Vol 31, Issue 2, 2020

Journal of Road Safety

Peer-reviewed papers

Contributed Articles

The Decepta

Hop in the front and let safety take a backseat

Bringing together the latest features with the finest flaws, the Decepta has everything you want, and lacks everything you need.

Bluetooth stereo, front and rear cup holders and other comforts will all make driving a dream. Crashing will be a nightmare though, without all those safety features you didn't know it didn't have.

Know what you're getting into. Always check a car's Star Safety Rating. The more stars, the safer you are.

WAKA KOTAHI NZ TRANSPORT AGENCY

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New Zealand Government

Introducing Road Safety Victoria and the Department of Transport

The Department of Transport (DoT) brings together all transport modes to design, plan, deliver and operate Victoria's transport system. We're focused on outcomes that deliver more choice, connections and confidence in our travel, ensuring the whole transport network works as one to deliver better services.

DoT's vision is to meet the aspirations of Victorians and businesses for a transport system that is simple, connected, accessible, reliable, safe and supports a productive, growing economy.

Victoria has a proud history of road safety innovation and within the Department, Road Safety Victoria (RSV) has recently been established to provide a dedicated office to improving safety for all Victorian road users.

RSV works closely with road safety partners – Transport Accident Commission, Victoria Police, the Department of Justice and Community Safety, and the Department of Health and Human Services – to deliver strategic and coordinated road safety policies, programs and initiatives.

Find out more at **transport.vic.gov.au**

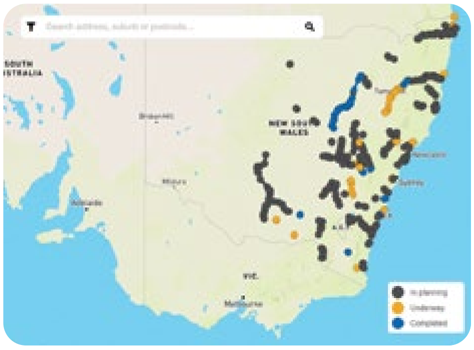
VICTORIA State Government | Department of Transport

Safety upgrades across NSW

Explore the Safer Roads Program on a new interactive map

Human error is a factor in most crashes. Safer road design and the installation of safety treatments can help minimise the impact of human error and so the NSW Government is investing $822 million over five years from 2018-19 to 2022-23 in the Safer Roads Program to upgrade roads to reduce trauma.

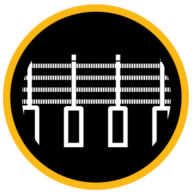
The Safer Roads Program is a targeted infrastructure treatment program which uses proven engineering treatments to reduce both the number of casualty crashes and the severity of injuries when a crash does occur. Safer Roads Program projects are identified through a robust technical assessment which includes analysis of crash history, road geometry, presence of roadside risk factors, presence of vulnerable road users and road characteristics (such as traffic volumes and speed limits).



Key treatments being installed across NSW include:

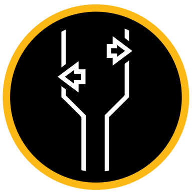
Audio tactile line marking:

Estimated to reduce road trauma when vehicles leave the road by 15% to 25%



Flexible safety barriers:

Reduce severity of high-risk crashes by up to 95%



Wide centreline:

Estimated to reduce head-on crashes by 50% and run-off crashes by up to 25%

In 2019-20, 412 Safer Roads Program projects are in planning or underway and another 207 will start in 2020-21.

Explore the interactive map on the Towards Zero website to find project information including:

- Initiative – Saving Lives on Country Roads or Liveable and Safe Urban Communities
- Status – Completed, Underway or In Planning
- Description of works.

To explore the map and find out more about how NSW is working Towards Zero through safer roads, visit **towardszero.nsw.gov.au/safesystem/safe-roads**

NSW GOVERNMENT | TOWARDS ZERO

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Cover image

Are cyclists increasing in Australia and what data are available to determine cycling exposure? See Original Road Safety Research articles: Olivier, J., Churches, T., Hayen, A., Walter, S. and Grzebieta, R. (2020). "Has cycling decreased in Australia? A comparison of 1985/86 and 2011 surveys". *Journal of Road Safety*, 31(2), 44-47. & Olivier, J., Esmaeilikia, M., Johnson, M., Beck, B. and Grzebieta, R. (2020). "Does the Australian Bureau of Statistics Method of Travel to Work data accurately estimate commuter cycling in Australia?". Journal of Road Safety, 31(2), 48-54. Photo source: Marilyn Johnson, Monash University & Amy Gillett Foundation.

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The *Journal of Road safety (JRS)* is an international, scholarly, cross-disciplinary, peer-reviewed and open-access journal purely focused on road safety. The JRS accepts papers from any country or region and aims to publish a diverse range of high quality papers on road safety from researchers, policy makers and other road safety experts.

All papers submitted to the JRS undergo a peer-review process, unless the paper is submitted as a Contributed Article or *Correspondence (Letter to the Editor)*. Peer-review Papers and Contributed Articles can take the form of the following articles types: *Original Road Safety Research; Road Safety Data & Research Methods; Road Safety Policy & Practice; Road Safety Case Studies; Road Safety Evidence Review; Road Safety Media Review; Perspective on Road Safety*.

All submissions are assessed 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. Once a paper is submitted, the Editor-in-Chief and/or Managing Editor initially review the submission. Authors are notified if their paper is judged to be outside of the JRS' scope or lacks originality or message that is important to the readers of the JRS.

Peer-review submissions that pass the initial screening process will be sent out to a minimum of three peer reviewers selected on the basis of expertise and prior work in the area. Additional peer reviewers may be called on at the discretion of the Editor(s), e.g. in the case of a disagreement between referees' opinions. The names of the reviewers are not disclosed to the authors. Each submission is peer-reviewed by a minimum of three experts in the field.

Based on the recommendations from the peer-reviewers, the Editor-in-Chief makes a decision, in consultation with the Managing 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 reviewer/s. Authors are informed of the decision after the first round of review. Revised submissions are sent out for a second round of review and authors are again notified of the decision based on the recommendations from the peer-reviewers.

Contributed Article submissions that pass the initial screening process will be reviewed in detail by the Managing Editor and an additional reviewer may be called on at the discretion of the Editor(s) or the paper may be subject to peer-review, e.g. in the case of contentious contents that need expert assessment. The Managing Editor makes a decision, in consultation with the Editor-in-Chief 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 reviewer/s. The names of the reviewers are not disclosed to the authors. Authors are informed of the decision after the first round of review.

As a rule of thumb, manuscripts can undergo only one major revision. Any editorial decisions regarding manuscript acceptance by the Editor-in-Chief and Managing Editor are final and further discussions or communications will not be entered into in the case of a submission being rejected. For both peer-review and contributed articles, one or more of the reviewers may require a major revision or reject the paper because of content that may otherwise be of general interest to readers but is not at the level expected of a caliber of a scientific journal paper.

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Authors are responsible for complying with all the requirements (including Article formatting, References, Ethics in publishing, Originality & plagiarism, Author declaration) before submitting their papers. Authors must write entirely original works, and appropriately cite the work and/or words of others to ensure originality and avoidance of plagiarism. Authors of original road safety research articles should present an accurate account of the work performed as well as objective discussion of the findings and their significance. Submission of an article implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint), that it is not under consideration for publication elsewhere, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder.

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Editorial Board

From the President

I had put aside this message to focus on the 3rd Global Ministerial Conference on Road Safety in Stockholm in February. But I can't ignore the public health and economic crisis that has so rapidly spread around the world.

So I shall start with three simple points:

Road traffic injury is a leading cause of death and disability throughout the world;

There are many simple and practical solutions to this public health issue;

Investment in road traffic injury prevention will improve national economies.

This is not to say that, as road traffic safety professionals, we should do anything other than stand in support of other public health issues. Our core values centre around human health and welfare, and we must always demonstrate that, particularly now. The leadership and response by our governments and communities in Australia and New Zealand has been breathtaking. Long may this generosity of spirit abound.

The professional frustration is that this public health crisis has engendered such negatively geared investments – investments aimed at limiting the extent to which our lives are worse. For years, road traffic safety, and many other areas of public health, has been offering forward positively geared investments – investments aimed at improving human life.

Claes Tingvall said at the 3rd Global Ministerial Conference on Road Safety that he was sick of safety having to explain itself. One day we may not need to, but for now we must say we cannot go back to the way we were. We will each play a critical role in a new future. Wouldn't it be great if this is the end of the age in which experts are ignored and disdained, regarded as elitist and out of touch, if public health professionals continue to be asked forward to speak on matters of life and health, informed by research and evidence, and if there is better investment in public health?

We should not be shy about putting road safety investments and decisions forward in this environment. There is so much that can be achieved now in Australia and New Zealand, and we have the knowledge and base capability to do it. The Global Ministerial Conference certainly highlighted the full range of options for progress.

The conference benefited greatly from the technical leadership provided by the Swedish Government and the World Health Organisation, and a wide range of partner organisations. The agenda was strong, with many compelling speakers delivering new and updated analysis and different perspectives from around the world.

The recommendations of the Academic Expert Group provided a great ideas platform. I recommend you download and read *Saving Lives Beyond 2020: The Next Steps*". The nine recommendations put forward a considered re-orientation of the road safety agenda – recognising, building upon and going beyond the "five pillars".

The first two recommendations – "sustainable practices and reporting" and "procurement" – give a flavour of their approach by addressing safety within the context of organisations and their value chain. An organisation's value chain is involved (negatively and/or positively) in every road traffic crash and particularly in the consequences of that crash.

The conference cemented road traffic safety as part of the wider sustainable mobility agenda. Clear progress has been made, but there is much more to be done, particularly in balancing the importance of modal shift and demand management within the road traffic system with the imperative to reduce trauma now. This seems to continue to be a weak point in road traffic safety, where we appear stuck in a negative cycle of underinvestment in safety, underinvestment in sustainable transport, and communities which keep spreading.

The strongest element in the conference was the jump ahead to the global sustainable development agenda. From one perspective, the figures are gloomily familiar: WHO estimates 1.35 million deaths and up to 50 million injuries each year. The Global Burden of Disease study estimates it is the leading cause of death for 10-29 year olds, and of disability for 15-29 year olds. iRAP released estimates of costs, using the well-accepted methodology they developed in 2008, at USD 2219 billion each year.

From another perspective, there was excellent and lively presentation of new material with significant contributions from the Global Road Safety Facility (which is amassing an exceptional body of analytical and practical work), the International Road Assessment Programme, the European Union (pushing forward on vehicle safety regulation like no other), the Towards Zero Foundation and Global NCAP, the FIA and the FIA Foundation (so critical to global road safety for so long), Bloomberg Philanthropies, the Global Road Safety Partnership … the list goes on. It was impressive. All the plenary sessions are able to be viewed online, and the conference website retains information about the various side events and parallel sessions.

The analysis keeps getting sharper and smarter. More programs have been tested and improved. Our safety issues are essentially the same, whether in high, middle or low-income countries. Once the national and cultural context in each country is fully incorporated into the analysis and programs, real and substantial progress can be made.

Investment is a real barrier. More than 60 donor Governments pledged a total of USD 51 billion to the Global Fund to Fight AIDS, Tuberculosis and Malaria between 2002 and 2019. Significant declines in fatalities have been achieved over the last decade across all three diseases. Road traffic fatalities have increased. The UN Road Safety Trust Fund was launched in 2018. It currently reports contributions of USD 8 million and pledges of USD 11.5 million.

A transformational funding effort is required, but investment is only ever part of the issue. It would be great if society as a whole assumed responsibility for road safety, but through their direct control of road infrastructure, market regulation, and service delivery. Governments hold the greatest potential for progress in their hands. It would be great if there were more development assistance priority for road traffic safety within low and middle-income governments but, through their relative wealth and power, our high income governments share responsibility to respond to the global safety (trauma) legacy of our technologies and practices over the decades.

Australia and New Zealand are not some isolated part of the global road traffic injury pandemic. We are part of it. Indeed, our poor recent performance means we need to return to some basic advice and determine how we match up. For example, what will it cost for us to achieve the voluntary road safety performance target agreed by UN Member States of 75% of travel on at least three-star safety rated roads by 2030? When will this performance target be set in Australia and New Zealand?

Which brings us to the presence of the Australasian College of Road Safety at the conference. In the survey conducted as part of our Strategic Review, our members rated promotion of road safety improvements in the Asia Pacific and at the global level lower than many other activities that ACRS should undertake. However, the growing status of our College and its membership domestically and globally was part of the reason that the Australian Government provided significant funding to the College to develop an International Chapter.

The conference was a perfect opportunity to test our ideas and possible approach with a range of stakeholders, possible partners and potential members. We received a lot of positive responses. The initial focus for developing an International Chapter will be Asia. Many low and middle-income scholarship winners of our Conference, and other attendees as well as authors publishing in this Journal, have been from Asia. As well, many ACRS members are already working in Asia for road safety and increasing their efforts.

We want to establish a self-sustaining International Chapter which will directly connect and support members in Asia. If successful, this could lead to the establishment of further chapters in different countries or regions of the world or evolve into the establishment of independent colleges in different regions of the world.

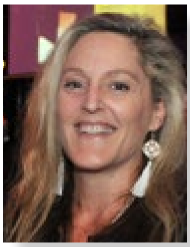
I think this initiative funded by the Australian Government reflects something of our potential future as a College. Our purpose is to support our members' work to eliminate serious road trauma through knowledge sharing, professional development, networking and advocacy. I for one see significant potential value in our purpose for our friends beyond these shores, and would like to see our members engaged in supporting the International Chapter.

As ever, there was a healthy spread of College Fellows, and many other Australasian practitioners, researchers and College members involved in leading and propelling the discussion forward at the Global Ministerial Conference. There are new actors entering the fray, bringing new ideas and capabilities and energy.

I think the governments of Australia and New Zealand should stand behind the Stockholm Declaration when it reaches the United Nations General Assembly. The International Chapter will provide a unique opportunity for Australia to lift again its contribution to global road safety, and New Zealand can do likewise.

Martin Small
ACRS President

From the CEO



Keeping our collective 'road-safety-thought-bubble' afloat during turbulent COVID-19 times

For my message to members in this issue of the *Journal of Road Safety* I am understandably focused on the impact of COVID-19 on all of us, from each of us personally through to the College as a whole and all of our members and stakeholders. Importantly I am particularly focused on COVID-19's impact on road trauma reduction outcomes.

In a few short months the focus of the entire world has undergone a seismic shift. We have been forced to re-frame every aspect of our lives whilst also keeping abreast of a seemingly never-ending stream of emerging information, personal health advice and community regulation.

As the pandemic evolves and our focus is inevitably drawn like a moth towards the flame, road trauma is still occurring.

Road trauma news and information across the myriad of media avenues may not be as prominent as it was, but, as members will be aware from the regular ACRS Weekly Alert e-newsletters and from this Journal you are reading, unfortunately road trauma has not gone into hibernation. And this continuing road trauma only serves to place increased pressure on our already over-burdened hospital and emergency response systems.

It's vital that we as a road safety community retain our focus on road trauma reduction. It's vital that we keep our collective 'road-safety-thought-bubble' afloat during these turbulent COVID-19 times.

As the pandemic and our reaction to it evolves, it is changing the parameters of the environment that we are used to operating in. This in turn is raising many questions, such as:

How can we ensure our extensive bank of work to date remains relevant, useful, and continues to be applied in this COVID-19 world and beyond?

Hovering above all of the College's operational and strategic work is our collective 'road-safety-thought-bubble'

What effect is the pandemic having on the current road safety environment – what data is available and how best can we use it for long-term benefits?

What effect will the pandemic have on our (as yet unknown) post-pandemic road safety world?

Many members are already working hard to respond to these and other emerging road safety-related issues, as well as staying focused on the activities and programs that we already know work. From our jurisdictional agencies, politicians, policing agencies, emergency response & trauma care sectors, to our data collection agencies, corporations, research agencies and community organisations – to name just a few – thank you for your ongoing work and dedication during this particularly difficult time.

The College will continue in our effort to support you all and keep you abreast of the latest road safety information in light of the evolving COVID-19 pandemic, and I particularly look forward to helping us all keep our collective road-safety-thought-bubble afloat.

As always, stay safe, and best wishes,

Claire Howe
Chief Executive Officer - ACRS

ACRS Chapter reports

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

Australian Capital Territory (ACT) and Region

We have an active 2020 program Plan, but our work is largely face-to-face. This is the strength of having a capital city of some 400,000 people located physically within a regional NSW area.

The escalating restrictions imposed by Governments in response to the Coronavirus pandemic developments have put these plans largely on hold.

We continue to develop the wildlife injury working group on-line with some limitations, but other proposed work with the Council of the Ageing on transition from driving, especially for car-dependent Drivers in both city and regional areas, have been put on hold for the time being, as has development of our regular joint forum with the ACT Government.

The Chapter will hold its Annual General Meeting by telephone or video link. All members and supporters will be contacted in advance.

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

South Australia (SA)

SA Chapter Committee Executive

The position of Deputy Chair has been taken up by Matthew Vertudaches (RAA). Matthew joins Jamie Mackenzie (Chair), Philip Blake (Secretary) and Jeffrey Dutschke (Treasurer).

Lunchtime Seminar 14 February 2020 - Latest CASR Road Safety Research: Distraction, cycling safety, alcohol and drugs, and more

An interested audience of over 60 attendees heard from six presenters at the latest SA Chapter lunchtime seminar. After A/Prof. Jeremy Woolley gave a brief introduction to CASR, Dr. Lisa Wunderbitz presented on in depth research in distraction in fatal and injury crashes. Dr. Matthew Baldock looked at the latest research in trends in alcohol and drugs in road crashes in SA after which Giulio Ponte gave an update on research on cyclist crashes in SA. Recent changes in SA driver licensing rates was the topic of Dr Trevor Bailey's presentation and finally Andrew van den Berg gave an update on CASR's laboratory capabilities including pedestrian crash testing and testing of advanced driving assistance systems.

People networked over pre-seminar wraps and sandwiches, and many continued afterwards asking questions of the speakers.

Thank you to the Department of Planning, Transport and Infrastructure for providing the venue.

The committee is exploring alternative ways to deliver road safety research and information to members and stakeholders during the current COVID-19 situation.

SA Chapter Chair and Secretary
Jamie MacKenzie and Phil Blake

Queensland (QLD)

SEMINAR 10th December 2019

Presented by Dr Judy Fleiter, Global Manager, Global Road Safety Partnership

SEMINAR TOPIC: Outline of the areas of work undertaken by the Global Road Safety Partnership in promoting road safety in low and middle income countries in Asia, Latin America and Africa

UPCOMING MEETING - Tuesday 2nd June 2020 AGM and Seminar.

Speaker to be confirmed. While originally planned for Department of Transport and Main Road, Mary Street, Brisbane @ 12pm, it is likely a virtual meeting will be held, subject to confirmation.

Further details and nomination forms will be available closer to the date.

QLD Chapter Chair
Dr Mark King

ACRS News

20+ Members Join (Advised) New Chair of Joint Select Committee in Road Safety + Federal Department at the 3rd Global Ministerial Conference on Road Safety in Stockholm 19-20 Feb 2020

The College is delighted to share that more than 20 ACRS members joined the delegation to Stockholm last week, for the 3rd High-Level Ministerial Conference on Road Safety. Representatives took part in plenary sessions, workshops and satellite events at this important global conference which attracted 1,700 international leaders in preparation for the next decade of work Towards Zero.

Background

The Third Global Ministerial Conference (Ministerial Conference) aimed to reach high-level consensus for continued global road safety targets and collaboration up to 2030. It was primarily targeted at national government ministers and their delegations. It was also be attended by policymakers, corporations, academics, and NGOs working in road safety.

What happened at the conference?

The purpose of the conference was to share successes and lessons from implementation of the Global Plan for the Decade of Action for Road Safety 2011–2020 (Decade of Action): chart future strategic directions for global road safety up to 2030 and beyond: and define ways to accelerate action on proven strategies to save lives.

Why is the conference important?

This is the final year of the Decade of Action. The Decade of Action has given road safety a strategic framework and built momentum in many countries, but the primary target, to reduce road deaths and injuries by 50% by 2020 has not been met and more time is needed to see it fully take effect. It is therefore key that governments commit to a new target for road safety at the Ministerial Conference and integrate this into their national strategies and policies. The conference looked at what has worked so far and what needs to be done, and aimed to get global agreement from national ministers to agree actions to make sure that the 50% target is achieved by 2030.

The Stockholm Declaration: https://www.roadsafetysweden.com/contentassets/b37f0951c837443eb9661668d5be439e/stockholm-declaration-english.pdf

Members of the Australian Delegation (above, l-r)

Mr Matthew Field - Chief of Staff for Mr Pat Conahan, **Dr Bruce Corben** - Independent Consultant, **Mr Mark Ellis** - Australian Department of Infrastructure, Transport, Regional Development and Communications, **Mr Craig Hoey** - Tasmanian Department of State Growth, **Dr David Logan** - Monash University, **Mr Pat Conaghan MP** - (Advised) Chair, Joint Select Committee into Road Safety, **Mr Martin Small** - President, ACRS, **Ms Gabby ONeill** - Manager, Australian Federal Office of Road Safety, **Dr Chika Sakashita** - ACRS Journal Managing Editor - Journal of Road Safety, **Professor Rebecca Ivers** - University of New South Wales, **Professor Jude Charlton** - Monash University Accident Research Centre, **Mr Eric Chalmers** - ACRS Vice-President, **Dr Julie Brown** - The George Institute, **A/Prof Jennie Oxley** - Monash University Accident Research Centre, **Ms Samantha Cockfield** - Transport Accident Commission, **Ms Claire Howe** - Chief Executive Officer, ACRS, **Mr Lauchlan McIntosh** - Immediate Past President, ACRS, & Chair, Towards Zero Foundation, **Ms Jessica Truong** - Towards Zero Foundation & GNCAP, **Ms Pip Spence** - Deputy Secretary, Australian Department of Infrastructure, Transport, Regional Development and Communications, **Mr Alan Hay** - Australian Road Research Board, **Mr Peter Frazer** - Safer Australian Roads And Highways (SARAH) Foundation, **Mr John Merrick** - Transport Accident Commission**.**

2019 AUSTRALASIAN ROAD SAFETY CONFERENCE

ARSC2019 Declaration

We, the participants of the 2019 Australasian Road Safety Conference in Adelaide 25-27 September 2019 declare that:

We are committed to the elimination of death and serious injury on the road.

We understand to achieve this vision we need to change the way we act in relation to all aspects of the design, management and use of the road traffic system.

While there are many successful safety programs across the system, their implementation has been variable and often disconnected. We recognise the need for a Safe System approach and commit to these underlying principles:

1. *Human beings are fallible and the road traffic system should evolve to minimise and accommodate human error*
2. *The human body is fragile, and needs to be protected from crash forces that may lead to death or serious injury*
3. *All organisations, communities and individuals who design, manage or use the road traffic system are ethically responsible for preventing road crashes, and ensuring that any crashes do not lead to fatal or serious injury*
4. *All parts of the road traffic system need to be strengthened so that if one part fails, another part will protect human life and health.*
5. *Safe mobility is the right of all road travellers, and the transport system should be designed for this.*

We know as professionals that it is possible to achieve significant and sustained improvements by applying these principles. We have a responsibility to act and influence others to take actions which support a harm elimination agenda.

We support the United Nations Sustainable Development Goals of halving road deaths and injuries and identifying road traffic injury as a major global development issue. We acknowledge and support the use of the Global Road Safety Performance Targets, agreed by UN Member States, as a minimum reporting level for all countries worldwide.

We call for the establishment in 2020 of specific interim national targets in all countries, with well-resourced baseline assessments, implementation plans and accountabilities in all countries to achieve a reduction in fatalities and serious injuries from road crashes by 50% by 2030.

THE GLOBAL GOALS For Sustainable Development

ACRS AUSTRALASIAN COLLEGE OF ROAD SAFETY

The Chairman's conclusions, called the "Stockholm Declaration", was presented by the Swedish Minister for Infrastructure, Mr. Tomas Eneroth, as the outcome document of the Third Global Ministerial Conference on Road Safety.

The global character of the road safety challenge calls for international cooperation and partnerships across many sectors of society. Given this, the Government of Sweden has worked to ensure broad stakeholder engagement around the Stockholm Declaration.

The Stockholm Declaration was prepared in close collaboration with the conference's steering group. The Declaration went through an extensive consultation with WHO Member States through their permanent representations in Geneva, and a transparent and inclusive public consultation open to everybody around the world.

Building on the Moscow Declaration of 2009 and the Brasilia Declaration of 2015, UN General Assembly and World Health Assembly resolutions, the Stockholm Declaration is ambitious and forward-looking and connects road safety to the implementation of the 2030 Agenda for Sustainable Development. The Stockholm Declaration also reflects the recommendations of the conference's Academic Expert Group and its independent and scientific assessments of progress made during the Decade of Action for Road Safety 2011-2020 and its proposals for a way forward.

Presentation of the ARSC2019 Conference Declaration from ACRS CEO Claire Howe to Etienne Krug of the World Health Organization

Many members will be aware of the ARSC2019 Conference Declaration which was signed by hundreds of conference delegates to symbolise our united support for the global goals outlined by the World Health Organization. ACRS CEO Claire Howe was delighted to present the ARSC2019 Declaration to Etienne Krug, Director of the World Health Organization at the conclusion of the first plenary session of the Stockholm Conference.

Our Road Safety Efforts in COVID-19 Times: An Update from ACRS CEO Claire Howe

Australasian College of Road Safety

At this unprecedented time when there is news and social media saturation around the COVID-19 pandemic, it's vital we take time to reflect on how this rapidly evolving situation is affecting us all - from our families and home lives through to our work lives and ultimately our united aim to combat road trauma. While the various national governments around the globe consider their own 'tipping points' in terms of Public Health outcomes vs Economy-wide protection, at an individual and organisational level we are all working to manage this unprecedented and unanticipated level of disruption in the best way we can.

The ACRS Administration Team - Working hard to support you

In terms of the College, I am very pleased that our administration team has undergone a relatively smooth transition to 100% working from home, to be able to continue to support you all in your valuable work in road safety. Over the last 9 months in particular we have focused our efforts on ensuring all financial and administrative systems are online and readily accessible and, provided we have access to reliable internet connections, we are well placed to connect virtually and continue our work from wherever we may be across the world.

Our administration team includes our Journal Managing Editor **Dr Chika Sakashita** in Washington DC, our Peer-Review Manager **Professor Raphael Grzebieta** in Melbourne, through to our conference team **Shanna Sheldrick** and **Amy Roberts** in Adelaide. In Canberra we also have a dedicated team working hard to support our response to this evolving situation - our Operations Manager **Anna Lang**, Finance Manager **Patrick Watts**, Administration Officer **Molly Stanly**, Consultant **Eric Chalmers**, our many suppliers and myself. I would like to take this opportunity to thank my entire administrative team for their ongoing commitment and dedication to ensure the continued smooth operation of the College on behalf of our many members.

The ACRS Governance Team - Leading our organisation

A cohesive environment is equally evident across the organisation's governing body, the College's **17-strong ACRS Executive Committee**, all of whom are dealing with this new reality in a similarly constructive and collaborative way. Our Executive Committee is communicating and meeting regularly to discuss the evolving situation and we look forward to keeping you abreast of outcomes.

Your Executive Committee is always available to be contacted, and consists of the following:

- Mr Martin Small | President | Martin Small Consulting Pty Ltd martin@martinsmallconsulting.com
- Mr Eric Chalmers | Co Vice-President and ACT Chapter Representative | Consultant chalmers@netspeed.com.au
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- Dr Mark King | Treasurer and QLD Chapter Representative | Centre for Accident Research & Road Safety - Qld (CARRS-Q) mark.king@qut.edu.au
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- Ms Melissa Weller | Committee Member | Australian Trucking Association Melissa.weller@truck.net.au
- Mr Lauchlan McIntosh AM | Immediate Past President | McIntosh Management Services lauchlan.mcintosh@bigpond.com

I am also fortunate to be able to rely on the expertise and advice of our **25-strong group of awarded ACRS Fellows**, many of whom continue their work around the globe in organisations ranging from the World Bank to the International Road Assessment Program and the Royal Australasian College of Surgeons. My heartfelt thanks go to these important members of the College community, our awarded ACRS Fellows:

2019 | Professor Michael Regan

2018 | Dr John Crozier & Associate Professor Jeremy Woolley

2017 | Ms Samantha Cockfield

2016 | Professor Ann Williamson

2015 | Mr Rob McInerney

2014 | Mr Iain Cameron

2013 | Professor Narelle Haworth

2012 | Ms Lori Mooren

2011 | Mr David Healy

2009 | Professor Barry Watson

2008 | Professor Mark Stevenson

2007 | Professor Raphael Grzebieta

2006 | Mr Lauchlan McIntosh

2004 | Dr Soames Job

2002 | Mr Ray Taylor

2001 | Mr Colin Grigg

2000 | Professor Mary Sheehan

1999 | Mr Ken Smith

1998 | Dr Jim McGrath

1997 | Dr Gordon Trinca

1996 | Mr Peter Makeham

1995 | Dr Michael Henderson

1994 | Mr Frank Green

1993 | Dr Brian Connor

1992 | Mr Harry Camkin

COVID-19 Current impact on Road Trauma & Road Safety efforts

Amidst the constant stream of COVID-19 updates, information about the effects of the pandemic, and associated government announcements and regulations, on road trauma rates/road safety efforts remains relatively scarce.

As a road safety community it's crucial that we have this space to openly discuss the impacts of COVID-19 on our sector. Some of the feedback to date has been around immediate impacts across our organisations in term of suspension of funding for projects and adverse effects on current road safety research projects.

This week for example we have seen announcements from Australian government stating the Joint Select Committee on Road Safety has suspended all activity, the New Zealand government stating ‘Work to cease on all non-essential state highway activities’ and from Roads Australia reporting more than a third of their surveyed industry members were affected in their capacity to deliver current projects, and by the creation of an environment of uncertainty about future project timing and funding.

We are also hearing of examples including:

- Academics and practitioners not being able to travel to complete existing projects;
- Research that requires face-to-face activity being put on hold;
- Observational data taken during this period potentially not being usable/comparable with existing data sets;
- Trucking sector impacted by significant increase in demand in conjunction with increased restrictions e.g. closure of rest stop facilities and lack of adequate access to medical practitioners;
- Jurisdictional agencies placing funding for future programs on hold, at this stage for the next few months. This effects workflow/funding through to practitioner and research agencies;
- Calls for reduced speeds on our roads in an effort to reduce trauma from crashes, freeing up hospital beds for COVID-19 patients;
- Stricter lockdowns are evolving and these are yet to be navigated.

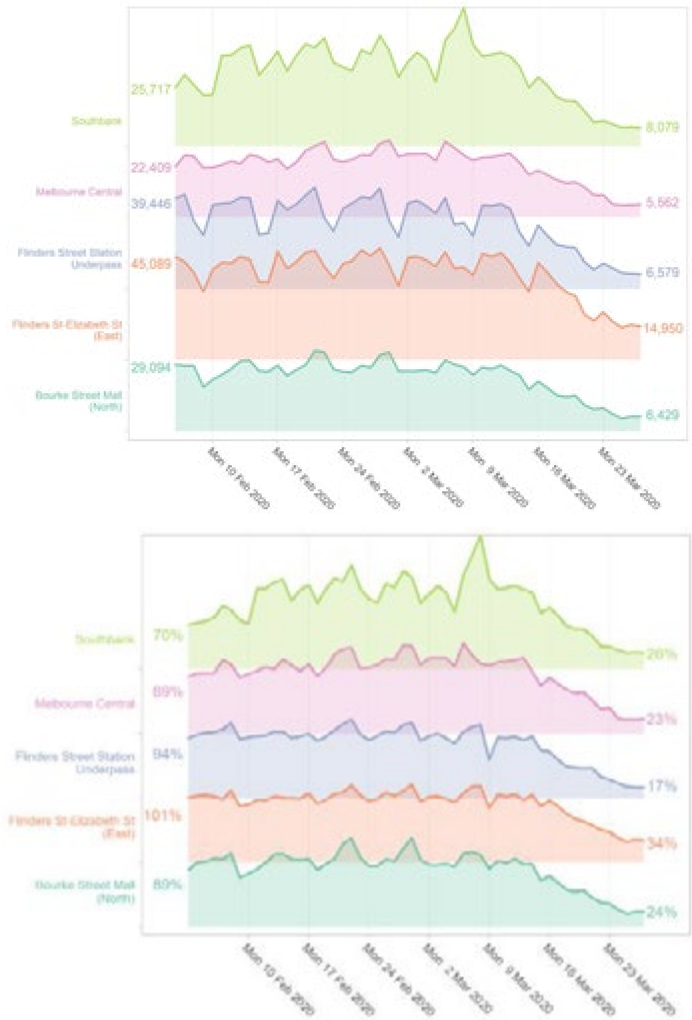
In terms of road trauma rates, the effects of COVID-19 are as yet unknown, apart from a limited number of articles circulating in the media such as ‘Seniors in some states won’t be required to undertake medical tests to renew their licence’, Emergency services left stretched after more than 20 crashes across Queensland less than 24 hours, ‘Calls to avoid drink-driving as surgeons report rise in trauma presentations’ and ‘Fears of blood shortages as donations drop during coronavirus’. In addition to this, ACRS member ARRB reports that ‘early data is having a significant effect on reducing traffic and pedestrian movement’. Whilst this currently does not correlate directly with any road trauma data, examples of the early exposure-related data from ARRB is below:

Following the implementation of COVID-19 restrictions, transport data collected by ARRB’s National Transport Performance Centre shows:

- *Significant drop-off in foot traffic of up to 83% in major Melbourne CBD areas as a result of COVID-19 restrictions;*
- *Major reduction in congestion on Melbourne’s Monash Freeway of between 88% and 95% for weekday peak periods;*
- *This reduction in congestion has been achieved off a much smaller reduction in traffic numbers – just 28% less vehicles using the Monash during this time, so slightly less vehicles has led to a significantly increased flow of traffic. This means that people are still getting around just much more efficiently;*
- *Heavy vehicle volumes on the Monash have stayed almost identical to pre-COVID-19 levels, so freight movements are similar to, or have slightly increased in the wake of the restrictions*

ARRB believes these impacts will be similar in most major capital cities of Australia following COVID-19.

We are also seeing articles in the media around the potential to lower speed limits in an effort to reduce road trauma and subsequently free up hospital beds for COVID-19 patients. These articles include ‘Speed limits: should they be lowered during coronavirus pandemic?’, and ‘WHO Must Push For Lower Speed Limits To Ease Pressure On Virus-Impacted Hospitals, Urge Experts’.



Figures 1 and 2. How pedestrian numbers are being affected at some key Melbourne landmarks with weekly comparisons before and after COID-19 restrictions.

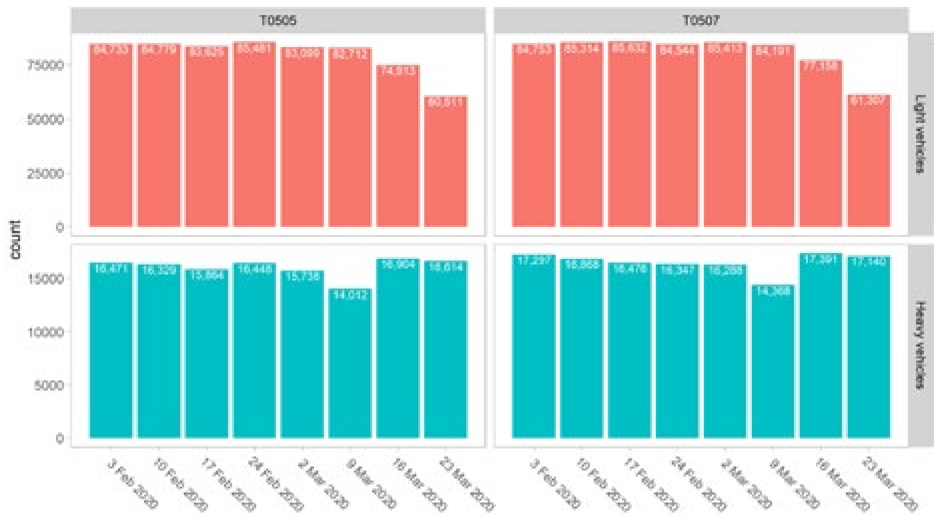


Figure 3. Actual counts of light vehicles and heavy vehicles on the Monash Freeway.

Sources: https://www.arrb.com.au/latest-research/data-sheds-new-light-on-covid-19-effects?utm_campaign=iNTRO&utm_source=hs_email&utm_medium=email&utm_content=85561287&_hsenc=p2ANqtz-8nqLbE-V0JF5vmFJT1iTCjQc2910i--j1Qll8rQCHV-rlGgDmxTBEE-b5UjS7WRhDnIp4eMAsJySEukHvuVclNzgylsA&_hsmi=85561287 &
https://cdn2.hubspot.net/hubfs/3003125/COVID%2019%20Transport%20MC%20V2.pdf

Diary

These events may change due to COVID-19 situation. Please check directly with the event website for latest updates.

5-7 May 2020
2nd United Nations Global Sustainable Transport Conference
https://sustainabledevelopment.un.org/transport2020
Beijing, China

12-14 May
Safer Roads 2020 Conference,
http://saferroads2020.atssa.com/
Virginia, USA

15-18 June
The 30th CARSP Conference and the 14th PRI World Congress
http://www.carsp.ca/carsp-conference/2020-joint-conference/
Montréal, Canada

25-27 August
7th ICTTP
https://icttp2020.se/
Gothenburg, Sweden

16-18 September 2020
Australasian Road Safety Conference 2020
www.australasianroadsafetyconference.com.au
Melbourne, Australia

27-29 September
International Alcohol Interlock Symposium
http://interlocksymposium.com/
Oslo, Norway

12-14 October
7th International DDI Conference
https://ddi2020.sciencesconf.org
Lyon, France

4-6 November
9th International Cycling Safety Conference
http://www.icsc-2020.net/app/netattm/attendee/page/92553
Lund, Sweden

Peer-reviewed papers

Original Road Safety Research

Police motorcycle crash casualty reports and their linkage with hospital trauma admissions in the Midland Region of New Zealand, 2012-2016

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Key Findings

- A total of 689 casualties, resulting from on-road motorcycle crashes in the Midland Region of New Zealand, were admitted to hospital as trauma patients during 2012-2016.
- Approximately 56% of trauma admission records could be linked with police records, while an additional 303 patient records could not be linked to any police records.
- Linkage rates were significantly associated with crash severity, patient injury severity, rurality of crash location, age, and self-presentation to hospital.
- Younger motorcycle crash patients, aged under 45 years, were significantly less likely to be linked across datasets, and appear to be under represented among police records.
- This may partly be explained by significantly higher rates of self-presentation to hospital by younger motorcycle casualties.
- A greater understanding of this behaviour may help guide prevention strategies aimed towards younger riders.

Abstract

Police records, held in the Crash Analysis System (CAS) by the New Zealand Transport Agency (NZTA), and hospital admission data held in the Midland Trauma System (MTS) trauma registry, were linked using probabilistic methods. A total of 1,331 casualties resulting from motorcycle crashes on roads in the Midland Region during 2012-2016 were recorded by police. During the same period, and occurring within the same geographical area, a total of 689 on-road motorcycle related crash casualties were admitted to hospital as trauma patients. Linkage of these two datasets revealed substantial under reporting to police of motorcycle crash casualties resulting in hospitalisation. Approximately 56% (386) of hospital trauma admission records could be linked with police CAS records with an additional 303 (44%) patient admission records which could not be linked to any police records. Linkage rates were significantly associated with crash severity as recorded by police, patient injury severity recorded in the trauma registry, patient age, rurality of crash location, and self-presentation to hospital. In particular, younger motorcyclists aged under 45 years were significantly more likely to self-present to hospital with the odds of linkage for self-presenters seventeen times lower than those who did not self-present. The merging of these two datasets has highlighted several sources of bias underlying reporting of motorcycle crashes to police. An understanding of these biases may help to inform policymakers when planning wider preventive strategies designed to reduce the burden of motorcycle crashes in New Zealand.

Keywords

Motorcycle, casualty, trauma, linkage

Introduction

Since the early 2000s there has been an increase in motorcycle deaths and injuries reported to police in New Zealand, an increase which has been comprised almost entirely of those aged over 40 years (Ministry of Transport, 2017). Motorcycle crash casualties have also been identified as an area of concern in the Midland Region of New Zealand, representing approximately 32% of all on-road transport related hospital trauma admissions in the region (Midland Trauma System, 2017). The aim of this study was to use data linkage between motorcycle crash records collected by police in the NZTA Crash Analysis System (CAS) and patient records in the MTS trauma registry to assess a. any under reporting of on road motorcycle crash casualties to police and b. assess the effect of age on linkage rates, and identify any other additional factors within the merged dataset which may affect linkage rates.

During the 1990s there was a marked drop in overall motorcycle deaths and injuries on roads recorded by police in New Zealand (Ministry of Transport, 2017). This drop was most pronounced amongst those aged between 15 to 29 years of age. However, during 2000 to 2010, motorcyclist deaths and injuries increased again and have since plateaued with almost all of this increase comprised of those aged over 40 years. Several data-linkage studies have previously shown that police traffic crash records frequently underestimate the number of road transport accidents which result in hospital admissions (Alsop, 2001; Noor Azreena Kamaluddin, Abd Rahman, & Várhelyi, 2018; Lujic, Finch, Boufous, Hayen, & Dunsmuir, 2008). This is particularly the case for motorcycle crashes which are significantly less likely to be reported to police compared with car crashes (Watson, Watson, & Vallmuur, 2015).

Previous linkage of hospital discharge and police traffic crash records in New Zealand has suggested that only 46% of motorcycle traffic crash hospital admissions during 2000 to 2004 could be linked to police records (Wilson, Begg, D.J., Samaranayaka, A., 2012). This low overall linkage rate was largely attributed to under-reporting of crashes to, or by, police. Furthermore, the degree of linkage was strongly influenced by injury severity with approximately 20% higher linkage rates for serious injuries compared to those with moderate injuries (Wilson, Begg, & Samaranayaka, 2012). However, the linkage study by Wilson et al. (2012) was performed at a time when motorcycle casualty records were at their lowest levels during the 1985 to 2016 period (Ministry of Transport, 2017).

The Midland Trauma System (MTS) trauma registry was established in 2010 to coordinate improvements in the quality of trauma care delivery within the Midland Region; comprising Bay of Plenty, Lakes, Tairāwhiti, Taranaki, and Waikato District Health Board catchments (Population 889,541)(MRTS, 2017). The Midland Region is the only region in New Zealand to collect data for both Major (Injury Severity Score, ISS > 12) and Non-major trauma (ISS < 13). Previous studies have relied on ICD10 diagnosis coding which does not readily allow for division into major and non-major trauma. The MTS registry also holds detailed data for trauma patients, such as self presentation, not available in datasets previously used for such linkage studies in New Zealand (Wilson et al., 2012).

In this study, we have applied linkage of trauma-specific registry admission data for motorcycle related injuries in the Midland Region during 2012-2016, together with police reports held within the NZ Transport Agency (NZTA) Crash Analysis System (CAS) database. A similar additional analysis within the CAS dataset will also be undertaken in the future. Given the increase in motorcycle injuries reported to police, and the new demographic underlying it, the linkage of trauma specific hospital admission registry data and police records is considered timely.

Methods

Police CAS and trauma registry datasets

A retrospective review of anonymised, prospectively-collected MTS registry data for the period from 1 January 2012 to 31 December 2016 was conducted to examine how age and other factors such as patient self-presentation and rurality of injury domicile may affect linkage rates. Inclusion criteria for the study were: patients admitted to a Midland base hospital as a result of, and within 7 days of a motorcycle or moped related injury occurring within the Midland region. Data for Tairāwhiti DHB was excluded as it was a more recent addition to the registry. Consistent with trauma registries internationally, patients were excluded if they sustained insufficiency or periprosthetic fractures, exertional injuries, hanging/drowning/asphyxiation without evidence of external force, poisoning, ingested foreign body, injury as a direct result of pre-existing medical conditions or late effects of injury, or the injury occurred more than 7 days prior to admission (Nwomeh, Lowell, Kable, Haley, & Ameh, 2006). Those who died at scene are not collected by the MTS registry. Event episodes (first admission) were the unit of analysis. Length of stay was inclusive of the total days admitted to all hospitals for the index event. Motorcycle riders and passengers who sustained non-fatal (at scene) injuries were identified by an external cause of injury code related to motorcycles and mopeds (ICD-10-AM eCodes V20-V29) and were restricted to those occurring on-road. An extensive review of all trauma registry injury memo descriptions was undertaken prior to the study to ensure that place of injury was correctly coded for the selection of on-road motorcycle crashes only. Variables examined included: patient demographic characteristics, injury event information, in-hospital management, type and severity of injuries, length of stay and rurality of injury and patient residence.

The Injury Severity Score (ISS) numerically describes the overall severity of injury, and is calculated from the three most severely injured body regions as scored by the AIS (Baker, O'Neill, Haddon, & Long, 1974). Non-Major trauma is classified as ISS < 13 and major trauma as ISS > 12 (Palmer, Gabbe, & Cameron, 2016). Ethnicity information was obtained from the patient's unique identifier (National

Health Index number [NHI]) or directly from the patients themselves. Mechanisms of injury were categorised using the International Classification of Disease (ICD-10AM 6th Edition) external cause codes (National Centre for Classification in Health., 2006).

Geographical location of injury and patient residence is recorded for all patients within the trauma registry at an NZ Census Area Unit (CAU) level. Statistics New Zealand classifications were used to classify CAU populations as urban (Main Urban, Satellite Urban, Independent Urban), semirural (Rural with moderate or high urban influence), and rural (Rural with low urban influence, Highly rural/ remote) (2013 NZ Census - normally resident population (Statistics New Zealand, 2014, Wellington).

The NZTA Crash Analysis System (CAS) is an integrated database system storing road crash and related data from throughout the whole of New Zealand. Data is collected directly at the scene of crashes by NZ Police attending road crashes using a standard Traffic Crash Report (TCR). The collected data is then coded and entered into CAS by NZTA for use in statistics reporting and research by a range of organisations. Both motorcycles and mopeds were included in both datasets as key vehicles. While crash collisions may involve one or more vehicles, and one or more persons, data are presented at an individual person level and identified as linked to the motorcycle party (including pillion) rather than a count of crash collisions. Injuries within the CAS system were recorded as Fatal - including death at scene or within thirty days and as a result of the crash, Serious – serious injuries, including broken bones, concussion, etc, or Minor – minor injuries, including cuts, sprains, bruises etc. Involvement of medical professionals, such as ambulance personnel, in the grading of patient injury severity at scene is not recorded within the police recorded dataset.

Linkage of datasets and Analysis

Data for both Police (CAS) records (includes injured, died, and non-injured persons) and Hospital-admitted (MTS registry) patients were matched temporally using incident (CAS) and injury (MTS) dates spanning from 1 January 2012 – 31 December 2016, and further matched spatially as occurring within the Midland Region encompassing the boundaries of the four DHBs, Bay of Plenty, Lakes,

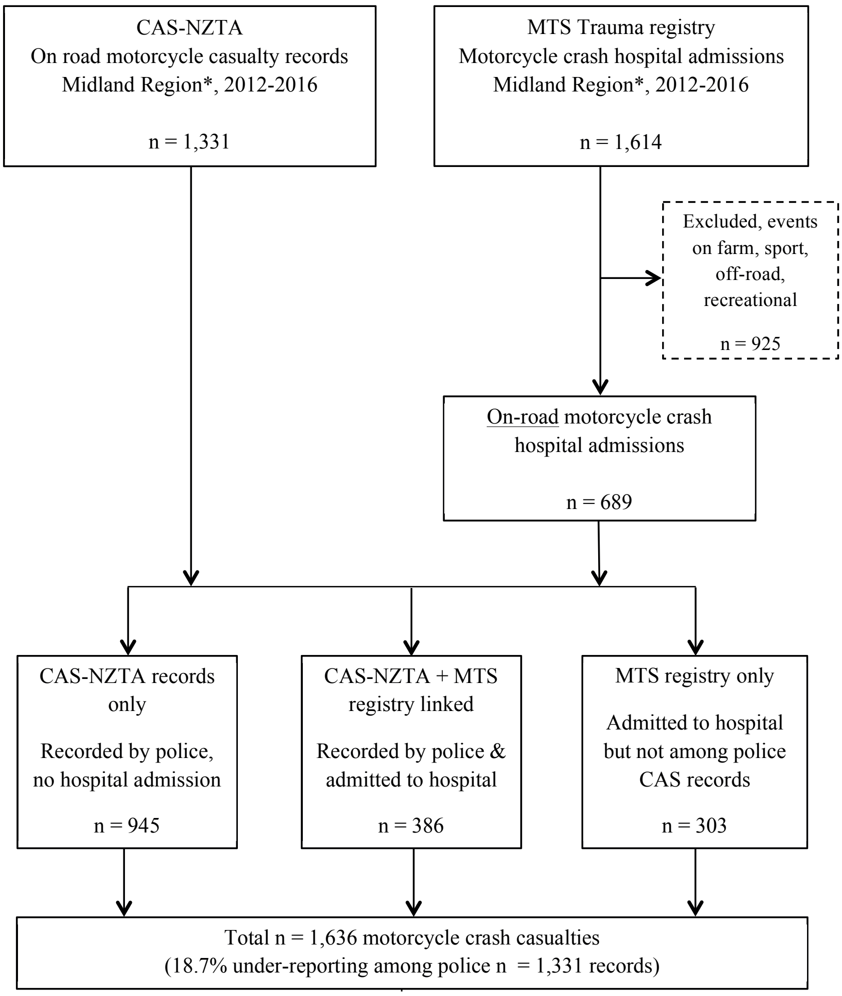

Figure 1. Flow diagram of data selection and linkage between police CAS and MTS trauma registry datasets. All data matched geographically and temporally: crash casualty (CAS) and injury (MTS) both occurring within Midland Region census area units (*Excluding Tairawhiti DHB) and occurring during 2012-2016.

Table 1. Linkage rates between police-CAS motorcycle crash casualty records and Midland Trauma System (MTS) hospital trauma admission records, Midland health region (Excluding Tairawhiti DHB) New Zealand (2012-2016) and Odds Ratio of record linkage across datasets as determined by logistic regression.

	Total (%)	Un-linked records (%)	Linked records (%)	Odds Ratio (CI) of linkage	P value
MTS Trauma					
Total	689 (100%)	303 (44.0%)	386 (56.0%)		
Injury severity					
Non-Major trauma (ISS*<13)	532 (100%)	258 (48.5%)	274 (51.5%)	Reference	
Major trauma (ISS>12)	157 (100%)	45 (28.7%)	112 (71.3%)	2.30 (1.56-3.44)	< 0.001

**ISS – Injury Severity Score*

Table 2. Concordance between police-CAS injury severity and MTS registry injury severity (Major versus Non-Major) for admitted patients linked between the two datasets, n = 386.

	MTS trauma severity		
Police CAS Crash injury severity	**Non-Major trauma (ISS*< 13)**	**Major trauma (ISS > 12)**	**Total**
Non-injury	-	-	-
Minor	79 (89.8%)	11 (12.2%)	90 (100%)
Serious	193 (68.7%)	88 (31.1%)	281 (100%)
Fatal	2 (13.3%)	13 (86.7%)	15 (100%)
Total	*274 (71.0%)*	*112 (29.0%)*	*386 (100%)*

**ISS – Injury Severity Score*

Taranaki, and Waikato. Tairāwhiti DHB was excluded from the study due to an incomplete data set. Data were matched using multiple fields including crash/injury date, crash/injury CAU, date of birth, and gender. Linkage rates were computed with hospital admitted patients as the primary group divided by the total number of police CAS person records (individual crash persons). All 689 hospital admission records were further checked manually at an individual record level. Microsoft Excel (Excel 2010) and R Statistical software were used for the analyses. The Chi square test was used to detect differences in proportions for non-normal distributions. P values were used to determine the result significance. Where significant differences in linkage rate were identified, the extent of concordance was assessed using multivariate logistic regression, with the response variable being ‘linked’ or ‘not linked’ and predictor variables being the factor categories and reference categories selected as high volume or representative of a baseline. Ethical approval was not required for this study as the analyses involved the use of anonymised secondary data. The study adhered to the MTS Data Use Policy and access to the trauma registry data was approved by the MTS Strategic Group.

Results

Figure 1 shows a flowchart of the linkage process. During 2012-2016, a total of 1,331 motorcycle casualties occurring on roads within the Midland Region (excluding Tairāwhiti DHB) were reported to police and recorded in the Crash Analysis System (CAS) held by the New Zealand Transport Agency (NZTA). Of these, 774 were classified by police as minor crashes, 433 serious crashes, 74 fatal crashes, and 50 as non-injury crashes. During the same period, and occurring within the same geographical area, the Midland Trauma System trauma registry recorded 1,614 motorcycle-related patient admissions. Of these, 689 occurred on-road, with the remaining 925 occurring on farm, during sport, or in the countryside being excluded from data linkage. A total of 386 records were linked between the two datasets equating to 29% of police recorded CAS records, and 56% of trauma hospital admitted patient records. There were 947 records in the police CAS dataset only, and an additional 303 records in the MTS trauma registry dataset only (Figure 1).

Table 1 shows a comparison of linkage rates according to police CAS crash severity classification and MTS trauma injury severity (Major trauma - ISS > 12, and non-major trauma - ISS < 13) for the 386 patients linked between the two datasets.

A higher rate of linkage (71%, 112/157) was seen among major trauma (ISS>12) patients compared with 52% (275/532) linkage among non-major (ISS < 13) admitted patients. Major trauma patients were 2.3 times more likely to be linked to police records compared to Non-Major trauma patients; however, a total of 45 major trauma patients could not be linked to police records (Table 1).

Table 3. Demographic characteristics of 689 motorcycle-related trauma patient hospital admissions in the Midland Region (Excl. Tairāwhiti DHB), 2012-2016, by linkage with police-CAS records and Odds Ratio of record linkage determined by logistic regression.

	Total admitted	MTS registry only, n (%)	Police-CAS/ MTS linked, n (%)	Odds Ratio (CI) of linkage	P value
Total	689	303 (44%)	386 (56%)		
Gender					
Female	96	41 (43%)	55 (57%)	Reference	
Male	593	262 (44%)	331 (56%)	0.94 (0.61-1.46)	0.83
Ethnicity*					
European	489	201 (41%)	288 (59%)	Reference	
Māori	177	92 (52%)	85 (48%)	0.64 (0.46-0.91)	0.013
Other/PI	21	9 (43%)	12 (57%)	0.93 (0.38-2.24)	1.00
Not stated	2	1 (50%)	1 (50%)		
Age (Years)					
0-14	20	16 (80%)	4 (20%)	0.17 (0.05-0.55)	< 0.002
15-19	61	36 (59%)	25 (41%)	0.49 (0.27-0.89)	0.02
20-24	84	35 (42%)	49 (58%)	0.98 (0.58-1.69)	1.0
25-34	122	63 (52%)	59 (48%)	0.66 (0.41-1.06)	0.09
35-44	109	45 (41%)	64 (59%)	1.00 (0.61-1.65)	1.0
45-54	157	65 (41%)	92 (59%)	Reference	
55-64	99	32 (32%)	67 (68%)	1.48 (087-2.5)	0.15
65+	37	11 (30%)	26 (70%)	1.67 (0.77-3.62)	0.3
Place of Injury					
Urban	316	134 (42%)	182 (58%)	Reference	
Semi-Rural	123	47 (38%)	76 (62%)	1.19 (0.78-1.83)	0.43
Rural	250	122 (49%)	128 (51%)	0.74 (0.51-1.07)	0.11
Patient domicile.**					
Urban	304	133 (44%)	171 (56%)	Reference	
Semi-Rural	125	53 (42%)	72 (58%)	1.06 (0.69-1.61)	0.80
Rural	172	86 (50%)	86 (50%)	0.77 (0.55-1.07)	0.19
Self-presenting***					
No	534	171 (32%)	363 (68%)	Reference	
Yes	145	129 (89%)	16 (11%)	0.06 (0.03-0.10)	< 0.001
Pillion passenger					
All	26	18 (69.3%)	8 (30.7%)	n/a	
Female	20	14 (70.0%)	6 (30.0%)		
Male	6	4 (66.6%)	2 (33.3%)		

*Where ethnicity and employment status was 'not stated', data were excluded from statistical tests. **Excludes 88 undetermined,***excludes 10 unknown.

Table 2 presents concordance rates between police recorded crash severity and patient trauma severity among the 386 linked records. There was a statistically significant association between record linkage and minor, serious, and fatal crash classification made by police ($\chi^2 = 328$, $P < 0.001$). Highest linkage rates were found among crashes classified by police as serious (59%, 281/473) with odds of record linkage 11 times higher than those classified by police as minor. At least 90 persons classified as being in a minor crash by police were still admitted to hospital. Similarly, there was a significant association between record linkage and trauma injury severity ($\chi^2 = 19$, $P < 0.001$). Highest concordance was found between crash casualties classified as minor by police and admitted to hospital as non-major patients (n = 79). 31% of casualties classified by police as serious were admitted as major trauma patients,

Table 4. Motorcycle injured trauma patients admitted (Midland Region, excluding Tairāwhiti DHB, 2012-2016), linkage rates by age under 45 years and older: patient demographic factors, place of injury, and self-presentation to hospital (ISS – Injury Severity Score)

	Age < 45 Years				Age ≥ 45 Years		
	MTS Registry (N)	Linked (%)	*P* value		MTS Registry (N)	Linked (%)	*P* value
Overall	396	51			293	63	
Injury severity			0.07				< 0.001
Non-Major (ISS<13)	326	48			206	56	
Major (ISS>12)	70	61			87	79	
Gender			0.27				0.37
Female	58	61			38	55	
Male	338	48			255	64	
Ethnicity*			< 0.02				0.89
European	258	56			230	63	
Māori	118	39			58	66	
Other/PI	18	56			5	66	
Place of injury			0.78				0.71
Urban	126	59			125	38	
Semi-Rural	66	58			56	68	
Rural	204	55			112	63	
Patient domicile**			0.21				0.96
Urban	109	43			63	62	
Semi-Rural	70	53			55	70	
Rural	178	53			124	61	
Self-presenting			< 0.001				< 0.001
No	293	64			242	73	
Yes	103	10			41	12	
Unknown	9	57			1	0	

*Exclude 2 cases ethnicity not stated, **Excludes cases where domicile unknown, P value from Chi-square test for independence (test of whether linkage is independent between categories of the variables.

and a further 11 patients admitted to hospital as major trauma cases had been in a crash classified by police as being minor.

Table 3 shows a comparison of admitted patient factors and demographics for CAS linked and non-linked patient records and odd ratios of linkage as determined by logistic regression. 86% (593/689) of all hospital admissions were male while the proportion of linked versus unlinked records was very similar between males and females (Table 3).

There was a significant association between ethnicity and linkage with significantly lower odds ratio of linkage noted among Māori compared to Europeans, as well as a significant association between age and linkage rates. Odds of linkage increased significantly with age, with a steeper increase in odds of linkage occurring among those aged 55 years and older. Hospital admission records for patients who were injured in a rural location were less likely (OR 0.74) to be linked with police CAS records compared to those injured in an urban area although this was not statistically significant. There were no significant variations in odds of linkage rates by rurality of patient domicile. Linkage rates varied significantly with patient self-presentation to hospital, patients who self-presented were almost 95 percent less likely to be linked to police CAS records (Table 3).

At least 26 admitted patients were pillion passengers, 69% (18/26) of these hospital records could not be linked with police records. A majority of pillion passengers were female (77%, 20/26), and constituted 78% of all pillion passenger patients who could not be linked with police records.

Table 4 shows a comparison of patient factors for those aged 0-44 years or 45 years and over. Significant relationships were found between ethnicity, rurality of place of injury, and self-presentation to hospital emergency department for those aged under 45 years.. Almost two-thirds of patient records which could not be linked to police CAS records involved patients aged under 45 years. Furthermore, only

Table 5. Motorcycle injured trauma patients admitted (Midland Region, excluding Tairawhiti DHB, 2012-2016), linkage rates by self-presentation to hospital: patient demographic factors, place of injury, and patient domicile rurality (ISS – Injury Severity Score).

	Non self-presenting				Self-presenting		
	MTS Registry (N)	Linked (%)	*P* value		MTS Registry (N)	Linked (%)	*P* value
Overall*	535	68			144	11	
Injury severity			0.11				1.00
Non-Major (ISS<13)	383	66			139	12	
Major (ISS>12)	152	74			5	0	
Gender			0.94				0.06
Female	73	67			21	24	
Male	462	68			123	9	
Age			0.02				1.00
0-44	293	64			94	11	
45+	242	75			50	12	
Ethnicity**			0.39				0.19
European	389	69			93	15	
Māori	129	64			45	5	
Other/PI	16	75			5	0	
Place of injury			0.01				0.36
Urban	229	74			83	11	
Semi-Rural	106	69			14	21	
Rural	200	60			47	9	
Patient domicile***			0.07				0.93
Urban	222	72			74	9	
Semi-Rural	101	70			24	8	
Rural	134	60			36	11	

*Excludes 10 cases means of presentation unknown, **Excludes cases where domicile unknown, P value from Chi-square test for independence (test of whether linkage is independent between categories of the variables.

fifty one percent of these younger motorcyclists could be linked across both datasets. For patients aged over 45 years, significant relationships were found for linkage rates with severity and with self-presentation. Gender did not appear to be related to age group while patients identifying as Māori or other/Pacific Islander had a significantly lower representation among those 45 years of age, suggesting a bias towards European representation among those aged over 45 years. No effect of rurality of patient domicile was found between the two age groups.

In both age groups, there was a very strong relationship between self-presenting behaviour and linkage rates. However, older patients aged over 45 years were less likely to self-present to hospital compared to those aged under 45 years, almost twice as many under 45 year olds self-presented compared to those aged over 45 years (Table 4).

Approximately 21% (144/689) of all hospital admissions were patients known to have self-presented to hospital. Approximately 89 percent ((129/144) of all self-presenting patient records could not be linked to police CAS records. Table 5 shows a comparison of linkage rates for patients who either self-presented to hospital or did not by injury severity, various demographic factors and injury circumstances. Linkage rates were associated with rurality of injury location for those patients who did not self-present. Lowest linkage rates for those who did not self-present had been injured in a rural location. Notably, at least five patients who self-presented were major trauma patients who could not be linked to police CAS records. For patients who did self-present to hospital, there were no apparent associations with any variable considered in our study.

While gender was not found to be a significant factor in self-presentation, 21 self-presenting patients were female, and approximately two thirds (14/21) of these self-presenting females had been pillion passengers..

Discussion

This study has shown that in the Midland Region of New Zealand, police records continue to underestimate motorcycle crash casualties resulting in hospital admission. Approximately 56% of admitted patient records within the MTS trauma registry could be linked with police CAS records for on-road motorcycle crash casualties in the Midland Region (2012-2016). This is higher than the 46% linkage rate previously found between NZ Ministry of Transport Traffic Crash Reports (TCRs) and NZ NMDS (National Minimum Dataset) hospital discharge records for on-road motorcycle crash casualties during 2000-2004 (Wilson et al., 2012).

A number of reasons may contribute to this difference in linkage rates. The MTS trauma registry holds detailed information regarding the circumstances of injuries, including injury descriptions provided directly by patients. This may allow more accurate ICD-10 coding and identification of patients with motorcycle related injuries than the more generalized hospital discharge records which contribute to the NMDS discharge dataset. Furthermore, the linkage study reported by Wilson et al. (2012) covered a period of time (2000-2004) when motorcycle crash casualties reported to police were at their lowest levels during the period 1985 to 2016 (Ministry of Transport, 2017). Such differences aside, the present study again confirms substantial under reporting of motorcycle crash casualties to police.

Previous studies have shown the increase in motorcycle crash casualties reported to police since the early 2000s was almost entirely among those aged over 40 years. Our study suggested a significantly higher probability of data linkage for older motorcyclists aged over 45 years. The general pattern of higher linkage rates with increasing age found in this study also agrees well with that previously reported for motorcycle casualties (Wilson et al., 2012). The combination of higher numbers of older motorcycle casualties, together with higher odds of linkage among older riders, may thus contribute to the higher linkage rate seen in this study compared to that seen during 2000-2004 (Wilson et al., 2012).

An association between injury severity and linkage rates has previously been noted in other studies and may reflect a higher rate of attendance by police at more serious crashes, as well as more often involving another vehicle increasing the likelihood of reporting (Kamaluddin, Abd Rahman, & Varhelyi, 2018; Watson et al., 2015; Wilson et al., 2012). In the current study, older riders aged incurring major trauma, had significantly higher linkage rates with police CAS records. The current study might therefore suggest a more complex interrelationship involving age, severity, and odds of data linkage, which may partly be related to circumstances of patient presentation to hospital, specifically self-presentation to hospital. The observation of eleven patients recorded as minor injuries in the police records, but recorded as major trauma in the hospital record is concerning. This may suggest a need for further training of police in injury severity assessment at scene. Similarly, the extent of medical professional involvement in such assessments at scene are currently not recorded, thus making any biases in linkage across regions or demography difficult to understand.

Patients are recorded in the MTS trauma registry as “self-presenting” if the patient arrived at the emergency department of their first presenting hospital without prior assistance from emergency services. A novel finding of this study was the significant number (21%, 144/689) of motorcycle related hospital admissions who had self-presented to hospital. Furthermore, and perhaps unsurprisingly, the odds of linkage with police CAS records for such self-presenting patient records are significantly lower. Linkage rates were almost 95% lower for patients who self-presented than for those who did not self-present across all demographic factors we examined. At least 129 (42.6%) of the 303 MTS trauma registry only patients had self-presented to hospital compared with only 16 (4.1%) self-presenting admissions linked with police CAS records.

There were twice as many patients who self-presented in the under 45 year old age group compared to those age 45 years and older. Significantly higher self-presentation rates by younger riders, and the high proportion of such self-presenting patients having non-major trauma (96.5%, 139/144 self-presenting patients), has a marked effect on linkage rates. In particular, motorcycle injury among younger riders appears to be under reported in police CAS statistics and the contribution of such self-presenting behaviour requires further study.

We also found that older motorcyclists who did not self-present were significantly more likely to be linked to police records. The effect of severity, and significantly greater linkage rates among older riders with major trauma among those who did not self-present warrants further study. Of concern was the observation that at least five of those patients who self-presented were admitted as major trauma patients, and of which none could be linked to police CAS records. In addition, several hospital admissions not linked to police CAS records were pillion passengers, particularly females, suggesting that police records fail to capture the full extent of motorcycle injuries, partly by under-recording of pillion passenger casualties.

In the present study, the linkage rates between police and hospital datasets was also associated with the rurality of injury location. Our finding of lower linkage amongst those injured in a rural location agrees with a similar study in Australia which found lower linkage rates for road crash casualties occurring in rural and remote locations (Watson et al., 2015). Although the Australian study included other road users such as cars and cyclists, the authors and those of other studies have suggested that this may be due to under-reporting to police in rural locations (Boufous, 2003; Langley, Stephenson & Cryer, 2003; Watson et al., 2015).

Almost two thirds of hospital admissions involving patients who were injured in an urban location were younger motorcyclists. The nature of motorcycling activity and crash rurality in these two age groups, and whether older riders are more commonly injured in rural areas during recreational riding, while younger riders, often injured in urban areas, may be more work or commute related, requires further study. It is also possible that the significantly lower linkage rates of self-presentation among those injured in rural and semi-rural areas is linked to either the greater proportion of riders injured rurally tending to be older riders and who are overall less likely to self-present, or crash and injury severity may be higher on open roads in rural areas. Similarly, greater rates of self-presentation for those injured in urban areas may simply be a function of proximity to major hospitals, or linked to the lower average age of motorcycle riders injured in such urban areas.

Some limitations of this study include the fact that that not all road crash casualties may be reported to police, motorcycle casualties who attended an emergency department but were not admitted for more than 24 hrs, or died at scene, are not captured in the trauma registry, and our study does not include motorcycle crash casualties who may have been treated in primary care. A further potential concern is the quality of data linkage, however, the availability of multiple linkage fields and our extensive manual checks provide us with confidence that any such effects are likely to be very minimal. Despite these limitations, this study has uncovered new insights concerning the wider extent of motorcycle injuries resulting in hospital admission and factors underlying variations in linkage with police records. In particular, age, rurality of injury, and self-presentation to hospital appear to be inter-related, an understanding of which is valuable given recent shifts in motorcycle crash demographics reported to police.

Conclusions

Across all motorcycle-related hospital admissions in the Midland Region, only 56% of records could be linked with reports collected by police. Significantly higher linkage rates were found for patients involved in crashes classified as serious by police, patients admitted with major trauma, patients aged over 45 years. Significantly lower linkage rates were found for those patients who were injured in a rural or semi-rural area, or who self-presented to hospital. Pillion passengers who were admitted to hospital, especially females, were also found to be under reported among police CAS records. Approximately 21% of all motorcycle-related hospital trauma admissions were self-presenting patients, arriving at their first presenting hospital without prior assistance from emergency services. Younger motorcycle crash casualties, under 45 years of age, were significantly more likely to self-present than older motorcyclists. Across all ages, only approximately 11% of self-presenting patients could be linked to police CAS records. This combination of factors may help to explain the overall higher linkage rates for older riders over 45 years. The merging of hospital admission and police records provides a greater understanding of the wider extent of motorcycle crash casualties and where biases may exist in reporting to police. In particular, the high rate of self-presentation to hospital by younger motorcycle riders warrants further study. Such wider studies should include such factors as insurance, work related motorcycling activity, alcohol or drug status, and any other behavioural risk factors.

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Considerations for the development of a driver distraction safety rating system for new vehicles

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Key Findings

- There is evidence that some vehicle cockpits are more demanding of drivers' attention, and have a higher potential to distract drivers, than others.
- It is predicted that a vehicle distraction safety rating system, when applied to the assessment of in-vehicle technologies other than mobile phones, has the potential to prevent three percent of all reported crashes.
- Three assessment methods are identified as being most suitable for incorporation into a vehicle distraction rating system: the Detection Response Task (DRT), the Visual Occlusion Test (VOT) and a Human-Machine Interface (HMI) design assessment checklist.
- A voluntary scheme to encourage vehicle manufacturers to produce less distracting in-vehicle technologies is the most feasible approach for introducing a distraction safety rating system in the short-term, with a longer-term vision of incorporating the test methods into established consumer rating systems such as New Car Assessment Programs (NCAPs).

Abstract

Drivers engage in a wide range of non-driving related tasks while driving that have potential to distract to them and compromise their safety. These include interactions with infotainment systems built into the vehicle by vehicle manufacturers. These systems enable the performance of communication, entertainment, navigation and internet browsing tasks. Performing these tasks can degrade driving performance and increase crash risk. Not all infotainment technologies in new vehicles are equal in terms of their potential to distract. This paper documents the findings of a study commissioned by the Victorian Department of Transport to determine the feasibility of developing a test protocol for rating the distraction potential of new vehicles entering the Australian market. A literature review, consultation with expert international researchers and industry representatives, and workshops, were conducted in order to determine those elements of the HMI design of infotainment systems that should be assessed, identify suitable candidate test methods for assessing the visual and cognitive load imposed on drivers when performing infotainment tasks, and derive options for a distraction rating system. In addition, safety/rating assessment program reviews and a cost-benefit analysis of introducing a distraction rating system were undertaken. Eight potential distraction test methods were discerned from the literature and consultation. It was concluded that the most suitable test protocol for a distraction rating system involves the use of an HMI design checklist in combination with measurement of the visual and cognitive load imposed on drivers when performing specific infotainment tasks, using the VOT and DRT, respectively. Eight options for introducing a distraction safety rating as a consumer or NCAP distraction rating are presented. Each option builds upon the previous, with the first option being the development of voluntary guidelines (where vehicle manufacturers work to these guidelines on a voluntary basis) to option eight, where NCAPs incorporate a distraction rating in the overall vehicle safety rating. The benefits of introducing a highly effective (best case) distraction rating system are estimated to result in a road crash saving of approximately AU$28 per 'improved/low distraction' vehicle per year.

Keywords

Driver distraction, workload, in-vehicle infotainment systems, rating, human factors, New Car Assessment Program (NCAP)

Glossary

Detection Response Task (DRT) – the DRT provides a measure of the level of cognitive load of a secondary task while driving, and an international standard has been developed by the ISO (International Organisation for Standardisation) for the standardisation of its use (ISO 17488).

Driving Activity Load Index (DALI) – is a tool for subjective evaluation of mental workload via self-report, purpose-developed for the driving context.

Human-machine interface (HMI) – a component of certain devices (in the vehicle; e.g. touch screens, buttons, dials) capable of handling human-machine interactions. The interface consists of hardware and software that allow driver inputs/tasks to be translated as signals for machines that, in turn, provide the required information and control to the driver.

Lane Change Test (LCT) – the LCT is a surrogate driving task for use in simulated driving studies that has been standardised (ISO 26022:2010).

NASA Task Load Index (NASA-TLX) – is a self-reported measure of workload divided into six subscales that measure mental demand, physical demand, temporal demand, performance, effort and frustration.

New Car Assessment Program (NCAP) – NCAP is a vehicle safety rating system that allows consumers to understand the safety level of vehicles based on crash tests and other safety assessments (with some NCAPs a star rating of zero to five is awarded to each vehicle, with five being the safest and zero the least safe). There are currently NCAPs in the USA, Europe, Asia and Latin America. The Australasian New Car Assessment Program (ANCAP) is an independent organisation with members from Australian and New Zealand.

Overall Workload Level (OWL) scale – is a self-report measure of workload gauged on a unidimensional scale from 0 (very low workload) to 100 (very high workload).

Secondary task – a non-driving-related task e.g., making phone calls, selecting music, using social media (e.g. via touching a visual display unit/infotainment system or using voice commands).

Visual Occlusion Test (VOT) – the VOT has been adapted to estimate the visual demand of a secondary activity. An international standard has been developed by ISO for the standardisation of its use (ISO 16673).

Introduction

Driver distraction is a significant road safety issue. Research suggests that it is a contributing factor in 16 percent of Australian crashes where a vehicle occupant is hospitalised (Beanland et al., 2013). Driver distraction is commonly defined as "...the diversion of attention away from activities critical for safe driving toward a competing activity, which may result in insufficient or no attention to activities critical for safe driving" (Regan, Hallett, & Gordon, 2011, p. 1776). Competing activities, according to this definition, can be driving or non-driving related. Drivers in Australia engage in a wide range of non-driving (secondary task) activities (Young et al., 2019). These include interactions with infotainment systems provided by vehicle manufacturers that allow for driver engagement in a wide range of communication, entertainment, navigation and internet browsing tasks. These interactions occur through a variety of technologies (e.g., screens built into dashboards, phone integration, head-up displays) controlled through touch, voice, gesture control and so on.

Performing infotainment tasks may distract drivers, resulting in delayed reaction times, poor lane keeping, increased eyes-off-road time and increased crash risk (Cunningham, Regan & Imberger, 2017).

Not all infotainment and other technologies, such as Advanced Driver Assistance Systems (ADAS) in new vehicles brought into Australia, are equal in terms of their potential to distract. The same technologies are often designed and implemented in very different ways across manufacturers. Research shows some vehicle cockpits are more demanding of drivers' attention, and therefore have higher potential for distraction, than others (Strayer et al., 2015; Strayer et al., 2017). Drivers often believe that if the HMI technology in the vehicle is provided, it has been deemed safe; however, this may not be so (Parnell et al., 2018).

Currently, there is no universally adopted method for assessing and rating, for any given vehicle, the level of distraction that may be created by driver interaction with in-vehicle infotainment systems. However, Strayer and colleagues from the University of Utah (2015; 2017) have developed a test protocol that is now being used to assess, rate and compare the distractibility of in-vehicle HMI interactions implemented in new vehicles. Methods investigated by Strayer et al. (2015; 2017) for inclusion in their test protocol assessing have included physiological measures (e.g. heart rate variability, eye movement/glances, brain waves (EEG)), self-report measures, such as the DALI and OWL, an HMI design check list and a measure of cognitive workload (the DRT).

Most new cars sold in Australia are tested under ANCAP, which now aligns with European NCAP safety protocols. The NCAP rating system has been highly successful in encouraging vehicle manufacturers to compete to produce safer vehicles (Paine & Regan, 2018). Incorporating into European NCAP or a similar rating program a distraction rating method, like that developed by the University of Utah, could be expected to encourage vehicle manufacturers to improve HMI design and produce less distracting vehicles. Incorporation of a distracting rating method in NCAP would also provide information to consumers regarding the distractibility of the in-vehicle infotainment system (or other systems, such as ADAS, if tested) in tested vehicles. At present no new vehicles are rated for their potential to distract drivers as part of any local or international NCAP programs.

The overall aim of this project was to determine the feasibility of developing an HMI distraction rating system, including its potential incorporation within Euro NCAP or another consumer information service. This research project involved extensive engagement and consultation with local and international stakeholders involved in NCAPs, driver distraction and road safety experts, as well as experts from the vehicle industry.

The study examined (a) how a safety rating system could be developed for assessing the level of distraction from in-vehicle technologies, and (b) how to develop and design a test protocol for rating the distraction potential of new vehicles in the Australian market. An in-vehicle HMI distraction rating system can support consumers to make safer purchasing choices, influence safer HMI design (for new vehicles, including Autonomous Vehicles [AVs]), and, possibly, development of future NCAP rating protocols. Options for introducing a consumer distraction rating system, and one suitable for incorporation into NCAP testing protocols, were also developed.

The exploratory study described in remaining sections of this paper was a first step in determining how to develop a distraction safety rating system and in determining how to implement it into new vehicles coming to market. Additional research, described later in the paper, will be required to further develop and refine a distraction safety rating system. The key outcomes of the study are reported here. More details of the methods, analyses and assumptions involved in deriving these outcomes can be found in the original reports documenting the outcomes of this research program (see Cunningham et al., 2017; Cunningham et al., 2018 a,b; Cunningham et al., 2018; Paine & Regan, 2018; Regan et al., 2018 and VicRoads, 2018).

Methods

The project had two components. Component One involved a major review of Human Factors and HMI guidelines, test methods, scoring criteria and other literature applicable to development of a Human Factors and Ergonomics star rating system - all with a focus on distraction from in-vehicle technologies. This enabled draft criteria to be identified for assessing safe Human Factors/ Ergonomics design, as well as test methods for assessing and rating the vehicle HMI against these criteria (Regan, Cunningham, & Paine, 2018).

Component Two involved the development of options outlining how a distraction rating system may be incorporated into existing vehicle safety ratings systems such as Euro NCAP; or how it could operate under an alternative regime. This component aimed to identify the most effective and feasible approach for introducing a distraction rating system and for estimating the potential crash savings from its implementation (Regan, Cunningham, & Paine, 2018).

Component One involved five main research tasks and associated sub-tasks. The tasks involved literature reviews, stakeholder consultations and use of the expertise held by the project team. The five main research tasks were as follows:

1. A review of the topics listed below. This involved a literature review, using transport and safety-related library search databases, google searches for grey literature, an ancestry approach, whereby the literature found was used to find further literature, and teleconferences and workshops with experts (more detail below) (Cunningham et al., 2017; Cunningham et al., 2018 a,b; Cunningham et al., 2018; Paine & Regan, 2018 and Regan et al., 2018):
    a. Types of distraction (visual, cognitive or bimanual interference [hands/feet off vehicle controls] caused by in-vehicle technologies and various interactions (e.g. touch screen, voice activation etc.), the driving performance decrements they cause and crash risks (if available) and links to poor or good HMI design, and any research gaps for developing an HMI distraction rating system. This information was distilled to create a distraction taxonomy that linked these items of information.
    b. Design and HMI components that enhance driver ease of use and safety that included solutions that mitigate distraction such as vehicle lock outs and workload managers.
    c. HMI guidelines and relevant best-practice Human Factors and Ergonomics principles (e.g. are HMI controls and their operation consistent with driver expectations, is information easily understood, are operational tasks remembered easily, etc.) and how they can be applied to an HMI distraction rating system.
    d. Criteria for assessing distracting activities and interactions with in-vehicle technologies, which included review of various HMI guidelines documents, e.g. those from the Japanese Automotive Manufacturer's Association, the Transport Research Laboratory (TRL) etc.
    e. Test methods used to assess distracting activities and interactions with in-vehicle technologies that included known ISO standards (e.g. for administering the DRT) and measures used to assess secondary task performance such as lane departure, reaction time etc.
    f. Any other issues and research gaps applicable to developing an HMI distraction rating system.
2. An assessment of HMI design attributes that should be rated and their basis (i.e. on a scale of one to five). The following issues were considered:
    a. how the attribute ratings (i.e. different functions/ technologies) should include the types of interaction used, e.g. making a phone call may occur via the use of dials, the touch screen and/or via voice command, resulting in three different ratings
    b. how different technologies may require different rating levels compared with others and how all ratings for a vehicle can be combined (i.e. into one score)

   c. rating technologies with more than one type of interaction, e.g. if voice commands were the safest to activate navigation, but other interactions were permitted, what is the final rating?
   d. quantifiable and reliable ratings.

5. Review of test methods for the HMI distraction rating system with an indication of their reliability and validity, and any barriers, risks and costs associated with use of them. Candidate test methods were rated against these criteria by the project advisory committee experts (see below).
6. Development of a potential HMI distraction rating system that considered practical issues for administration of the checklist, such as checklist rater qualifications, equipment and materials and scientific issues relating to administration of the VOT and DRT, such as the minimum duration of distracting (secondary) tasks necessary for measurement. A means of calculating a distraction rating score, by combining scores from the HMI design checklist, VOT and DRT, was also developed.
7. Future steps, potential costs and timeframes involved to develop a final HMI distraction star rating system were also considered.

Component Two involved six main research tasks and several associated sub-tasks, using literature reviews and consultation methods as per Component One. In addition, information was sourced from published protocols, consultations with selected NCAPs, presentations at recent Global NCAP meetings and the resources published by CARHS, a technical training organisation based in Germany (safetywissen.com). The main tasks were (Regan, Cunningham, & Paine, 2018b; Cunningham et al., 2017):

1. Outline how the current NCAP star ratings operate, important change processes/approvals required, components and barriers/issues to changing NCAP protocols (including Australasian NCAP, Euro NCAP and US NCAP).
2. Determine which government, industry and vehicle manufacturing stakeholders, worldwide, that are essential for participation in, and advocacy for, developing a distraction safety rating now and in the future; e.g., Australian NCAP, European NCAP, US NCAP, road authorities, insurers, vehicle manufacturers, other industries and academia.
3. Determine each stakeholder’s role, including ongoing support; potential financial or in-kind contribution; importance and degree of influence and any other functions for developing and providing an ongoing distraction rating.
4. Document how to include an HMI distraction rating in Euro NCAP assessments (including requirements that cover the distraction rating as part of an overall NCAP score or a separate standalone rating) or for alternative methods that will have an impact on vehicle manufacturers and consumer behaviour. Component Two resulted in eight options for introducing a distraction safety rating system, with each option building upon the previous in terms of being able to achieve the desired outcomes, particularly in terms of the uptake of improved HMI design.
5. Document barriers, risks, benefits and disbenefits, future steps and research requirements, costs, advocacy levers and timeframes for different methods of introducing an HMI distraction rating system.

The project was supported by ANCAP and Euro NCAP through in-kind support. Consultation was undertaken with these NCAPs for Component Two of the project and both stakeholders were on the project advisory Committees (described below). At the beginning of the project the project team organised and ran a special session on this project at the 5th International Conference on Driver Distraction and Inattention (held in Paris, France; April 2017). The outcomes of this session provided a basis for identifying key issues requiring consideration throughout the project, especially in relation to the suitability of possible distraction test methods. Scientific and Ratings Advisory Committees (for Components One and Two of the project, respectively), consisting of local and international experts, were established to provide project guidance (Table 1). The Scientific Advisory Committee, chaired by the Department of Transport, comprised local and international driver distraction and HMI design experts. The Ratings Advisory Committee, chaired by ANCAP, comprised representatives from local and international vehicle safety rating organisations, including NCAPs. Committee members provided in-kind support via teleconferences, ad hoc advice and peer review of select deliverables.

During Component One of the project, the project team engaged closely with two distraction experts from the University of Utah who had undertaken related work sponsored by the American Automobile Association Foundation for Traffic Safety (AAAFTS; USA). This involved a week-long workshop in Melbourne and ad-hoc communication as required (and through the Scientific Advisory Committee). The AAAFTS has recently published in-vehicle distraction safety ratings for over 40 vehicles produced by the University of Utah (AAA Exchange, 2017).

Results and discussion

Key outcomes of the project are reported here. Further details can be found in the original reports documenting the outcomes of this research program (see Cunningham et al., 2017; Cunningham et al., 2018 a,b; Cunningham et al., 2018; Paine & Regan, 2018; Regan et al., 2018; VicRoads, 2018).

Distraction testing methods

The literature review and expert consultations identified eight potential methods by which the distraction potential of the HMI for vehicle infotainment system interactions might be evaluated for rating purposes. These methods, along with

Table 1. Scientific and Ratings Committees experts

Expert	Organisation	Country
Scientific Advisory Committee		
Dr Linda Angell	Touchstone Evaluations	USA
Prof Klaus Bengler	University of Munich	Germany
Dr Marie-Pierre Bruyas	IFSTTAR	France
Prof Gary Burnett	University of Nottingham	UK
Dr Peter Burns	Transport Canada	Canada
Prof Oliver Carsten	Leeds University	UK
Dr Maria Beatriz Delgado	IADIA/Euro NCAP	Spain
Dr Johan Engstrom	Virginia Tech/Volvo Cars	Sweden
Emeritus Prof Don Fisher	Volpe Institute	USA
Dr Joanne Harbluck	Transport Canada	Canada
Dr William Horrey	AAA Foundation for Traffic Safety	USA
Adj. Prof Michael Lenné	Seeing Machines	Australia
Adj. Prof Alan Stevens	(ex) Transport Research Laboratory	UK
Dr Ingrid Skogsmo	Swedish National Road and Transport Research Institute	Sweden
Adj. Professor Trent Victor	Volvo Cars	Sweden
Dr Kristie Young	Monash University	Australia
Ratings Advisory Committee		
Matthew Avery	Thatcham Research	UK
David Beck	Transport for NSW	Australia
Mark Borlace	Royal Automobile Association	Australia
Andrew Dankers	Department of Infrastructure and Regional Development	Australia
Dr David Kidd	US Insurance Institute for Highway Safety	USA
Robert McDonald	IAG Insurance	Australia
Peter Martin	National Highway Traffic Safety Administration, US	USA
Richard Schram	Euro NCAP	Belgium
Mark Terrell	Australian New Car Assessment Program	Australia
Andre Wiggerich	BASt, Germany	Germany
Dr David Yang	AAA Foundation for Traffic Safety	USA

their identified advantages and disadvantages, are contained in Table 2 below (Cunningham, Regan & Imants, 2018b).

HMI assessment method(s) need to be sensitive enough to reliably discriminate, from a distraction perspective, between good and poorly designed HMIs. This is a critical scientific consideration. Distraction may induce one or more of the following "triggered behavioural responses": eyes off road, mind off road and hand(s) off the steering wheel (Regan, Hallett, & Gordon, 2011). Therefore, to adequately assess the level of distraction produced through an HMI and the tasks it supports, assessment method(s) are needed that tap into each of these components of distraction (Cunningham, Regan & Imants, 2018).

Table 2. Candidate HMI assessment methods for use in distraction rating system

HMI assessment method and description	Advantages and disadvantages
1. Checklist – HMI design A suitably qualified assessor rates the physical and software design attributes of the HMI using a checklist containing design criteria against which the distraction potential of the HMI design is assessed. Undertaken whilst the vehicle is stationary.	Advantages: • quick to administer, cheap, no participants required • minimal equipment – checklist and pen/paper or tablet computer • many physical and software HMI design attributes can be assessed, particularly key attributes leading to distraction • taps into all three distraction types (visual, cognitive and auditory), with design guidelines and principles that derive predominantly from established human factors theory and principles – a draft checklist was developed by the project team as part of this project. • Disadvantages: • no known validated distraction assessment checklists exist • very little guidance available on checklist assessor qualifications required for administration • lack of empirical evidence that ‘optimal HMI design based on adherence to a set of design guidelines/checklists reduces crash risk • does not involve driving.
2. Checklist – interference potential Similar to Method 1. A suitably qualified assessor rates the HMI for distraction interference potential using a checklist. However, the focus is not on rating the physical and software design attributes of the HMI itself. Rather, the assessor rates the interference potential of the secondary tasks (e.g. interacting with the infotainment system to change music, instigate navigation or make a phone call) that are to be performed using the HMI while driving.	Advantages: • quick to administer, cheap, no participants required • minimal equipment – checklist pen/paper or tablet computer • detail on distraction potential of secondary tasks (Method 1 does not achieve this). • Disadvantages: • similar to Method 1
3. Simulator or real vehicle to assess distraction An experimenter measures the impact of distraction on driving performance. Normally involves a driving simulator, instrumented vehicle or surrogate driving task that mimics some part of the driving task (e.g. Lane Change Test). A tester and participant are required. Involves a comparison between driving performance in a baseline condition (undistracted driving) and a distracted condition (in which the test subject performs a secondary task through the HMI).	Advantages: • direct measure of impact of distraction on driving performance • extraneous variables (e.g. road type, weather) can be easily controlled • safe driving environment. • Disadvantages: • may be unsafe to assess distraction on real roads • simulator sickness for some participants • difficult/costly to reproduce different HMI designs for a simulator • simulation often doesn’t allow self-regulation of driver engagement in secondary tasks as in real-world driving.

HMI assessment method and description	Advantages and disadvantages
4. Expert rater to assess distraction using a checklist Similar to Method 3 but requires tester to rate driving performance using a checklist (like the Vienna Fahrprobe checklist used in Europe to rate driving performance for progression to solo driving), using a simulator or real vehicle. This method does not currently exist. If it did, it would require a suitably qualified assessor and a participant. It would involve a comparison of ratings of driving performance between a baseline condition (undistracted driving) and a distracted condition (in which the participant engages with a secondary task(s) while being rated).	Advantages: • assessment tool available. Disadvantages: • not time efficient - at least a week needed to collect enough data to assess each vehicle • may not discriminate between visual and cognitive distraction • traffic situations in current version of Vienna Fahrprobe would need to be updated.
5. Surrogate assessment tasks to measure cognitive and visual load Involves the use of a surrogate assessment task to measure and rate the degree of cognitive load (e.g. using the DRT) or visual load (e.g. using the VOT) imposed by the performance of a secondary task. Unlike Method 3, it does not measure changes in driving performance due to a driver interaction. Rather, it measures the *load* imposed by a secondary task (cognitive load for the DRT, and visual load for the VOT, which may then be used to make an inference regarding the level of interference [distraction] between the secondary task and activities critical for safe driving). It requires an assessor and a participant and surrogate assessment tasks can be performed in a simulator or real vehicle.	Advantages: • standards defining procedures for administering some surrogate assessment tasks have been developed by ISO (e.g. for VOT and DRT) • inexpensive, easy to use • can validly discriminate between tasks for visual and cognitive demand. Disadvantages: • VOT - doesn't show how a task affects the return of driver gaze to the forward roadway; presentation rate of occlusion/unoccluded events is predictable • DRT - test is time consuming - takes around three weeks per vehicle for data collection (N=24) and duration of secondary tasks needs to be at least five seconds long as DRT stimulus is presented every two to three seconds.
6. Measure perceived (self-reported) workload Involves the collection of self-reported ratings of workload (associated with a secondary task) from participants after a drive. Workload ratings may be compared between a baseline condition (undistracted driving) and a distracted condition (in which the test subject engages with a secondary task[s] while being rated). Alternatively, workload ratings may be compared between different secondary tasks. Three questionnaires are commonly used: the National Aeronautics and Space Administration Task Load Index (NASA-TLX), the Driving Activity Load Index (DALI) and the Overall Workload Level (OWL) scale.	Advantages: • easy and cheap to administer in conjunction with other assessment methods • can easily compare ratings across different tasks • participants are particularly good and robust at self-rating the visual and cognitive load they experience when undertaking a certain task. Disadvantages: • difficult to determine if participants reporting overall workload levels averaged over the entire testing period or to specific peaks in workload • ratings lack objectivity, so less acceptable for rating regimes (e.g. NCAPs).

HMI assessment method and description	**Advantages and disadvantages**
<u>7. Measure driver psycho-physiological characteristics</u> An experimenter assesses the secondary task in terms of the degree to which it elicits psycho-physiological responses in the driver which are known to be correlated with increases or decreases in visual and cognitive load (e.g. heart rate variability, eye movement/glances, pupil dilation, brain waves (EEG)). Requires a tester and participant.	Advantages: • Eye glance metrics are consistently reported to be among the best performing diagnostic metrics for measuring distraction and workload and have good predictive validity with respect to crashes (e.g. two seconds eyes off road doubles crash risk). Disadvantages: • not entirely reliable e.g. other factors can influence these signals (related to a driver's reaction to physical exertion, emotional state or ambient lighting) – occasionally leading to unclear conclusions • complex technology required • can be intrusive • need multiple measurement indexes • very expensive.
<u>8. Analytical modelling</u> This method involves an analysis and modelling of the tasks a driver would perform when interacting with an in-vehicle device/function and prediction of the level of distraction produced from those interactions. The aim is to break the task down into its fundamental components to understand the characteristics that will increase distraction (e.g. visual demand for an in-vehicle touchscreen will increase with a greater distance between an on-screen 'button' and the steering wheel, or when there are more buttons on the touchscreen, etc.). This method does not require a test driver to conduct the assessment. However, an experienced analyst is required to develop the predictive model.	Advantages: • practical, very quick to undertake and subsequently extremely cost-beneficial • identifies HMI tasks that are particularly distracting so can prioritise tasks for further assessment through user trials • can be applied much earlier in HMI design process, as a working HMI prototype is not required compared with other assessment methods. • Disadvantages: • predicts the distraction potential for a given task as opposed to measuring distraction directly • can currently only be applied to simplistic in-vehicle tasks using HMI touchscreens (e.g. entering destination on in-vehicle navigation system) • not yet refined enough to assess voice input tasks.

The number of experts on the Scientific Advisory Committee (13 in total) who definitively endorsed the suitability of each HMI assessment method for the purposes of this study (ranked from most to least endorsed), based on these and other relevant considerations, was as follows (Cunningham, Regan & Imants, 2018):

- Method 1: HMI design checklist – eight experts
- Method 5(a): Surrogate driving task (DRT) – six experts
- Method 5(b): Surrogate driving task (VOT) – six experts
- Method 8: Analytical modelling – six experts
- Method 3: Simulation – three experts
- Method 6: Self-reported workload – three experts
- Method 4: Test drive with expert rater – one expert
- Method 7: Physiological measures – no experts endorsed its use
- Method 2: Interference potential of secondary task checklist – no experts endorsed its use.

Overall, the international experts recommended HMI assessment Method 1 (checklist), Method 5(a) (DRT) and 5(b) (VOT) as the three most suitable for the purposes of this project. While Method 8 (analytical modelling) was also highly endorsed, it was not regarded as being sufficiently mature enough for use when investigated. This combination of endorsed methods is therefore recommended for inclusion in a distraction rating system (Cunningham, Regan & Imants, 2018).

The DRT is an internationally recognised and validated measure of cognitive demand (ISO 17488:2016; (ISO, 2016)). The VOT is, similarly, an internationally recognised and validated measure of visual demand (ISO 16673:2017 (ISO, 2017)). Both measures are used by many vehicle manufacturers early in the in-vehicle HMI design process. The checklist, developed by the project team, derives from several well-established vehicle HMI design guidelines and standards (VicRoads, 2018). The checklist can tap into visual and cognitive distraction and bi-manual interference, with design guidelines and principles that derive predominantly from established human factors theory and principles (e.g. NHTSA, 2013). Together, these three methods were judged by the project team, and the international experts, as being capable of being combined to measure and rate the potential for distraction deriving from driver interactions with in-vehicle infotainment systems (Regan, Cunningham, & Paine, 2018).

Options for introducing a distraction rating system

In terms of introducing a distraction rating system, the following schemes were identified and listed in a hierarchy. The hierarchy, going from Option 1 to Option 8, represents the least favourable to most favourable, respectively, in terms of likely effectiveness (e.g. uptake of improved HMI in new vehicles). In general, schemes with less oversight are likely to cost less and be easier to implement but are less effective at changing the vehicle fleet. A staged approach could fast-track introduction of improved HMI designs in the short term and allow incorporation in NCAP (or other) rating systems in the longer term. The hierarchy of possible rating systems is outlined below, together with page references to Regan, Cunningham, and Paine (2018).

Option 1 - Voluntary guidelines

"Guidelines for HMI design and testing are published by a suitably recognised organisation (e.g. ISO) and vehicle manufacturers work to these guidelines on a voluntary basis, possibly through a memorandum of understanding with NCAPs/regulators" (page 35).

Option 2 - Voluntary standards with self-certification

"Standards are published by a relevant organisation, such as an NCAP or a standards association. The vehicle manufacturer designs the HMI to these standards and states that the vehicle meets the guidelines. Consumer law discourages vehicle manufacturers from making false claims but there is no formal auditing/enforcement. This avoids the cost and difficulties of a formal certification system" (page 36).

Option 3 - Voluntary standards with independent certification

"Standards are published. Vehicle manufacturers arrange third party certification to these standards. This method is used for safety products such as child restraints and bicycle helmets" (page 36).

Option 4 - Voluntary protocols with recognition by NCAP

"Test protocols are developed, and vehicle manufacturers work to these protocols. Vehicle manufacturers approach an NCAP and seek acknowledgement that they have designed the vehicle to the guidelines. This is like the Euro NCAP 'Advanced Rewards'. The NCAP does not publish a rating in these cases but simply acknowledges that the vehicle manufacturer has designed the vehicle to the agreed protocol" (page 36).

Option 5 - Voluntary rating with auditing by NCAP

"Vehicle manufacturers submit test results to the NCAP for the full range of tests set out in an HMI/distraction protocol. The NCAP conducts a random selection of tests as an audit of the vehicle manufacturer submission. Scores are adjusted if the audit finds significant discrepancies. The NCAP publishes distraction ratings, where available" (page 36).

Option 6 - Mandatory rating with auditing by NCAP

"The NCAP publishes a distraction rating for all new safety ratings using Option 5. Vehicle manufacturers who chose to not submit test data for Option 5 above could still receive a distraction rating, but it would default to 'poor'. However, a checklist approach could be utilised to give the vehicle manufacturer the options of improving this default (to say 'marginal')" (page 36).

Option 7 - Mandatory independent rating with all tests conducted by NCAP

"The NCAP conducts the full suite of tests - that is, measuring/testing done in laboratories with no vehicle manufacturer data" (page 36).

Option 8 - Distraction rating incorporated in overall safety rating

"The NCAP incorporates a distraction rating in the overall safety rating, using the same procedures as Options 5 or 7. This option could be implemented if the above options do not result in a reasonable improvement in HMI across the fleet" (page 36).

Options 1 to 4 are pass/fail systems where the HMI design meets (or does not meet) agreed minimum requirements, similar to the way in which regulations operate. Options 5 to 8 have an independent organisation scoring/rating the HMI system. The options were assessed using the Strategic Merit Test methodology (Rose & Richardson 2010) that rates the likely effect of each option on a range of desired outcomes related to safety and a sustainable framework (details of this analysis can be found in Regan, Cunningham, & Paine, 2018). Based on this analysis, the following three options are considered viable options for consideration by rating organisations such as NCAPs:

- Option 5 – Voluntary rating with auditing by an independent rating organisation
- Option 6 – Mandatory rating with auditing by an independent rating organisation
- Option 7 – Mandatory independent rating with all tests conducted by the independent rating organisation.

All of these options involve the development of a test and assessment protocol that results in a scaled (e.g. 'poor' to 'good') distraction rating. This is expected to have better safety outcomes than guidelines or a simple pass/fail system such as in Options 1 to 4. This is because a simple pass/fail system provides no incentive for manufacturers to achieve performance that is much better than the minimum pass level. This was evident in early results of NCAP crash tests where it was found that many vehicles barely passed the equivalent regulation requirements, but some vehicles did much better at protecting occupants. The NCAP system is designed to reward better performance and discourage consumers from buying the least safe vehicles.

The difference between the three recommended options is the degree to which vehicle manufacturers and rating organisations conduct tests, as well as the level of scrutiny applied to the assessment of distraction from the in-vehicle HMI. Recently Euro NCAP and Australasian NCAP have moved towards the audit of test results submitted by manufacturers (this "grid method" is used for pedestrian protection tests, autonomous emergency braking tests and lane support system tests) and is similar to Option 5 (voluntary rating with auditing by an independent rating organisation) discussed above. This is considered viable for a distraction rating system and would substantially reduce operating costs for the rating organisation (manufacturers would need to conduct all the tests if they wished to achieve good ratings). Obviously, Option 8 would be the most effective option, but would pose additional costs for NCAPs.

It should be noted that the introduction of improved HMI design to reduce distraction through mandatory regulation was not considered by the project Ratings Advisory Committee to be a viable option due to the constraints of international harmonisation.

Benefits and costs from a distraction rating system

The potential benefits and costs of a distraction rating system were analysed, but it is important to remember that the actual benefits of any implementation option will depend on many factors, including the proportion of the vehicle fleet that has improved HMI design to reduce distraction (and its uptake by consumers). Experience with other NCAP initiatives is that it typically takes several years for more than 50% of new models to perform well in a particular area. National fleet penetration is slow, so it takes many more years before most vehicles in use have a particular safety performance level (Regan, Cunningham, & Paine, 2018).

Due to these uncertainties, the benefits and costs of various implementation options have not been estimated at this stage. Instead, a range of estimated cost benefits is provided. The benefits and costs analyses showed (Paine & Regan, 2018):

- *Potential crash savings through improved HMI to reduce driver distraction.* It is estimated that the proposed distraction rating system (using the checklist, DRT and VOT), when applied to in-vehicle technologies other than mobile phones, has the potential to prevent 3% of all reported crashes. This is based on the Dingus et al. (2016) analysis of 905 US non-fatal crashes where naturalistic driving data were available. In brief, 6% of crashes would likely have been avoided if the driver had not been distracted by one of the non-phone technologies. Members of the Scientific Expert Group estimated that, with 100% effectiveness, improved HMI would have saved half of these cases, giving an overall saving of 3%.
- *Cost of road crashes in Australia.* Dividing the estimated costs of road crashes in Australia in 2006 (Bureau of Infrastructure, Transport and Regional Economics report 'Cost of Road Crashes in Australia 2006') by the number of registered motor vehicles in that year gives an annual crash cost per registered vehicle of AU$1,166. Costs will have increased since that time and so any analysis based on 2006 data will be conservative (data beyond this date was not available for analysis).
- *Effectiveness of a rating system.* It was estimated that the potential effectiveness of a distraction rating system ranged from 20% to 80% depending on the success of the system in encouraging improved HMI. This translates to crash reductions of 0.6% to 2.4% respectively (3% x 20% = 0.6%, 3% x 80% = 2.4%). Assuming that a highly effective distraction rating system (80% effectiveness) reduces all types of crashes by 2.4%, then the annual saving is estimated to be AUD$28 per 'improved' vehicle (2.4% of AUD$1,166). A distraction rating system with low effectiveness (20%) is estimated to result in an annual saving of AUD$7 per 'improved' vehicle (0.6% of AU$1,166).
- *Increased cost of new vehicles.* Subject to many factors, it is estimated that the typical incremental cost of producing a vehicle with good HMI design will increase by AUD$20. Amortised over 5 years, this is about AU$5 per year. Therefore, a distraction rating system with low effectiveness will be barely cost-effective (net saving AUD$7-$5=$2 per vehicle per year). A high-effectiveness system is estimated to save about AUD$23 per vehicle per year (AUD$28-$5=$23).
- *Cost of implementing and operating a rating system.* Details of the rating system are yet to be finalised, so there is considerable uncertainty about costs of implementing such a system. Based on experience with other rating systems, estimated implementation costs (for administration, contractors to manage the implementation of the scheme, test equipment acquisition and set-up and marketing) totals AUD$300,000. Estimated annual costs, again with uncertainty (for administration, contractor overheads, testing overheads, marketing and testing of 20 vehicles per year [assuming the rating organisation conducts all tests]) totals AUD$500,000.
- *Benefit-cost analysis.* The benefit/cost analysis indicates that a distraction rating system will break-even after five years given relatively few vehicles with improved HMI entering the fleet each year - for the analysed baseline parameters about 8,483 new vehicles per year or 0.84% of new vehicle sales in Australia. For a higher benefit/cost ratio, as is usually required for justifying regulatory action, more new vehicles will need to have improved HMI. For example, for

the base case that assumes a median annual cost of AUD$550,000, AUD$5/vehicle/year and 7% discount, increasing the number of new vehicles with improved HMI from 8,483 (0.84%) to 16,967 (1.68%) produces a benefit/cost ratio of 2.

- *The benefit-cost analysis was confined to implementation in Australia.* Any improved HMI design resulting from this scheme is likely to influence vehicle HMI design in other regions, particularly if a globally-recognised rating system is implemented. The economies of scale can be expected to produce lower costs and therefore a better benefit/cost ratio than the analysed case.

Conclusions

There is evidence that distraction from in-vehicle infotainment technologies may degrade driving performance and safety. Therefore, it is important to influence vehicle manufacturers to design the in-vehicle HMI in a way that minimises distraction from these systems. Developing a distraction rating system is an important step to make this happen and improve vehicle safety for consumers.

Driver distraction from in-vehicle technologies, generally, has the potential to degrade multiple psychophysiological processes and therefore no single test can comprehensively evaluate distraction potential. The findings from this study suggest three assessment methods that, in combination, are most suitable for assessing the distraction potential of in-vehicle technologies– the DRT and VOT that measure cognitive and visual load, respectively, and an HMI design checklist. The results of these assessment methods can be used to create a distraction rating system for vehicle cockpit testing.

Once distraction ratings become available through conducting these tests on vehicles in Australia, a voluntary scheme (with auditing by an independent rating organisation) for encouraging vehicle manufacturers to produce less distracting vehicle HMIs is considered the most feasible approach to implementing a rating system in the short-term, with a longer-term vision of incorporating the test method into consumer rating systems such as NCAP. The type of vehicle buyer that could be the initial target of a consumer distraction rating system is likely to be company fleets. An alternative option to establishing a consumer rating is to seek the development of a UN Vehicle Regulation to address HMI-related distraction issues in new vehicles but this would likely mean several years of delay in seeing the benefits of improved HMI design, assuming the proposal proceeds to international regulation.

It is concluded that this area of driver distraction requires a dedicated and innovative ongoing international research effort. An HMI distraction rating system that is credible to industry and consumers is feasible but requires further validation and possibly demonstration of its potential to reduce crashes - similar to evidence requirements directing the policies of NCAPs.

The ability to undertake a proof-of-concept study that will employ the distraction safety rating system described in this paper to rate the distraction potential of a small number of new Australian vehicles is currently being investigated. This study is required to determine the efficacy of the proposed distraction testing protocol (HMI checklist (which requires development), DRT and VOT) and if a distraction rating can be computed. The distraction rating computations will be based on the outcomes of the proof-of-concept study and the distraction rating method developed by Strayer and colleagues (2015; 2017) with the additional inclusion of the VOT. The aims of the study are to:

- develop an extended distraction rating method for use in Australian conditions
- build Australian domestic capability for conducting assessment of the distractibility of HMIs in vehicles
- establish the basis for a wider-scale project to test additional vehicles that will ultimately lead to improved designs of future vehicle HMIs to reduce distraction and crash risk.

If the proof-of-concept study can be undertaken and proves successful, a much larger study with a large range of vehicles available for distraction assessment will need to be undertaken. To continue to rate new vehicles coming to market for their distraction potential ongoing funding would be required. This would ideally be undertaken by an independent rating organisation who would source such funding.

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How do we prevent and mitigate crashes? Evidence from Australian at-scene in-depth crash investigations

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Key Findings

- Most crashes investigated can be prevented or mitigated
- Prevention and mitigation interventions are most commonly road or vehicle based
- Key road interventions related to intersections and dealing with errant vehicles
- Key vehicle technologies were found to be; ESC, AEB, EBA, LKA, ISA-L
- Reductions in impact speed through speed limits or other means is important

Abstract

The Centre for Automotive Safety Research conducts at-scene in-depth investigations of South Australian injury crashes that allow detailed analysis of the crash in order to determine the factors that contributed to the crash occurring, and the interventions that could prevent or mitigate them. This initial analysis of such a dataset (n=116) showed that the most common contributing factors are human errors, but the interventions to prevent or mitigate the crashes are most commonly infrastructure treatments or vehicle technologies that eliminate the human error and/or reduce the vehicle's speed prior to impact in the event of a human error. It also found that most crashes can be prevented or mitigated. Key factors in meeting the goals of the safe system (zero deaths and serious injuries) were found to be: road infrastructure-based interventions at intersections (e.g. roundabouts); increased fleet penetration of the vehicle technologies Electronic Stability Control, Autonomous Emergency Braking, Emergency Braking Assist, Lane Keep Assist, Intelligent Speed Assist – Limiting; road interventions for errant vehicles that depart their lane or the road (e.g.median barriers); speed limit reductions; and a reduction in driving under the influence of alcohol and/or drugs.

Keywords

Crash Investigation, Human Factors, Road Design, Vehicle Safety, Safe System

Introduction

Road crashes and the resulting trauma is a large-scale problem facing both developed and developing countries. In Australia alone the most recent published statistics show that there were 1,137 deaths in 2018 (BITRE, 2019a) and 38,945 hospitalisations in 2016 from road crashes (BITRE, 2019b). In order to tackle any problem, the problem itself must first be adequately understood. Understanding road crashes involves accurately identifying the factors that contribute to their occurrence. Once these are understood interventions can be identified that can either prevent the crash from occurring or mitigate its outcome.

Many countries task their police with collecting a basic level of information for most crashes. This data collection function of the police is often based in an independent determination of legal fault for the crash. It is also limited in scope due to the large number of crashes for which data are collected. These data are useful for general analysis, but often lack the fidelity to fully understand crashes through identification of contributing factors.

In-depth crash investigations are used to provide the detailed understanding of crashes and their associated contributing factors that cannot be gained from police crash reports. The data gained from in-depth crash investigations compliments that collected in routine police crash reports in order to provide a more complete understanding of road crashes and the associated trauma. In-depth crash investigations in Australia began in 1963 in Adelaide, South Australia, conducted by the University of Adelaide (McLean, 1972). The University of Adelaide continues this method of crash data collection to the present day through the Centre for Automotive Safety Research (CASR), with the most recent series of investigations beginning in late 2014.

Only a small proportion of the groups that conduct in-depth crash investigations worldwide routinely publish results that include aggregate information on the contributing factors identified. The contributing factors are usually broadly categorised into human, vehicle and road/environment, though there may be considerable variance in how the factors are categorised within these groups. The most recent published results from the United Kingdom's Road Accident In-Depth Study (RAIDS) found that all crashes had at least one human contributing factor, 30% had a road/environment factor and 11% had a vehicle factor. Numbers for all individual contributing factors were not provided in the most recent report, but the most frequent human contributing factors were "Poor turn or manoeuvre, loss of control of vehicle, failed to stop, failed to avoid object or vehicle on carriageway and failed to give way" (Cuerden and McCarthy, 2016). Initial data from the German In-Depth Accident Study (GIDAS) looking at contributing factors on a vehicle level, rather than the crash level, found that 96% of vehicles had a human contributing factor, while only 7% had an environment factor, and 2% had a vehicle factor (Jänsch *et al*., 2012). A four-year in-depth study focussed on serious injury in Australia published a list of the top ten contributing factors, all of which were human factors. The most common human factors were: driver fatigue, failed to see other road user (stated by driver), blackout pre-crash due to medical conditions, driver emotional state, and driver misjudged road layout (Fitzharris *et al.*, 2016).

While it is common practice for in-depth investigations to identify the factors that contributed to the crash, the authors could not identify any that had also included interventions that could have prevented or mitigated the crash in their findings. The most recent series of in-depth crash investigations conducted by the Centre for Automotive Safety Research at the University of Adelaide took the additional step of identifying these interventions. The purpose of the present study was to examine the factors that contributed to a sample of crashes investigated by CASR and identify the most common interventions that could have prevented or mitigated the crashes.

Methods

CASR's in-depth crash investigation team is composed of researchers from engineering, psychology and health backgrounds. Crash investigations begin with notification by pager from the local ambulance service immediately after an ambulance call out to a crash. Investigators attend the crash if it occurs within 100 km of Adelaide and is not within a rural township. These limitations are designed to limit travel time so that the scene evidence is sufficiently preserved upon a team's arrival. Other criteria for case selection are: at least one participant must be transported by ambulance, the crash occurred on a public road, and it involved at least one motor vehicle (including motorcycles). The team is on-call to immediately attend crashes during the hours 9am to 9pm, Monday to Friday. In addition, fatal and life threatening injury crashes occurring outside of these hours, which are attended by SA Police Major Crash, are investigated in the following days.

On arrival at a the scene of a crash (Figure 1), CASR investigators undertake the following tasks: talk to emergency services' personnel, participants and witnesses; mark the scene evidence; photograph the scene, vehicles and road infrastructure; collect data on the vehicles, road and crash circumstances; digitally map the road environment and crash evidence; and record videos from each road user's direction of travel.

After the crash, further sources of information are obtained, including: the police report, hospital and ambulance notes, driver and witness interviews, Coroner's report (if fatal), forensics report (alcohol and drugs test results), and the crash history of the location and drivers. The injuries noted by hospital are coded using the abbreviated injury scale (AIS). The speeds of the vehicles are also determined, if possible, by a crash reconstruction that utilises the scene evidence.

All cases are then reviewed by a multidisciplinary panel comprised of experts in human, road and vehicle factors to determine which factors contributed to the crash occurring. The review panel members remained consistent for the crashes included in this paper's analysis. In the current

Figure 1. CASR crash investigation being conducted at a crash scene

series of crash investigations, interventions (or treatments) that could have prevented the crash or mitigated its severity are also nominated by the case review panel along with a confidence level (high, medium, low) that the intervention would have prevented or mitigated the crash. Both contributing factors and interventions are selected from pre-determined lists, with all listed contributing factors and interventions being considered for each case. Additional interventions can be added if not already on the list, and would be considered for all cases reviewed to date. The lists are shown in the Appendix.

Contributing factors are selected on the basis of all the evidence collected over the course of the investigation. They can never be selected based on mere speculation. Multiple contributing factors can be selected for each crash. While any member of the expert review panel may propose a given contributing factor, experts in the specific area, e.g. human factors, must demonstrate to the group why that factor is or is not relevant in the particular crash. Decisions on human factors rely heavily on interviews with the crash participants and witnesses but statements made by individuals regarding their own behaviour are not taken as fact and are judged against other statements and the evidence from the scene and subsequent reconstruction. Road contributing factors are related to road design, operation or condition. Australian Standards and the Austroads' Guides can be used to support inclusion of these contributing factors; however, adherence to these does not necessarily preclude the factor from contributing. Also, the mere presence of an unsafe road factor does not mean it will be identified as contributing. Vehicle contributing factors are related to vehicle fault (e.g. tyre blowout), condition (e.g. worn tyres), or an inherent quality of a vehicle (e.g. dynamic rollover stability) that contributed to a crash. Determination of vehicle factors relies largely on the physical examination of the vehicle but can also draw upon driver and witness account and scene evidence. It is important to note that contributing factors do not take into account factors that affect the severity of the crash, just the crash occurring in the first place.

The interventions that are nominated by the panel are done so on the basis of their ability to prevent or mitigate the crash. Cost and practicality are not generally considered. The exception to this is the road infrastructure interventions of grade separation and traffic signals, which are limited to intersections between two arterial roads, and arterial and collector roads. Automated and connected vehicles were not considered as their operation in specific crash related situations is still largely unknown. The confidence level that is selected is based on the expert's knowledge of the probability of that intervention being effective under the specific circumstances of the crash. The interventions are grouped, like the contributing factors, into the categories of human, vehicle or road-based interventions. Interventions in all these areas may be attempting to modify or allow for human factors, but the human category is focussed on interventions that do not relate to a vehicle technology or road infrastructure, such as enforcement of illegal behaviours. Mitigation factors must also consider the actual injuries sustained in the crash and the ability of a given intervention to prevent these injuries. Multiple interventions can be selected for each crash but each intervention is considered on its own merits. Interactions between interventions were not considered. Crashes were classified as preventable if at least one intervention that is rated as having a medium or high confidence is nominated for that crash. The same method is applied to classifying crashes as mitigable.

Contributing factors and interventions from the first 116 crashes investigated in the current series were analysed for this paper. These crashes occurred between October 2014 and January 2017.

Results

The characteristics of the sample of crashes investigated are summarised in Table 1 in terms of injury severity by maximum abbreviated injury score (MAIS), speed zone, and broad crash types. Just over half occurred in low speed zones (<60 km/h) and two thirds resulted in minor injuries, despite the criterion of ambulance transport. Of the 19 crashes that resulted in serious injury (MAIS 3+), six were fatal. Crashes between vehicles at intersections and single vehicle crashes made up more than two-thirds of the sample.

Table 1. Characteristics of the 116 crashes investigated

Speed Zone	Number	Percentage
<60 km/h	66	56.9%
70-90 km/h	22	19.0%
100-110 km/h	28	24.1%
Injury Severity		
MAIS <2	77	66.4%
MAIS 2	20	17.2%
MAIS 3+	19	16.4%
Crash type		
Intersection	41	35.3%
Pedestrian	9	7.8%
Single vehicle	39	33.6%
Rear end	10	8.6%
Head on	5	4.3%
Other	12	10.3%

Table 2 shows the top most commonly identified contributing factors. An average of 2.5 contributing factors were identified per crash. Human factors were the most common contributing factors, with an average of 1.6 human factors per crash, followed by road factors (0.8 per crash) and vehicle factors (0.2 per crash). Most of the crashes involved at least one human factor (92%) and about half involved at least one road factor (53%). Relatively few involved at least one vehicle factor (16%).

Table 2. Ten most commonly identified contributing factors found from CASR's at-scene in-depth crash investigations

Contributing factors	Number	Percentage
Human: speed too high for conditions	20	17.2%
Road: visibility	19	16.4%
Human: unspecific fail to give way	18	15.5%
Road: junction layout	14	12.1%
Vehicle: conspicuity	12	10.3%
Road: unsealed	12	10.3%
Human: recognition failure	12	10.3%
Human: exceed speed limit	12	10.3%
Human: Alcohol	10	8.6%
Human: Drugs	10	8.6%
Total cases reviewed	116	100.0%

Speed features prominently in the top ten contributing factors, with speed too high for conditions contributing to 20 crashes and exceeding the speed limit contributing to another 12. The top contributing factor in the road category was visibility of a key part of the road or infrastructure (e.g. limited sight distance at a junction), followed by the layout of the road (particularly at a junction) and the road surface being unsealed. An unspecific failure to give way is only selected where there is not enough information to select the specific human factor behind the driver's failure to give way, such as a failure to check for traffic. Recognition failure was the most common of these human factors that leads to a failure to give way. This pertains to cases where it is known that the driver who failed to give way did look in the appropriate direction but failed to see an approaching vehicle. The only contributing factor from the vehicle category in Table 2 is vehicle conspicuity. This is usually related to a vehicle that did not have any lights illuminated and was a colour that blended into the background, contributing to a driver's failure to recognise it.

A total of 460 prevention and mitigating interventions were nominated by the review panel, and 111 of the 116 crashes (96%) were found to have applicable interventions, at a medium to high confidence level.

The ten most common interventions that were judged by the review panel as being effective at preventing the crash (medium or high confidence) are shown in Table 3. The vast majority of the crashes had at least one prevention intervention (91%); on average, three prevention interventions were nominated per crash. The top three interventions are all infrastructure interventions related to intersection crashes. It should be noted that the 'traffic lights' intervention assumes that these lights would have controlled right turns, and so the 'controlled right turn at signalised intersection' intervention is limited to crashes at signalised intersections that did not have a controlled right turn active at the time of the crash. Compliance with traffic lights is generally assumed, although the behaviour of the driver in the actual crash is considered. Vehicle technologies also featured strongly as prevention interventions, with Electronic Stability Control (ESC) preventing the most crashes, followed by Autonomous Emergency Braking (AEB) and Lane Keep Assist (LKA). AEB assumes a system that functions in urban and intercity environments as includes pedestrian detection. Only one human behaviour type intervention was in the top ten prevention interventions, "apprehension for drink/drug driving offence". This

Table 3. Most common interventions for preventing the crashes investigated

Prevention interventions	Number	Percentage
Road: roundabout	34	29.3%
Road: prevent right turn	29	25.0%
Road: traffic lights	23	19.8%
Vehicle: Electronic Stability Control (ESC)	20	17.2%
Human: apprehension for drink/drug driving offence	15	12.9%
Road: grade separated junction	15	12.9%
Vehicle: Autonomous Emergency Braking (AEB)	14	12.1%
Road: speed limit reduction	14	12.1%
Vehicle: Lane Keep Assist (LKA)	12	10.3%
Road: controlled right turn at signalised intersection	8	6.9%
Total prevention interventions	322	-
Total crashes preventable	106	91.3%
Total crashes reviewed	116	100.0%

Table 4. Most common interventions for mitigating the crashes investigated

Mitigation interventions	Number	Percentage
Road: speed limit reduction	21	18.1%
Vehicle: Autonomous Emergency Braking (AEB)	13	11.2%
Road: centre barrier	13	11.2%
Road: vertical deflection at intersection	10	8.6%
Road: side barrier	10	8.6%
Road: roadside clear zone to guidelines	7	6.0%
Vehicle: Emergency Braking Assist (EBA)	5	4.3%
Vehicle: Intelligent Speed Assist - Limiting (ISA-L)	5	4.3%
Vehicle: Knee airbag	5	4.3%
Total mitigation interventions	138	-
Total crashes mitigable	58	50.0%
Total crashes reviewed	116	100.0%

intervention assumes that the driver was apprehended on their journey prior to the crash and prevented by police from continuing their journey.

Table 4 shows the nine most common interventions for mitigating the severity of the crash (medium or high confidence) as judged by the review panel. There are nine interventions rather than 10 as there were several interventions that tied for 10th position. Half of the crashes had at least one mitigation intervention. Of those crashes that could be mitigated, an average of 2.4 interventions were nominated. It should be noted that it in some cases of low injury severity, such as minor bruising, it is difficult to nominate any intervention that could have mitigated the injury with a medium to high level of confidence.

Speed limit reduction is the most common mitigation intervention as well as featuring in the most common prevention interventions (Table 3). The size of the speed limit reduction is dependent upon the location and type of crash, guided by the current knowledge on safe speed limits, and is generally limited to no greater than 20 km/h. The compliance of the driver(s) in the actual crash is also taken into account. Vertical deflection at an intersection, is an infrastructure treatment that is also aimed at reducing travel speed. The other infrastructure treatments are aimed at mitigating road or lane departures, with centre barriers mitigating the greatest number of these crashes, followed by side barriers and a clear zone that meets the current Austroads guidelines.

Of the vehicle technologies, Autonomous Emergency Braking (AEB), Emergency Braking Assist (EBA), Intelligent Speed Assist – Limiting (ISA-L) and knee airbags made the top nine mitigation interventions, with AEB mitigating almost as many as the others combined. Intelligent speed assist is a technology that knows the speed limit of the road and, in its limiting version, does not allow the vehicle to travel above the limit. This, along with a reduction in speed limit and vertical deflection featuring in the top nine, demonstrates the large potential to mitigate the severity of crashes by reducing travel speed.

Discussion

The results presented in this paper show that a human contributing factor was present in most crashes, consistent with Treat *et al.'s* (1979) finding of 93% and similar to more recent studies in the United Kingdom Cuerden and McCarthy, 2016) and Germany (Jänsch *et al.* 2012). However, the interventions that can prevent or mitigate the crashes are most likely to be road infrastructure or vehicle technologies. This is in line with the systems-based approach to human error outlined by Reason (2000) that recognises that humans are fallible, and this cannot be changed, but that the conditions under which they operate can. Indeed, that the prevalence of human factors (error) is remarkably similar between studies conducted some 40 years apart in different countries provides further support for idea of the universal and unchanging nature of the human condition in relation to road crashes, and the need to provide a system that provides defences against this unchanging condition.

The results also show that the vast majority of the crashes could have be prevented or mitigated (96%) and that there are often multiple interventions for each crash that could have prevented or mitigated it. This does not mean that the interventions are easy, cost effective, or even practical, as these factors were given almost no consideration when nominating interventions, but it does show that they are possible. It is also an important finding in light of the current vision in road safety, that of zero fatalities and serious injuries, as it suggests that such a vision may be attainable in the future. It also reveals that there is still a small residual of crashes that cannot be confidently prevented or mitigated with current interventions. This residual may grow when considerations around cost and practicality are taken into account. These crashes will need to be the focus of future work to develop innovative interventions. New interventions that reduce cost and improve practicality will also be important for addressing the residual related to these factors.

When interpreting the results, the nature of the sample of crashes must be considered. The crashes investigated may not be fully representative of injury crashes in Australia as it was conducted in a single geographic area (100 km radius from Adelaide), during the hours of 9am to 9pm from Monday to Friday with sampling of only very serious crashes outside this time, and deliberate oversampling of rural crashes within the nominated area. Therefore, the sample is lacking the following crashes: those at lower injury severity levels; those at dawn, late at night and on weekends; those in remote areas; and those in metropolitan areas. The exact effect of these biases on the results is difficult to determine, as the whole purpose of the collection of in-depth data is to collect data not readily available from other sources, but some effects can be surmised. It is likely that alcohol, fatigue, recreational driving / riding and non-restraint use are under-represented in the sample.

The much lower number of crashes that could be mitigated than prevented is a product of the sample, and not an indication that prevention is more likely to be possible than mitigation. Despite the criterion of ambulance transport and the sampling bias towards serious crashes, many of the crashes in the sample had a MAIS of less than two, with a proportion of these having no injury noted by the hospital at all. This made it difficult, or not applicable in the case of no recorded injuries, to nominate mitigation interventions. Both prevention and mitigation have a role to play in reducing road trauma.

The review process where contributing factors and interventions were nominated relied on the knowledge of the panel of experts and was, by its nature of attempting to predict the outcome had a certain condition been different, somewhat subjective. Having experts across the three main areas of road safety – human factors, road design and vehicles – helped to provide an approach where individual bias towards each expert's own area of expertise was balanced. Additional expertise was drawn on in specific sub-fields when required, such as the influence of drugs at a given level or the influence of a certain medical condition on driving performance. This ensured that any subjective opinion was grounded in a sound knowledge base. Furthermore, it was up to the expert proposing an intervention to the panel to demonstrate why an intervention would be successful for that particular crash, often with some debate taking place before a decision was reached. While this process cannot be claimed to have eliminated bias entirely, it seems reasonable to claim that a different panel of similarly qualified experts would have produced similar results, and it appeared to provide substantial benefits over having a single person choosing interventions.

The only intervention in the top ten for prevention or mitigation that was not road or vehicle related was apprehension for a drink/drug driving offence. Despite a noticeable shift in public acceptability of drink driving, driving under the influence of alcohol continues to be large problem (Wundersitz and Raftery, 2017), and driving under the influence of drugs has been found to be increasing in line with increased use in the wider community (Wundersitz and Konstad, 2017). While alcohol interlocks represent a good defence against drink driving, a drug interlock is not yet available. Alcohol interlocks were just outside the top ten prevention interventions as around half of the cases that could have been prevented with apprehension were related to driving under the influence of an illicit drug, or drugs. Wundersitz and Raftery (2017) found that the majority of alcohol consumption prior to drink driving occurred at a private home rather than public venues, making the task of apprehension by police more challenging. The alcohol and illicit drug consumption underlying the issues of drink and drug driving is a wider societal issue and therefore may also be addressed through broader measures than those typically considered by road safety advocates.

The results indicate that road infrastructure treatments at intersections have the most potential to prevent crashes occurring. Prevention of crashes at intersections involves eliminating conflicts, reducing the complexity of the decisions (cognitive load) on the driver, reducing the speed of traffic through the intersection, or a combination of these. The top treatment, a roundabout, fundamentally changes the dynamics of the intersection and, when implemented appropriately, reduces the complexity of the decisions to be made by the driver, reduces conflicts, reduces speeds and alters impact angles that reduces severity if a crash does occur (Jurewicz et al,. 2017, Elvik et al., 2009). Treatments that aim to eliminate conflicts that feature in the top ten were prevent right turn and grade separation. Traffic lights with the inclusion of a fully controlled right turn aim to reduce the complexity for the driver by relieving them of responsibility for selecting a gap. The exact intervention that is optimal for preventing crashes at a given intersection will depend on the traffic flows through the intersection. Speed limit reductions were another intervention that was applied to crashes at intersections.

The findings of the reviews further highlight the key role reduced speeds can play in crash prevention and mitigation. A reduced speed limit was the top treatment to mitigate the outcomes of crashes in addition to featuring in the top ten prevention interventions. Also featuring in the mitigation top ten was a vehicle technology to prevent drivers from exceeding the speed limit (ISA-L), vehicle technologies to reduce impact speed (AEB and EBA), and an infrastructure treatment designed to slow vehicles at intersections (vertical deflection). Furthermore, some of the benefit of the top prevention treatment, a roundabout, is in its slowing of vehicles through an intersection (Elivk *et al.*, 2009). This is consistent with prior research that found that speed and speed limits play a key role in both the number and severity of crashes ((Kloeden *et al.*, 1997; Elvik *et al.*, 2019; Doecke *et al.*, 2018)).

ESC is the top vehicle technology for preventing crashes. This is despite it being mandatory for new models of light vehicles from November 2011 and all models from November 2013, being mandatory to gain an Australasian

New Car Assessment Program (ANCAP) 5-star rating from 2008, and achieving standard fitment rates to new vehicles of 50% in 2009 (Anderson *et al.* 2011). This demonstrates the time taken for vehicle technologies to penetrate the proportion of the fleet that is involved in a crash following 'soft' (ANCAP) and 'hard'(Australian Design Rules) regulation. This is in contrast to infrastructure improvements that provide only a localised benefit, but that benefit is available to all drivers at that location immediately. Other vehicle technologies that feature in the top ten lists include AEB, LKA, EBA and ISA-L. Of these, only EBA is mandatory in Australia (since July 2019), while AEB, LKA and the advisory version of ISA will be assessed as part of the latest ANCAP protocol. Early identification of beneficial safety technologies and subsequent programs and policy to ensure rapid take up in the vehicle fleet is key to realising the safety benefit for the most people as quickly as possible.

Conclusions

Almost all recent crashes investigated as part of CASR's in-depth crash investigation program could have been prevented or mitigated using currently available interventions. Many of these could have been prevented in multiple ways. A small residual of crashes remains that will require innovative interventions to prevent or mitigate them. This shows that the goal of zero deaths and serious injuries is achievable.

Human factors contributed to most crashes, consistent with prior research, but the interventions that could have prevented or mitigated the crashes were mostly road improvements or vehicle technologies. This adds further support to the systems principle that human drivers will always be fallible, but that the system in which they operate (roads and vehicles) should be designed with this fallibility in mind, rather than simply blaming humans for their inherent fallibility.

Key to meeting the goals of the safe system will be a combination of the following: road infrastructure-based interventions at intersections; increased fleet penetration of the vehicle technologies ESC, AEB, EBA, LKA, ISA-L; road interventions for errant vehicles that depart their lane or the road; speed limit reductions; and a reduction in driving under the influence of alcohol and/or drugs.

Recommendations for further work

This study included all crashes that required ambulance transport. As the focus of the Safe System is fatal and serious injuries, it is recommended that further work should be conducted that focuses on Safe System failures in crashes with fatal or serious injuries and crashes where the potential for such injury was high (e.g. crashes in high speed zones and vulnerable road user crashes). Further work should also be conducted that examines the small number of crashes that could not currently be prevented or mitigated and proposes innovative interventions that could accommodate their specific circumstances.

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Appendix

Contributing factors list

Human: exceed speed limit
Human: speed too high for conditions
Human: alcohol
Human: drugs
Human: inexperience
Human: young driver
Human: vision
Human: medical condition
Human: suicide
Human: unfamiliarity with vehicle
Human: unfamiliarity with road
Human: unsafe overtaking
Human: deliberate unsafe act
Human: misjudgement
Human: fail to give way
Human: disobey traffic signal
Human: fatigue
Human: fail to check for traffic
Human: recognition failure
Human: distraction
Human: inattention
Human: competing demands for attention
Human: attention unspecified
Human: tailgating
Human: avoid other errant vehicle
Human: incorrect positioning
Human: impulsive decision
Human: peer effects
Human: pedestrian conspicuity
Human: other

Road: wet road
Road: obstacle on road
Road: large roadside drop off
Road: unsealed road
Road: horizontal alignment
Road: vertical alignment
Road: delineation
Road: road marking
Road: road layout
Road: visibility
Road: road surface
Road: signage
Road: signal control
Road: unsealed shoulder
Road: unexpected road or traffic conditions
Road: roadworks
Road: weather conditions

Vehicle: brakes
Vehicle: conspicuity
Vehicle: steering
Vehicle: dirty
Vehicle: tinted windows
Vehicle: dynamic stability
Vehicle: tyre low tread depth
Vehicle: tyre blowout
Vehicle: overload
Vehicle: modified vehicle
Vehicle: other

Interventions list

Human based interventions

Apprehension for speed offence
Apprehension for drink/drug driving offence
Apprehension for young driver restriction offence
Alcohol interlock in all vehicles
Alcohol interlock for all prior drink driving offenders
Unlicensed driver interlock
Addition of drug to drug driver testing
Suspension of licence for being medically unfit to drive
Better medical control of/advice regarding medication
Geographical restriction on licence
Mental health treatment
Medical treatment
Driver training/re-training
Mobile phone blocking technology
Trip planning
Route planning
Brighter clothing worn
Wearing of seatbelt
Wearing of helmet
Wearing of better protective clothing

Vehicle based interventions

Correct tyre pressures
More tread depth on tyres
Puncture resistant / run flat tyres
Emergency Braking Assist
Correctly maintained brake system

Combined braking system
ABS
ESC
Traction Control
Lane Departure Warning
Lane Keep Assist
Blindspot warning
Adaptive Cruise Control
Collision Warning
AEB
Drowsiness Detection / Warning
ISA - Advisory
ISA - Limiting
Curve Speed Warning
Top Speed Limiter
Seatbelt interlock
Seatbelt pretensioners
Seatbelt load limiters
Rear facing child restraint
Forward facing child restraint
Booster seat
Lower centre of gravity
Rollover structural integrity
Side intrusion protection
Frontal impact intrusion protection
Active head rest
Drivers airbag
Passenger airbag
Knee airbag
Side airbag
Curtain airbag
Removing bull bar
Adding a bull bar
Pedestrian protection
Daytime running lights
More Visible colour
Automatic Crash Notification
Anti-theft device
Window tinting removal
Side under-run protection on truck
Rear under-run protection on truck

Road infrastructure based interventions

Speed limit reduction
Clear zone to guidelines
Side barrier
Motorcycle protection on barrier
Centre barrier
Improved barrier end treatment
Improved sight distance
Give way sign
Stop sign
Traffic lights
Retro reflective signs
Street lighting
Sealed shoulders
Audio tactile edge line
Audio tactile centre lines
Narrow centre median (1m)
Wide centre median (5m+)
Raised median
Separated road
Improved surface friction
Warning signs
Curve speed advisory sign
Improved geometry of junction
Grade separated junction
Edge of road line
Centre line
Overtaking lane
Rest area
Solid centre line (overtaking prohibited)
Guide posts
Chevrons
Right turn lane
Left turn lane
Prevent right turn
Controlled right turn (signalised intersection)
Roundabout
Improved superelevation
Pedestrian signals
Improved line marking
Vertical deflection
Improved channelisation
Curve re-profiling
Active warning sign

Has cycling decreased in Australia? A comparison of 1985/86 and 2011 surveys

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Key Findings

- There is a scarcity of Australian cycling data, which makes it difficult to assess whether cycling has increased or decreased over time;
- Surveys conducted in 1985/86 and 2011 estimate a 25.1% increase in bicycle trips when the Australian population 9 years and older increased by 58.5%
- Australian demographics have changed substantially and must be accounted for in an analysis;
- Comparison using indirect age-sex standardised rates indicates trips by bicycle have increased by 11%;
- Australian governments should increase investments into cycling infrastructure to accommodate increased cycling and to improve cycling safety.

Abstract

There has historically been very little data on cycling in Australia. This lack of data has made it difficult to track whether cycling has changed over a long period of time. The number of cycling trips per day per person increased by 25.1% from the Day-to-Day Travel in Australia 1985/86 Survey to the 2011 National Cycling Participation Survey, while the Australian population 9 years of age and older has increased by 58.5%. The crude rate estimates a 20% reduction in cycling relative to population; however, this analysis does not account for changing Australian demographics during that time. When the rates of cycling are age-sex standardised, cycling trips in Australia increased by an estimated 11.0% (95% CI: 10.8%, 11.1%). The estimated increases in cycling trips, both in raw numbers and age-sex adjusted rates, support increased investments in cycling in Australia.

Keywords

Bicycling; Cycling exposure; Research methods; Epidemiology

Introduction

Accurate travel data is needed to estimate modal share and its trends over time. This data can then be used to make informed decisions regarding optimal allocation of limited resources and to assist in estimating rates of injuries or fatalities. Data on cycling in Australia has been very limited which makes it difficult to determine if cycling has increased or decreased over time.

The Australian Bureau of Statistics (ABS) has collected the Method of Travel to Work for Persons (MTWP) data since 1976 and data collection has continued as part of the census every five years (ABS, 2012). This data is limited in its usefulness since data is collected on single days five years apart, Census Day has changed from late June to early August, it is impossible to identify a traveller's primary travel mode, and the 1976 data was a 50% sample and not a census (ABS, 2005).

Other Australian-wide data sources include the Day-to-Day Travel in Australia 1985-86 (DDTA) Survey (Adena & Montesin, 1988), Exercise, Recreation and Sport Survey (ERASS) collected annually from 2001 to 2010 (Australian Sports Commission, 2010), and the National Cycling Participation (NCP) Survey collected every other year since 2011 (Munro, 2019). These surveys utilised different methodologies and their estimated trends are in opposite directions: the ERASS surveys estimate increased cycling, while NCPS estimates a decline. Irrespective of the results from these data sources, it is difficult to estimate trends in cycling without routinely collected surveys using a standard methodology.

The majority of available Australian data report the proportion who have ridden a bicycle over a fixed time frame, while the 1985-86 DDTA and 2011 NCP surveys report bicycle trips per day. Other measures of cycling such as kilometres or time travelled have not been collected Australia-wide or they have been estimated from other data sources (Cosgrove, 2011).

A previous study (Gillham & Rissel, 2012) compared the number of bicycle trips per day from the 1985-86 DDTA and 2011 NCP surveys, and contrasted these results to changes in Australian population estimates. The authors report the daily average number of bicycle trips for those aged 9 years and older increased by 26.2%; however, the Australian population increased by 58.4% during that time. This led the authors to conclude daily cycling participation decreased by 32.2% relative to population growth, which is the difference in their estimates of population and bicycle trip growth.

A crude comparison of changes in bicycle trips and the population is likely to be inaccurate for a few reasons. First, the two surveys were collected for different reasons with dissimilar methodologies. For example, the 1985-86 survey covered all modes of travel with data prospectively collected over 13 months using a travel diary. The 2011 survey collected data on cycling only, was performed over the phone, and responders were retrospectively asked about cycling in the past week, month or year. These differences make any comparison between these surveys tenuous at best, and any analysis should clearly identify these issues as limitations.

The absolute difference of percentages is not a valid comparison of one measure relative to another. A more appropriate comparison is to the ratio of crude rates of trips per person per day for the two surveys. In this case, the crude rates were an estimated 0.1326 and 0.1032 trips per person per day respectively for the 1985-86 and 2011 surveys. This is a rate ratio of 0.778 which can be interpreted as a 22.2% decrease from 1985-86 to 2011 surveys. These values are population estimates and therefore contain a certain amount of uncertainty in their values. This uncertainty can be expressed with a confidence interval or estimated standard error.

Finally, a simple comparison of crude rates does not account for the changing Australian population, and so the comparison of crude rates is also not correct. This can be done by comparing age-sex standardised rates via the basic epidemiological method of standardised incidence ratios. The aim of this study, therefore, is to compare cycling exposure, measured by trips per person per day, estimated from the 1985-86 DDTA Survey and 2011 NCP Survey while accounting for changing demographics in the Australian population and differences in survey methods.

Methods

Cycling travel data was extracted from the 1985-86 DDTA Survey (Adena & Montesin, 1988) and the 2011 NCP Survey (Munro, 2011). Australian population data was downloaded from the ABS website.

For the DDTA survey, the number of trips per person per day was tabulated by strata for age (9-15 years, yearly strata for 16-25 years, 26-29 years, 30-59 years, 60-64 years, 65+ years) and sex. This report also provided the 1981 Australian population by age and sex strata. The 2011 NCP survey collected data on when a responder last cycled (“last 7 days”, “last month” or “last year”). Those who cycled in the past week were also asked how many bike trips they made over the last seven days. Those who had cycled in the past month or year but not the past week did not provide data on their number of bike trips.

The age categories between the surveys can be matched, with one notable exception. The DDTA surveyed those nine years of age and older, while the NCP survey included all ages and those nine years of age are part of the 5-9 years group. To minimise potential computation errors, NCP survey data for those aged under 10 years have been excluded from the analysis.

The 2011 NCP survey reported an average of 5.4 bike trips were taken for those who had cycled in the past week. Note this estimate is across all age groups including those under 10 years of age. Clearly, those who responded they had cycled in the past month or year but not the past week should contribute data to the total number of trips. With those issues in mind, some assumptions are needed to estimate the number of bike trips taken to be as consistent as possible with the DDTA survey. These include that the average number of trips is the same across all strata for those cycling in the past week, those who cycled in the past month but not the past week took 12 bike trips on average in the past year, and those who had cycled in the past year but not the past month took 1 bike trip in the past year and no more. Under those assumptions, the total estimated number of trips per person per day T_1 from the 2011 NCP Survey is

$$T_1 = \sum_{i=1}^{k} \left(\frac{5.4p_{1i}}{7} + \frac{12(p_{2i} - p_{1i})}{365.25} + \frac{p_{3i} - p_{1i} - p_{2i}}{365.25} \right) n_i \qquad (1)$$

for age/sex strata $i = 1, \ldots, k$, where $p_1 i$, $p_2 i$ and $p_3 i$ are the estimated proportions of those cycling in the past week, month and year respectively, and n_1 is the 2010 population.

Letting T_0 be the total bike trips from the DDTA survey, the crude rate is then the ratio T_1/T_0. As discussed, this is a naïve comparison as it does not account for changing demographics. A more appropriate comparison is the standardised incidence ratio (SIR) which is the ratio of observed trips and the expected number of trips.

The expected number of trips is computed assuming the average bike trips per person per day in 1985-86 by age and sex has remained constant, given by

$$E_1 = \sum_{i=1}^{k} \frac{t_{0i}}{n_{0i}} \times n_i \tag{2}$$

where t_{0i} is the average trips per person per day and n_{0i} is the population size for strata $i = 1, \dots, k$ in the DDTA survey. The SIR is then the ratio of the number of estimated trips versus the expected number of trips,

$$SIR = \frac{T_1}{E_1} \tag{3}$$

and a $(1 - a)$ confidence interval can be computed as

$$\left[\frac{\chi^2_{2T_1,\alpha/2}}{2E_1}, \frac{\chi^2_{2(T_1+1),1-\alpha/2}}{2E_1}\right]. \tag{4}$$

It is common to report the SIR and its confidence interval by the transformation ($SIR - 1$) as it can be interpreted as a percentage increase or decrease in the number of events relative to what was expected.

The extracted data and R code (v3.4.3 "Kite-Eating Tree") to compute the statistical results are provided as supplementary material.

Results

The estimated number of bicycle trips in Australia increased by 25.1% from the 1985-86 DDTA survey to the 2011 NCP survey, while the Australian population nine years and older increased by 58.5%. The crude rate was 0.80 or an estimated 20% reduction in bike trips relative to population. When age and sex standardised, the SIR estimated an increase in bike trips of 11.0% (95% CI: 10.8%, 11.1%).

Table 1. Summary statistics of 1985-86 DDTA and 2011 NCP surveys

	1985-86 DDTA	**2011 NCP**	**Comparison**
Estimated Trips (per person per day)	1,656,100	2,072,478	+25.1%
Population (9+ years)	12,488,000	19,515,563	+58.5%
Crude Rate			0.8008
Expected Trips		1,867,758	
SIR (95% CI)			1.110 (1.108, 1.111)

Discussion

This study estimates the number of bicycle trips in Australia increased by 11% from 1985/86 to 2011 using age-sex standardisation to account for changing population demographics. In raw numbers, the estimated trips by bicycle increased by 25% which was less than the increase in population. The discrepancy between crude and age-sex standardised rates can readily be explained by the ageing Australian population. Both surveys support the hypothesis that as one gets older, the less likely they are to cycle. These results do not suggest older people should not cycle, but it does suggest older age makes cycling less attractive, albeit the data used in this study predate the recent popularity of e-bikes among older persons.

This study highlights the general lack of Australian cycling data and the need to collect relevant data in the future. This data is crucial to our understanding of trends in road safety by allowing estimation of injury and fatality rates per amount of cycling exposure instead of simple population rates. Mobility data can take on several forms such as number of trips, distance and time travelled by mode of transport including by bicycle. Other countries such as The Netherlands and Finland have collected such data using stratified random sampling surveys and travel diaries (SWOV, 2013; Radun & Olivier, 2018). It is recommended that Australia collects high-quality mobility data using standard methods collected on a routine basis.

The results from this study contrast greatly with Gillham and Rissel (2012) who claimed Australian cycling reduced by 32.2%. Changes in Australian population demographics over the past several decades have been well-documented and need to be accounted for in any analysis such as age-sex standardisation. The authors attributed the decline to a focus on motorised transport, a lack of cycling infrastructure, and bicycle helmet legislation. The results from this study do not support the argument Australian bicycle helmet legislation has deterred cycling.

This study does support the increase in cycling infrastructure expenditures since Australian bicycle trips have increased by 25%. Further, the majority of Australians identify a lack of cycling infrastructure as the reason for not cycling or not cycling more (National Heart Foundation, 2011), while Australian mobility is instead often centred on personal motorised vehicles (BITRE, 2012). Increased cycling infrastructure may also help address rising congestion in urban areas (Department of Infrastructure and Regional Development, 2016).

Any analysis using these data has several limitations. The primary comparison is the number of bike trips in 1985-86 to

2011; however, the 2011 NCP survey provided little detail on how the average trips were computed and estimates are not available by age or sex. There are also some discrepancies in the 2011 NCP survey on bike trips. The possible categories in the survey script (Appendix A) are “1 or 2 trips”, “3 to 5 trips”, “5 to 10 trips”, “More than 10 trips”, and “Don’t know”. However, this data summarised in Table 4.6 of Munro (2011) contain the categories “≤2 trips”, “3-4 trips”, “5-6 trips”, “7-10 trips”, and “11+ trips”. In Section 4.2 and Figure 4.1 of the NCP report, the average number of trips by state, territory and Australia-wide are provided; however, it is unclear how these were computed from those categories.

It is unclear whether the estimated SIR holds for later NCP surveys. The question regarding number of trips was not included in any of the later surveys. For the 2011 survey, the number of bike trips was not collected for those cycling in the past month or year but not the past week. It is clear their data should contribute to the estimated number of bike trips, but the approach chosen may provide inaccurate results. However, when trips are counted only for those cycling in the past week, there is still an estimated increase in cycling (+7.86%, 95% CI: 7.71%, 8.01%). Finally, as we noted in the methods section, the age categories used between the surveys did not fully match and data aggregation could not reconcile those nine years of age. Finally, variance estimates in accordance to the study design were not reported in the DDTA survey and, therefore, the reported confidence intervals are likely too narrow. Bootstrap confidence intervals were computed and the results were similar albeit the intervals were slightly wider (95% CI: 1.109, 1.126).

Conclusions

There are far too few data on cycling in Australia, and the limited available data is often misused or incorrectly interpreted. When accounting for changing population demographics, the results of this study suggest cycling has increased in Australia from 1985-86 to 2011 by 11%, although any analysis on disparate data sources should be interpreted with caution. The estimated increase in bike trips, both in raw terms and age-sex adjusted, supports increasing resources for cycling in Australia.

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Does the Australian Bureau of Statistics Method of Travel to Work data accurately estimate commuter cycling in Australia?

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Key Findings

- Method of Travel to Work data is collected for Australian Census Day every 5 years;
- MTWP data has been used to estimate Australian cycling;
- It is unclear if MTWP accurately estimates Australian cycling;
- No change in MTWP cycling data among active transport users from before to after bike helmet laws;
- Estimated changes after helmet laws are heterogeneous at the state/territory level.

Abstract

The Australian Census of Population and Housing includes a responder's Method of Travel to Work for Persons (MTWP) on Census Day. With some exceptions, responders can select multiple modes of transport. In Australia and overseas, this data has been used to estimate mode share and the proportion of Australians who utilize various active transport modes. This is especially true for cycling as there are scant data sources for Australian cycling exposure. The aims of this paper are to discuss weaknesses of MTWP data and the appropriateness of MTWP data to estimate cycling in Australia, and to assess changes in MTWP data relative to the introduction of bicycle helmet legislation. The use of MTWP data to estimate Australian cycling is limited due to: (1) data collection occurring on single days in winter once every five years, (2) it is not possible to identify a primary mode of transport, and (3) the 1976 data was not a full enumeration. MTWP data estimates about 1.5% of Australians cycle while other data sources are much higher ranging from 10% to 36%. With regard to bicycle helmet legislation, comparisons were made for each state/territory for the census immediately preceding helmet legislation and the following census. Overall, the proportion of cyclists among active transport users is similar from pre- to post-legislation (relative change=+1%, 95% CI: -13%, +18%), although all but two states/territories estimate an increase in cycling. In conclusion, the Australian government should invest in routinely collecting high-quality mobility data for all modes of travel to assist in the decision-making and assessment of road safety policies.

Keywords

Cycling exposure, Cycling mode share, Census data, Bicycle travel, Cycling temporal patterns, Bicycle helmet law

Introduction

The Australian Bureau of Statistics (ABS) has collected data on the Method of Travel to Work for Persons (MTWP) since 1976 with observations occurring five years apart and on a single day of the year (ABS, 2012; Mees & Groenhart, 2012). The Census Day has varied from the end of June prior to the 1991 census and then to early August for all subsequent censuses (see Table 1).

For the 2011 census, the question read "How did the person get to work on Tuesday, 9 August 2011?" (see Figure 1). Responders can mark either train, bus, ferry, tram (including light rail), taxi, car – as driver, car – as passenger, truck, motorbike or motor scooter, bicycle, walked only, worked at home, other, or did not go to work. Multiple responses are allowed and recorded in the order written on the form. The responses "did not go to work", "worked at home",

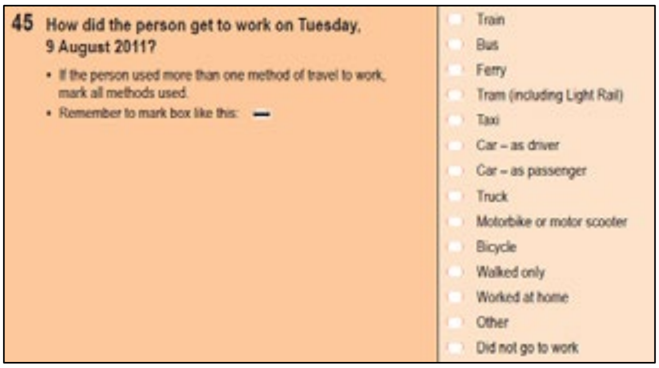
Table 1. Australian Census Day (1976-2011)

Census Year	Census Day	Day of Week
1976	29 June	Tuesday
1981	29 June	Monday
1986	30 June	Monday
1991	6 August	Tuesday
1996	6 August	Tuesday
2001	7 August	Tuesday
2006	8 August	Tuesday
2011	9 August	Tuesday
2016	9 August	Tuesday

and "walked only" are not meant to be part of a multiple response (ABS, 2012). When this occurs, a single response is recorded with preference in the order given above. For example, someone responding with "did not go to work" and "walked only" is recorded as "did not go to work".

The MTWP data has been used to describe temporal patterns in Australian capital city commuter travel since 1976 (Mees, Sorupia & Stone, 2007; Mees & Groenhart, 2012). In these reports, cycling to work is considered negligible with the notable exception of Canberra.

Additionally, the MTWP bicycle data has been used in a cycling "league table" that compares cycling participation



45 How did the person get to work on Tuesday, 9 August 2011?

- If the person used more than one method of travel to work, mark all methods used.
- Remember to mark box like this:

- Train
- Bus
- Ferry
- Tram (including Light Rail)
- Taxi
- Car – as driver
- Car – as passenger
- Truck
- Motorbike or motor scooter
- Bicycle
- Walked only
- Worked at home
- Other
- Did not go to work

Figure 1. Question 45 from 2011 Census Household Form

between countries (Pucher & Buehler, 2008). Australian bicycle trips are presented as being uncommon compared to select European countries, while having similar cycling participation to North American countries, Ireland and the UK (see Figure 2).

On several occasions, the MTWP bicycle data has been used to advocate for the repeal of bicycle helmet legislation (BHL). Figure 3 includes examples from Wikipedia (2019), online news outlets (Alter, 2014; Rachele, Badland & Rissel, 2017), anti-helmet advocacy websites (Freestyle Cyclists, 2014; Gillham, 2019), and submissions to government inquiries (Clarke, 2015). In each instance, the message conveyed is that bicycle helmet legislation has deterred cycling in Australia.

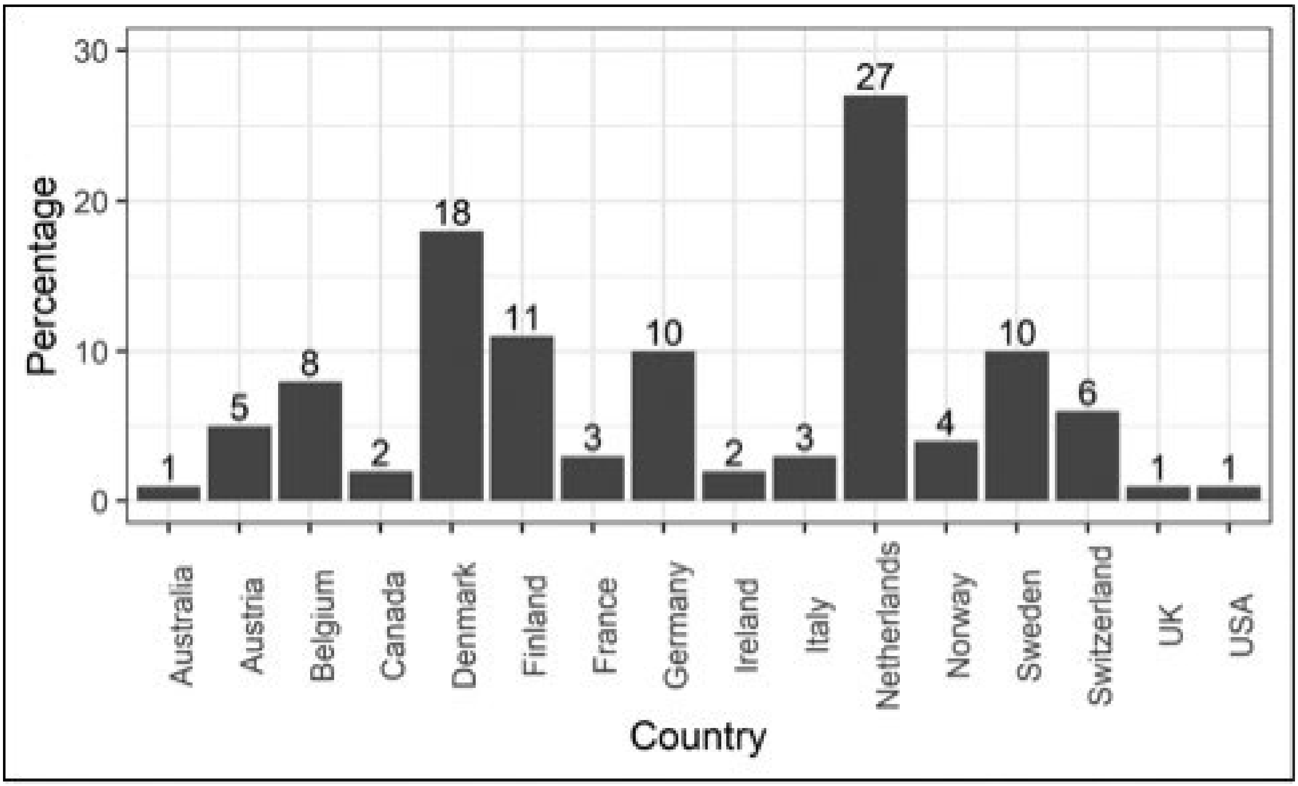
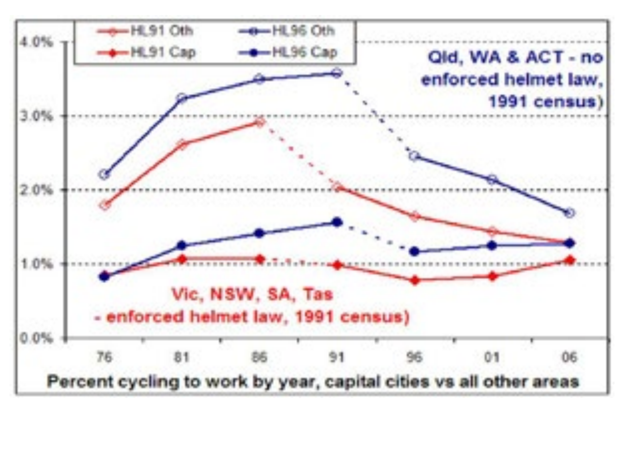
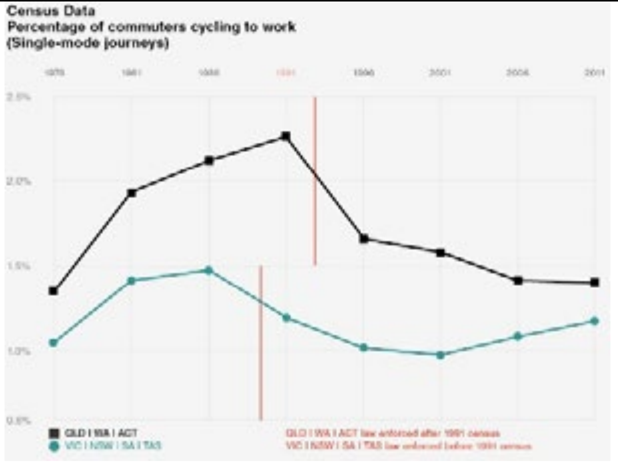


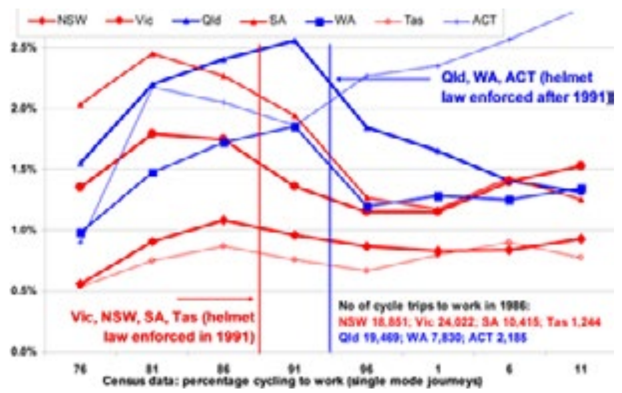
Figure 2. Reported percentage of trips by bicycle (source: Pucher & Buehler, 2008)



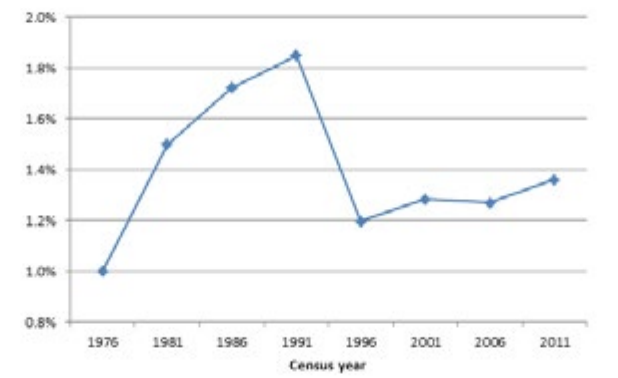
Source: Alter (2014), Clarke (2015)



Source: Freestyle Cyclists (2014),



Source: Wikipedia (2019)



Source: Rachele et al (2017)

Figure 3. Examples of using MTWP data to advocate for repeal of Australian bicycle helmet legislation

Although often presented as yearly aggregated data, the MTWP data is collected for single days with repeated observations 5 years later. That is, from 1976-2016, nine days of data were collected and not 40 years' worth. The Census Day has always occurred in Australian winter, which may impact on the generalisability of the results to the adult population across an entire year. The change in Census Day from late June to early August makes comparisons between the 1976-1986 and 1991-2016 censuses tenuous. The data collection (single days in winter) make it impossible to account for day of the week, monthly or seasonal variation. Further, the MTWP captures travel to work for adult Australians and, therefore, cannot be an accurate representation of all types of cycling by all Australians.

Since MTWP allows for multiple response, it is not possible to identify a responder's "main mode" of travel (Olivier, Esmaeilikia & Grzebieta, 2018). For example, a person who rides their bicycle to a train station, travels on the train with their bicycle, and then cycles the remaining distance to work would always be recorded as "train, bicycle". This would be the same response for any trip where train and bicycle travel were combined irrespective of trip distance or time spent in either travel mode (e.g., ride from home to the train station and leave bicycle locked at the station). Some authors focus on those travelling by bicycle only (e.g., Gillham, 2019); however, this approach miscategorises those who combine cycling with other transport modes as non-cyclists. Rain, temperature and wind speed could also influence MTWP data, although any analysis would have difficulty in reconciling weather data collected at approximately 900 sites to the six Australian states and two territories.

The 1976 Australian Census did not include a full enumeration or count (ABS, 2005a). Due to budgetary constraints, a full count was performed only on age, sex, marital status and birthplace (ABS, 2005b). For all other questions including MTWP, a 50% sample was processed, and a post-census assessment found undercounting was higher for the 1976 Census than previous ones. That is, it is unlikely the 1976 MTWP data is an accurate representation of those travelling to work on Census Day.

Travel modes using MTWP data are often represented as a proportion of those travelling to work on Census Day, often called modal share. Note the MTWP cannot be used as a measure of modal share in the strictest sense as not all trips are enumerated. Representing this data as a proportion can also hide temporal patterns. For example, the numbers of cyclists could increase from one Census Day to the next, but

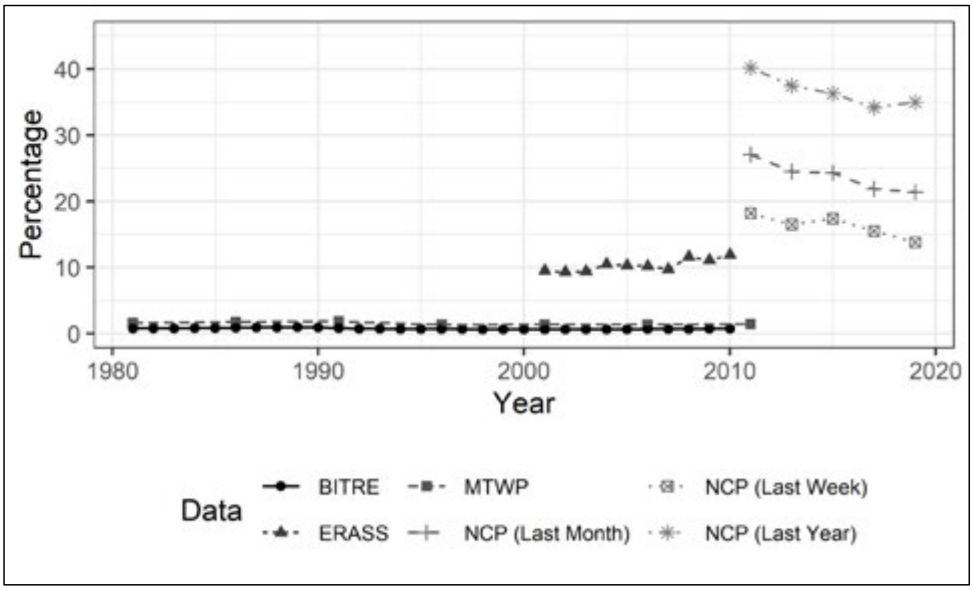


Figure 4. Estimated proportion of Australians who ride a bicycle (sources: BITRE, 2012; ABS, 2011; ASC, 2010; Munro, 2019)

the mode share could decrease if increases were larger in other travel modes. In that case, a decline in mode share does not necessarily imply less cycling but could be interpreted as an increase in cycling that did not keep pace with other travel modes.

The aims of this study are to highlight the often unreported weaknesses in the MTWP data, discuss the accuracy of MTWP data to estimate Australian cycling, and to assess the validity of whether the MTWP bicycle data supports the claims bicycle helmet legislation deters cycling.

Australian Cycling Data

MTWP data has been provided by the Australian Bureau of Statistics for years 1976-2001 while data for 2006 and 2011 were extracted from the ABS website. The 1976 data was excluded since only a 50% sample was counted.

As discussed, it is not possible to identify a responder's "main mode" of travel, while focusing on single mode travel miscategorises those involved in multimode travel. Since the purpose of this study is to assess changes in MTWP cycling data, transport modes were defined as using a bicycle for any leg of travel (Bicycle), walking only (Walking), the use of a bus, ferry, train or tram for any leg of travel except when a

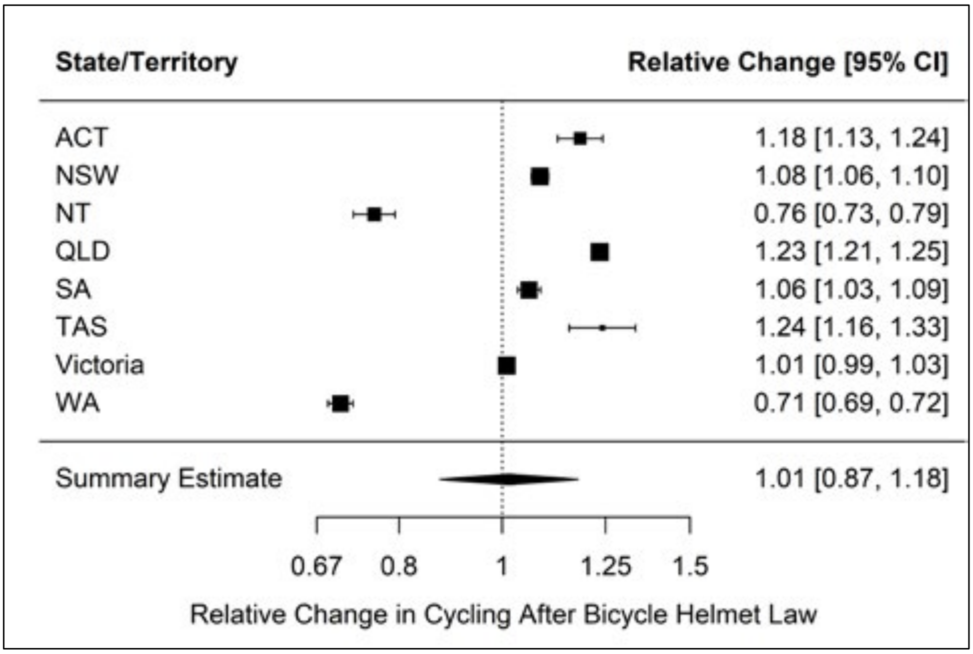


Figure 5. Forest plot of relative change in cycling to work following bicycle helmet legislation among active transport modes by state/territory

bicycle was used (Public Transport), and the use of a car or truck when neither a bicycle or public transport were used for any leg of travel (Vehicle). The total travellers exclude those who did not go to work, worked at home, or whose mode of travel was unknown.

There are very few data sources for Australian cycling, and data that does exist has not been collected routinely using a standard methodology. In addition to MTWP, the available Australian-wide data sources include the Participation in Exercise, Recreation and Sport Survey (ERASS) (Australian Sports Council, 2010), the Australian National Cycling Participation Survey (NCP) (Munro, 2019), kilometres travelled in capital cities (BITRE, 2012; Cosgrove, 2011), and Day-to-Day Travel in Australia (Adena & Montesin, 1988). For comparisons with MTWP data, ERASS, NCP, BITRE and Day-to-Day Travel in Australia summary data were extracted from their respective reports.

MTWP and Australian Cycling

Australian bicycle travel as a percentage of responses for each data source is given in Figure 4. A notable exception is the Day-to-Day Travel survey which collected data over a 13-month period in the mid-1980's and, to date, has not been repeated. The NCP data provide estimates for those cycling in the past week, month and year with each included in the figure, while ERASS data are proportions cycling in the past year for exercise, recreation or sport only. BITRE data are estimated from several data sources (Cosgrove, 2011) including MTWP data, so they are likely to provide similar estimates.

The differences in the average proportions cycling between the data sources is large. MTWP data estimates about 1.5% of Australians cycle (when cycling is examined for one day every 5 years) while other data sources are much higher ranging from 10% to 36% (when cycling is examined over extended periods such as a year). This can be partially explained by differences in data collection methods and the types of cycling that are captured. However, such differences make it difficult to accurately estimate cycling across Australia and, therefore, how Australia compares internationally. For example, when contrasted with the Pucher and Buehler (2008) league table, Australians cycling would rate highly according to ERASS or NCP (last week) surveys instead of MTWP data.

MTWP and Bicycle Helmet Legislation

The MTWP data has been organised by state or territory since bicycle helmet laws were enacted at those levels (Esmaeilikia, Grzebieta & Olivier, 2018). As discussed, MTWP data cannot accurately estimate temporal trends in cycling and, in particular, it is not possible to estimate the pre-helmet law trend as data exists for only two Census Days for most states. Additionally, changes in cycling may be part of other changes in active transport modes (i.e., cycling, walking, public transportation). To account for these issues, comparisons of the proportion of cyclists among active transport users are made using the census immediately preceding bicycle helmet legislation and the following census by state/territory. The summary results are given in Figure 5.

The proportion of cyclists among active transport was similar from pre- to post-bicycle helmet legislation in Australia (RR (rate ratio) = 1.01, 95% CI: 0.87, 1.18). There was an estimated increase for all states/territories except for the Northern Territory and Western Australia. Both jurisdictions introduced BHL after the 1991 census date and their decline could be due to a general reduction in cycling across Australia as reductions were observed from the 1991 to 1996 censuses for all other jurisdictions except the ACT. Additionally, there were large increases in the use of public transportation since the 1996 census for many jurisdictions which could indicate a shifting among active transport modes. The observed reduction in WA could also be an artefact of the inaccuracies of MTWP data as stratified random sampling surveys at this time did not estimate a reduction in cycling (Olivier, Boufous & Grzebieta, 2016).

Overall, the numbers who reported using a bicycle for travel to work prior to any helmet legislation was 92,517 in 1986 which increased to 104,470 in 1991 when most of Australia had helmet legislation. Cycling mode share increased slightly between these years as well from 1.74% to 1.84%.

Discussion

There are very few data sources for cycling in Australia. The Australian Method of Travel to Work for Persons data may provide an accurate picture of travel to work on each Census Day, but this data is limited in answering other important bicycle-related questions. Further, when compared to other Australian-wide data sources, it is unclear how many Australians are cycling.

Accurate cycling data is important for health and infrastructure planning. Cycling exposure data helps us better understand the size of bicycle-related injury/fatality by helping explain changes in injury patterns that are not due to changes in injury risk. Better cycling data could be used to justify increased cycling infrastructure expenditures for areas with increased cycling. This last point highlights the need for localised data that is not possible with highly aggregated, nation-wide estimates. For example, although the MTWP data estimate 1.7% of Victorians cycled to work in 2011, an estimated 22% of City of Melbourne residents cycled in the past week in 2013 and cyclists constituted 16% of vehicle movements during morning commuting in 2017 (City of Melbourne, 2019). Although this comparison does not demonstrate the inaccuracies of MTWP data, it underscores the unsuitability of high level data for decisions made at localised levels such as building cycling infrastructure.

Routinely collected travel surveys are unfortunately not the norm. For example, Sweden has conducted only four in the past 30 years (Petersen et al, 2015), while Finland has conducted three (Radun & Olivier, 2018). In our opinion, the current best-practice country for cycling data collection is The Netherlands who have conducted yearly mobility surveys since the 1980's (SWOV, 2013). About 100 Dutch residents per week are randomly selected and complete a travel diary over the following week. Data on trips and kilometres travelled are stratified by transport mode and age group.

Conclusions

Despite its limitations, MTWP data is often used as an estimate of cycling mode share. The use of this data is problematic for several reasons including: (1) single day observations in winter with sampling only every five years, (2) month of data collection changed when bicycle helmet laws were introduced, (3) not possible to identify a primary travel mode, (4) the 1976 data was not a census, and (5) representing the data as a proportion can hide temporal patterns.

When some of these issues are addressed (elimination of 1976 data and all bicycle travel counted), the MTWP data indicates a mixture of increasing and decreasing bicycle travel on Census Days over time. However, when contrasted with other cycling data, it is unclear whether MTWP data accurately captures cycling in Australia.

With respect to bicycle helmet legislation, the proportion of cyclists among active transport users was similar for Census Days before and after the introduction of these laws. However, caution should be exercised in interpreting these results in light of many limitations.

Australia needs to collect high-quality mobility data using a standard methodology on an annual basis. This data is vital to our understanding of how to make transport safer and to inform policymakers where often scarce resources should be applied.

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Contributed Articles

Road Safety Policy & Practice

Child restraints for cars in low and middle-income countries

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Key Findings

- Modern child restraints are designed to be compatible with modern cars such as those with ISOFIX/iSize and top-tether anchorages
- In low and middle-income countries (LMIC) most cars, including new models, do not have these advanced anchorage systems and many do not have seat belts in rear seats
- These LMIC vehicles can be retrofitted with rear seat belts and top-tether anchorages so that children can be safely transported in restraints appropriate for their age
- Schemes that encourage local automotive repair businesses to carry out these retrofits should be introduced in LMIC
- Low-cost child restraints with top-tethers and shoulder height labels should be encouraged

Abstract

When used correctly, modern child restraints provide exceptional protection for children in car crashes. Most vehicles sold in high-income countries (HIC) have top tether anchorages and/or ISOFIX lower anchorages that are intended to reduce the incidence of misuse, in addition to improving occupant protection. Most vehicles in LMIC do not have these features and many do not have seat belts in rear seats or have inferior lap-only seat belts in these seats. Children in these vehicles are at much greater risk of severe injury in the event of a crash. This paper examines ways to safely restrain children in these ill-equipped vehicles, mainly through retrofitting child restraint anchorages and seat belts.

Keywords

Child restraint, crashworthiness, seat belts

Introduction

Modern child restraints are designed to be compatible with modern cars that have i-Size anchorage systems (e.g. ISOFIX lower anchorages) or seat belts and top-tether anchorages (e.g. LATCH). These combinations provide exceptional crash protection for children as well as minimise risks due to incorrect installation in vehicles (Durbin, 2011). Most vehicles in LMIC do not have these modern features and many older vehicles do not have seat belts in rear seats or have inferior lap-only seat belts in these seats. Children in these vehicles are at much greater risk of severe injury in the event of a crash.

This paper examines ways to safely restrain children in these ill-equipped vehicles by drawing on experiences in Australia in the 1980s and early 1990s when many ill-equipped vehicles were still in use on Australian roads.

Principles of child restraint

The principles for safe restraint of children in motor vehicles were described in an Australian in-depth study of children in car crashes (Henderson, 1994) and earlier research (Herbert et al., 1974):

- The child should be retained within the vehicle;
- The child's head and torso should be prevented from hitting the interior of the car;

Table 1. Risk of death or serious injury for a 3-4 year old child

Type of Restraint	Odds Ratio (3-pt seat belt = 1)	% Saved (if in child seat)	Reference
Child seat with integrated harness	0.22	0%	Abogast 2002
Booster with 3-point seat belt	0.55	60%	Durbin 2003, 2011
3-point seat belt	1	78%	Abogast 2002
2-point seat belt	2	89%	Abogast 2002
Unrestrained	3	93%	Durbin 2005

- The restraining systems in forward- facing devices should distribute the crash forces between the chest and pelvis, without heavy loading of other parts of the body.

Numerous studies have shown that it is very important that children be correctly restrained in safety devices that are appropriate for their age (Henderson 1994, Durbin 2005, Durbin 2011, Weber 2000). The following analysis considers children in the 3 to 4 year age range, which is when most children move from a child seat with integrated harness to a booster seat and adult seat belt, if one is available. It illustrates the benefits of remaining in a dedicated child seat for as long as possible. The analysis is based on a 2007 review of Australian child restraint laws by the National Transport Commission (NTC 2007) and data published by the US Centers for Disease Control and Prevention (CDC 2017). The baseline for the odds-ratio in Table 1 is the risk of death or serious injury for a 3-4 year old using a 3-point seat belt with no booster seat. The estimated savings in deaths and serious injuries ("% Saved") are based on the risk for a 3-4 year old using a child seat with integrated harness since this is the safest configuration for this age group. For example, it is estimated that 93% of deaths and serious injuries could be prevented if unrestrained infants were properly restrained in a child seat with integrated harness. This is illustrated in Figure 1.

Rice and Anderson (2009) derive fatality risk ratios that are less than those in Table 1 but these are not directly comparable since they do not account for serious injury. The data presented in Table 1 are mostly based on crash data from the USA between 1990 and 2000 and include serious injuries. Modern cars in high-income countries are likely to be much safer than those in use during that period and so current effectiveness of child restraints in HIC may differ from those findings. However, the typical car now in use in LMIC is similar to those in the studies in Table 1 and therefore these data are considered relevant for the current analysis.

The safest configuration for an infant (age approximately 1 year to 4 years) is a child seat with integrated harness. The child seat needs to be securely anchored to the vehicle with a means to prevent it tipping forward (pitching) and so reduce head excursion and the risk of head and neck injury. This can be achieved by using a seat belt or ISOFIX lower anchorages to anchor the bottom of the child seat and a top tether to anchor the top of the child seat, as illustrated in Figure 2. This configuration has been used in Australia since the mid-1970s and has been found to provide exceptional protection (Henderson, 1994; Henderson et al., 1994; Brown et al., 2002; Paine et al., 2003). The use of a top tether provides much better protection than the use seat belts alone without another means of providing pitch control.

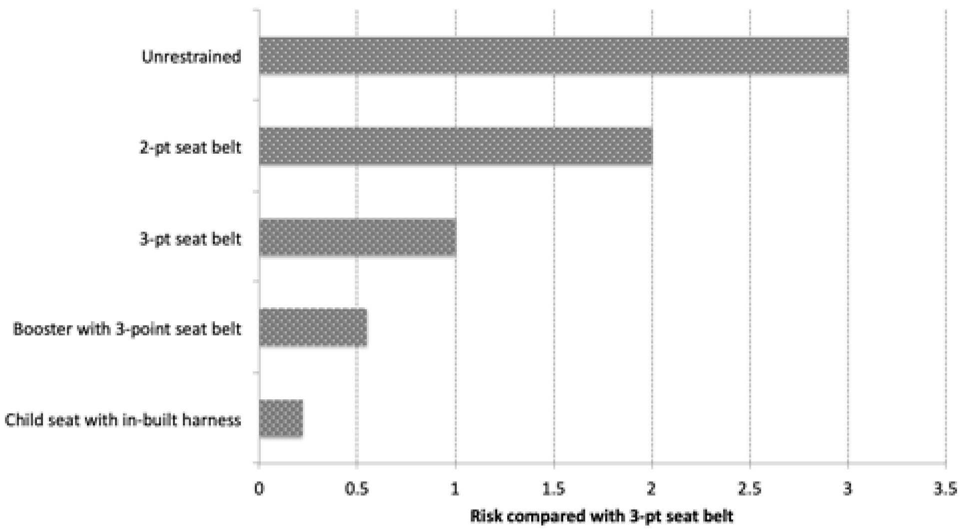

Figure 1. Relative risk of death or serious injury for a 3-4 year old child

Figure 2. Child seat with 6-point harness, anchored to vehicle with a top tether and seat belt

Child occupant safety in LMIC

In its 2018 Global Report on Road Safety, the World Health Organisation (WHO) lists the status of child restraint laws and usage rates for 181 countries (WHO 2018: Table A8). This indicates that only eleven out of about 150 LMIC have child restraint laws. Very few LMIC have any usage data and, where available, the percentage of children using child restraints is very low.

WHO/UNICEF reported that an estimated 262,000 children and youths aged up to 19 years died in traffic crashes in 2004 (Peden et al., 2008). It also reported that more than 90% of traffic fatalities occur in LMIC. Assuming that about 20% of the child/youth fatalities were in the one to four year age range and that around 30% of these were car occupants then it is estimated that in 2004 more than 14,000 children aged one to four died as car occupants in traffic crashes in LMIC.

Applying similar proportions to the estimated 10 million children aged up to 15 years who were hospitalised as a result of traffic crashes in 2004 (Peden et al., 2008) gives an estimated 675,000 children aged one to four who were seriously injured as car occupants in traffic crashes in LMIC. The actual number might be much higher than this because surveys from Africa and Asia that found for every child who died 254 children were presented to a hospital with injuries as a result of road traffic crashes (14,000 estimated fatalities times 254 equals more than 3 million serious injuries).

Most of these infant car occupants in LMIC would have been unrestrained (WHO, 2018). As shown in Figure 1, an unrestrained infant has a much higher risk of death or serious injury compared to an infant secured in a child seat with integrated harness. This suggests many child casualties in LMIC could be prevented by appropriate child restraint use. Child restraint use in LMIC may be improved via 1) equipping vehicles with child restraints and 2) assisting carers to acquire and use appropriate child restraints.

Equipping vehicles with child restraints

A child seat with integrated harness and top tether is intended for cars with 2-point or 3-point seat belts in the rear seat combined with a top tether anchorage. Seat belts and seat belt anchorages are specified in UN Regulations 14 and 16 and equivalent national regulations but WHO reports that around 70% of countries have not regulated for basic vehicle safety standards such as seat belts (WHO 2018). As a result many cars in LMIC have no seat belts in the rear seats and very few have top tether anchorages.

Most new cars that are designed for international markets already have provision for top tether anchorages. However new cars intended for domestic markets in LMIC are unlikely to have these anchorages. For example, Indian Automotive Industry Standard 72 specifies top tether anchorages but it appears that very few locally made cars in India have these anchorages (author's observations).

For those cars that do not have them, top tether anchorages are easily retrofitted to the rear parcel shelf of a sedan, as shown in Figure 2 (Henderson, 1994). There are simple installation solutions for other styles of vehicle. In Australia in the 1980s there was an extensive program of retrofitting top tether anchorages to vehicles. For example, in New South Wales, a network of "Restraint Fitting Stations" was established where private businesses such as automotive repair shops were trained and equipped for child restraint installation services, including retrofitting seat belts and top tether anchorages (Centre for Road Safety, 2017). These businesses also provide advice to clients on correct installation of child restraints. A similar system operates in the USA (https://cert.safekids.org/find-tech-0).

Other methods of preventing pitch rotation, such as support legs, are used in some regions but these tend to rely on ISOFIX lower anchorages that are not universally fitted. Furthermore, ISOFIX anchorages are not easily retrofitted to most vehicles. The preferred solution for most LMIC cars is to retrofit seat belts, where not fitted, and top tether anchorages.

Low-cost child restraints

Modern child restraints in HIC have tended to become relatively expensive, likely due to the addition of features or functions that are not directly related to safety. For example, many are promoted on the basis that they can be converted from one mode to another (e.g. rearward-facing to forward-

Figure 3. Early Australian child restraints - Safe-n-Sound Baby Capsule and Series 3 Child Seat with top tethers. The lap belt passes around the front of the Series 3 making it simple to install.

facing). This often involves compromises and tends to add complication to the design as well as increasing the risk of misuse. Evidently there is a need for simple, low-cost child restraints for widespread use in LMIC.

In Australia there have been at least two basic designs of child restraint that have proved to be highly effective in sled tests and real-world crashes but were relatively inexpensive to produce. These are the Safe-n-sound Baby Capsule and the Safe-n-Sound Series 3 child seat (Figure 3). They are no longer in production but both appear to be well-suited to modern mass production techniques and could be considered as a basis for development of low-cost child restraints for LMIC (subject to patents and copyrights). The provision of low-cost child restraints is one of the strategies suggested by WHO to improve child occupant safety in LMIC (Peden et al., 2008)

Figure 4. Shoulder height labels showing the size range for occupants.

In 2010 the Australian Standard for child restraints was revised to require shoulder height labels that indicate when a child is too small or too large for the restraint (Figure 4). These labels should be considered for child restraints in LMIC because they assist carers to select the appropriate type of restraint for the size of the child.

Summary of strategies to improve child occupant safety

A range of strategies should be considered in order to improve child occupant safety in LMIC. These include addressing shortcomings in regulations for new vehicles, retrofitting seat belts and child restraint anchorages to existing vehicles that lack these features, encouraging carers to use child restraints and giving guidance on the correct use of these restraints.

Child occupant deaths and serious injuries in LMIC may be prevented through the following steps:

Require all new light vehicles to be fitted with seat belts in accordance with UN Regulations 14 and 16 or equivalent

Where seat belts are fitted to rear seats, encourage the fitting of top tether anchorages to vehicles that do not have them

Where seat belts are not fitted, encourage the fitting of seat belts and top tether anchorages

Encourage schemes to support automotive repair shops and similar businesses that are able to retrofit top tether anchorages and seat belts to older vehicles

Encourage the availability and purchase of child restraints with top tethers for use in vehicles with top tether anchorages and consider supporting the manufacture of simple, affordable child restraints with top tethers

Provide guidance to carers on the use of child restraints that are appropriate for the size of the child and consider the introduction of shoulder height labels to assist in correct selection of child restraints for the size of the child.

Conclusions

Many old and new vehicles in low and middle-income countries are unsuitable for safely transporting children due to a lack of seat belts in rear seats. Many also lack upper anchorages for top tethers or other means to secure child restraints and reduce head excursion. Many deaths and serious injuries could be prevented by addressing these shortcomings and by encouraging carers to acquire and correctly use child restraints.

This situation is similar to that in Australia in the 1980s and 1990s and some of the strategies introduced in Australia at that time can be applied to child occupant protection in LMIC. In particular a program for retrofitting seat belts and top tether anchorages through a network of approved automotive repair businesses could be implemented. This network could also provide guidance to carers on the correct use of child restraints.

In addition there is a need for low-cost child restraints with top tethers and shoulder height labels for use in these upgraded vehicles. This would provide a level of protection approaching that of child restraint systems in use in high-income countries.

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Early work on the development of child restraints was conducted by the test laboratory of the NSW Traffic Accident Research Unit (now Crashlab). The author was not involved in that innovative work.

This document represents the author's views and does not represent the views or policies of any organisation. The advice and recommendations provided in this paper are of a general nature. Always check with local authorities when considering the restraint of children in vehicles.

"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**

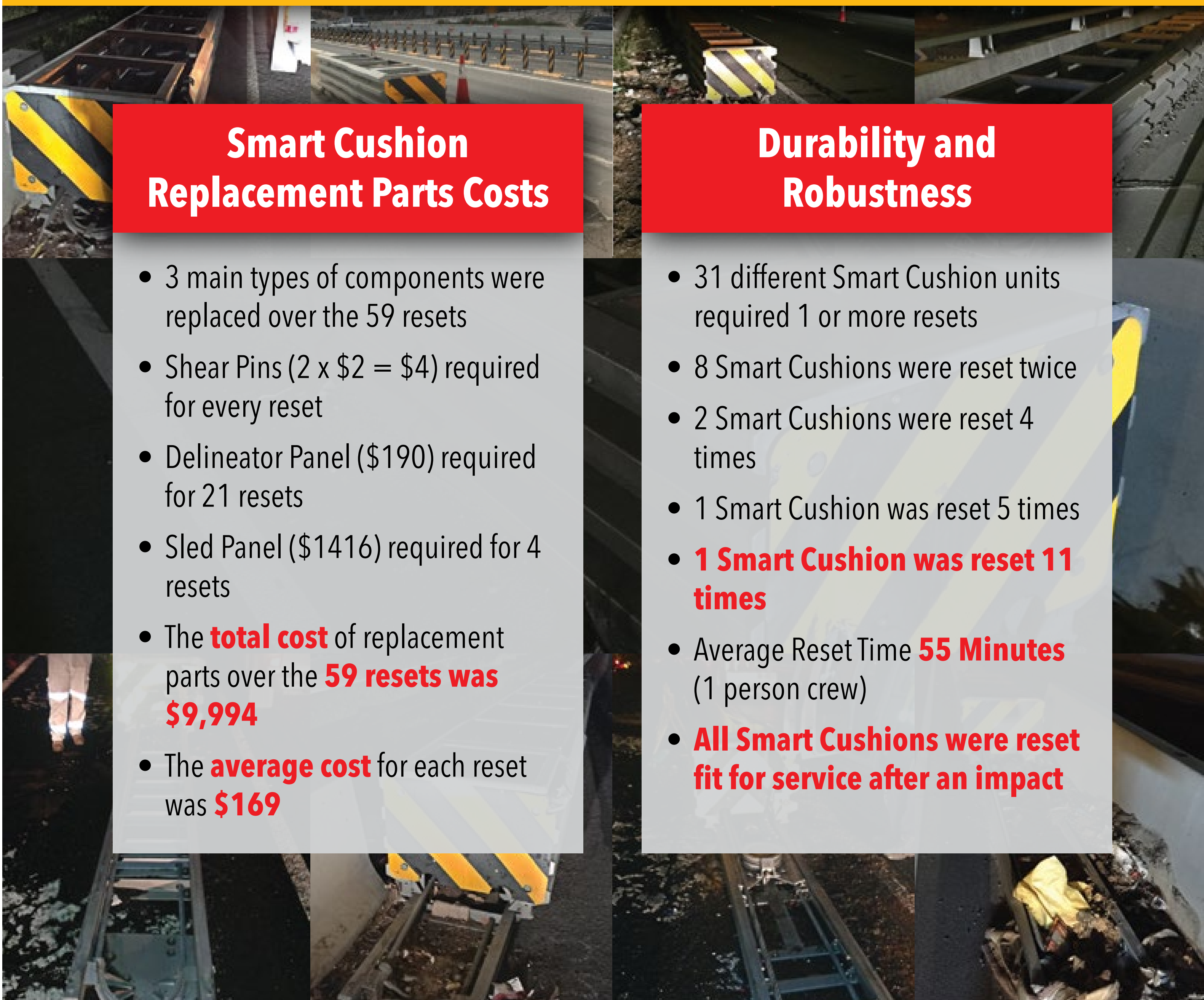
By drawing on the Register of Road Safety Professionals, the College assists members with access to expertise such as expert witnesses for court proceedings and to field media enquiries.

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 AUSTRALIAN 2 YEAR IN-SERVICE PERFORMANCE REPORT



Smart Cushion Replacement Parts Costs

- 3 main types of components were replaced over the 59 resets
- Shear Pins (2 x $2 = $4) required for every reset
- Delineator Panel ($190) required for 21 resets
- Sled Panel ($1416) required for 4 resets
- The **total cost** of replacement parts over the **59 resets was $9,994**
- The **average cost** for each reset was **$169**

Durability and Robustness

- 31 different Smart Cushion units required 1 or more resets
- 8 Smart Cushions were reset twice
- 2 Smart Cushions were reset 4 times
- 1 Smart Cushion was reset 5 times
- **1 Smart Cushion was reset 11 times**
- Average Reset Time **55 Minutes** (1 person crew)
- **All Smart Cushions were reset fit for service after an impact**

SMART CUSHION
Speed Dependent Crash Attenuators

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