quad bike will be used mostly off-road or in off-road areas, but needs limited access to the road network, where there will be limited mixing with general traffic on sealed roads and when it will be floated from site to site (Roads & Maritime Services, 2015).

Dynamic Handling Attributes of Quad Bikes

Steady-state cornering characteristics

One method of assessing a vehicle's 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. Furthermore, a vehicle that has the same amount of slip at the front and the rear is said to have a 'neutral steer' characteristic. Grzebieta et al. (2015b) identified that several commercially available quad bikes tested demonstrated an oversteer handling characteristic. This characteristic has also been identified by several other studies that investigated quad bike handling (Forouhar, 1997; Grzebieta R., Rechnitzer G., Simmons K., 2015a; Allen et al., 1989; Chen, Tsal, Chen, and Holloway, 1989).

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 illustrated in Figure 1. 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 its handling and spin out or rollover. The critical speed of an oversteering vehicle is found using the following mathematical relation expressed in equation (1) (Gillespie,1992):

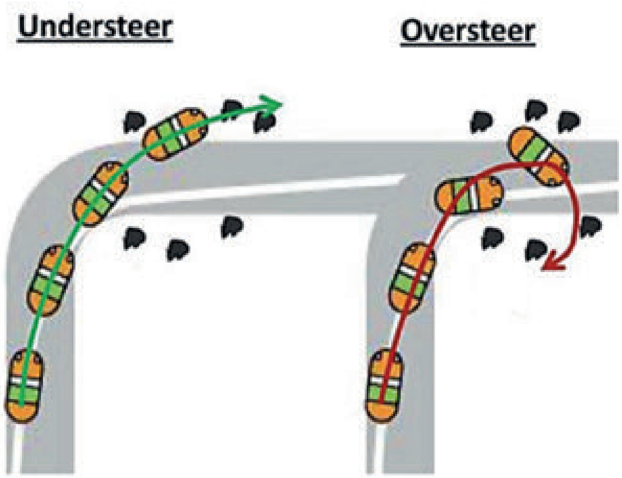


Figure 1. Understeer and oversteer path (Pollitzer and Little, 2014)

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

where, L = wheelbase (m), g = 9.81 m/s^2, k = understeer gradient (rad/g).

Previously noted above, quad bikes are predominantly manufactured with an oversteer characteristic. On the other hand, Recreational Off-highway Vehicles (ROVs) are an example of a vehicle with predominantly understeer characteristics (ROVs are also referred to as Side-by-Side Vehicles (SSV's)). However, one particular vehicle, namely the Yamaha Rhino, possessed an oversteer characteristic which was highlighted by the US Consumer Product Safety Commission (CPSC) as a concern. They stated 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; CPSC, 2014). In addition, 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"*.

Obstacle Traversing Characteristics

Mattei et al. (2011) demonstrated 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 (Grzebieta et al., 2015b & 2015c; Hicks, Mongiardini, Grzebieta, Rechnitzer, Simmons, 2015). It was hypothesised that this lateral displacement and unintentional steering of the quad bike could lead to quad bike roll-overs.

As previously mentioned, it is recommended that when traversing bump-like obstacles, the quad bike rider should assume an 'active riding' standing position (Honda Australia Rider Training, 2012). In an on-road environment, the Authors believe that quad bike riders are less likely to use 'active riding' techniques because of the number of factors, e.g. avoiding colliding with other traffic, that require the rider's attention. In addition, the psychological perception of a sealed road being an easier riding environment than off-road could relax the rider into a non-active posture. Obstacles are commonly found in the form of speed humps, kerbs and traffic islands on public roads. Figure 2 shows two traffic islands which could be ridden over in an errant driving scenario.

Objective

This paper aims to investigate whether the dynamic handling characteristics of a quad bike affect their performance on sealed road surfaces. Using the oversteer gradient obtained for the series of quad bikes tested during the dynamic handling phase of the Quad Bike Performance Project (QBPP) the 'critical speed' for these vehicles was determined and considered in light of current road speed limits (Grzebieta et al, 2015b). In addition, computer simulations were performed to observe whether a quad bike can safely manoeuvre over speed humps and roadside features including kerbs and traffic islands. The Author are not aware of any similar analysis having been carried out and published in the open literature.

Barrier Kerb Profile

Semi-mountable Kerb Profile

Figure 2. Examples of traffic islands

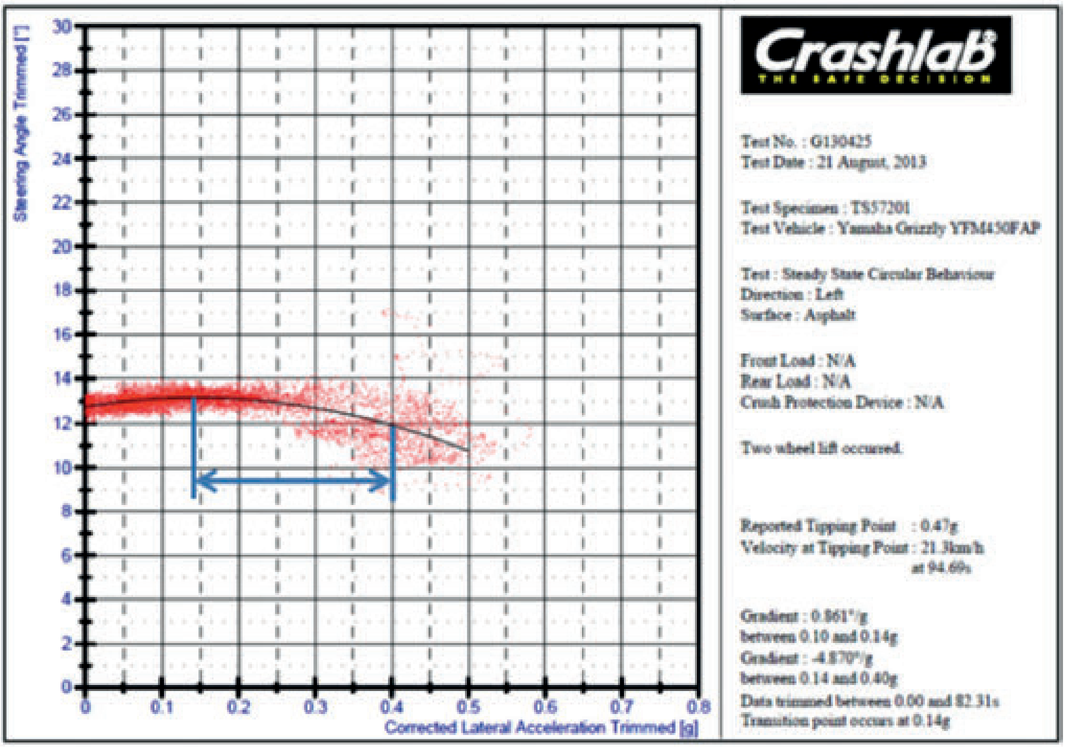


Figure 3. Lateral acceleration versus steering angle measured for a Honda TRX250 during the QBPP, transition point at 0.14 g (Grzebieta et al, 2015b).

Method

Cornering Hazard

The critical speed of the eight commercially available adult-sized quad bikes was calculated. It was calculated using the critical speed equation (1) and inputting the oversteer gradient published by Grzebieta et al. (2015b). The oversteer gradient (i.e. steering angle/lateral acceleration) between the transition point (0.14 g) from understeer to oversteer and 0.4 g lateral acceleration was used for these calculations (indicated by arrows in 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 (indicated by arrows in Figure 4). This method provides a conservative estimation of the quad bike's oversteer gradient. Further detailed description of the experimental test setup used to determine the oversteer/understeer gradient is presented elsewhere (Grzebieta et al, 2015b).

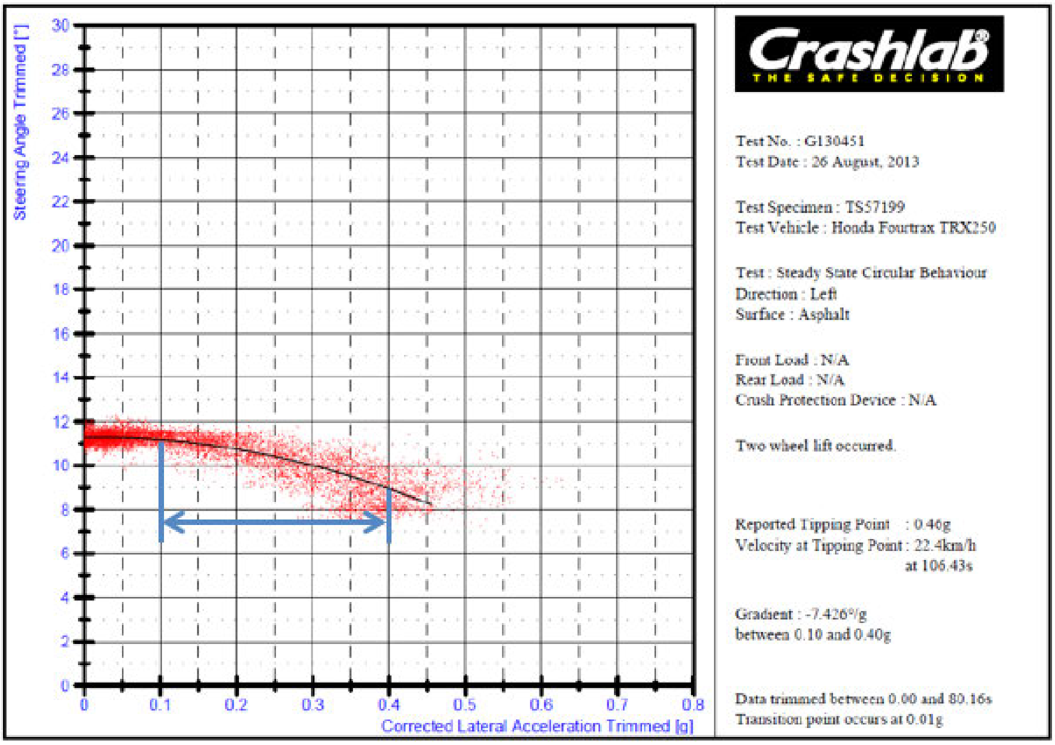


Figure 4. Lateral acceleration versus steering angle measured for a Honda TRX250 during the QBPP, transition point at 0.1 g (Grzebieta et al, 2015b).

Infrastructure Hazards

Simulations were performed to determine whether on-road obstacles such as speed humps, kerbs and traffic islands present a hazard to quad bike riders and can potentially cause them to lose control of the 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 to represent a seated rider traversing a semi-cylindrical obstacle (Hicks et al., 2015; Mongiardini, Hicks, Grzebieta, Rechnitzer, 2014). A seated 95th percentile HIII Anthropometric Test Device (ATD), commonly referred to as a crash test dummy, was used for this analysis. The hands of the ATD were attached to the handle bar while traversing the speed humps and road side kerb structures.

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 on suburban 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 5). 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.

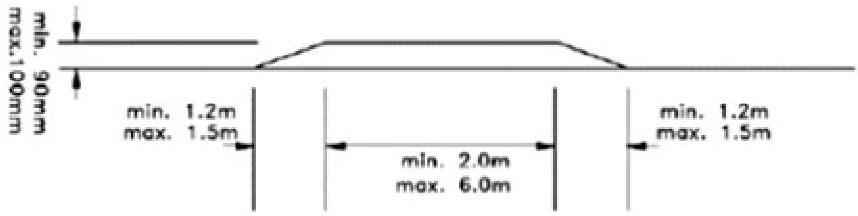
These simulations were performed at the range of speeds that each type of speed hump was designed to be traversed (Austroads, 2015). The speed hump simulations performed is shown in Table 1. Each speed bump was positioned perpendicular to the direction of travel and in-line with both wheel tracks of the quad bike. In addition to this, the 100 mm tall 'Watts Profile' speed hump was simulated placed in-line with only one wheel track, 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 traversing 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 6) (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.

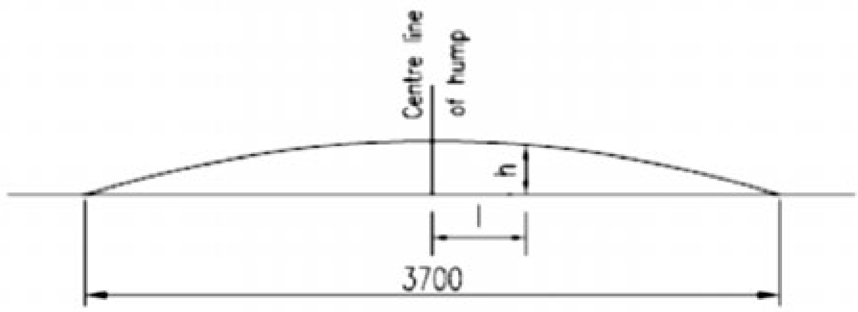
Table 1. Speed Hump Simulations

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

No = not simulated
Yes = Simulated



Flat Top Profile (Austroads, 2015)



Watts Profile (Moreland City Council)

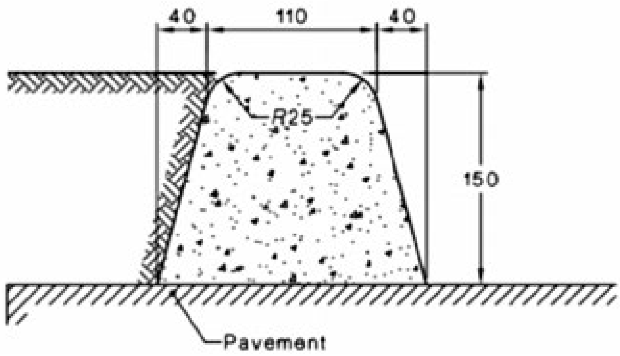
Figure 5. Speed Hump Types

Table 2. Kerb Simulations

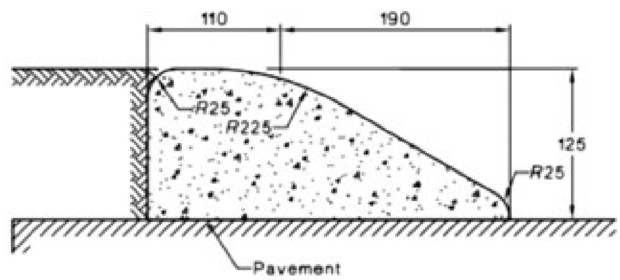
Kerb Type	Wheel Track(s)	Speed (km/h)	
		30	40
Barrier	Both	Yes	Yes
	Single	Yes	Yes
Semi-mountable	Both	Yes	Yes
	Single	Yes	Yes
Infinite Barrier	Both	Yes	Yes

Yes = Simulated

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.



Barrier Curb



Semi-mountable Kerb

Figure 6. AS 2876 Kerb Profiles (Standards Australia, 2000)

Results

Cornering Hazard

The critical speeds calculated for the quad bikes tested during the QBPP are shown in Table 3. The critical speed results ranged from 26 km/h to 34 km/h with an average speed of around 30 km/h.

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
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 (100 mm high) 'Watts profile' speed hump traversed with one-wheel track did not displace the rider off the seat of the quad bike (Table 4). In contrast, in all simulations of the seated quad bike rider traversing a kerb or traffic island, the rider was displaced vertically off the seat and in the single wheel track scenarios laterally as well (Table 5). 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 resulted in the ATD being 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 Track/s	Speed (km/h)			
		20	25	30	35
Flat Top (100 mm)	Both	No	No	No	-
Watts 1 (100 mm)	Both	-	No	No	-
Watts 2 (75 mm)	Both	-	-	No	No
Watts 1 (100 mm)	Single	-	No	No	-

No = No separation

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

Yes = Separation

Discussion

A vehicle that has an oversteer characteristic can become uncontrollable and spinout if perturbed during use at or above it's critical speed (Pollitzer and Little, 2014; Grzebieta et al., 2015b). For quad bikes with low lateral stability and higher friction tyres on sealed roads, the vehicle may instead rollover suddenly (Gillespie, 1992). The critical speed results presented in this study provide an understanding of when an oversteering quad bike could become directionally 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 (i.e. below 50 km/h). Thus, if regulators permitted the use of quad bikes on-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 factors that would require the rider's full attention, such as avoiding collisions with other road users. These factors 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.

It is recommended by industry trainers that when traversing obstacles, e.g. on private and farm roads, riders should use active riding from a standing position (Honda Australia Rider Training, 2012). However, as previously discussed, this may not always be realistic in the on-road environment. The simulations suggest that well designed speed humps on public roads may not necessarily present a risk to quad bike riders if traversed at a safe speed, i.e. at or below the speed humps design velocity. However, the simulations indicate 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. 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 road surface (Grzebieta et al., 2017; 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 a public road environment (Denning, Jennisson, Harland, Ellis, Buresh, 2012; Denning, Harland, Ellis, Jennissen, 2013; Grzebieta et al., 2014b).

Unfortunately, there is not enough detail known about the crash mechanisms of on-road quad bike crashes to determine whether operation at speeds higher than the critical speeds indicated, have contributed to crash scenarios. Nevertheless, the authors are aware of a fatality where a rider travelling on a bitumen road at a speed above the critical speed of the quad bike, suddenly underwent violent steering oscillations as described by a witness, resulting in the vehicle crashing. Hence, it is possible that loss of control due to 'critical speed', may have contributed to some of the single vehicle crashes that have occurred. This is especially likely 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 exceed the speed limit (Williams et al., 2014). Similarly, there is insufficient detail known about on-road quad bike crash mechanisms, to determine whether roadside structures including traffic islands and kerbs were causal to on-road quad bike crashes.

Conclusions

Quad bike manufacturers warn against riding on sealed 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. If the number of on-road quad bikes continue to increase, pressure could come to bear on Australian regulators to relax current laws. This study highlights and discusses the dynamic handling characteristics of quad bikes, indicating that these vehicles have an increased crash risk when used on sealed surfaces and are therefore unsuitable for use on-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 roadways. 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 rollover.

Acknowledgements

The Authors would like to gratefully acknowledge: WorkCover Authority of NSW (now Safework NSW) and the Australian Competition and Consumer Commission (ACCC) who funded the QBBP; Ross Dal Nevo, Drew Sherry and staff from Crashlab, Roads and Maritime Services, who carried the testing referenced; and Dr. Andrew McIntosh and Dr. Patton who collected and analysed the Australian Coroner's Case Files. The authors would like to also thank the Victorian Institute of Forensic Medicine (VIFM) as the source organisation of the National Coroners Information System from which fatality quad bike data relevant to public roads referenced in this paper.

References

Allen, W., Szostak, H., Rosenthal, T., Klyde, D. (1989). Steady State and Dynamic Properties of All terrain Vehicles Related to Lateral directional Handling and Stability. *SAE Technical Paper*, 891105.

Austroads. (2015). *Local Area Management, in Guide to Traffic Managment Part 8*.

Chen, S., Tsal, L., Chen, J., Holloway, D. (1989). Steady-State Handling of Four-Wheeled All Terrain Vehicles (ATVs). *SAE Technical Paper*, 891117.

Denning, G., Harland, K., Ellis, D., Jennissen, C. (2013). More Fatal All-Terrain Vehicle Crashes Occur on the Roadway Than Off: Increased Risk-Taking Characterises Roadway Fatalities. *Injury Prevention*, 19, 250-256.

Denning, G., Jennisson, C., Harland, K., Ellis, D., Buresh, C., 2012. All-Terrain Vehicles (ATVs) on the Road: A Serious Traffic Safety and Public Health Concern. *Traffic Injury Prevention*, 14, 78-85.

European Union. (2013). *Regulation (EU) No 168/2013*. Journal of the European Union.

Forouhar, F. (1997). *All-Terrain Vehicles Frequency Domain Response Analysis and Rider Behavior*. Paper presented at the IEEE International Conference on Control Applications, Hartford, CT.

Gillespie, T. (1992). *Fundamentals of Vehicle Dynamics*. Society of Automotive Engineers.

Gillespie, T. (2015). *Comments on CPSC NPR for ROVs*.

Grzebieta, R., Rechnitzer, G, McIntosh, A., Mitchell, R., Patton, D., and Simmons, K. (2014a). *Investigation and Analysis of Quad Bike and Side by Side Vehicle (SSV) Fatalities and Injuries*, Quad Bike Performance Project (QBPP) Report 3-2014: Supplemental Report, Transport and Road Safety (TARS) Research Report, The University of New South Wales, Sydney, Australia.

Grzebieta, R., Rechnitzer G., Simmons K., Hicks D., Patton D., Mongiardini M., McIntosh A., Sherry D. and Dal Nevo R.

(2015a, June). *The Australian Terrain Vehicle Assessment Program (ATVAP)*, Proc. 24th Int. Technical Conf. on the Enhanced Safety of Vehicles (ESV) Gothenburg, Sweden.

Grzebieta, R., Rechnitzer, G., Simmons, K. (2015b). *Dynamic Handling Test Results,* Quad Bike Performance Project (QBPP), TARS Research Report No. 2, University of New South Wales, Sydney, Australia.

Grzebieta, R., Rechnitzer, G., Simmons, K. and McIntosh, A. (2015c). Final Summary Project Report: Test Results, Conclusions, and Recommendations, Quad Bike Performance Project (QBPP), TARS Research Report No 4, University of New South Wales, Sydney, Australia.

Grzebieta, R., Rechnitzer, G., McIntosh, A., Simmons, K., Mitchell, R., and Patton, D. (2014b, November). *Road-Related Quad Bike and Side by Side Vehicle Casualties*, Proceedings of 2014 Australasian Road Safety Research, Policing and Education Conference, Melbourne, Australia.

Grzebieta, R., Soufiane, B., Simmons, K., Hicks, D., Williamson, A., Rechnitzer, G. (2017). *Quad bike and OPD Workplace Safety Survey Report: Results and Conclusions*, Transport and Road Safety (TARS), University of New South Wales, Sydney, Australia.

Hall, A., Bixler, D., Helmkamp, J., Kraner, J., Kaplan, J. (2009). Fatal All-Terrain Vehicle Crashes: Injury Types and Alcohol Use. *American Journal of Preventative Medicine*, 36, 311-316.

Hicks, D., Mongiardini, M., Grzebieta, R., Rechnitzer, G., Simmons, K. (2015). *Analysis Of Quad-Bike Loss-Of-Control Using Experimental and Simulated Dynamic Bump Tests*, presented at the Enhanced Safety of vehicle (ESV), Gothenburg, Sweeden.

Honda Australia Rider Training (HART). (2012). *ATV Course Rider Handbook, Honda Training Pty Ltd*, Version 4.

International Organisation for Standardisation (ISO). (2012). *ISO 4138:2012 Passenger cars--Steady-state circular driving behaviour--Open-loop test methods*, Geneva, Switzerland.

Lenkeit, J., Broen, P. (2014). *Measurment of "Rider Active" Effects on ATV Performance*. Dynamic Reasearch Inc.

Mattei, T., Bond, B., Hafner, J., Morris, M., Travis, J., Hannah, G., Webster, J., Lin, J. (2011). Definition and Measurement of Rider-Intrinsic Physical Attributes Influencing All-Terrain Vehicle Safety. *Neurosurgical Focus*, 31(5).

Maciag, M. (2016). *ATVs and Public Roadways: A Deadly Combination*. Public Safety & Justice. Governing. (http://www.governing.com/topics/public-justice-safety/gov-roads-atvs-fatalities.html)

McIntosh, A. , Patton, D., Rechnitzer, G. and Grzebieta, R. (2016). Injury mechanisms in fatal Australian quad bike incidents, *Traffic Injury Prevention*, 17(4), 386-390.

Milosavljevic, S., McBride, D., Bagheri, N., Vasiljev, R., Carman, A., Rehn, B., Moore, D. (2011). Factors Associated with Quad Bike Loss of Control Events in Agriculture. *International Journal of Industrial Ergonomics*, 21, 317-321.

Mongiardini, M., Hicks, D., Grzebieta, R., Rechnitzer, G. (2014). Modeling a Quad Bike (All-Terrain Vehicle) for Simulating Rollover Events, *Journal of the Transportation Research Board*, 1, 50-60.

Moreland City Council. (Accessed: 2016). *Road Hump - Watts Profile A180.01*.

National Highway Traffic Safety Administration (NHTSA). (2015). *Fatalities in Traffic Crashes Involving All-Terrain Vehicles*. U.S. Department of Transport. Available at: (https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812193)

Persson, J. (2013). *Better safety on Quad Bikes*. The Swedish Transportation Administration.

Pollitzer, P., Little, B. (2014). *Proposed Rule: Recreational Off-Highway Vehicles (ROV)*. Consumer Product Safety Comission.

Renfroe, D. (1996). Effects of Surface Anomalies and Tire Mechanics on ATV Tire Friction Coefficients. *SAE Technical Paper*, 961000.

Roads & Maritime Services (Accessed: 2015). (2015). *All terrain vehicle/quad bike*. Available: (http://www.rms.nsw.gov.au/roads/registration/get-nsw-registration/vehicle-sheets/all-terrain-vehicle.html)

Shulruf, B., Malemi, A. (2010). Risk and Preventive Factors for Fatalities in All-Terrain Vehicle Accidents in New Zealand. *Accident Analysis and Prevention*, 42(2), 612-618.

Society of Automotive Engineers (SAE) Internaltional. (2002). *SAE J 266, Steady-State Directional Control Test Procedures for Passenger Cars and Light Trucks*, Vehicle Dynamics Standards Committee, Warrendale, PA, USA.

Standards Australia. (2000). *Concrete kerbs and channels (gutters) - Manually or machine placed*, AS 2876.

SVIA (Accessed: 12/05/2014). (2013). *Position in Oposition to on-road operation of ATVs*. (http://www.svia.org/Downloads/PositionPaperOpposingOn-RoadUse.pdf)

US Consumer Product Safety Commission (CPSC). (2014). *Safety Standard for Recreational Off-Highway Vehicles (ROVs)*, Notice of Proposed Rulemaking, 16 CFR Part 1422, RIN 3041-AC78, Docket No. CPSC-2009-0087.

Vicroads (Accessed: 2014). (2014). *Special work vehicles (quad bikes)*. Available: (https://www.vicroads.vic.gov.au/registration/new-registration/register-non-compliant-vehicles/special-work-vehicles)

Weir, D., Zellner, D. (1986). *An Introduction to the Operational Characteristics of All-Terrain Vehicles*. SAE International, 860225

Weintraub, R., Best, M. (2014). *ATVs on Roadways: A safety Crisis*. The Consumer Federation of America.

Williams, A., Oesch, S., McCartt, A., Teoh, E., Sims, L. (2014). On-road all-terrain vehicle (ATV) fatalities in the United States. *Journal of Safety Research*, 50, 117-123.

Wright, R., Carpenter, T.Johnson, F., Nelson, R. (1991). Stability and Maneuverability Problems of ATVs. *SAE Technical Paper*, 911944.

Contributed articles

Road Safety Policy & Practice

Truck Rear Underrun Dynamic Crash Test in AS/NZS 3845.2:2017 Standard – a World's First for Heavy Vehicle Crashworthiness

Raphael Grzebieta[1] and George Rechnitzer[1,2]

[1] *Transport and Road Safety (TARS) Research Centre, University of New South Wales, Sydney, Australia*

[2] *George Rechnitzer and Associates Pty Ltd, Melbourne, Australia*

Corresponding Author: Raphael Grzebieta, Level 1, West Wing, OMB, UNSW Sydney, NSW 2052, Australia, r.grzebieta@unsw.edu.au, +61 411 234 057.

Key Findings

- Around 10 to 12 car occupants are killed in rear truck underrun crashes yearly;
- Cars crashing into trucks with rear overhangs represents extreme incompatibility;
- Car crashworthiness systems entirely negated in fatal truck rear underrun crashes;
- New AS/NZS 3845.2 Standard includes truck underrun dynamic test and safety criteria;
- Crashes into AS/NZS 3845.2 compliant truck rear underrun barriers are now survivable;

Abstract

Each year around ten to twelve fatalities occur as a result of truck rear underruns in Australia and New Zealand. The injuries are usually horrific. Any car impact protection devices such as crumple zones, frontal airbags, or pre-tensioning belts are completely negated by an obvious mismatch between truck with an extended rear frame and a car's crashworthiness systems. Given both Australia and New Zealand have adopted a 'Safe System Approach' road safety strategy, all such foreseen fatalities need to be addressed if a design countermeasure can be implemented. Despite the need for a standard having been recognised for some decades, there has been no effective legislation or Australian Design Rule requiring truck rear under run barriers. It was not until this year (2017) that the redrafted AS/NZ 3845.2 standard set out a crash test performance requirement for such barriers. This is the first time anywhere in the world such a dynamic crash test requirement has been specified in any official document agreed to by regulators. Brief details of the crash test matrix, the criteria for a barrier to be compliant with the standard and the basis on which requirements were established for a truck rear underrun protection device (barrier) is presented. A five star ANCAP rated car crashing into AS/NZS 3845.2 compliant truck rear underrun barriers at speeds of up to around 70 km/h are now survivable.

Keywords

Truck Underrun, AS/NZS 3845.2, Barrier, Crash Testing, Rear Underride

Glossary

AS/NZS	Australian Standard/New Zealand Standard
ADR	Australian Design Rule
NCAP	New Car Assessment Programme
IIHS	Insurance Institute of Highway Safety
NZ	New Zealand
RUPD	Rear Underrun Protection Device
US	United States (of America)

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 shows some real world crashes where people have died as a result of such horrific impacts 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 2. 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 to 12 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 truck rear and side underrun barriers. Disturbingly, the Australian Federal Government office responsible for introducing and maintaining ADRs assessed over a decade ago that the cost benefit of introducing such a vehicle design rule as too small despite the horrific injuries identified in real world data. The United States (US) Insurance institute of Highway Safety (IIHS) has also identified that truck rear and side underrun fatalities and serious injuries are occurring as a result of inadequate truck underrun barriers and the lack of a US crash performance test standard (IIHS, 2014, 2017a, 2017b).

Truck Rear Underrun Protection Devices (RUPDs) (truck underrun barriers) 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 Figures 3 and 4. RUPDs are permanently fixed to the rear of any truck or trailer. A considerable amount of research work was completed into establishing what is a suitably crashworthy RUPD almost two decades ago now (Rechnitzer, Powell & Sayer, 2001, Zou, Rechnitzer & Grzebieta, 2001, Rechnitzer, 2003).

Current vehicle crashworthiness technology indicates that cars can be designed to prevent occupants from serious injury at a frontal impact speed (ΔV) of 64 km/h into a deformable barrier and also when crashing into a rigid barrier at a narrow 25% offset, if the car is a modern five star New Car Assessment Programme (NCAP) crashworthy rated vehicle.

Hence, based on this recent technology and to address the ADR shortcomings within a 'Safe System Approach' paradigm, the new Australian Standard AS/NZS 3845.2: Road Safety Barrier Systems and Devices was recently developed and released as a 'world's first' underrun crash test for regulators and operators who want to specify crashworthy RUPDs fitted to trucks that operate in the work place as well as on public roads. This article presents the main components of the RUPD section.

How and Why the New RUPDs Standard Was Developed

All nature of trucks can operate within a road works site or be delivering materials to a road works or road maintenance site via a public road. The hierarchy of controls for managing fatality and injury risks within Australia's and NZ's Work Health and Safety legislation specifies that engineering controls which design out the hazard are considered more effective control measures than

Figure 1. Under Crashes (Rechnitzer & Fong, 1991)

Figure 2. Under Crashes (Rechnitzer & Grzebieta, 2001)

administrative controls (SafeWork Australia, 2011, Peace, 2016). A truck that is delivering materials or used in the workplace is considered as mobile plant in Work Health and Safety legislation. Given that the technology was already been developed by Rechnitzer and others (Rechnitzer, 2003, Rechnitzer, Powell & Sayer, 2001, Rechnitzer, Zou & Grzebieta, 1997) it was appropriate for the Australian/New Zealand CE 33 Committee commissioned with re-drafting AS/NZS 3845 (and within member's duty of care), to specify a crash test protocol and safety criteria for the design of a crashworthy RUPD.

RUPDs are usually attached to a truck or trailer of any large mass vehicle that is greater than 3500 kg Tare mass. The trailer would typically be towed such as in the example of a tip truck and dog or a prime mover towing a semi-trailer, B double or B-triple configuration. The vehicle with the RUPD attached can travel on any public road and is not necessarily associated with any road maintenance or roadwork. However, it was deemed that a public vehicle delivering materials to a roadwork site should have a RUPD attached.

To ease the process of accepting a suitable crash test protocol and safety criteria, it was decided to base the standard on existing internationally accepted crash test protocols and safety criteria already adopted in the US, Europe, Australia and NZ for testing and certifying roadside and median safety barriers. Around four decades of crash testing and crashworthiness technology that has been validated against real world crash data, computer simulations and engineering biomechanics, have been incorporated into road safety barrier test protocols and safety criteria. Hence, the underrun crash test was principally based on crash test using components from the US Manual for Assessing Safety

Figure 3. RUPD rigid barrier design (Rechnitzer, Powell & Sayer, 2001)

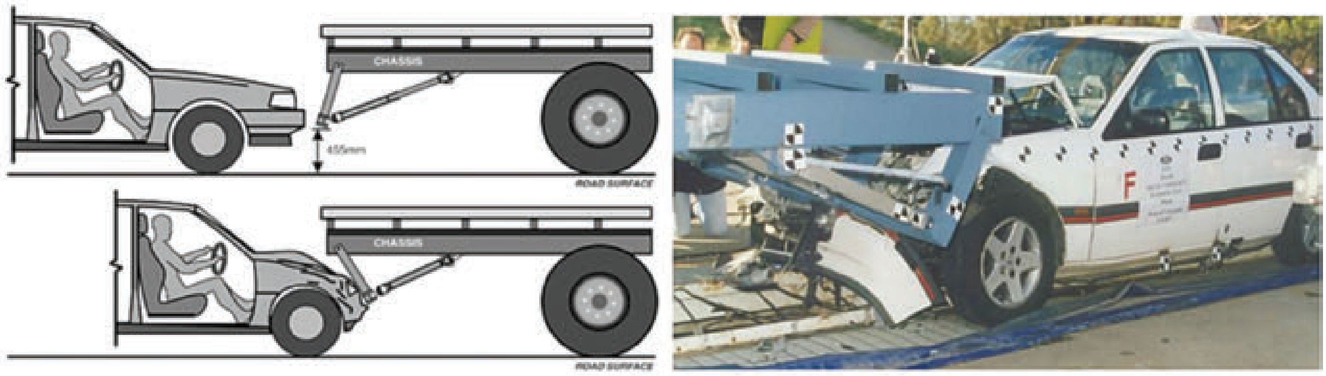


Figure 4. Energy dissipating RUPD barrier design (Rechnitzer, Powell & Sayer, 2001)

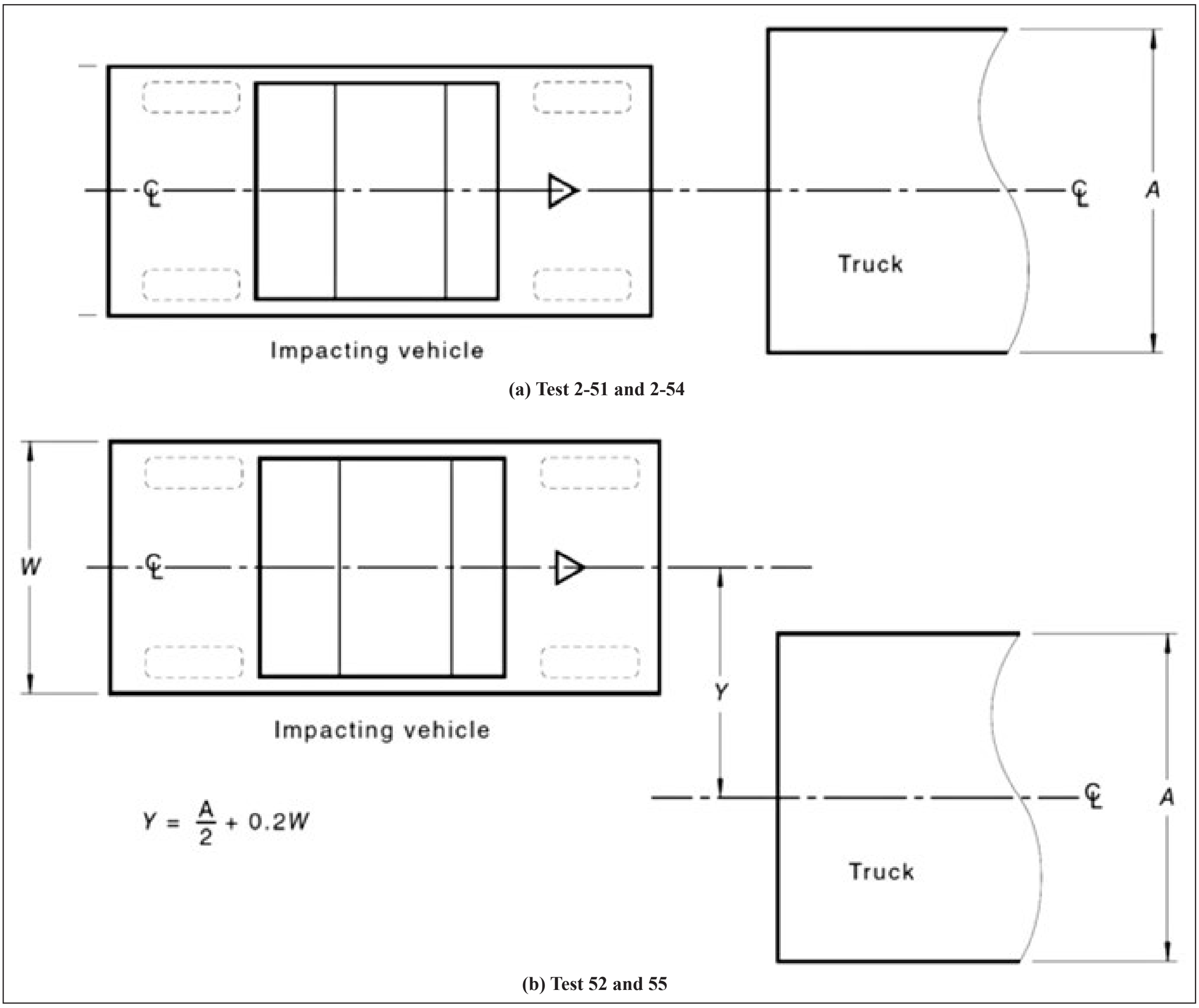
Table 1. Test Matrix For Rear Underrun Protection Devices (Standards Australia, 2017)

Test Level	Feature	Test designation	Impact conditions			Impact point	MASH Evaluation Criteria
			Vehicle	Nominal Speed (km/h)	Nominal Angle deg.		
2	Rear underrun protection device	2-51	2270P	70	0	Fig. 5	C,D,F
		2-52	2270P	70	0	Fig. 5	C,D,F
		2-54	1500A	70	0	Fig. 5	C,D,F
		2-55	1500A	70	0	Fig. 5	C,D,F

Hardware (MASH) crash test vehicles and testing protocols commonly used in Australia and New Zealand.

Underrun Test Standard

The performance requirements are set out in Section 7 of AS/NZS 3845 for RUPDs. These devices may 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. RUPDs are permanently fixed to such vehicles. The RUPD usually does not protrude from the rear of the truck or trailer and mostly relies on the impacting vehicle's frontal crash protection system for ride down decelerations for the occupants although some of the impact kinetic energy can be dissipated by the RUPD.



(a) Test 2-51 and 2-54

(b) Test 52 and 55

Figure 4. Impact Conditions For Rear Underrun Protection Devices

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 utility vehicle (2270P) are impacted into the RUPD at a speed of 70 km/h in a centred and a 30% offset configuration as indicated in Figure 5 (AASHTO, 2016).

The barrier must meet certain crashworthiness criteria (C, D, F) detailed in MASH (AASHTO, 2016). They are:

C: Acceptable test article performance may be by redirection, controlled penetration, or controlled stopping of the vehicle. Research has demonstrated that if the maximum permitted rearward displacement of the RUPD beyond the face of the rear of the truck does not exceed 500 mm, then survivability is improved. This dimension is to ensure that underrun resulting in hazardous penetration of the vehicle windshield is prevented in most crash situations.

D: Detached elements, fragments or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present undue hazard to other traffic, pedestrians, or personnel in a work zone.

F. The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.

For all tests the RUPD is mounted on a standard MASH 10,000 kg single unit heavy truck test vehicle (designated a 10000S vehicle). During the tests, the test vehicle is placed in second gear and the parking brake set. The RUPD is fixed to the rear of the truck in the same way as it would be installed in service. The RUPD may deform under the impact loading but there cannot be any joint failures or buckling of the RUPDs key support structures or of the support truck structure.

Whilst the RUPD can deform under the impact loading the requirements that there are to be no joint failures or buckling of RUPDs key support structures or of the support truck structure, is to ensure the RUPD has residual load capacity for impacts above 70 km/h. While an impact at 100 km/h would be desirable, this speed is considered too onerous with the current technology.

The research work by the Authors referred to above have established that all criteria can be readily met by well-designed RUPD.

While the performance requirements set out in AS/NZS 3845.2 for RUPDs are intended for trucks servicing work sites and maintenance, the 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 a truck or trailer. In other words, crashworthy effective RUPDs can now be designed and fitted to any truck that is used within a work or maintenance site or delivering materials to such sites.

In the USA, the IIHS carries out evaluations of the performance of rear underrun guards on semitrailers made by the major manufactures (IIHS, 2017c). The crash tests are described on the IIHS website, and use a mid-sized sedan crashed into a parked semitrailer at 56km/h, in centred 50% offset and 30% offset impacts. Trailers that pass these tests, i.e. prevent underrun (no intrusion into the passenger compartment) qualify for the IIHS TOUGHGUARD Award.

Conclusions

For nearly 30 years the Authors and others have been advocating that the tragic and senseless deaths arising from rear underrun crashes could be largely eliminated by the requirement of effective rear underrun barriers on heavy vehicles. The necessary performance criteria and crash testing for the effective design of truck rear underrun barriers are now finally incorporated in the Australian Standard AS/NZS 3845.2: Road Safety Barrier Systems and Devices.

Although this standard is intended to apply to trucks involved in roadworks and road maintenance, the AS/NZS 3845.2 RUPD requirements are able to be used for all heavy vehicles. This should be promoted to industry, road safety and heavy vehicle regulators.

It would also be appropriate for ANCAP to explore introducing the IIHS type crash test evaluation of the performance of rear underrun barriers on heavy vehicles in Australia, and eventually tests in line with AS/NZS 3845.2:2017 RUPD requirements. This would quickly identify pseudo RUPDs and promote effective properly engineered RUPDS.

Acknowledgements

The Authors would like to thank the members of the CE-033 Committee and in particular Professor Rod Troutbeck (Chair) and Mr. Julian Chisnall, for supporting the introduction of these lifesaving tests and criteria in the Australian and NZ Standard.

References

American Association of State Highway and Transportation Officials (AASHTO), (2016). *Manual for Assessing Safety Hardware (MASH)*. See: https://bookstore.transportation.org/Item_details.aspx?id=2707 (accessed 9/10/2017)

Grzebieta, R.H., Rechnitzer, G.R., 2001. *Crashworthy Systems – a paradigm shift in road safety design (Part II)*, Transport Engineering in Australia, IEAust, Vol. 7, Nos. 1&2, Dec.

Haworth, N., Symmonds M., 2003. *A Cost-Benefit Analysis of Heavy Vehicle Underrun Protection*, Proc. Australasian Road Safety Research, Policing and Education Conference, http://acrs.org.au/files/arsrpe/RS030141.pdf (accessed 9/10/2017).

Insurance Institute of Highway Safety (IIHS), Status Report, Vol. 49, No. 7, October 9, 2014. http://www.iihs.org/iihs/sr/statusreport/article/49/7/1

http://www.iihs.org/iihs/news/desktopnews/new-crash-tests-underride-guards-on-most-big-rigs-leave-passenger-vehicle-occupants-at-risk-in-certain-crashes (accessed 9/10/2017).

Insurance Institute of Highway Safety (IIHS), *Side guard on semitrailer prevents underride in 40 mph test*, August, 2017a.

http://www.iihs.org/iihs/news/desktopnews/side-guard-on-semitrailer-prevents-underride-in-40-mph-test (accessed 9/10/2017).

Insurance Institute of Highway Safety (IIHS), *IIHS Crash Tests Show Side Underride Guards on Trucks Save Lives,* May, 2017b.

https://www.trucks.com/2017/05/10/iihs-truck-underride-guards-save-lives/ (accessed 9/10/2017).

Insurance Institute of Highway Safety (IIHS), Truck Underride Guard Evaluations, 2017c.

http://www.iihs.org/iihs/ratings/Truck-underride-guard-evaluations (accessed 9/10/2017).

Peace, C., 2016. Hierarchy Risk of Controls, Risk Management Lt., Wellington, New Zealand.

Rechnitzer, G., 2003. The Improvement of Heavy Vehicle Design to Reduce Injury Risk in Crashes with Other Road Users, PhD Thesis, Accident Research Centre and The Department of Civil Engineering, Monash University.

https://www.filesanywhere.com/fs/v.aspx?v=8b6a69875e67767ca2a4 (accessed 9/10/2017).

Rechnitzer, G., Foong, C.W., 1991. *Truck Involved Crash Study: Fatal and Injury Crashes of Cars into the Rear of Trucks*, MUARC Report No. 26, Monash University, Clayton, Australia. http://www.monash.edu.au/miri/research/reports/muarc026.pdf (accessed 9/10/2017).

Rechnitzer, G., Grzebieta, R.H., 2001. *Crashworthy System – a paradigm shift in road safety design (Part I)*, Transport Engineering in Australia, IEAust, Vol. 7, Nos. 1&2, Dec.

Rechnitzer, G., Zou, R. and Grzebieta, R.H., MADYMO Computer modelling of energy absorbing rear underrun barriers for heavy vehicles-A pilot study, MUARC Research Report No 112, Monash University, 1997. http://www.monash.edu/muarc/research/reports/muarc112 (accessed 9/10/2017).

Safework Australia, *How To Manage Work Health And Safety Risks Code of Practice*, 2011. https://www.safeworkaustralia.gov.au/system/files/documents/1702/how_to_manage_whs_risks.pdf (accessed 9/10/2017).

Standards Australia, *AS/NZS 3845.2:2017 Road Safety Barrier Systems and Devices Part 2: Road Safety Devices*, SAI Global Limited, Sydney, Australia.

Perspective on Road Safety

It is time to consider a presumed liability law that protects cyclists and other vulnerable road users

Soufiane Boufous[1]

[1]*School of Aviation, Transport and Road Safety (TARS) Research, University of New South Wales, Sydney, Australia*

Corresponding Author: Soufiane Boufous, School of Aviation, UNSW, Sydney, NSW Australia 2052, soufiane@unsw.edu.au. +61 2 9385 6227.

Key findings

- Cycling participation is falling and cyclist hospitalisations are on the rise.
- Motorists are more likely to be at fault in crashes with cyclists.
- A presumed liability law that places the burden of proof on motorists in crashes with cyclists is needed.
- The law would allow better compensation for cyclists and encourage motorists to exert extra care.
- Presumed liability along with other measures are likely to improve safety and cycling participation.

It is widely agreed that cycling is an effective way to promote physical health and mental well-being, reduce congestion on roads and improve the quality of the environment. In recognition of the benefits of cycling, the National Cycling Strategy 2011-2016 set out the objective to double cycling participation by Australians between 2011 and 2016 (Australian Bicycle Council & Austroads, 2010). Unfortunately, the latest National Cycling Participation Survey, run every two years to measure progress, showed that Australia has not only failed to reach this objective but participation has in fact declined between 2011 and 2017 in five jurisdictions, including the two most populous states of NSW and Victoria (Austroads & Australian Bicycle Council, 2017).

Most people cite concerns about safety, particularly fears of sharing the road with motor vehicles and the lack of appropriate infrastructure, as the main barriers to cycling (Heart Foundation & Cycling Promotion Fund, 2012). Available statistics show that cyclists' safety fears are not unfounded. While cyclist deaths have decreased steadily over the last two decades (Boufous & Olivier, 2016), hospitalisations associated with cycling crashes are on the rise. Recent data from Victoria show that while there was no significant change in the incidence of hospitalised major trauma for motor vehicle occupants, motorcyclists or pedestrians, the incidence for pedal cyclists increased 8% per year between 2007–2015 (Beck et al., 2017). 2007–2015.

More efforts are needed to reverse this trend. As previous road safety lessons tell us, education campaigns and better infrastructure can only work in combination with strong legislation and enforcement. Legislation in the area of cycling safety is still inadequate and arguably puts an unfair burden on cyclists.

This is despite many reports, such as the one released by the RAA, South Australia's peak motoring body, earlier this year showing that cars are more likely to be at fault in the event of a crash with a cyclist (Royal Automobile Association, 2017). The findings confirm those of another South Australian study that examined police crash records and found four in every five crashes between cars and bicycles to be caused by the motorist (Lindsay, 2013); and another from Victoria that examined camera footage of similar incidents and found that the driver was responsible for the action that preceded the incident in 87% of cases (Johnson et al., 2010). All previous studies show that most of these crashes occur at intersections and generally involve a cyclist travelling straight on a single carriageway at the time of the collision with the motor vehicle.

In addition, in bicycle-motor vehicle collisions, cyclists are more likely to become injured than drivers because of mass and power disparity. However, currently if a car collides with either a bicycle or a pedestrian on Australian roads, the cyclist or pedestrian needs to make a case against the motorist to claim on the motorist's insurance. If the insurance company contests the claim, then the injured cyclist or pedestrian must take the case to a civil court.

Surely the burden of proof should shift onto the more powerful road user that is more likely to cause harm who also happens to be the party more likely at fault in the event of a crash. There is a need for a presumed liability law that protects vulnerable road users as it is the case in Canada and in many European countries, including Netherlands, Germany, Netherlands, Denmark and France (Maker, 2015). While the level of implementation varies between countries and so does the name as it sometimes also referred to as the "reverse onus" or "strict liability law", the principle remains the same. Under the law, the onus is on drivers to prove that a collision with a cyclist or a pedestrian was not their fault (Schepers et al., 2017). It places the burden of proof on the party more likely to cause injury or death.

The law only affects civil cases and is not about removing the presumption of innocence as it focuses on the principle of "liability" rather than "guilt" (Maker, 2015). In criminal law, drivers in collisions with vulnerable road users would remain innocent until proven guilty. It is not about blaming motorists either. So, if a cyclist runs a red light and causes a collision, then it's their fault and they will not be compensated.

The law would mean that cyclists are more likely to be fairly compensated for injury and any damage to their bicycle in the event of a crash than present. More importantly, it would encourage motorists to exert extra care when driving at the proximity of vulnerable road users. The underlying message is that motor vehicles are potentially "dangerous weapons" that requires extreme caution and diligence (Maker, 2015).

The laws are relevant to a country like Australia where cycling participation rates are relatively low and cycling infrastructure remains largely inadequate leaving cyclists with little choice but to share public roads with motor vehicles. Strict liability is already applied to other areas of law in Australia, including product safety, environmental protection as well as work health and safety laws (Australian Law Reform Commission, 2015).

It is difficult to isolate the impact of presumed liability laws on road safety as they are often implemented at the same time as other preventative measures. However, in European nations presumed liability, which was originally introduced to reduce traffic crashes, is widely believed to be a key component within a package of measures credited with encouraging safer cycling (Maker, 2015; Pucher & Buehler, 2008).

A key factor that is keeping Australians from taking up cycling is the perception that it is an unsafe activity. This is backed by available statistics. To improve participation rates and get the full health, environmental and social benefits of cycling, a presumed liability law is needed to protect vulnerable road users, including cyclists, on our roads. However, as experience from elsewhere indicates, the law alone is not sufficient. It needs to be complemented with improved education about better sharing the roads, traffic calming with an emphasis on reduced speed limits in residential areas; and better cycling infrastructure with appropriate intersection treatments.

References

Australian Bicycle Council, & Austroads. (2010). *The Australian National Cycling Strategy 2011–16*. Austroads Publication No. AP-C85/10. Sydney: Austroads Ltd.

Australian Law Reform Commission. (2015). *Traditional Rights and Freedoms— Encroachments by Commonwealth Laws*. Sydney: Commonwealth of Australia.

Austroads & Australian Bicycle Council. (2017). *National cycling participation survey*. Austroads Publication No. AP-C91-17. Sydney: Austroads Ltd.

Boufous S., & Olivier, J. (2016). *Recent trends in cyclist fatalities in Australia*. Injury Prevention, 22: 284-287.

Beck, B., Cameron, P.A., Fitzgerald, M.C., Judson, R.T., Teague, W., Lyons, R.A., & Gabbe B.J. (2017). *Road safety: serious injuries remain a major unsolved problem*. Medical Journal of Australia, 207(6): 244-249.

Heart Foundation, Cycling Promotion Fund. (2012). *Riding a Bike for Transport. Survey Findings.* Sydney: Heart Foundation, 2012.

Johnson, M., Charlton, J., Oxley, J., & Newstead, S. (2010). *Naturalistic cycling study: identifying risk factors for on-road commuter cyclists.* Annals of Advances in Automotive Medicine, 54: 275-283.

Lindsay, V. (2013). *Injured cyclist profile: an in-depth study of a sample of cyclists injured in road crashes in South Australia.* Adelaide: Centre for Automotive Safety Research, The University of Adelaide.

Maker, C. (2015). *Strict Liability in Cycling Laws to Ready the Roads for Environmentally Friendly Commuting*. Boston College Environmental Affairs Law Review, 42 (27): 473-505.

Pucher, J., & Buehler, R. (2008). *Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany.* Transport Reviews, 28(4): 495-528.

Royal Automobile Association (RAA). (2017). *RAA reveals most dangerous suburbs and roads for cyclists.* Available from http://www.raa.com.au/community-and-advocacy/media-releases/1208

Schepers, P., Twisk, D., Fishman, E., Fyhri, A., & Jensen, A. (2017). *The Dutch road to a high level of cycling safety.* Safety Science, 92: 264-273.

Calling for submissions

to the *Journal of the Australasian College of Road Safety (JACRS)*

February 2018 Issue: We are soliciting contributions for the February 2018 Issue on all topics of road safety. Sample topics may include, but are not limited to: in-depth analyses of the rising road deaths in Australia with practical implications on actions to address them; evaluation of Safe System interventions; drug-driving related research, technology, and countermeasures; research related to autonomous vehicles; research/evaluation of road safety activities in low and middle income countries; case studies of best practice evidence-based enforcement.

SUBMISSION DEADLINE for February 2018 Issue:
Peer-review papers: *Wednesday, 6th December 2017*
Contributed (non peer-review) articles: *Wed nesday, 20th December 2017*

For more details on article types, the scope and requirements see the **Instructions to Authors** available from the ACRS website: http://acrs.org.au/contact-us/em-journal-conference-contacts/ (scroll down). Please submit your manuscript online via the Editorial Manager: http://www.editorialmanager.com/jacrs/default.aspx. Authors wishing to contribute papers and discuss their ideas with the Managing Editor in advance of submission or to ask any questions, please contact Dr Chika Sakashita: journaleditor@acrs.org.au

You can also search for current and past papers here:

- https://trid.trb.org/
- http://acrs.org.au/publications/acrs-conference-papers/acrs-database/
- http://search.informit.com.au/
- https://www.safetylit.org/

Hard copies of the *JACRS* are also available at the National Library of Australia.

The *JACRS* citations are being indexed in the **Emerging Sources Citation Index (ESCI)** and citation activity is visible in **Web of Science**. We thank you for your continued support and contribution towards JACRS attaining an Impact Factor.

"Together we can improve road safety"

Become a member of the College today!

The Australasian College of Road Safety (ACRS) is the peak membership association focussed on saving lives and injuries on our roads.

What membership benefits do we provide?

- **Communication** – weekly e-newsletters, quarterly peer-reviewed journal, social platforms (LinkedIn and Facebook), media releases... **We keep you up to date!**
- **Professionalism** – Awards, Code of Professional Conduct.... **We reward innovations to save lives and injuries!**
- **Accreditation** – Register of Road Safety Professionals.... **We support our experts!**
- **Networking** – National conference, Chapter events, social platforms.... **We keep you connected!**
- **Advocacy** – International, Australasia0n, National and Chapter-based advocacy.... **We talk to those in leadership positions on your behalf!**

Who can be members?

In a word: Everyone!

Individuals contribute a variety of views and perspectives.

A range of businesses bring expertise and innovations which contribute to road safety.

Community organisations can use their membership to join with others to promote changes to improve road safety. Success stories are shared with other Councils and groups.

The College promotes government programs and initiatives, coordinating activities between agencies and across communities. This collaboration builds strong road safety messages and achieves greater results by sharing resources.

Police and emergency services contribute valuable perspectives to the road safety issues in local regions.

ACRS provides researchers and academics, with a forum for discussion, advocacy and collaboration across disciplines, agencies and on an international scale.

How can you support the College and our work to reduce road trauma?

There are a variety of ways to showcase your support in reducing road trauma, including:

- **Membership**

All people and organisations are responsible for road safety and we encourage an inclusive environment via our diverse membership.

- **Sponsorship (e.g. events and awards)**

Showcase your support to combat road trauma and be associated with a prestigious organisation endorsed by the Governor-General of Australia.

- **Attending events**

A myriad of events are linked in the weekly e-newsletter - take your pick!

- **Registering as a Road Safety Professional**

By drawing on the Register of Road Safety Professionals, the College assists members with access to expertise such as expert witnesses for court proceedings and to field media enquiries.

To become a member, contact the College:

Australasian College of Road Safety
Ph: (02) 6290 2509

Email – Finance and Administration:
faa@acrs.org.au

SMART CUSHION

Speed Dependent Crash Attenuators

The SMART MONEY
in Road Safety...

is on
SMART CUSHION

- Less Waste
- Less Mess
- Faster Reinstatement
- Fewer Replacement Parts
- Temporary Or Permanent Installations
- Complete Standalone Unit
- Low Maintenance
- Lowest Whole Of Life Costs
- All Steel Construction
- MASH TL3 Tested

DESIGNED FOR SAFETY

- Low ride down accelerations on vehicle occupants in end-on impact
- Reduced spare parts inventory: In almost 50% of all resets to date the only replacement parts needed are two 1/4" shear bolts
- Increased crew safety: The average reset/repair time (often with just a one man crew) is 56 minutes
- Reduced call out increase crew safety: to date there has been no call outs for side angle impacts, a similar pattern to that in the USA
- Reduced lane closure time: Fewer call outs and faster repairs keep traffic lanes open for longer
- Happier motorists: Fewer lane closures, less blockages and faster repairs
- SMART DESIGN, SAFER SITES FOR ROAD CREW and SAFER MOTORING

ROAD SAFETY DESIGN AT ITS BEST

The SMART CUSHION Spare parts detailed record to date for the first 47 resets.

sci-01	07/15	sci-02	07/15	sci-03	09/15	sci-04	10/15	sci-05	10/15	sci-06	11/15	sci-07	11/15
1st	SP	1st	SP	1st	SP	1st	SP	1st	SP	1st	SP	1st	SP
sci-08	11/15	sci-09	11/15	sci-10	12/15	sci-11	04/16	sci-12	05/16	sci-13	05/16	sci-14	06/16
1st	SP+DP	1st	SP	1st	SP	1st	SP	1st	SP	1st	SP+DP	1st	SP+DP
sci-15	07/16	sci-16	07/16	sci-17	10/16	sci-18	10/16	sci-19	11/16	sci-20	11/16	sci-21	11/16
1st	SP+DP	1st	SP+DP	1st	SP	1st	SP+DP	1st	SP	1st	SP	1st	SP+DP
sci-22	11/16	sci-23	02/17	sci-24	02/17	sci-25	02/17	sci-26	02/17	sci-01	09/15	sci-02	02/17
1st	SP	1st	SP	1st	SP	1st	SP+Sd	1st	SP+Sd	2nd	SP+DP	2nd	SP
sci-06	11/15	sci-07	07/16	sci-08	12/15	sci-09	12/15	sci-14	07/16	sci-25	11/16	sci-01	11/15
2nd	SP+DP	2nd	SP+DP	2nd	SP	2nd	SP+DP	2nd	SP	2nd	SP+DP	3rd	SP
sci-06	11/15	sci-09	05/16	sci-01	12/15	sci-06	09/16	sci-09	12/16				
3rd	SP	3rd	SP	4th	SP	4th	SP+DP	4th	SP				
sci-01	12/15	sci-01	01/16	sci-01	01/16	sci-01	05/16	sci-01	06/16	sci-01	06/16	sci-01a	08/16
5th	SP+DP	6th	SP	7th	SP	8th	SP+Sd	9th	SP+DP	10th	SP	11th	SP

Code for Unit number / date / sequence

sci-XX	unique Smart Cushion number
MM/YY	Month reset/repaired
1st / etc	Reset sequence per unit

Reset/Repair required

SP	only Shear Pins were required
SP+DP	Delinator panel also replaced
SP+Sd	Sled panel also replaced

GAME CHANGER

To date 26 Smart Cushions have been impacted, one of these has been impacted 11 times. **The total cost of all Spare Parts used in 47 resets is $7,338.00 at an average of $160.00 per reset.**

distributed exclusively by

LB AUSTRALIA

For further information, please contact:

Paul Hansen, LB Australia Pty Ltd

Ph: 02 9631 8833

www.lbaustralia.com.au

Australasian College of Road Safety Inc.

ACRS, PO Box 198, Mawson ACT 2607 Australia
Tel 02 6290 2509
Fax 02 6290 0914
Email eo@acrs.org.au
Head Office
Pearce Centre, Collett Place, Pearce ACT Australia

Visit the College website at www.acrs.org.au

Proudly sponsored by
LB Australia
NSW Transport Centre for Road Safety,
and New Zealand Transport Agency