Vol 30, Issue 2, 2019

Journal of the Australasian College of Road Safety

Peer-reviewed papers

Contributed articles

What does the data say?
Explore NSW road crash and trauma trends

NSW has some of the most extensive and high quality information on road crashes in the world.

This quality data helps us understand and better respond to what is causing road trauma, so it is important that we continue to enhance data collection and supporting systems to increase our understanding.

Given the importance of this information, we make it available to road safety practitioners, delivery partners and the community.

Explore the interactive road crash data on the Centre for Road Safety website to find:

- **In 2017, how many people sustained a serious injury on NSW roads?**
- **How many of those with a serious injury were motorcyclists?**

Motorcycle riders are more exposed and risk serious injuries if they are in a crash. Protective gear, including helmets, can be life-saving.

- **In 2017, how did metropolitan and country areas differ in relation to the occurrence of fatalities and serious injuries?**

Trauma rates are influenced by the different elements of the safe system: road characteristics, behavioural factors, speed and vehicle type. For example, country areas have more high-speed roads and people tend to drive longer distances. In metropolitan areas, there are more areas with high volumes of pedestrian activity.

- **In 2017, how many pedal cyclists were admitted to hospital?**
- **How many of those pedal cyclists had a head injury? Hint: See location of injuries**
- **How many of those pedal cyclists had a high threat to life?**

Research shows that helmets reduce head injuries by up to 74 per cent in crashes with motor vehicles.

For more information visit **www.roadsafety.transport.nsw.gov.au**

Note: The 2018 preliminary serious injuries data will be available in July 2019

NSW GOVERNMENT

TOWARDS ZERO

The Australasian College of Road Safety (ACRS) and Austroads invite you to attend the largest road safety-dedicated conference in the Southern Hemisphere. The 2019 Australasian Road Safety Conference (ARSC2019) will be held in Adelaide at the Adelaide Convention Centre from Wednesday 25 to Friday 27 September 2019.

ARSC2019 will showcase the region's outstanding researchers, practitioners, policy-makers and industry spanning the plethora of road safety issues identified in the United Nations Decade of Action for Road Safety: Road Safety Management, Infrastructure, Safe Vehicles, User Behaviour, and Post-Crash Care. ARSC2019 will bring with it a special focus on engaging all levels of government and community, from the city to the bush, to move "Leading the Way – Towards Zero". The comprehensive 3-day scientific program will showcase the latest research; education and policing programs; policies and management strategies; and technological developments in the field, together with national and international keynote speakers, oral and poster presentations, workshops and interactive symposia.

WHO SHOULD ATTEND?

ARSC2019 is expected to attract 500-700 delegates including researchers, policing and enforcement agencies, practitioners, policymakers, industry representatives, educators, and students working in the fields of behavioural science, education and training, emergency services, engineering and technology, health and rehabilitation, policing, justice and law enforcement, local, state and federal government, traffic management, and vehicle safety.

REGISTRATION NOW OPEN

AWARD NOMINATIONS NOW OPEN

Register Your Interest

To register your expression of interest as a delegate, speaker, sponsor or trade exhibitor, or for further information about the conference, please visit **www.australasianroadsafetyconference.com.au.** Additional enquiries should be directed to the Conference Secretariat, Premier Event Concepts on **(+61) 437 377 107** or **shanna@premiereventconcepts.com.au**

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AUSTRALASIAN COLLEGE OF ROAD SAFETY

ACRS

Enter & Get Recognised!

Have you or a colleague recently developed a road safety treatment/initiative that stands out beyond traditional activities and delivered improved road safety? You could be the winner! We are looking for entries from any road safety practitioner who works within the Australasian private or public sector. Don't miss out on your chance to win and be recognised!

The individual team leader from the winning project will receive a trip to the USA to attend the 50th ATSSA annual convention and also **visit 3M head office in Minnesota.**

Who will judge entries?

All entries will be judged by an independent committee of industry representatives, established by the ACRS.

To enter & more information, visit theaustralasianroadsafetyawards.com.au

Entries open 1st March 2019 and close 5pm (EST) 12th of July 2018.

Contents

Cover image

Area-wide 30 km/h speed limit zones have been utilised widely in various internationaljurisdictions outside Australia and New Zealand (NZ). A survey of the road transport authorities in Australia and NZ show that while none of them opposed to lowering the speed limit to 30 km/h in appropriate locations, only five jurisdictions have either planned or implemented 30 km/h speed zones. An area wide 30 km/h zone can be applied to an entire activity centre boundary that incorporates pedestrian and shared zones, and aligns well with Safe System principles. See Road Safety Policy & Practice article on the development of guiding principles for implementing 30 km/h speed limits and zones (Karndacharuk, A. and McTiernan, D. (2019). Implementation Principles for 30 km/h Speed Limits and Zones.. *Journal of the Australasian College of Road Safety*, 30(2), 45-54.). Photo source: Based on Transport for London 2018.

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

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

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

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

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

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

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

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

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

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

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Editorial Board

From the President

Eleven years ago, I wrote my first column for this Journal (August 2008) after being elected President of the College. As I will stand aside at the May AGM, this will be my last.

Since that time, 100s of peer-review and contributed articles have been published along with reports of ACRS activities under four excellent Journal Editors. Our past President Raphael Grzebieta remains as Editor-in-Chief and our current Managing Editor, Chika Sakashita has recently led a review of our Editorial Board.

My role as President over those years has evolved with the development of the College as we have increased our activities to assist members and encourage improvements in a wide range of road safety initiatives.

Road trauma in Australia and NZ has decreased in that 11 years, due to many factors, including the efforts of the members of the College and others. The risks of crashes and trauma to road users per kilometre travelled are also generally less. We do know we can reduce that trauma further. We also recognise that implementation of the solutions we know to make that reduction continue to be difficult. The UN Special Envoy for Road Safety, Jean Todt, in Melbourne recently, when commenting on Australian successes in road safety, encouraged us to “keep fighting”. We should celebrate the success achieved, but recognise that we can and must achieve more.

That August 2008 Journal published an excellent paper by Dr Steve Jiggins, a paper on his findings from a Churchill Fellowship called “Road Safety is No Accident” relating to how the community through the press sees road trauma as acceptable, as the result of an “accident” not as a crash which could be avoided. It also presented an article on the concern of blind pedestrians with “the expected increase in silent hybrid and electric cars” and discussed bicycle helmet use. These topics are still relevant today with this Issue publishing a paper on bicycle helmet use.

Interestingly one paper in 2008 discussed the value of ABS braking in vehicles. Since 2008 we have seen considerable positive developments in vehicle safety from ABS braking – not only in crash worthiness but also in crash avoidance technologies such as ESC, AEB and hopefully soon ISA. Around 50% of new cars 11 years ago were 5 Star ANCAP rated. That figure is now well over 90% and the ratings are considerably tougher. The challenge for the future will be to ensure the next generation of vehicles are also safe. Automation, from driver assistance to driver replacement, is creating opportunities as well as risks in the challenge to reduce road trauma.

Star ratings of our road system has progressed more slowly since first introduced in 2006, and hopefully soon will become conditional for all future road projects. The recent national 2018-2020 Action plan has an "aim to achieve 3-star AusRAP ratings or better for 80% of travel on state roads, including a minimum of 90% of travel on national highways". With the crash costs reducing by 50% for every extra star, the challenge has to be to make sure road funding has safety as a priority.

That national Action Plan a decade ago set out projects for all Governments under the National Road Safety Strategy (2011-2020) to reduce the number of deaths and injuries from road crashes by at least 30% in this decade. A Ministerial Review of that Strategy published last year concluded that while we knew what to do there had been "implementation" failure in reducing so much unnecessary road trauma. I was pleased that last year that the Co-Chairs of that Inquiry, Associate Professor Jeremey Woolley and Dr John Crozier, were appointed Fellows of the College. I was pleased along with Fellow Rob McInerney to be a Principal Adviser to that Inquiry.

The more recent national 2018-2020 Action Plan does have a raft of positive projects. The Inquiry however identified management, capacity, resources, accountability and scale across the nation needed to make a step change so we could not only achieve the targets in the Plan but continue to reduce road trauma into the next decade. It made twelve recommendations for such a step change.

In 2008 I reported "I have written to the Prime Minister seeking direct support for a multidisciplinary, whole of government support for reducing road trauma and also separately I have offered to the Federal Government the College's support for any national road safety initiatives." The challenge to achieve that support unfortunately remains.

At that time the College was a lead member of the SaferRoads Coalition which had some 20 members. While that coalition did achieve some success, with the rapid changes in government and ministers since that time we have not been as effective in reducing road trauma at the rate we thought possible.

One of the most important successes has been the number of local government areas with zero fatalities for a number of years in the decade. This is very encouraging and I hope we can identify why they have been so successful so we can transfer the knowledge to others.

In March this year the College was a participant with 11 other organisations seeking action from both the responsible Minister and Shadow Minister on those twelve recommendations from the 2018 Inquiry, before this Parliament rose. At the time of writing (April 2019) the current Federal Government has announced a package for specific road safety initiatives which begin the process of the step change needed to ensure the known solutions can be implemented. We are hoping for bipartisan approach from the Opposition, who have already announced their support for a National Office of Road Safety (and now agreed by the Government). I hope that Office will assist the collaboration, leadership and independence needed to build the necessary step change in management identified in the Inquiry.

The process of research in road safety and the reporting and translation of the results into saving lives and injuries is extensive and complex. Assessing the effectiveness of and relevance of research is being challenged with the new systems of artificial intelligence, learning and data management. Building scale, transferring knowledge into action and importantly managing and being responsible for change will remain as key opportunities for success.

The College and this Journal are vital for the building of "capacity" in road safety in Australia and New Zealand. That is simply the process of ongoing education, collaboration and the building of professionalism of members in the many relevant areas and disciplines which make up the factors of road travel. New research, data, systems, technologies will continue to provide a broad canvas for our work. We will need to measure what our capacity is. We need to contribute to ensuring that it continues to build, and this Journal can remain as an essential tool to that end.

In signing off let me encourage you to maintain your membership and contributions: by working together in a collaborative way in building our capacity and professionalism, we can reduce road trauma. Let me extend my appreciation to you all: to our CEO and her staff, our Executive Committee, our Chapter Chairs, our Conference Committees, our Fellows, our Editorial Board and of course our Managing Editor for all your valuable contributions.

Lauchlan McIntosh AM FACRS FAICD FAusIMM
ACRS President

ACRS Chapter reports

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

South Australia (SA)

Vehicles as Workplace

Over 40 people attended a lunchtime presentation by Martin Small on the recently launched Vehicles as a Workplace Guide. It was encouraging to hear that seven work safety organisations have endorsed the guide for use, including Comcare at the national level. After outlining differing statistics on the problem of workplace vehicle fatalities and serious injuries, he presented on the work, health and safety approaches taken to the issue, starting with the legalities and who has a duty of care. Martin then presented on the principles and the structured hierarchy of control WHS process while intersecting this with the safe systems approach. Also emphasised were the need for leadership in organisations, good consultation and coordination as well as planning and performance management. While outlining the guide, he also shared the learning journey taken as a road safety professional into the parallel world of work, health and safety. Interest was high with many questions being asked in the Q&A session.

Next Seminar - Motorcycle Safety – Lunchtime Wednesday 19 June 2019.

The Chapter committee is putting together a program of three or four speakers that will make for an engaging seminar on the challenges of motorcycle safety. Further information closer to the date. We look forward to seeing members and guests there.

SA Chapter Chairs and Secretary
Jeremy Woolley, Jamie MacKenzie and Phil Blake

Australian Capital Territory (ACT) and Region

No new events have occurred since the last Chapter Report in the February 2019 Issue. The Chapter continues to work with Government and our Members on a number of initiatives to link people and ideas and to foster improved road safety outcomes.

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

New South Wales (NSW)

No new events have occurred since the last Chapter Report in the February 2019 Issue.

NSW Chapter Representative
Mr David McTiernan

ACRS News

ACRS AGM TUE 14 MAY - NOMINATE FOR THE ACRS AUSTRALASIAN EXECUTIVE COMMITTEE! HELP GUIDE US ONWARD AND UPWARD

ACRS 2019 Australasian AGM: Tuesday 14 May 2019 at 1.30pm AEST

As an ACRS member or guest you are warmly invited to participate in the 2019 ACRSAGM to be held Tuesday 14 May 2019 at 1:30pm AEST via videoconference at Chapter venues. The AGM provides an opportunity for members to be informed of ACRS activities, be involved in the future direction of the College, and to nominate for any vacant position(s) on the ACRS Australasian Executive Committee.

The College has 4 elected Executive Committee members who will be reaching the end of their 2-year term on the Committee: Lauchlan McIntosh, Julie Hatfield, Mark Stevenson and Teresa Senserrick. As a result, these 4 positions will be declared vacant at the 2019 AGM and an election will take place.

The closing date for nominations was 5:00pm AEST 9 April 2019.

ARSC 2019 CONFERENCE GALA DINNER & ROAD SAFETY AWARDS + CONFERENCE AWARDS – NOMINATIONS NOW OPEN!

Many awards to be presented to our *** ROAD SAFETY STARS! *******

Be rewarded for your expertise and efforts to reduce road trauma!

ARSC2019 is expected to attract over 600 delegates and will bring you the best of the best road safety research and practitioner papers from experts across our region. We will be rewarding our outstanding individuals and groups for their efforts through a wide variety of awards - all detailed below.

We sincerely appreciate your efforts to reduce road trauma. In tandem with your participation at ARSC2019, we are delighted to invite you to join us for the premier networking opportunities planned during the event:

1. **Conference Cocktail Welcome Reception** to be held in the Exhibition Hall
2. **Conference Gala Dinner & Awards Ceremony** in the Panorama Ballroom

Nominations by College Members Invited. The Australasian College of Road Safety first instituted the award of College Fellow in 1991 as a means of recognising outstanding contributions made by individuals to road safety. Nominees for a Fellowship Award must be current members of the College.

The presentation of the 2019 ACRS Fellowship award will take place during the 2019 Australasian Road Safety Conference Gala Dinner & Award Ceremony on Thursday 26 September at Adelaide Convention Centre, in front of 600+ of the creme-de-la-creme of international and regional road safety advocates and stakeholders.

The ACRS Fellowship is the highest honour that the College bestows. It is regarded as an unquestionable sign of excellence. The Executive Committee of the College awards the Fellowship on the recommendation of its Fellowship sub-Committee, and nominations must be made in accordance with the procedures detailed below.

The Fellowship sub-Committee makes its decisions on the written evidence placed before it. It may sometimes be unable to recommend a candidate because it has insufficient or inadequate information to make a recommendation. These guidelines have been prepared to assist nominators in preparing nominations and supporting details upon which the Fellowship Sub-Committee will make its recommendations to the Executive Committee.

2019 3M-ACRS DIAMOND ROAD SAFETY AWARDS *** WIN A TRIP TO USA! ***

Have you or a colleague recently developed a road safety treatment/initiative that stands out beyond traditional activities and delivered improved road safety? You could be the winner! We are looking for entries from any road safety practitioner who works within the Australian and New Zealand private or public sector.

Don't miss out on your chance to win and be recognised! The individual team leader from the winning project will receive a trip to the USA to attend the 50th ATSSA annual convention and also visit 3M head office in Minnesota.

The 3M-ACRS Diamond Road safety Award calls for any road safety practitioner from the public or private sector, (which typically includes, but is not limited to individuals or teams of Road Engineers, Contractors, Road Safety Officers, Road Safety Equipment Manufacturers, Asset Managers, Town Planners etc.) to submit highly innovative, cost-effective road safety initiatives/ programs which they have recently developed that stand out from the standard, everyday practice and deliver significant improvements in road safety for the community.

The award winner or team leader will recieve a trip to the USA to attend the 50th ATSSA Annual Convention & Traffic Expo in 2020 in USA and also visit 3M Global Headquarters in Minnesota. This individual will also present their winning entry and USA trip at the next Australasian Road Safety Conference and may also be eligible to present at the ATSSA Convention.

The announcement of the 2019 3M-ACRS Diamond Road Safety Award will be made during the ARSC2019 Conference Gala Dinner & Awards Ceremony on Thursday 26 September 2019, in the Panorama Ballroom, Adelaide Convention Centre, in front of 500 of our most eminent road safety professionals.

The winner will receive a trip to the USA to attend the 50th ATSSA Annual Convention & Traffic Expo in New Orleans, Louisiana in 2020, and will also visit 3M Global Headquarters in Minnesota. The winner will also present their winning entry and USA trip at the next Australasian Road Safety Conference, and may also be eligible to present at the ATSSA Convention.

Please visit the https://australasianroadsafetyconference.com.au/ and https://theaustralasianroadsafetyawards.com.au/ for further information.

AUSTRALIAN PRIME MINISTER SCOTT MORRISON ANNOUNCES ROAD SAFETY INITIATIVES (29 MARCH 2019), SUPPORTED BY STATEMENTS FROM THE DEPUTY PRIME MINISTER MICHAEL McCORMACK

On 29 March 2019 Australia's Prime Minister, Scott Morrison, announced funding to include road safety initiatives aimed at saving lives on our roads. "The Government is committed to working in a bipartisan spirit to progress the 12 recommendations made by the National Road Safety Strategy Inquiry in September 2018." Australia's Deputy Prime Minister and Minister for Infrastructure, Transport and Regional Development made several supporting statements in the media. See ACRS CEO Claire Howe's LinkedIn Article detailing background to the Inquiry and subsequent activities and actions.

Funding/initiatives detailed in the Prime Minister's media release and Deputy Prime Ministers supporting statements includes the following:

- Infrastructure funding for roads in regional Australia, and for the Bridges Renewal Program
- Funding for the Black Spot Program to target known high-risk locations
- Funding for heavy vehicle programs including the Heavy Vehicle Safety and Productivity Program and Heavy Vehicle Safety Initiatives
- A new $12 million Road Safety Innovation Fund to support research and development in priority areas such as regional road safety, driver distraction from mobile devices, protecting vulnerable road users and reducing drug driving
- A National Office of Road Safety is to be established, within the federal Department of Infrastructure, Regional Development and Cities.

We look forward to hearing greater detail from last night's budget release, including which initiatives/programs involve new funding (and over what period), whether and how the funding could support ACRS and member/stakeholder activities, and what the opposition response entails.

We encourage all members to keep a close watch on future Weekly alerts where we will provide more detail on these statements.

"ROAD SAFETY PACKAGE FINALLY FEATURES IN BUDGET": SAYS SENATOR GLENN STERLE

In its Budget, the Government formally committed to establish a National Office of Road Safety – a body which was abolished by former Prime Minister John Howard. Labor's Shadow Assistant Minister for Road Safety Senator Glenn Sterle has welcomed this decision but has said that its time the Government stops playing catch up with Road Safety and gets serious with its announcements.

"The investment in Road Safety measures in the 2019-20 Federal Budget has shown that the Morrison Government finally acknowledges the fact that more needs to be done to improve Road Safety outcomes for all Australians," said Senator Sterle.

"It also begs the question as to why the National Office of Road Safety was abolished in the first place. Road crashes cost the national economy about $30 billion a year. During the 12 months prior to the end of February 2019, there were 1,172 road deaths on Australian roads. There were 93 deaths on our roads in February alone. More needs to be done to address this crisis. Re-establishing the National Office of Road Safety is a good start," said Senator Sterle. "But this is the first time we are getting details on solid commitments from the Government on Road Safety. Labor however, began outlining our policies for Road Safety more than 4 months ago.

"On the 17th of December 2018, I was extremely proud to announce at the National Conference of the Australian Labor Party in Adelaide that a Shorten Labor Government would re-establish a National Office of Road Safety – after the Howard Liberal Government abolished it. We announced that if elected, a Shorten Labor Government would ensure that the national safety standards applying to motor vehicles are up to date and fit for purpose. A Shorten Labor Government will also amend the Australian Design Rules to mandate proven vehicle safety technologies in new vehicles. We also announced our commitment to legislate safe and sustainable rates for truck drivers.

"As far as the Government's announcements go, there is a very real difference between what the Government says on Budget night and what actually happens on the ground thereafter. For example, between the 2014-15 and 2018-19 financial years, there has been a $100million underspend through the Black Spot Program and a $134.1million underspend in the Heavy Vehicle Safety and Productivity Program.

"The Government needs to ensure that this sort of under-spending will not happen with the announcements made for Road Safety in the 2019-20 Budget. "The Labor Party is committed to improving Road Safety outcomes and has demonstrated that by the policies that we have already announced," said Senator Sterle, Labor's Shadow Assistant Minister for Road Safety.

Diary

22-24 May 2019
ITF 2019 Summit: Transport connectivity for regional integration
https://www.itf-oecd.org/itf-2019-summit-transport-connectivity-regional-integration
Leipzig, Germany

26-31 May 2019
15th World Conference on Transport Research
http://http/www.wctrs-conference.com/
Mumbai, India

9-12 June 2019
Global Public Transport Summit
https://uitpsummit.org/
Stockholm, Sweden

13-14 August 2019
8th International Symposium on Naturalistic Driving Research
https://mailchi.mp/b2fe9d6f5001/ndrs-2019-conference-call-for-abstracts
Melbourne, Australia

18-21 August 2019
22nd International Council on Alcohol, Drugs and Traffic Safety Conference
https://t2019.org/
Edmonton, Canada

25-27 September 2019
Australasian Road Safety Conference
http://australasianroadsafetyconference.com.au/
Adelaide, Australia

6-10 October 2019
26th World Road Congress
www.piarcabudhabi2019.org
Abu Dhabi, United Arab Emirates

18-20 Nov 2019
8th International Cycling Safety Conference
https://www.icsc2019.com/
Brisbane, Australia

Peer-reviewed papers

Original Road Safety Research

Determining Fitness to Drive for Drivers with Dementia: A Medical Practitioner Perspective

Joanne M. Bennett[1,2], Eugene Chekaluk [2], Jennifer Batchelor [2]

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[2]*Macquarie University, Sydney, Australia*

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This peer-reviewed paper was first presented as an Extended Abstract and Oral Presentation at the 2018 Australasian Road Safety Conference (ARSC2018) held in Sydney, NSW, Australia and first published in the ARSC2018 Proceedings in the form of an Extended Abstract. It was expanded into a 'Full Paper' and underwent further peer-review by three independent experts in the field. It is being reproduced here with the kind permission of the authors and is now only available in this edition of the JACRS.

Key Findings

- Fitness to drive determinations are predominately left to medical practitioners
- Practitioners largely rely on self-report information to make decisions
- Almost all practitioners reported belief that they missed cases of unsafe driving
- Over 85% of practitioners support the need for an objective assessment tool
- Practitioners have not received professional development

Abstract

Currently in Australia medical fitness to drive decisions for people with dementia are largely conducted by front line medical practitioners. Little is known about the processes that these practitioners use to make these decisions, and how current guidelines assist in making determinations about driving capacity. A short survey was completed by 42 practitioners. The results of the survey supported previous findings that practitioners do not feel comfortable with making the decision regarding fitness to drive for people with dementia. Practitioners relied largely on self-report or informant information regarding current driving practices. Although practitioners reported that the level of cognitive functioning was the most important factor in determining safe driving, only 25% of practitioners employed cognitive assessments. Whilst the vast majority of practitioners were aware of the fitness to drive guidelines, over half did not find them to be sufficient in enabling determinations of driving capacity. Due to this, almost all practitioners reported that they believe they have missed cases of unsafe driving in this population with over 85% endorsing the need for a more objective tool. Significantly, over three-quarters of practitioners reported that they have never received training on how to make fitness to drive decisions. Given that the current driver licensing system for people with dementia depends on medical fitness to drive reviews, the lack of confidence by practitioners regarding making fitness to drive decisions can have a detrimental impact on both the safety of the individual drivers, but also the community as a whole.

Keywords

Dementia, Driving, Fitness to Drive, Practitioners

Introduction

Dementia is an overarching term for a variety of conditions, all of which encompass a progressive loss of global cognitive function beyond what is expected from normal ageing (McKhann et al., 2011). As the population ages, the prevalence of dementia is set to increase, with incidence projected to double to 115.4 million people worldwide by the year 2050 (Prince et al., 2013). Due to the increasing prevalence of dementia, coupled with the desire to remain mobile in older age, it is anticipated that there will be a large jump in the number of people with dementia driving (Carr & O'Neill, 2015). Given the increased risk of people with dementia being involved in a motor vehicle crash (Carr & Ott, 2010), the rising prevalence of these individuals on the roads has serious road safety implications, both for themselves and for other road users. Whilst the impact of dementia on driving performance is clear, simply having a diagnosis of dementia is not considered an automatic preclusion from driving. This is because in the early phases of the disease many people with dementia can continue to drive safely for some time (Ott et al., 2008). Due to the progressive nature of dementia all people with dementia will eventually need to cease driving, but the process for deciding when one is no longer fit to drive is not clear cut.

As it stands globally there are different standards regarding driving licensing requirements for people with dementia (Seiler et al., 2012). Most concur that simply having a diagnosis of dementia should not preclude an individual from driving (Carr & O'Neill, 2015). In a number of countries such as the UK, USA and Canada, medical fitness to drive reviews for people with dementia are routine (Lincoln & Radford, 2014; Meuser, Carr, Unger & Ulfarsson, 2015; Moorhouse, Hamilton, Fisher & Rockwood, 2011; Rapoport et al., 2014). The benefit of in-office reviews is that they are widely accessible and cost effective compared to on road assessment (Wilson & Pinner, 2013). Currently there is no universal approach to in-office fitness to drive determinations, with each country differing in terms of the recommendations given to practitioners on what methods to use to make this decision (Lincoln & Radford, 2014). This lack of a universal approach is in large part because to date research has not been able to formulate a consensus on a reliable battery of tests (Rapoport et al., 2018). Furthermore, usable cut off scores have not been validated, limiting the clinical utility of proposed tests (Bennett, Chekaluk & Batchelor, 2016). In an attempt to address these issues, a team of international experts reviewed the literature and have proposed potential international guidelines on dementia and driving (Rapoport et al., 2018).

In Australia, it is mandatory that once diagnosed an individual must report the diagnosis to the relevant driving licensing agency and undergo periodical medical fitness to drive assessments with their general practitioner or primary medical care practitioner (Carmody, Traynor & Iverson, 2012). Practitioners are required to assess an individual's driving capacity by following the medical fitness to drive guidelines provided by Austroads (2012; 2016). The guidelines by Austroads (2012; 2016) are designed to provide practitioners with the information necessary to make decisions regarding driving competence for people with various medical conditions, including dementia. Currently under these guidelines all dementia aetiologies are grouped together, with no distinctions made between the different syndromes despite there being mounting evidence of the differential impact of dementia aetiology on driving performance (Piersma, de Waard, Davidse, Tucha, & Brouwer, 2016). The guidelines provide four pages of information on making fitness to drive assessment for people with dementia. Information covered includes: how dementia impacts on driving, an outline of points helpful in assessing a person (i.e. questions to ask about their driving history and driving habits), the medical standards for licensing (i.e. that an individual cannot hold an unconditional licence and an explanation of a restricted licence) and a table of medical standards which states that to hold a conditional licence information must be provided by a doctor regarding level of impairment of visuospatial perception, insight, judgement, attention, comprehension, reaction time or memory, and the likely impact on driving performance. Whilst these guidelines provide a general overview for practitioners, little guidance is provided on what tests they should use to examine these factors, and what levels of performance on the above skills correspond with either safe or unsafe driving outcomes. In New South Wales, if a medical practitioner does not feel confident in making the decision, they can refer the patient for on-road testing, which in the case of dementia is completed by a trained occupational therapist. These assessments, whilst an effective judge of fitness to drive, are costly and therefore not an option for all patients. As a result, for many patients and practitioners, the medical fitness to drive assessment is their only assessment of driving capacity. Whilst final determinations of drivers licence status are made by the relevant driver licencing agency, the recommendation of the medical practitioner made as a result of the fitness to drive assessment is often implemented.

It is unknown whether practitioners find the information provided in these guidelines to be sufficiently useful. It would be prudent to determine whether these guidelines assist practitioners in determining how to test the above mentioned cognitive skills and also whether they feel that this in-office assessment extends to providing reliable information about the on-road driving performance of their patients. It would therefore be important to examine what they believe determines safe driving, the methods/tests they are employing in clinical practice, how long they set aside to make these decisions and the degree of consistency across practitioners in the methods utilised. Furthermore, little is known about whether practitioners are comfortable with their role in making fitness to drive decisions for people with dementia.

As it currently stands in Australia, whilst researchers have examined the role of practitioners for fitness to drive for older drivers generally (Jones et al., 2012; Lipski, 2002; Sims et al., 2012), they have not yet isolated the experiences related specifically to people with dementia with the exception of one study conducted over a decade ago (Snellgrove & Hecker, 2002). As a result, the current study was designed to fill this gap by examining practitioner perspective on this decision making process for people with dementia. Despite previous research focusing on the primary care general practitioner, to examine the full scope of various perspectives, the current study examined all key practitioners who have a role in this decision making process, including, general practitioners, geriatricians, neurologists, neuropsychologists and occupational therapists. By examining the perspectives of front line practitioners who are responsible for making these determinations, this study aimed to provide insight into both current practices that are effective, and areas which need might need improvement to provide a better and more accurate system for determining fitness to drive for people with dementia.

Methods

Recruitment

Between the months of August and November 2016, a cross-sectional survey was mailed out to practitioners in NSW. A total of 400 questionnaires were distributed to practitioners who are likely to be involved in decision making regarding fitness to drive for people with dementia within NSW. In total, 305 General Practitioners, 41 Geriatricians, 24 Neuropsychologists, 15 Occupational Therapists and 15 Neurologists were contacted. Ethics approval was obtained for this study from the Macquarie University Faculty of Human Sciences Research Ethics Sub-Committee (Ref: 201600371).

Potential participants were selected at random to cover both rural and metropolitan regions of NSW from online databases obtained through a Google search, which listed practitioners by specialty and location. Participants had the option to complete the survey online or via a paper and pen format. All potential participants received, via mail, an introductory letter, the questionnaire, a flyer with the link to the online version of the questionnaire and a reply paid envelope so they could return completed questionnaires anonymously and without cost. Key governing bodies such as the Royal Australian College of General Practitioners were contacted to assist with disseminating the questionnaire to members, but no response was received.

The Questionnaire

The questionnaire consisted of 31 questions, which encompassed five sections. The development of the questionnaire drew upon previous literature, and followed discussions with key stakeholders including practitioners, dementia care support workers and dementia carers. The questionnaire consisted of both closed and open questions. As the questionnaire was designed to be anonymous to increase response rates, demographic information about the practitioners was not obtained. The five sections of the questionnaire included: 1) professional practice (including practitioner type, years practising, number of clients with dementia), 2) level of awareness of driving (5 point likert scale of level of awareness of licence status and driving behaviours), 3) their driving assessment procedure (type of questions asked of patients, assessment tools used, time spent on the assessment etc), 4) reactions to the driving assessment (both patient and family), and 5) their understanding and opinions regarding the current guidelines and future developments (how informative do they find the guidelines, what changes would they make etc.).

Surveys were analysed via a mixed methods approach through the examination of descriptive statistics and thematic analysis of response where appropriate. Between profession group differences were examined through analysis of variance where appropriate.

Results

Return Rates

A total of 42 responses were received, 16 completed online and 26 returned via paper, yielding a response rate of 10.5%. A further 30 questionnaires were returned to sender accounting for a further 7.5%. In total responses were received from nineteen general practitioners (6.2% return rate from general practitioner sample), nine geriatricians (21.95%), seven neuropsychologists (29%), six occupational therapists (40%) and one neurologist (6.67%).

Professional Practice

The majority of practitioners had been working in their profession for more than 20 years, accounting for 74%, with 14% having worked between 10 and 20 years, and 12% having been in their profession for less than 10 years. In a typical month, they reported seeing more than 15 patients with dementia (28%), between 10 to 15 patients (10%), between 5 and 10 patients (26%), between 2 and 5 patients (24%), only 1 patient (5%) and no patients with dementia (7%). Practitioners cited on-going care (67%), diagnosis (48%), and treatment (43%) as their primary reason for involvement with patients. A further 12% mentioned that their involvement with patients was purely to perform driving assessments, with all of these respondents (n=5) being occupational therapists who specialise in driving assessment. On average, 59% of practitioners estimated that they saw the patient on more than one occasion.

Level of Awareness of Driving

Practitioners were asked to report on how aware they were of the driving habits of their dementia patients. Over half of all respondents were always aware of whether their patients held a drivers licence (56%), with the remainder (44%) reporting being aware of the licence status of their patients most of the time. A total of 42% of practitioners reported always being aware of whether their patients had access to a car, whilst 49% reported being aware of this most of the time. Practitioners were asked if they were aware of whether their patients drove on a regular basis. A total of

39% reported being always aware, 54% being aware most of the time, and the remainder of practitioners reported only sometimes being aware of whether their patients drove on a regular basis. Finally, practitioners were asked if they knew of the reasons that their patients would have for driving (i.e. running errands, family commitments, social activities), and therefore the locations to which their patients drove (i.e. residential driving, highway driving, city driving). A total of 27% reported that they were always aware of the driving habits of their patients, 58% reported being aware of this in most cases, with the remainder stating that they were only sometimes aware of the driving habits of their dementia patients.

Driving Assessment Procedure

Practitioners reported making, on average, 11.58 (*SD*=17.3) fitness to drive assessments for patients with dementia per year, with general practitioners reporting on average making 4.53 (*SD* = 4.2) assessments per year. Furthermore, practitioners reported that on average they spent 64.61(*SD*=59.39) minutes making a fitness to drive assessment, with general practitioners spending the least amount of time on assessments, averaging just 22.22 (*SD*=15.74) minutes.

The questions that practitioners asked their patients when investigating fitness to drive were organised into eight themes, with these themes as well as the percentage of practitioners who reported each reported in Table 1. Further, practitioners were asked whether they utilised any specific in-office tests to assist with making this determination. The list of tests used was divided into physical, cognitive and driving tests and is presented in Table 2. Of note, when asked about in-office tests, 38.1% still reported using results of an on-road driving assessment to make their determination.

When asked what they believed determined safe driving for people with dementia, six themes emerged, these included: level of cognitive function (67% reported), level of insight (38%), on-road performance (38%), family response to their driving (31%), driving history (21%) and physical capacity (14%).

A total of 33% practitioners reported always referring patients for an on-road assessment, 33% as sometimes referring on, and 33% as never referring for on-road assessment (occupational therapists who conduct driving assessments were excluded from this analysis). Of those who cited reasons for not referring on, the most common reason (*n*=5) for not doing so was *"when impairment was obvious enough to make the decision in-office"*. Furthermore, 77% reported that they did not adjust their assessment procedure depending on the dementia diagnosis, with one general practitioner reporting *"All dementia is the same with regards to driving"*. Finally, 87% of the practitioners reported that they have likely missed cases of unsafe driving in patients with dementia.

Table 1. Themes investigated by practitioners when determining driving safety for patients with dementia

Themes	% Of Practitioners who investigated (n)
Current Driving Behaviours	64 (27)
Informant Interview	33 (14)
Cognitive Tests	21 (9)
Driving History	10 (4)
Medical History	7 (3)
Physical Tests	7 (3)
Insight	2 (1)
Vision	2 (1)

Table 2. In-office tests used to make fitness to drive determinations

Tests	% Practitioners Reported Use (n)
Physical Tests	
Non-Specific General Physical Screen	17 (7)
Vision Test	10 (4)
Strength	5 (2)
Coordination	5 (2)
Hearing Test	2 (1)
Cognitive Tests	
Mini Mental State Exam	29 (12)
Trail Making Test Part B	19 (8)
Trail Making Test Part A	17 (7)
Non-Specific General Cognitive Screen	14 (6)
Montreal Cognitive Assessment	12 (5)
Clock Drawing Test	12 (5)
Insight Test	7 (3)
Visuospatial Test	7 (3)
Frontal Battery	5 (2)
Rey Complex Figure	5 (2)
Block Design	2 (1)
Digit Span	2 (1)
Maze Test	2 (1)
Wechsler Adult Intelligence Scale IV	2 (1)
Wechsler Memory Scale IV	2 (1)
Visual Reproduction	2 (1)
Driving Tests	
DRIVESafe	7 (3)
Road Rule Knowledge	2 (1)

Reactions to the Driving Assessment

Practitioners were asked whether there were any instances in which they would prefer not to discuss the issue of driving with a patient, with 72% reporting that they are always prepared to have this conversation. Of those who reported that they do not always discuss driving with patients, the main reason (*n*=12) cited *"it is a difficult conversation to have"*.

When asked about the reactions from patients, 72% of practitioners reported that reactions from patients were very variable. Similarly, when asked about the reactions from family 59% cited that the responses tend to be mixed. A list of the reactions identified is presented in Table 3. Of important note, a number of practitioners (*n*=8) noted that the reaction by the patient depended greatly upon the level of insight that the individual had into their condition. With respect to family reactions, various practitioners (*n*=5) noted that the nature of the reaction was influenced by whether they had a vested interest in the patient continuing to drive.

Table 3. Reactions of patients and carers to conversations regarding driving

Reactions to Driving Conversations	% Practitioners who reported (n)
Patients	
Accepting/Positive	52 (22)
Angry	40 (17)
Denial/Defensive	29 (12)
Upset/Anxious	21 (9)
Worried/Concerned	7 (3)
Carers/Family	
Relief	43 (18)
Happy	26 (11)
Supportive	14 (6)
Vested interest in driving continuance	12 (5)
Concern for their independence	12 (5)
Concern about backlash from patient	10 (4)
Angry	7 (3)
Shock	5 (2)

Current Australian Guidelines and Future Developments

Approximately, 67% of practitioners reported being aware of the legal requirements with respect to driving with dementia, and were correctly able to identify the nature of those requirements, however, this means that 32% were unaware that there were any legal requirements related to driving with dementia. A total of 87% were aware of the Austroads medical fitness to drive guidelines, however, opinions regarding the usefulness of the guidelines were mixed with 43% reporting that they were very informative, 31% reporting that they are somewhat useful and 26% did not find them useful. Reasons for not finding the guidelines useful included: "*long winded*", "*very general*", *"vague in the area of dementia",* "*not helpful in a clinical setting*", and "*not very helpful as leaves discretion to the practitioner*". For those who did not find the guidelines very useful, a few suggestions were made for improvements. The most frequent suggestion was that there need to be more detailed, specific and objective instructions (*n*=8). A few suggested the need for detailed decision pathways (*n*=3), one named the need for cut-off scores, one named a need for the guidelines to be updated regularly, and one mentioned that a hard copy desk version should be provided to practitioners. This quote summarises the views of a number of the practitioners, *"A lot is left up in the air in terms of making final decisions about suitability to continue driving"*.

When asked if there should be a more objective assessment for determining driving capacity for people with dementia, 85% stated that a more objective test was needed. The key rationale for a more objective test was summarised as "*it would be helpful to take the onus off general practitioners who generally want to maintain their relationships with patients*". Suggestions for the form that this assessment should take included an on-road driving assessment (24%), a battery of tests (14%), a brief questionnaire/checklist (10%), and using road rule tests (2%). Of those who mentioned on-road assessments, four went on to say that these tests were only appropriate if they were more affordable and available in rural communities. Furthermore, of priority to a number of practitioners (17%) was that any objective assessment introduced was shown to be a reliable predictor of driving performance.

A total of 25% of those surveyed believed medical practitioners should be responsible for making fitness to drive decisions for people with dementia, whilst conversely 25% believed that it should not be up to practitioners. On the other hand, the majority (50%) of practitioners believed that it should be a combined approach. Of those who advocated for a combined approach, 66% believed that assessments should be performed by a multidisciplinary team with occupational therapists performing on road assessment, such as *"in conjunction with specialists and where applicable, occupational therapist driver assessors"*. Family members were also mentioned as needing to be involved in the decision making process with 9% mentioning *"families must also take responsibility"*.

In relation to professional development, 78% reported never having any professional development in the area of dementia and driving, with 98% reporting that they would like to receive professional development.

Discussion

The current study aimed to investigate the perspectives and experiences of the key practitioners: general practitioners, geriatricians, neurologists, neuropsychologists and occupational therapists, involved in making fitness to drive determinations for people with dementia. The comments in this discussion are to be considered in light of the small sample size of this study. The respondents to this questionnaire fell across the range of professions and were mostly experienced practitioners with greater than 20 years' experience who engaged with dementia patients on a regular basis. The majority of practitioners surveyed reported being aware of the driving habits of their dementia patients. This suggests that practitioners are largely mindful that driving is an important consideration in this population.

General practitioners reported spending on average less than half an hour making fitness to drive assessments. This is consistent with findings from previous research which revealed that when making decisions on driving performance practitioners spend anywhere from less than 10 minutes to about 30 minutes (Omer et al., 2014). This issue of time is an important consideration for both researchers and policy makers to take into account when suggesting in-office clinical tools. Any in-office tool must be able to be conducted in less than 30-minutes to align with the time frames that general practitioners have available (Omer et al., 2014).

The current Austroads guidelines provide information on the factors about which physicians should ask questions but few details are provided on how practitioners should achieve this. Given this lack of direction provided by the guidelines, this study examined the procedures employed by practitioners when examining fitness to drive. Most commonly, practitioners asked questions around current driving behaviours, which required self-report answers. Whilst self-report is often a reasonable approach, in the case of dementia, this form of questioning might not be the most reliable indicator of real world driving performance due to limits in memory and insight. Given these limitations previous research by Carr and colleagues (2006) has recommended that informant interviews about driving behaviours should be conducted, however, the current study showed that only 33% of practitioners under took this practice. Given that informant interviews are not always reliable, cognitive testing has been regularly employed in clinical settings (Breen et al., 2007). In the current sample, almost one quarter of practitioners reported utilising cognitive tests, however, there was little consistency in the specific measures that they employed. This is likely a consequence of the lack of consensus regarding which cognitive tests are reliable, and a lack of cut off scores to enable their clinical use. Research is still continuing to try to develop such a clinical tool, and should be a priority (Bennett, Chekaluk & Batchelor, 2016). Whilst current international recommendations stipulate that a single test is not sufficient for determining fitness to drive, abnormal performance on cognitive tests could reveal that a more extensive evaluation of their driving performance is necessary (Rapoport et al., 2018). Whilst recommendations on specific cognitive tests are not possible yet, this kind of recommendation should be incorporated into the Austroads guidelines to better inform practitioners on how cognitive testing can assist in their determinations.

Despite only a quarter of practitioners utilising cognitive tests, when asked what they believed determined safe driving, the most common response was level of cognitive function, with almost two thirds of respondents reporting this. It therefore appears that there is a disconnect between what practitioners believe contributes to safe driving, and what they actually test in-office. Future research needs to further examine the reasons why this disparity exists and perhaps how to better train practitioners in the use of cognitive testing so that this form of assessment is implemented in day to day practice.

The current study was the first, to the authors knowledge, that examined whether practitioners employed different approaches when assessing driving for the various dementia aetiologies. This was important to investigate due to the fact that recent research has highlighted that the various dementia profiles have differential impacts on driving performance (Piersma, de Waard, Davidse, Tucha & Brouwer, 2016). Piersma and colleagues (2016) argued that different approaches to assessing fitness to drive might be required for the various forms of dementia. The findings of this study suggests that the majority (77.5%) of practitioners may not be aware of the differential impact that the dementia aetiologies have on driving performance and therefore they reported that their approach to assessing driving performance does not change in light of diagnosis type. It is important therefore that further exploration is conducted into the distinctions between the dementia types, the impact that these have on driving performance, and the best ways to examine these differences in an office setting. Furthermore, a component of any future education for practitioners must include evidence based information on the differences between the dementia aetiologies and guidelines on how to perform driving assessments for the various forms.

Practitioners across the board reported having a reasonable level of awareness of the driving situation of their patients with dementia. Furthermore, the majority also reported that they were always prepared to discuss driving and driving cessation with their patients. Consistent with similar studies, a number of practitioners reported that conversations with patients regarding driving are difficult to have and therefore at times it is a conversation which is avoided (Alzheimer's Australia, 2016; Jones et al., 2012). A large contributing factor to the difficult nature of conversations regarding driving is the reaction by the patient/carer. Overwhelmingly practitioners reported that reactions from both patients and carers are mixed and can range from positive and accepting, to negative and aggressive. As a result, part of the rationale for avoiding this conversation was that having discussions regarding driving capacity with patients can negatively impact on the doctor/patient relationship. This concern regarding the breaking down of the client/practitioner relationship is one which has been regularly highlighted in the literature, both nationally and internationally (Jang et al., 2006; Jones et al., 2012; Sims et al., 2012). As has been previously highlighted by Jang and colleagues (2006), further training for practitioners in how to have these conversations with clients is needed. This will help ensure that practitioners feel confident in their ability to have this difficult conversation whilst simultaneously managing and maintaining their relationship with patients.

Almost three quarters of practitioners reported that they were familiar with the legal requirements surrounding fitness to drive decisions for people with dementia. Whilst this is a majority, it does mean that over one quarter of practitioners are not aware of the requirements surrounding reporting, completion of assessments, conditional licensure etc., which is a concern. It is therefore essential that awareness is raised regarding the legal issues surrounding dementia and driving. Although the vast majority of practitioners were familiar with the Austroads medical fitness to drive guidelines, opinions on the utility of these guidelines were mixed. Practitioners continue to report that these guidelines are not useful, particularly because they are long winded, not translatable to the clinical setting and very general. This is consistent with issues regarding the guidelines raised by general practitioners back in 2002 (Snellgrove & Hecker, 2002). Practitioners were asked to provide suggestions for improvement of the guidelines. Responses include making the instructions more detailed, specific and objective, with the provision of a detailed objective decision making pathways and/or checklists that would be more suitable for use in a clinical setting rather than a large tome containing relatively general information. Similar suggestions have been expressed in previous research by Sims and colleagues (2012).

During the data collection phase of this study, in October 2016, an updated Austroads medical fitness to drive guidelines was released (Austroads, 2016). This update was largely similar to the previous version of the guidelines, with the exception of the introduction of a dementia and driving pathways flow diagram. This updated version does address some but not all of the concerns raised by practitioners. The pathways flow diagram was a suggestion made by one of the practitioners in this study, and provides a good overview of the steps involved in the driving licensing process for people with dementia. These steps include that practitioners should raise the issue of driving with patients, determine if a patient wants to continue driving, that a medical fitness to drive assessment needs to be conducted and then the patient is determined either fit or unfit to drive. With this addition, the guidelines now provide practitioners with an easy to interpret flow diagram on the process involved in driver licensing for people with dementia, however, the guidelines do not provide any additional information on how practitioners determine if an individual is actually fit to drive. This is the key area of concern as there is very little guidance on what determines whether an individual is safe to drive. The information relating to how practitioners assess driving have not been updated since 2012, and there is no mention of what test/tools to use beyond a statement that they should not rely heavily on the Mini Mental State Exam. As a result, practitioners are still left to make a largely subjective decision regarding what constitutes whether an individual with dementia is safe to continue driving, a decision which many report they do not feel comfortable making. These issues therefore still need to be addressed by the policy makers who develop the guidelines. Practitioners have mentioned they would benefit from a checklist with instructions on how to make the decision regarding driving capacity. It might be prudent to determine whether a checklist like approach, whereby the sequential order of each question/test is laid out, with information on administration and score interpretation accompanying each point, such as the one suggested by Molnar and colleagues (2009) might be able to implemented in Australia. It is important to note however the limitations of the Austroads guidelines, namely that it is a national set of guidelines that has to apply to different legislations in different states. It is not necessarily possible for the national guidelines to provide the level of specificity of information requested by the practitioners, when this will differ from state to state. As such, the implementation of state based specific information packages might also be worthy of consideration by the different driver licencing authorities.

Only a quarter of respondents believe that medical practitioners should be solely responsible for making fitness to drive decisions for people with dementia. This is not the first time that practitioners have expressed unease with being the final decision maker on driving performance (Jang et al., 2006; Jones et al., 2012; Sims et al., 2012) and is consistent with the argument that practitioners do not believe that they are able to accurately determine the on road driving skills of patients (Jones et al., 2012). As a result, half of the sample advocated for a multidisciplinary approach for determining driving capacity. Although the majority of practitioners also endorsed the need for an objective assessment, they were divided over the form that assessment should take. The two most frequent suggestions were an on-road driving assessment and a battery of in-office tests. Given previously highlighted concerns regarding the cost and accessibility of on-road assessments (Alzheimer's Australia, 2016), the development and implementation of an in-office battery of tests should be a priority for researchers. This is especially crucial given that 89% of practitioners reported that they have likely missed cases of unsafe driving for patients with dementia. Given that the risk of being involved in an accident increases if someone with dementia who is no longer fit to drive continues to do so, it is essential to equip practitioners with the skills, tools and confidence in making reliable fitness to drive decisions.

Of note, over three quarters of practitioners reported never receiving professional development in this area, with almost all reporting that they would like further education into dementia and driving. There is obviously a gap in the training of practitioners and one which needs to be rectified. This study is not the first to report that practitioners are in need of further education with this being a key conclusion made by Jang et al., 2006, Jones et al., 2012, Sims et al., 2012, and Perkinson et al., 2005. Despite further education being consistently highlighted as an important area of need, little has been done to develop and roll out a sufficient training program for practitioners. Such a training program would need to cover issues such as how to approach the topic and manage conversations regarding driver licensing, the legal requirements of fitness to drive, the questions to ask both patients and informants to get a driving history, how to determining medical fitness to drive, the administration and scoring of appropriate assessments, and how to manage the patient/practitioner relationship during this process. Researchers in conjunction with practitioners and policy makers need to ascertain the specific content that needs to be covered in such a training program, and also the best way to deliver this to practitioners (ie. determine whether face to face, webinars or written documents would be the most appropriate). It is acknowledged that a training program is not a solve all, and that some of the concerns of practitioners, such as maintaining the doctor-patient relationship, will not be entirely solved by such a program. It is hoped however that training will improve the reliability of making fitness to drive determinations, and also provide practitioners with skills to better communicate with patients during the process, and therefore help to maintain the doctor-patient relationship.

This study has provided some insight into the processes and perspectives of the key practitioners involved in making fitness to drive decisions for people with dementia. It is important, however, to note that this is a starting point, and further research is required. This study had a relatively small sample size with a low response rate. Possible reasons for this low response rate could include that significant time pressures exist for doctors during working hours meaning engagement with this research was not possible. Engaging with doctors outside of work might be a more beneficial approach, perhaps through targeting recruitment at medical conferences. Furthermore, this research was completed on a voluntary basis with no incentive for participation, perhaps this needs to be rectified to improve the response rate. Given this, the possibility of response bias must be acknowledged whereby those who engaged with completing the survey are those practitioners who are more invested in this topic area. As a result, the views expressed by the respondents might not be representative of practitioners more generally. To overcome the low response rate and try to reduce response bias, follow up letters to all practitioners should be employed in future as a method to increase response rates. Also it would be beneficial to gain access to databases such as those of the various professional groups to enable recruitment to be targeted towards those practitioners who will engage with people with dementia, as opposed to a more general approach. Furthermore, the authors would have liked to do a between discipline analysis to determine if there are any systematic differences across profession type, however, were unable to do so due to the sample size. A large sample size of each of the professions would be beneficial in future research in order to achieve these between discipline analyses.
It would be beneficial to further investigate practitioner differences to develop educational programs targeting the specific needs of the various professions. Finally, this study only engaged practitioners in NSW, and it would be prudent to examine the approaches practitioners take country wide. Whilst the different states of Australia have different driver licensing agencies and therefore requirements, the Austroads medical fitness to drive guidelines are the same across the country. It would be beneficial to determine if there are any systematic differences between the states to make informed decisions on best procedure and practice. Finally the addition of further questions related to any cut-off scores practitioners used to make their determination of "fit to drive" or "unfit to drive" would be beneficial. This would enable understanding of not only the tests that they use to make their determinations but also the criteria the patient needs to meet.

Conclusions

Medical and allied health practitioners consistently report that the current guidelines regarding assessment of fitness to drive are not sufficient to enable them to reliably make this decision and that moving forward a more objective, multidisciplinary approach needs to be adopted. Future research therefore is required to investigate the most appropriate objective assessment tool for clinical use. Furthermore, in this study due to the overwhelming lack of professional development practitioners have received, there needs to be a focus on the development and implementation of appropriate educational and training programs. Of note, the perspectives expressed in this paper are from a small sample and a variety of practitioners based solely in NSW, and so it is crucial to continue this research in a more representative national sample to determine if these opinions are felt by the majority of practitioners. This study does however highlight the call for continual work into the implementation of education and an in-office objective assessment tool. If these aims are achieved, practitioners will be able to make better informed decisions on driving capacity for people with dementia which balances individual independence with overall community safety.

Acknowledgements

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Cycling Overseas: Decisions regarding helmet use

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Key Findings

- Majority of survey respondents (60.4%) indicated that they would not ride a bicycle whilst travelling overseas.
- Survey respondents who had ridden a bicycle in the last 12 months were more likely to indicate they would be likely to ride overseas.
- High helmet use amongst survey respondents, although required by law, is a predictor of high likelihood of intention to wear a helmet if cycling overseas.
- Survey respondents who regularly cycle and wear a helmet are more likely to think cycling injuries are preventable.

Abstract

Background: Cycling engagement in tourists is increasing; yet, bicycle helmet usage is not widely mandated internationally. Exploring hypothetical helmet use intentions when cycling in a foreign location for residents were the ability to decide in their home setting is removed presents a novel enquiry into the relationship between habit and tourist safety behaviour intentions. **Methods:** Queensland Social Survey (phone survey) of Queensland (Australia) residents (n=1,256) exploring current cycling participation, hypothetical cycling and helmet use whilst travelling overseas. Ethics approval was obtained. Backward logistic regression analyses were performed to identify the socio-economic and health characteristics that were significantly associated with hypothetical cycling and helmet use overseas. **Results:** One-third (39.6%) of respondents indicated they might cycle overseas and this was related to recent cycling engagement at home ($p < 0.01$). Helmet usage at home was related to hypothetical helmet use overseas ($p < 0.01$); with self-reported helmet use 'every time' cycle a positive predictor of hypothetical helmet use overseas (OR=10.78; 95%CI=2.04-47.67). **Conclusions:** Safety habits from a home setting, which likely exist due to legislation, might transfer to a foreign non-legislated settings. Promoting of safe cycling practices regardless of location has utility and warrants discussion within the disciplines of travel medicine and road safety. It is recommended before cycling overseas that individuals familiarise themselves with road rules, right of way, cycling infrastructure and the general conduct of other cyclists. Route planning will also likely be faciliated by this familiarisation and enable strategic sightseeing opportunities.

Keywords

Safety, bicycle, helmet, travel

Introduction

Individuals travel for a variety of reasons; however, a "desire for stimulation and excitement" is a key motivator (Leggat & Fischer, 2006; Schneider & Vogt, 2012). Riding a bicycle whilst on holiday, particularly in a foreign location, fulfils this desire and is becoming increasingly easy given the growth in cycling infrastructure, supportive policies and the availability of bicycles for hire due to bike-sharing programs (Kaplan, Manca, Nielsen, & Prato, 2015a, 2015b; Pucher, Dill, & Handy, 2010). Cycling while traveling is an activity undertaken for a wide range of reasons including leisure, transport or thrill-seeking. Cycling undertaken whilst travelling can be viewed on a continuum from opportunistic leisure engagement to pre-planned adventure-orientated mountain biking. While there is a continuum of engagement, the majority of cycle tourists are those who prior to traveling had intended to cycle during their travels and it was pre-planned as an activity and/or as a mode of transport (Faulks, Ritchie, & Fluker, 2007; Ritchie, 1998).

There are three categories of cycle tourists: 'incidental', 'premeditated' and 'pure cycle tourists'. Incidental cycle tourists are those individuals who do not intend to undertake cycling whilst overseas but who cycle at least once at the destination. Injuries often befall travellers who use modes of travel not normally used or activities in which they do not regularly participate and this might be the case for incidental cycle tourists (Leggat, 2006). Premeditated cycle tourists are those individuals who plan to engage in cycling whilst on holiday but as a once-off activity. Pure cycle tourists are those individuals for whom the majority of their holiday is cycling focused. An example is a spectator of the Tour de France who also follows the tour around using a bicycle (Faulks et al., 2007). Note those who are cycling as part of sport, including racing events, whilst on holidays are classified as sport tourists (Simonsen, Jørgensen, & Robbins, 1998). Cycle tourists who sustain an injury whilst cycling are noted to have increased risk for infection as well as other health concerns (Gundacker, Rolfe, & Rodriguez, 2017).

Safety of Cyclists

Cyclists generally represent a vulnerable road user group; however limited literature exists exploring the demographic and injury incidence specific to the cycle tourist (Kim, Park, Kang, Park, & Lee, 2011; Piyaphanee et al., 2014). Although injury incidence for adventure cyclists, those for whom cycling is adrenaline orientated, are documented particularly within New Zealand's adventure tourism sector (Bentley, Meyer, Page, & Chalmers, 2001; Bentley, Page, Meyer, Chalmers, & Laird, 2001; Bentley, Page, & Walker, 2004; Bentley & Page, 2008; Bentley, Page, & Laird, 2001; Bentley, Page, & Macky, 2007). It is recognised that assorted medical problems may arise when undertaking cycling in a foreign location and as such considering existing health conditions, fitness level, experience and seeking pre-travel advice in relation to these issues are important factors recommended for any cycle tourist, and tourists generally (Gundacker et al., 2017; Nikolic, Missoni, & Medved, 2005). A factor which may influence injury experiences of cycle tourist is the disparate risk environments relating to cycling infrastructure and the novelty present in these settings (Gushulak & MacPherson, 2004). Road surfaces and segregated bicycle facilities are factors important in determining perceived safety when cycling generally and increase attractiveness of bicycle tourism destinations (Deenihan & Caulfield, 2015; Haworth & Schramm, 2011; Lee & Huang, 2012; Pucher & Buehler, 2008).

Evidence demonstrates that bicycle helmet use can reduce head and brain injuries (Olivier & Creighton, 2016; Thompson, Rivara, & Thompson, 1999). Australia and New Zealand have mandatory helmets laws requiring helmets to be worn by all cyclists with the only exception for adult cyclists riding on separated bike paths in the Northern Territory (Haworth, Schramm, King, & Steinhardt, 2010). Queensland, a state in Australia, has had mandatory blanket helmet laws in effect since 1 July 1991 with enforcement by police commencing on 1 January 1993 (Haworth et al., 2010). A recent review highlights there are nine countries with blanket bicylce helmet legislation with a number of other countries having age specifications (Esmaeilikia, Grzebieta, & Olivier, 2018). For those tourists who might wish to wear a helmet whilst cycling overseas, there are issues when hiring a helmet around availability, hygiene, size, comfort, attractiveness, age and condition; or the challenge of packing a helmet (Fishman, Washington, & Haworth, 2012; Hargarten, 1994). However given modern bicycle helmets are becoming increasingly lightweight (typically 250-300grams), this will increase the potential for a helmet to be packed or form part of luggage carry-on (Lu & Yu, 2003).

Impromptu decisions to cycle are likely to be undertaken without a helmet if one is not easily accessible, which is likely if utilising bike-sharing programs outside Australia (Ma et al., 2016; Shaheen & Guzman, 2011). In the Netherlands those who are wearing a helmet are generally treated with caution by other motorists as they are presumed to be a foreigner and more likely to behave erratically (Aland, 2010) cited in (Haworth et al., 2010). As to whether the preponderance to 'gear-up' with safety equipment in locations where their use is voluntary is a result of the perceived value of helmets, habit or related to the perception that cycling is less safe (generally or specifically in foreign locations) is unknown (Kaplan et al., 2015b). Regardless, tourists should be encouraged to wear a helmet that is appropriately sized and fitted when cycling overseas. Helmet use is recommended for two reasons: firstly the protective effect of mitigating head injuries; and also for the potential to act as an indicator for others to proceed with caution (Olivier, Wang, Walter, & Grzebieta, 2014; Thai, McIntosh, & Pang, 2015).

While helmet use is recommended it is not known whether existing mandatory safety behaviours in the tourists' home environment impacts their subsequent behaviour intentions in a non-legislated setting. This paper aims to explore in a sample of Queensland resident's their hypothetical likelihood of cycling engagement when travelling overseas and, if an intention to cycle whilst overseas exists, their hypothetical likelihood of wearing a bicycle helmet, even if helmet use is not legally required.

Methods

Procedure and Participants

Data for this study was collected as part of the annual Queensland Social Survey (QSS) 2012. The QSS utilises computer-assisted telephone interviewing (CATI) system and trained interviewers to randomly interview individuals residing in the state. It is conducted by Central Queensland (CQ) University's Population Research Laboratory and allows, through cost-sharing arrangements, questions to be incorporated by researchers, government and community groups. It uses a two-stage sampling strategy whereby the state of Queensland is split into two regions with geographically proportionate number of respondents sampled for South-East Queensland (n=843) and the remainder of Queensland (n=413). Within each region random digit dialling of landlines was used with the required gender of the respondent being pre-determined prior to the household being called. Interviews were conducted across a four week period (22 October- 22 November 2012), at various times of days, including weekends, which enables a higher contact rate and the potential to reach a wider demographic (i.e. full time workers). A total of 3130 households were contacted or with whom contact was attempted, with an overall response rate of 40.27% (n=1256).

Measures

General questions

The interview contains a standardised introduction along with a brief overview of the question topics which are incorporated. All researchers have access to the responses to the health and demographic question along with the response to their research questions. The questions incorporated by the research team related to bicycle use (or non-use), motivations, ownership, bicycle safety questions and hypothetical cycling participation whilst overseas.

Cycling overseas

The focus of this article relates to the responses to the two questions related to bicycle use overseas. The first question asked was "If you were travelling overseas, how likely would you be to ride a bicycle as part of a tour or leisure activity?", with the response format of a four-point Likert scale ('not at all likely'; 'somewhat likely'; 'moderately likely'; and 'very likely'). Any participant who stated they were unsure or they were 'not at all likely' were not asked the second question. The second question asked if when cycling on that hypothetical tour or independently, "if legislation in that country did not require compulsory bicycle helmets, how often do you think you would wear a bicycle helmet when riding?" A five-point Likert scale was used ('never'; 'almost never/rarely'; 'sometimes'; 'almost every time'; and 'every time) (Table 1).

Coding and analysis

Responses to these two questions were than dichotomized into 'No' and 'Yes' (Table 1). An exploratory of basic demographic characteristics and current cycling behaviour (Table 1) were compared for hypothetical cycling and helmet use overseas by using chi-square tests and multivariate logistic regression analysis. Backward stepwise logistic regression analyses were performed to identify the socio-economic and health characteristics that were significantly associated with hypothetical cycling and helmet use overseas. Statistical analysis was undertaken using SPSS, with statistical significance set at $p<0.05$ and confidence intervals of 95% (IBM Corporation, 2013). The QSS 2012 had ethics approval provided by CQ University (H10/06-121).

Results

Of the 1,256 respondents half (50.3%) were male. Respondents ages ranged from 18 to 91 years (M=55.6, SD= 16.2) with over half the sample (n=661; 53.1%) being aged 55 and older which is an overrepresentation compared to the Queensland population. A third (39.5%) of respondents household income was over A$100,000 (n=313). Over half of the sample indicated they hadn't cycled in the previous 12 months (n= 831; 66.4%).

Majority of the sample indicated that if they were travelling overseas they wouldn't ride a bicycle (n=747; 60.4%) (Table 2). People who had ridden a bike in the previous 12 months were significantly more likely to indicate they would cycle when travelling overseas (55% vs. 19.5%; $\chi^2 = 166.67$, $p < 0.01$). One quarter (26.8%) of respondents who indicated, despite not having cycled at home in the previous year, they would be likely to cycle overseas and 35.2% of current cyclists would not cycle overseas (Table 3). Current cyclists who always wear their helmet when cycling in Australia indicated this behaviour would continue when cycling overseas even if helmet use was not compulsory (69.8%; $\chi^2 = 25.23$, $p < 0.01$).

Significant differences were found between the respondents likelihood of indicating they will cycle overseas and: perceptions of bicycle injury preventability, cycling engagement including frequency, duration and exposure of cycling in hours per annum ($p<0.01$). Individuals who responded that they were 'very likely' to cycle whilst overseas were more likely to indicate that they thought cycling injuries were preventable ($\chi^2 = 14.01$, $p < 0.01$), classified as moderate and frequent cyclists ($\chi^2 = 20.06$, $p < 0.01$), more likely to cycle for a duration longer than 31 minutes and engaged in high levels of cycling ($\chi^2 = 14.28$, $p < 0.01$) (Table 4).

Within the bivariate results significant associations were found for cycling overseas and bicycle helmet use overseas (Table 3). For cycling overseas the characteristics where it is more likely were for: males ($\chi^2 = 5.37$, $p < 0.05$), young adults (aged 18-34) ($\chi^2 = 127.69$, $p < 0.01$), people who cycle frequently at home ($\chi^2 = 173.34$, $p < 0.01$) and those who had a higher gross household income (A$100,000 or more per annum) ($\chi^2 = 53.24$, $p < 0.01$). For helmet use those who wear the helmet every time they cycle were more likely to wear it overseas ($\chi^2 = 25.23$, $p < 0.01$).

Multivariate analysis was also conducted with the outcome variables of hypothetical cycling engagement and helmet use when cycling overseas. All independent variables entered into the model are outlined (Table 5). Controlling for confounding, individuals who were aged 55 years and older (*OR*=0.363; 95%*CI*: 0.170-0.777) and those who have 11-12 years of education are less likely to cycle overseas (*OR*=0.315; 95%*CI*: 0.140-0.709). Whereas predictors of cycling overseas were engaging in sufficient physical activity of 30 minutes or more on five or more days/sessions a week (*OR*=1.986; 95%*CI*: 1.194-3.303), cycled for a usual duration of more than 30 minutes (*OR* =1.721; 95%*CI*: 1.066-2.777), perceive cycling as neither unsafe or safe (*OR*=2.153; 95%*CI*: 1.084-4.276) and perceive cycling as safe (*OR*=2.689; 95%*CI*: 1.335-5.416) (Table 5). Individuals who wear a helmet every time they cycle in Queensland are more likely to continue this behaviour even if not required when cycling overseas (*OR*= 9.870; 95%*CI*: 2.044-47.665) (Table 5).

Table 1. Cycling Questions and Coding: Behaviour and Safety in Queensland and Hypothetically Overseas

Topic	Question	Respondents	Original Coding	Recoded
Cycling Overseas	"If you were travelling overseas, how likely would you be to ride a bicycle as part of a tour or leisure activity?"	All Sample	1. 'Not at all likely' 2. 'Somewhat likely' 3. 'Moderately likely' 4. 'Very likely'	1 = 'No' 2-4 = 'Yes'
Helmet Use if Cycling Overseas	"If legislation in that country DID NOT require compulsory bicycle helmets, how often do you think would you wear a bicycle helmet when riding?"	All except those who responded 'Not at all' or 'Unsure' to the question above.	1. 'Never' 2. 'Almost never/rarely' 3. 'Sometimes' 4. 'Almost every time' 5. 'Every time'	1-3 = 'No' 4-5 = 'Yes'
Cycling Injuries Preventable	"To what extent do you think it is possible to prevent people from being injured while riding a bicycle?"	Whole Sample	1. 'Impossible' 2. 'Some could be prevented' 3. 'About half could be prevented' 4. 'Most could be prevented' 5. 'All could be prevented'	**Possible to prevent All bicycle injuries:** 1-4 = 'No' 5= 'Yes'
Queensland Cycling Frequency	"Over the past 12 months, how often have you ridden a bicycle?"	Whole Sample	1. Note: These responses are already recoded 2. 'Frequent' (min. once in last week) 3. 'Moderate' (min. once in last month) 4. 'Infrequent' (min. once in last year) 5. 'Non-Cyclist' (no cycling in last year)	**Cycled in last 12 months:** 1-3 = 'Yes' 4 = 'No'
Queensland Cyclists Reasons for Cycling	"What is the main reason that you ride your bicycle?"	Cyclists	1. 'Transport' 2. 'Leisure' 3. 'Fitness' 4. 'Sport' 5. 'Other'	'Other' Recoded: New categories ='Family Activity' & 'Mixed motive'
Helmet Use when Compulsory (Qld)	"How often do you wear a helmet when riding your bike?"	Cyclists	1. 'Never' 2. 'Almost never/rarely' 3. 'Sometimes' 4. 'Almost every time' 5. 'Every time'	1= 'Never' 2-4 = 'Sometimes 5 = 'Every time'

Note: Unsure and no response were always classed as missing.

Table 2. Responses to likelihood of riding a bicycle whilst travelling overseas and helmet usage whilst riding overseas if not compulsory

Response	N (%)	Recoded Response	Sub-Total N (%)
"If you were travelling overseas, how likely would you be to ride a bicycle as part of a tour or leisure activity?"			
Not at all likely	747 (60.4)	No	747 (60.4)
Somewhat likely	182 (14.7)	Yes	489 (39.6)
Moderately likely	132 (10.7)		
Very likely	175 (14.2)		
"If legislation in that country DID NOT require compulsory bicycle helmets, how often do you think would you wear a bicycle helmet when riding?"			
Never	89 (18.3)	No	167 (34.3)
Almost never/rarely	23 (4.7)		
Sometimes	55 (11.3)		
Almost every time	47 (9.7)	Yes	319 (65.6)
Every time	272 (56)		

Table 3. Bivariate Associations between demographic, health and cycling characteristics by hypothetical cycling engagement and bicycle helmet use when travelling overseas

Parameter	*N*	Would Cycle Overseas?			*N*	Helmet Use Overseas*		
		Yes	No	*p* value		Yes	No	*p* value
		n (%)	*n* (%)			*n* (%)	*n* (%)	
Gender								
Male	632	266 (54.4)	356 (47.7)	<0.05[a]	265	161 (50.5)	104 (62.3)	<0.05[a]
Female	624	223 (45.6)	391 (52.3)		221	158 (49.5)	63 (37.7)	
Age								
18-34	128	77 (15.8)	51 (6.9)	<0.01[b]	77	47 (14.8)	30 (18.1)	0.821
35-44	188	104 (21.4)	82 (11.1)		103	68 (21.4)	35 (21.1)	
45-54	267	144 (29.6)	117 (15.9)		143	95 (29.9)	48 (28.9)	
55+	661	162 (33.3)	487 (66.1)		161	108 (34.0)	53 (32.9)	
Years of Education								
1-10 years	314	81 (16.7)	226 (30.8)	<0.01[b]	81	50 (15.8)	31 (18.7)	0.860
11-12 years	259	77 (15.8)	180 (24.6)		77	51 (16.1)	26 (15.7)	
13-14 years	157	69 (14.2)	86 (11.7)		68	44 (13.9)	24 (14.5)	
15+ years	507	259 (53.3)	241 (32.9)		257	172 (54.3)	85 (51.2)	
Income Category								
A $0-26K	144	39 (8.0)	103 (13.8)	<0.01[b]	39	27 (8.5)	12 (7.2)	0.894
A $26,001 -52 K	158	42 (8.6)	112 (15)		41	27 (8.5)	14 (8.4)	
A $52,001 -100K	177	83 (17.0)	92 (12.3)		83	52 (16.3)	31 (18.6)	
A $100K	313	167 (34.2)	144 (19.3)		165	112 (35.1)	53 (31.7)	
Did not Report income	464	158 (32.3)	296 (39.6)		158	101 (31.7)	57 (34.1)	

Parameter	N	Would Cycle Overseas?			N	Helmet Use Overseas*		
		Yes	No	p value		Yes	No	p value
		n (%)	n (%)			n (%)	n (%)	
Cycling Injuries Preventable								
Unpreventable	159	50 (10.4)	107 (15.1)	<0.05[a]	50	28 (8.9)	22 (13.5)	0.275
Neutral	676	266 (55.4)	404 (56.9)		266	176 (56.1)	90 (55.2)	
Preventable	368	164 (34.2)	199 (28)		161	110 (35.0)	51 (31.3)	
Cycling Frequency								
Non Cyclist	831	220 (45.0)	601 (80.5)	<0.01[b]	218	147 (46.1)	71 (42.5)	0.115
Infrequent	169	97 (19.8)	70 (9.4)		97	55 (17.2)	42 (25.1)	
Moderate	105	67 (13.7)	36 (4.8)		67	42 (13.2)	25 (15)	
Frequent	147	105 (21.5)	40 (5.4)		104	75 (23.5)	29 (17.4)	
Reasons for Cycling								
Transport	63	46 (17.2)	16 (11.2)	0.183	46	29 (17.0)	17 (17.9)	0.454
Leisure	212	137 (51.3)	72 (50.3)		137	83 (48.5)	54 (56.8)	
Fitness	116	66 (24.7)	48 (33.6)		65	45 (26.3)	20 (21.1)	
Sport	13	11 (4.1)	2 (1.4)		11	8 (4.7)	3 (3.2)	
Family Activity	4	2 (0.7)	2 (1.4)		2	1 (0.6)	1 (1.1)	
Mixed Motive	8	5 (1.9)	3 (2.1)		5	5 (2.9)	0 (0)	
Usual Duration when Cycle								
< 30 minutes	196	109 (40.8)	84 (57.5)	<0.01[b]	108	66 (38.4)	42 (44.7)	0.361
> 31 minutes	223	158 (59.2)	62 (42.5)		158	106 (61.6)	52 (55.3)	
Perceived Safety when Cycling across all Infrastructure Types								
Unsafe	58	23 (8.6)	35 (24.3)	<0.01[b]	23	15 (8.8)	8 (8.4)	0.657
Neither Unsafe or Safe	177	117 (43.8)	60 (41.7)		116	71 (41.5)	45 (47.4)	
Safe	176	127 (47.6)	49 (34)		127	85 (49.7)	42 (44.2)	
Helmet Use								
Never	23	12 (4.5)	10 (6.8)	0.166	12	2 (1.2)	10 (10.5)	<0.01[b]
Sometimes	25	20 (7.5)	5 (3.4)		20	6 (3.5)	14 (14.7)	
Every time	371	236 (88.1)	131 (89.7)		235	164 (95.3)	71 (47.7)	
Chronic Health Problems								
No	690	325 (66.5)	358 (48)	<0.01[b]	324	212 (66.5)	112 (67.1)	0.920
Yes	565	164 (33.5)	388 (52)		162	107 (33.5)	55 (32.9)	
Presently a smoker								
No	1110	432 (88.3)	660 (88.5)	1.000	430	289 (90.6)	141 (84.4)	0.052
Yes	145	57 (11.7)	86 (11.5)		56	30 (9.4)	26 (15.6)	
Physical Activity (PA) Classification (Sufficient is 30 minutes on five or more days per week)								
No Reported PA	191	43 (8.8)	140 (18.7)	<0.01[b]	42	23 (7.2)	19 (11.4)	0.300
Insufficient PA	466	157 (32.1)	303 (40.6)		157	105 (32.9)	96 (57.5)	
Sufficient PA	599	289 (59.1)	304 (40.7)		287	191 (59.9)	52 (31.1)	

[a] Significant chi square for trend at p<0.05; [b] Significant chi square for trend at p<0.01; [c] Not able to run a chi square test as this category only relates to cyclists * This represents people who said they would ride a bicycle overseas. Missing values are not included in the table.

Table 4. Exploring the Likelihood of Cycling Overseas by Cycling Behaviours and Perceptions on the Preventability of Cycling Injuries

Cycling Behaviour in Queensland	Likelihood of Cycling Overseas			
	Somewhat Likely	Moderately Likely	Very Likely	p value
	n = 177 (%)	n = 130 (%)	n = 173 (%)	
Bicycle Injuries Preventable [a]				
Unpreventable	20 (40.0)	21 (42.0)	9 (18.0)	<0.01[c]
Neutral	100 (37.6)	74 (27.8)	92 (34.6)	
Preventable	57 (34.8)	35 (21.3)	72 (43.9)	
Cycling Frequency [a]				
Non Cyclist	98 (44.5)	57 (25.9)	65 (29.5)	<0.01[c]
Infrequent Cyclist	36 (37.1)	33 (34.0)	28 (28.9)	
Moderate Cyclist	19 (28.4)	17 (25.4)	31 (46.3)	
Frequent Cyclist	29 (27.6)	25 (23.8)	51 (48.6)	
Duration Spent Cycling				
<30 minutes	43 (39.4)	36 (33.0)	30 (27.5)	<0.01[c]
>31 minutes	41 (25.9)	37 (23.4)	80 (50.6)	
Helmet Use in Queensland when Cycle				
Never	3 (25.0)	5 (41.7)	4 (33.3)	0.813
Sometimes	7 (35.0)	6 (30.0)	7 (35.0)	
Every time	74 (31.4)	63 (26.7)	99 (41.9)	
Middle Exposure Estimate Categorised into Hours Cycling Per Annum [b]				
Infrequent Cycling	32 (43.8)	23 (31.5)	18 (24.7)	<0.01[c]
Moderate Cycling	28 (31.1)	26 (28.9)	36 (40.0)	
High Cycling	24 (23.1)	24 (23.1)	56 (53.8)	
Perceived Safety When Cycling Across All Infrastructure Types				
Perceive Cycling as Unsafe	10 (43.5)	7 (30.4)	6 (26.1)	0.555
Perceive Cycling as Being Neither Unsafe or Safe	35 (29.9)	34 (29.1)	48 (41.0)	
Perceive Cycling as Safe	38 (29.9)	33 (26.0)	56 (44.1)	

[a] These two questions were asked to the whole sample whereas the rest were only asked or calculated for those individuals who had indicated they had cycled at least once in the previous 12 months.

[b] Infrequent Cycling is cycling between 0 and 3 hours per annum; Moderate Cycling is cycling between 4 and 27 hours per annum and High Cycling is cycling more than 30 hours per annum.

[c] Significant chi square for trend at $p<0.01$.

Missing values are not included in the table.

Table 5. Independent Predictors of Hypothetical Cycling Engagement Overseas and Helmet Use

Dependent Variable / **Independent Variables**	**Sig.**	**AOR**	**95% CI**
Cycling Overseas			
Aged 18-34 years (REF)	0.001		
Aged 35-44 years	0.799	1.111	0.493-2.503
Aged 45-54 yeasrs	0.771	0.891	0.411-1.933
Aged 55 and older	**0.009**	**0.363**	**0.170-0.777**
Self Reported Health Status - Poor	0.022		
Self Reported Health Status - Fair	0.249	0.393	0.08-1.922
Self Reported Health Status - Good	0.545	1.55	0.375-6.413
Self Reported Health Status – Very Good	0.722	1.29	0.318-5.228
Self Reported Health Status - Excellent	0.324	2.103	0.48-9.22
Engage in Insufficient Physical Activity (REF)	0.001		
Engage in Sufficient Physical Activity	**0.008**	**1.986**	**1.194-3.303**
No reported Physical Activty	0.119	0.463	0.176-1.22
Duration Average Cycle >30 minutes	**0.026**	**1.721**	**1.066-2.777**
Perceive Cycling as Unsafe (REF)	0.021		
Perceive Cycling as Neither Unsafe or Safe	**0.028**	**2.153**	**1.084-4.276**
Perceive Cycling as Safe	**0.006**	**2.689**	**1.335-5.416**
Years of Education – 1 -10 years (REF)			
Years of Education – 11-12 years	**0.005**	**0.315**	**0.140-0.709**
Years of Education – 13-14 years(2)	0.065	0.436	0.181-1.051
Years of Education – 15 years and over (3)	0.844	0.931	0.457-1.896
Helmet Use When Cycling Overseas			
’Never’ Wear Helmet when Cycle (REF)	0.000		
Wear Helmet ’sometimes’ when Cycle	0.505	1.862	0.299-11.583
Wear Helmet ‘Every time’ Cycle	**0.004**	**9.870**	**2.044-47.665**

Sig. = significance; AOR = adjusted odds ratio; 95%CI = 95% confidence interval. Bold independent variables are significant positive or negative predictors of dependent variable.

Note: Odds ratios are adjusted for all relevant confounders.

Discussion

Promoting the health and safety of Australian tourists whilst overseas is a challenge given the variety of destinations, activities and potential hazards to which they may be exposed (Wadhwaniya & Hyder, 2013). However gaps currently exist in our knowledge about Australian tourists including their cycling participation rates, types of cycling engagement and epidemiology of cycling injuries sustained (Faulks et al., 2007). This paper has sought to examine hypothetical cycling engagement and helmet use whilst travelling overseas amongst a sample of Queensland residents. This analysis is a first step in addressing some of the current knowledge gaps regarding potential Australian cycle tourist numbers and to begin to disentangle the relationship between safety enhancing habits, generated by legislation, and behaviour intentions in a non-legislated setting. This study acts as a initial proxy measure of attitudes towards cycling overseas and helmet wearing in a non-legislated setting.

Cycling Overseas

Most of the Queenslanders who participated in this study expressed that it was unlikely that they would engage in cycling whilst travelling overseas. Considering the current levels of cycling participation within Australia (36.3% have cycled in last year), and Queensland specifically are low (33.2% have cycled in the last year), it is understandable that if they do not currently engage in cycling the propensity to do so overseas is likewise going to be limited (Austroads, Australian Bicycle Council, & Munro, 2013; Austroads, Australian Bicycle Council, & Munro, 2015). The high proportion of respondents who indicated they would not cycle overseas is suggestive that bicycle helmet laws may not be restricting cycling participation in Australia.

Behaviour intentions for holiday cycling are influenced by perceived cycling ease related to concerns about weather, distance, traffic and crowding (Kaplan et al., 2015a). Furthermore it has been noted that older adults may have lower levels of trust in their own cycling abilities and as such it is unlikely they would cycle in foreign locations (Bernhoft & Carstensen, 2008). Cycle tourists are exposed to a novel cycling and road environment, unfamiliar bicycle and may underestimate the importance of confidence in cycling ability (Bentley, Meyer, et al., 2001). Furthermore, they may not expect the confidence of cyclists with whom they will engage in established cycling cities (Chataway, Kaplan, Nielsen, & Prato, 2014).

There is a current dearth of information about the experience, motivations and fitness level of Australian cycling tourists. The inclusion of cycling specific questions in the International and National Visitor Survey could further help establish some baseline information and identify profiles of cycle tourism engagement (Faulks et al., 2007). Cycling engagement generally and cycle tourism have economic, social and environmental benefits where undertaken (Faulks et al., 2007). Therefore knowing about Australians who engage in cycling tourism experiences domestically and overseas will provide insights into an emerging area of tourism but one which has the potential implications for road safety.

Bicycle Helmet Use Overseas and Safe Cycling

One issue which might have influenced the respondent's hypothetical use of a helmet is the perceived or real logistic difficulties of locating a bicycle helmet when helmets are not routinely worn within the country (Hargarten, 1994). It is antedotally suggested however that this logistic difficulty may be decreased given the boom in cycling tourism and the need to ensure the safety of participants (Shaheen & Guzman, 2011). Using the behaviour of change model to understand how to increase helmet usage for those cycling overseas where legislation requiring helmet use is non-existent, is needed. For example, the group of hypothetical travelers who are not considering wearing a helmet overseas are in the pre-contemplation phase, this group would require different strategies compared to the group who would like to wear a helmet overseas (action/maintenance stage) but may not do so due to other factors. Such a factor could be concerns regarding helmet hygiene (Grenier et al., 2013).

Advocating for safe cycling practices amongst all cyclists offers benefits regardless of helmet availability and use. For cycle tourists it is suggested that they familiarise themselves with the cycling infrastructure (if present), general conduct of other cyclists and pedestrians (including their interactions), road rules and general road environment prior to jumping on a bicycle. Relatedly selection of cycling routes where there is separation from other road traffic represents an optimal safe cycling practice.

Regardless of the type of cycle tourism, it is important that all cycle tourists, and all tourists, generally have appropriate travel insurance, which includes coverage for medical care and hospitalisation, and that their travel plans are registered (Leggat & Fischer, 2006). It is recommended in particular that the traveller checks that their insurance will cover bicycle riding as this may be classified as a hazardous recreational activity (Leggat, Carne, & Kedjarune, 1999; Leggat & Fischer, 2006).

Limitations

There are a few limitations to the current study, which should be noted. This study used a cross-sectional survey methodology, using a landline based telephone number with a response rate 40.3%. Although the response rate is low this was found to be on par with other CATI research (Steeh, Kirgis, Cannon, & DeWitt, 2001). Further, the respondents may not be representative with an overrepresentation of older adults in the sample relative to the Queensland population. Despite these limitations, other various tests of integrity are performed to assess the potential for sampling error, sample representativeness and data consistency checks.

Another limitation is respondents were asked about hypothetical behaviour whilst overseas. The use of such hypothetical questions without the use of a scenario enables respondents to answer based on their own preferences and not linked to actuality. However using such a methodology without obtaining information on their previous experiences or what influences their hypothetical tourist behaviour significantly limits interpretation, albeit we do know about their current levels of cycling engagement. There is also the potential that respondents were answering based on what they thought would be the most socially desirable response.

Future research which explores actual behaviour and/or behaviour intentions will be undertaken. This research will help to address the current dearth of information regarding the number of Australians who engage in cycling tourism overseas, types of cycling participation, epidemiology of cycling injuries, barriers to helmet use in practice and locations of cycling with respect to the road environment. Obtaining a sufficient sample to enable adequate power will be an important consideration. Exploring actual behaviour, factors that influence cycling particpation and safety decision making will promote further insights into safety legislation as an influencer on safety perceptions and habit formation.

Conclusions

Cycle tourism is an expanding travel niche with a third of all respondents saying they would undertake cycling when traveling. It is important, like any emerging tourism niche, that the specific safety concerns be addressed. People who wear helmets on a regular basis in a home setting are more likely to say they will wear a helmet when travelling. While wearing a helmet should ideally be promoted were possible this might not always be readily available overseas. Promoting other mechanisms to promote safe cycling participation of residents overseas regardless of helmet use and availability will offer benefits. Such approaches include familiarisation with road rules, right of way, general conduct of fellow cyclists including interactions with other pedestrians and reviewing the road and cycling infrastucture. This familiarisation process will also likely foster route planning and enable strategic sightseeing opportunities.

Acknowledgements

A poster was presented at the 15th Conference of the International Society of Travel Medicine.

Funding: This work was supported by the Department of Industry, Innovation, Science, Research and Tertiary Education (DIISRTE), Australian Government, Research Infrastructure Block Grant (2013).

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Road user perception of safety at Safe System intersections

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Key Findings

- Survey respondents perceive roundabout controlled intersections to be safer than stop or give way controlled intersections in both rural and metro scenarios.
- Survey respondents perceive plateau (raised platform) intersections to be less safe than stop or give way controlled intersections in metro scenarios.
- Study findings suggest that public perception of the benefits of increasingly Safe System aligned intersection designs are tied to their familiarity to the public.

Abstract

This study examined driver perceptions of safety at metro and regional intersections with different types of control. Data were collected using an on-line survey with 696 participants drawn from the Royal Automobile Association of South Australia's Member Panel. Results demonstrate a greater perception of safety associated with the use of roundabouts, yet a reduced perception of safety associated with a lesser known Safe System aligned design of raised plateaus, suggesting a need for greater public awareness of the benefits of less well-known treatments.

Keywords

Intersection, control, Safe System, roundabout

Introduction

In South Australia, 508 of the 1,211 right angle fatal and serious injury (FSI) crashes that occurred in the 10 years between 2007 and 2016 were at intersections where stop or give way control was applied. An additional 479 right angle FSI crashes occurred where no control was employed (i.e. where no control device such as a give way/stop sign or traffic signal was present at the intersection). Together, these represent over 11% of all FSI crashes on South Australian roads. These statistics are based on South Australian police crash data.

The design of non-signalised intersections in Australia has traditionally relied on stop and give way controls. In some jurisdictions, the T-junction rule has been employed in-lieu of stop or give way control in certain situations. At these intersections, safe operation is predicated on road user attention and decision-making; road users must identify the intersection, comply with any controls and make the right decisions to avoid conflicts with other vehicles (Austroads 2018). Research has found that the increased cognitive workload induced by complex traffic environments can lead to delayed response times and reduced driving performance (e.g., lane keeping, speed choice, response to safety critical events, etc.). Such findings suggest complex driving environments, including intersections, may increase the likelihood of driving errors, particularly for inexperienced or older drivers (Austroads, 2016; Cantin et al., 2009; Edquist et al., 2012; Patten et al., 2006; Ross et al., 2014).

A study undertaken by Andersson (1982) concluded a 44% reduction in all crashes and a 65% reduction in right angle crashes at 4-leg intersections where give way control was replaced with stop control. Other research has also shown crash reductions where stop control was installed at intersections with no previous control (Elvik et al. 2009, Frith and Harte 1986). In light of such research, the use of stop control in-place of give way control based on safety related concerns may be appropriate: in Australia, stop control is allowed in-place of give way control where there is insufficient sight distance at an intersection (Standards Australia 2009). Stop control is also used as a means of treating intersections with a poor safety record, though this is not formally acknowledged in either the Australian Standards or Austroads Guides. However, a substantial number of FSI crashes occur at stop-controlled intersections in South Australia, giving rise to concern that such a method of improving safety at intersections is not well-aligned to the Safe System objective of eliminating serious injuries and death on our roads.

While the increase in control by using stop control may reduce crash likelihood, it will not reduce the severity of a crash should it occur. Safe System aligned designs that are aimed at reducing the severity of crash outcomes through the control of impact speed and impact angle, such as roundabouts and raised plateaus (Austroads 2015, 2018), have historically been employed on a less common basis but are becoming more widely used throughout Australia.

While there is a large professional body of knowledge related to the safety benefits of Safe System aligned designs (e.g., Austroads, 2018), little is known about public perception of these designs.

Research shows that the provision of treatments on roads and at intersections can alter cyclists' and pedestrians' perceptions of safety at those sites (e.g., Emo et al., 2011; Ng et al., 2017; Perdomo et al., 2014; Wang & Akar, 2018). While no research regarding driver perceptions of intersection safety was identified however, investigations of some treatments, including road delineation and perceptual countermeasures have been found to influence driver behaviour via driver perceptions of comfort and risk (e.g., Elvik et al., 2009; Horberry et al., 2006; Walton et al., 2011). Other elements of the road network, including intersection complexity, traffic volume, and vehicle travelling speeds can also influence the perceived safety of intersections (Wang et al., 2002). As such, the aim of this study is to identify road user perception of safety at non-signalised intersections where different types of control are employed, including approaches aligned with Safe System.

Methods

The data presented in this study were collected through an online survey that was commissioned as part of a larger research project undertaken for the Department of Planning, Transport and Infrastructure (DPTI) in South Australia. The larger research project was framed around identifying whether an increase in control translates into improved safety. This study focusses on the results of the survey and not the wider research project for which it was commissioned.

Survey distribution

The survey was developed and distributed with the assistance of the Royal Automobile Association of South Australia (RAA). This method was chosen as:

- A greater number of responses were likely compared to other feasible methods (e.g. recruitment through the Centre for Automotive Safety Research [CASR] website, recruitment of university students).
- CASR has a longstanding relationship with the RAA who were receptive to the idea of collaboration.
- All other methods displayed bias that may be equal to or greater than that of the selected method.

The RAA elected to recruit respondents through their Members Panel. The Members Panel consists of subscripted RAA members who elect to respond to regular surveys. At the time of the survey, the RAA had more than 685,000 members able to participate in Member Panel surveys, though only a small proportion were registered to receive the surveys. The survey was completed online through the RAA Member Panel website and was available for one week. Multiple attempts were not allowed. The survey was restricted to respondents who were at least 18 years of age, were residents of South Australia, and had a full driver's licence. A total of 846 people attempted the survey, of which 696 completed and submitted their responses. Incomplete surveys were excluded from analysis.

Questions

The survey consisted of four general themes of inquiry organised in four sections. Only the questions related to the aim of this study are discussed. These are the general profiling questions and "perception of personal safety at intersections" questions. The other two themes ("negotiating rural T-junction intersections" and "understanding of intersection warning signs") are not discussed in this study.

General profile questions

This consisted of questions regarding demographic, driving practices and behaviour, and general perception of risk. The purposes of these questions were to establish the profile of respondents, their general driving practices and behaviour, as well as establishing the respondents' perception of personal safety in terms of the general task of driving and from where this risk (i.e. sources of risk such as one's own behaviour, the behaviour of others, or the road environment) arises.

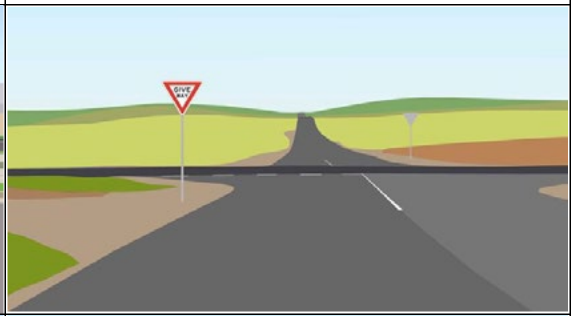
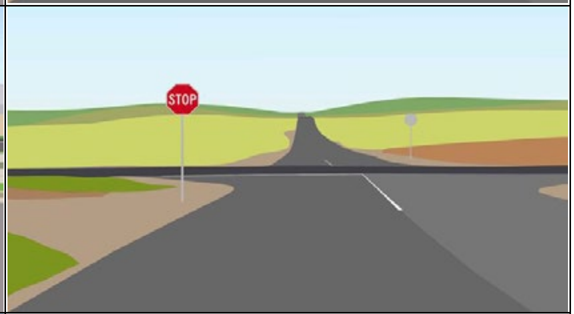
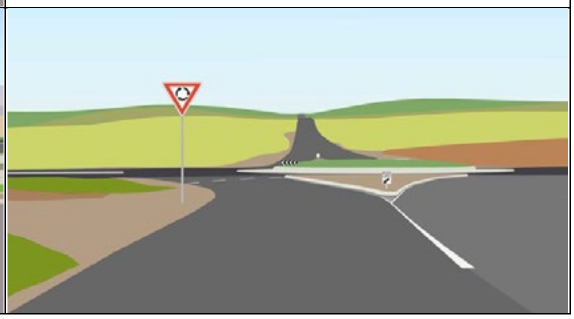
For one general profile question in the survey ("Considering all factors [e.g. the road environment, other drivers, your own driving ability], how safe do you perceive the task of driving to be?"), respondents were asked to select an answer from a rating scale (very safe; moderately safe; neither safe nor dangerous; moderately dangerous; very dangerous). This same rating scale was used for the "perception of personal safety" questions (below). The terms "safe" and "dangerous" were not defined to the survey respondents.

Perception of personal safety at intersections questions

These questions were related to the core objective of the project and consisted of questions regarding respondents' perceptions of risk when faced with a specific scenario of turning right at a two-lane/two-way cross road intersection. The respondents were presented with an image from a driver's point of view on the approach to the intersection along the minor road. The wording for each question was identical ("You are driving a passenger vehicle and approaching a "cross road" intersection along a [metro/rural] road. How safe do you perceive performing a right turn to be?").

Seven scenarios were presented: four at a metro intersection and three at a rural intersection (Table 1). Each scenario differed by the type of control used to control the movements of minor road vehicles. Four types of control were presented: give way (single sign, control line), stop (single sign, control line), raised plateau (raised intersection footprint, single give way sign, control line) and roundabout (roundabout intersection footprint, single roundabout sign, control line). All four scenarios were presented for both metro and rural locations, with the exception of no raised plateau scenario

Table 1. Images presented to respondents for each scenario of the perception of personal safety at intersections questions

	Image presented to respondents	
	Metro scenarios	**Rural scenarios**
Give way control		
Stop control		
Plateau		Not presented
Roundabout		

for the rural location due to the treatment's relative scarcity in rural areas. Respondents were not informed about the differences between each intersection, instead relying solely on what was visually presented to them with each image. The intention behind including these intersections was to assess road user perception of safety at intersections that are objectively safer (roundabout and raised plateau) than that of traditional cross road designs (Austroads, 2015, 2018).

Results

General profile questions

Demographic questions identified most respondents (78.9%) as residing in the Adelaide metropolitan area (5000 – 5199 postcode area) (see Table 2). A further 17.5% resided in the inner rural areas of South Australia (5200 – 5499 postcode area) and 3.6% resided in the outer rural areas of South Australia (> 5500 postcode area), including one from Broken Hill, NSW (2880 postcode).

Table 2. Residential postcode of survey respondents

Residential postcode	N	%
5000 – 5199 (metro)	549	78.9
5200 – 5499 (inner rural)	122	17.5
5000 and above (outer rural)	24	3.5
2880 (Broken Hill)	1	0.1

Most respondents were aged 45 years and over (90.9%) with 11.2% being 75 years and over (see Table 3). The majority of respondents had held an unrestricted driver's licence for 20 or more years (93.7%) (see Table 4).

Table 3. Age range of survey respondents

Age range	N	%
18 – 24 years old	2	0.3
25 – 34 years old	21	3.0
35 – 44 years old	40	5.7
45 – 54 years old	108	15.5
55 – 64 years old	174	25.0
65 – 74 years old	273	39.2
75 – 84 years old	72	10.3
85 years old and above	6	0.9

Table 4. Time having held an unrestricted drivers licence of survey respondents

Time holding unrestricted license	N	%
Less than 1 year	2	0.3
1 – 2 years	2	0.3
3 – 4 years	2	0.3
5 – 9 years	8	1.1
10 – 14 years	12	1.7
15 – 19 years	18	2.6
20 years or more	652	93.7

Almost all respondents had driven a passenger vehicle in the past six months (99.0%) (see Table 5). Less had ridden a bicycle (26.6%), motorcycle (11.5%), or had driven a heavy vehicle (14.8%) in the past six months. Five respondents had not driven/ridden any of these vehicles in the past six months.

Table 5. Vehicles having been driven by survey respondents in past six months

Vehicles driven/ridden in past 6 months	N	%
Bicycle	185	26.6
Motorcycle	80	11.5
Passenger vehicle (e.g. car, van)	689	99.0
Heavy vehicle (e.g. truck, bus)	103	14.8
None of the above	5	0.7

Most respondents reported that in the past six months, they had driven on metro roads most days (65.9%) (see Table 6). Only 4.0% reported having rarely or never driven on metro roads. In comparison, the minority of respondents reported having driven on rural roads most days (19.8%), with nearly half reporting having driven sometimes, rarely or never on rural roads (48.8%).

Table 6. Frequency of survey respondents driving on metropolitan and rural roads in past six months

	Metropolitan roads		Rural roads	
Frequency of driving in past 6 months	N	%	N	%
Never	5	0.7	12	1.7
Rarely	22	3.2	76	10.9
Sometimes	88	12.6	252	36.2
Often	122	17.5	218	31.3
Most days	459	65.9	138	19.8

The majority of respondents reported driving for two or less hours per day (87.1%) (see Table 7). Only 2.9% reported driving for five or more hours per day.

Table 7. Average hours per day driven by survey respondents

Average number of hours driving per day	N	%
Less than 1 hour	286	41.1
1 – 2 hours	320	46.0
3 – 4 hours	70	10.1
5 or more hours	20	2.9

The majority of respondents perceived themselves as driving at about the same speed as other traffic around them (80.5%) (see Table 8). A small proportion perceived themselves as generally driving slower (11.9%) or faster (7.6%) compared to other traffic around them.

Table 8. Self-reported driving speed of survey respondents compared to other traffic

Driving speed respective to other traffic	N	%
Slower than most	83	11.9
About the same speed as those around me	560	80.5
Faster than most	53	7.6

Regarding perceptions of the general task of driving (see Figure 1), the majority of respondents regarded driving to be moderately safe (50.3%). A substantial proportion regarded it as being very safe (14.9%), while a minority regarded it as being very dangerous (1.7%).

When asked about their perception of the greatest risk to their own safety as a road user, most respondents nominated the action of other road users (82.2%), while few nominated their own actions (7.8%) or the road environment in which they drive (10.1%).

Perception of personal safety at intersections questions

For each intersection scenario, the respondents were asked to rank their perception of their own personal safety if they were to perform a right turn from a minor road at a non-signalised intersection, as per the four metro and three rural scenarios described above.

The results for the metro scenarios were broadly similar, with a near majority of respondents perceiving each scenario as "moderately safe" (see Figure 2). The results for the give way control and stop control scenarios showed no statistically significant different at a 95% confidence level ($p = 0.58$) (see Table 9). A similar proportion of respondents perceived the give way control and stop control to be moderately or very dangerous (22.3% and 21.7%, respectively) (see Table 10). The results for the plateau scenario showed a near statistically significant difference compared to the give way control scenario ($p = 0.09$) with a greater proportion of respondents perceiving the plateau scenario to be moderately or very dangerous (24.4% versus 22.3%). The results for the roundabout scenario showed a statistically significant difference compared to the give way control scenario ($p = 0.00$) with a lesser proportion of respondents perceiving the roundabout scenario to be moderately or very dangerous (17.0% versus 22.3%).

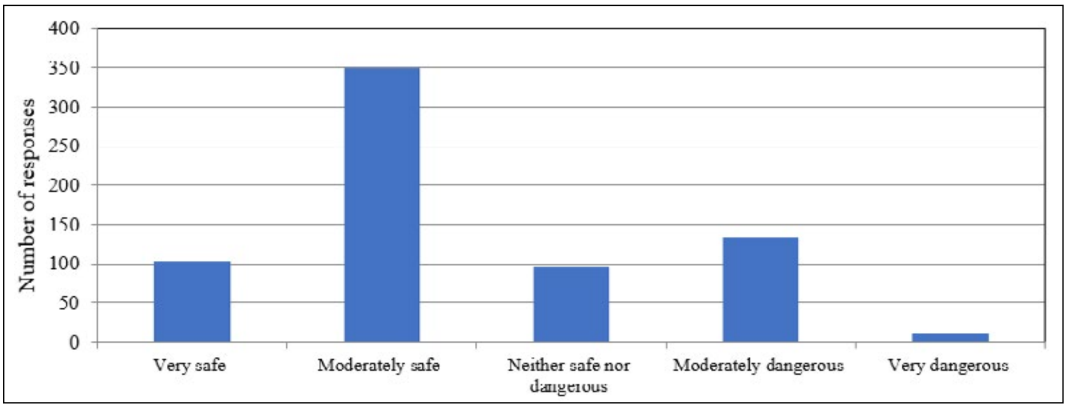


Figure 1. Results of perception of personal safety for the general task of driving

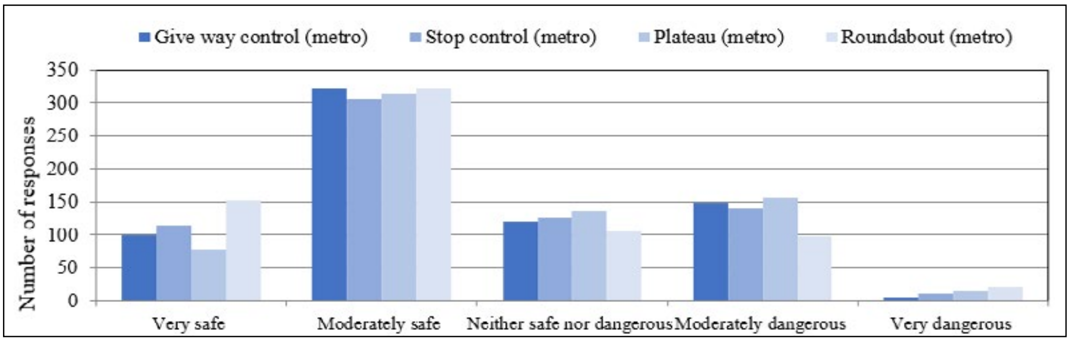


Figure 2. Results of perception of personal safety at metro non-signalised intersections given four different control/design scenarios

Table 9. Results of perception of personal safety at metro non-signalised intersections given four different control/design scenarios

Type of control	Response category					Chi-squared analysis		
	VS*	MS*	N*	MD*	VD*	$X^{2\#}$	df	p-value
Give way	99	321	121	149	6	2.89	4	0.58
Stop	115	305	125	141	10			
Give way	99	321	121	149	6	7.95	4	0.09
Plateau	76	314	136	155	15			
Give way	99	321	121	149	6	31.65^	4	0.00
Roundabout	152	321	105	97	21			

*VS = Very safe; MS = Moderately safe; N = Neither safe nor dangerous; MD = Moderately dangerous; VD = Very dangerous.

#Right tail Chi-squared statistic

^Statistically significant difference between response category distributions at a 95% confidence level

Table 10. Aggregated results of perception of personal safety at metro non-signalised intersections given four different control/design scenarios

Type of control	% responses moderately safe or very safe	% responses moderately dangerous or very dangerous
Give way	60.3%	22.3%
Stop	60.3%	21.7%
Plateau	56.9%	24.4%
Roundabout	68.4%	17.0%

As with the metro scenarios, the results for the rural scenarios were broadly similar, with a substantial proportion of respondents perceiving each scenario as "moderately safe" (see Figure 3). The results for the give way control and stop control scenarios showed a near statistically significant difference at a 95% confidence level (p = 0.07) (see Table 11). A lesser proportion of respondents perceived the stop control scenario to be moderately or very dangerous when compared to the give way control scenario (26.0% versus 29.5%, respectively) (see Table 12). The results for the roundabout scenario showed a statistically significant difference compared to the give way control scenario (p = 0.00) with a lesser number of respondents perceiving the roundabout scenario to be moderately or very dangerous (15.2% versus 29.5%).

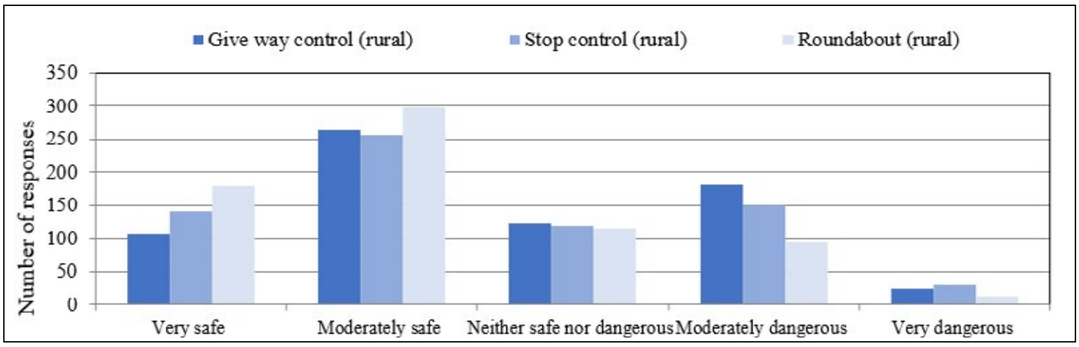


Figure 3. Results of perception of personal safety at rural non-signalised intersections given four different control/design scenarios

Table 11. Results of perception of personal safety at rural non-signalised intersections given four different control/design scenarios

Type of control	Response category					Chi-squared analysis		
	VS*	MS*	N*	MD*	VD*	$X^{2\#}$	df	p-value
Give way	106	263	122	181	24	8.50	4	0.07
Stop	141	255	119	151	30			
Give way	106	263	122	181	24	52.56^	4	0.00
Roundabout	179	297	114	94	12			

*VS = Very safe; MS = Moderately safe; N = Neither safe nor dangerous; MD = Moderately dangerous; VD = Very dangerous.

[#]Right tail Chi-squared statistic

^Statistically significant difference between response category distributions at a 95% confidence level

Table 12. Aggregated results of perception of personal safety at rural non-signalised intersections given four different control/design scenarios

Type of control	% responses moderately safe or very safe	% responses moderately dangerous or very dangerous
Give way	53.0%	29.5%
Stop	56.9%	26.0%
Roundabout	68.4%	15.2%

Discussion

The results indicate that, for both metro and rural scenarios, roundabouts were perceived as being safer than other forms of non-signalised control, which is in-line with professional knowledge of roundabout performance with regard to vehicle occupant safety (Austroads 2018). However, plateau (or raised platform) intersections seem to be perceived as less safe than a similarly controlled intersection without a plateau. This is counter to professional understanding and could suggest a lack of public understanding of the design.

The difference between the results for the roundabout scenario and the conventionally control scenarios (i.e. give way and stop control scenarios) was greater for the rural scenarios than for the metro scenarios. This suggests that an awareness of the environmental differences skewed the perception of the respondents. In other words, the difference between the perceived safety of a roundabout intersection versus a conventionally controlled intersection is greater for the rural environment where the speeds are fast, compared to the metro scenario where the speeds are generally much slower. For the metro scenarios, the speed environment appears to be sufficiently slow that the difference between intersection control does not play as greater role in determining the perceived safety.

For the rural scenarios, the stop control was perceived as safer than the give way control. This result is counter-intuitive considering the justification for installing stop control instead of give way control is a lack of sight distance (a generally more dangerous scenario) or as an informal treatment for intersections with a poor safety record.

Limitations

The primary limitation in the present study is the use of a convenience sample for data collection, including:

- The recruitment process was not randomised and was selective of a specific cohort.
- The wider population outside of RAA members were not recruited.
- The Member Panel demographic does not generally reflect the demographic of the wider population of South Australian road users

The generally older and more experienced demographic of the survey respondents was the most noticeable difference between the survey sample and the general population in South Australia. This could lead to results that do not accurately reflect the younger and less experienced cohort.

In general, the limitations of this study mean that systematic bias could be introduced by recruiting RAA Member Panel members such that the results that may not accurately reflect the perceptions of the broader population of South Australian road users. Future research should endeavour to recruit a more representative sample.

Conclusions

This study has shown a possible mixed understanding of safety risk associated with Safe System aligned intersection design; more commonly encountered roundabouts are seemingly perceived as safer while less commonly encountered raised plateaus are perceived as less safe. Such a finding suggests safe intersection designs may not be intuitively perceived as safe and highlights the importance of demonstrations in pursuing the Safe System aligned innovations required to eliminate harm from the road network.

Acknowledgements

This study was undertaken with the support of personnel from the Royal Automobile Association of South Australia (RAA), who helped to design the study survey and distributed the survey amongst its members. This study was also supported by personnel from the Department of Planning, Transport and Infrastructure (DPTI) in South Australia, who helped design and manage the project of which the survey was a part.

Funding: This study was funded by the South Australian Department of Planning, Transport and Infrastructure (DPTI) through a Project Grant to the Centre for Automotive Safety Research. The DPTI Project Manager was Alex Duerden.

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Validation of a driving simulator for research into human factors issues of automated vehicles

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This peer-reviewed paper was first presented as an Extended Abstract and Oral Presentation at the 2018 Australasian Road Safety Conference (ARSC2018) held in Sydney, NSW, Australia and first published in the ARSC2018 Proceedings in the form of an Extended Abstract. It was expanded into a 'Full Paper' and underwent further peer-review by three independent experts in the field. It is being reproduced here with the kind permission of the authors and is now only available in this edition of the JACRS.

Key Findings

- The driving simulator is a valid tool for human factors research in automated vehicles;
- Events and conditions with the best transfer of behavioural validity have been identified;
- Findings will be used for the design of future studies investigating automated driving;
- Further simulator validation issues were identified, e.g. simulator representation of on-road situations requiring high mental workload.

Abstract

This study evaluated the behavioural validity of the Monash University Accident Research Centre automation driving simulator for research into the human factors issues associated with automated driving. The study involved both on-road and simulated driving. Twenty participants gave ratings of their willingness to resume control of an automated vehicle and perception of safety for a variety of situations along the drives. Each situation was individually categorised and ratings were processed. Statistical analysis of the ratings confirmed the behavioural validity of the simulator, in terms of the similarity of the on-road and simulator data.

Keywords

Vehicle automation, driving simulator, human factors, validation, willingness to resume control, perception of safety

Glossary

SAE – Society of automotive engineers
TH – Time headway
POS – Perception of safety
WTE – Willingness to engage automated driving system
WTRC – Willingness to resume manual control of the vehicle
TD – Traffic density
SC – Situation complexity

Introduction

Driving automation is on the brink of becoming the mainstream from a technological point of view. The SAE classifies six levels of automation. These levels are summarised in Figure 1, with the deployment predictions being derived from multiple sources such as Chan (2017) and Litman (2015). The majority of academic research found is focussed on levels 2 and 3. Level 3 is acknowledged as being associated with the greatest number of human factors issues because it requires the driver to remain in the loop enough to regain manual control in the event of an emergency or if driving conditions move outside of the automation operational design domain (Logan et al, 2017).

There are many unanswered questions from a human factors perspective that are preventing legalisation of automated driving, such as transfer of control from automated to manual driving and driver acceptance of new technology. These questions are difficult to answer without proper testing. The obvious approach to this problem is the utilisation of driving simulators. Simulators provide a

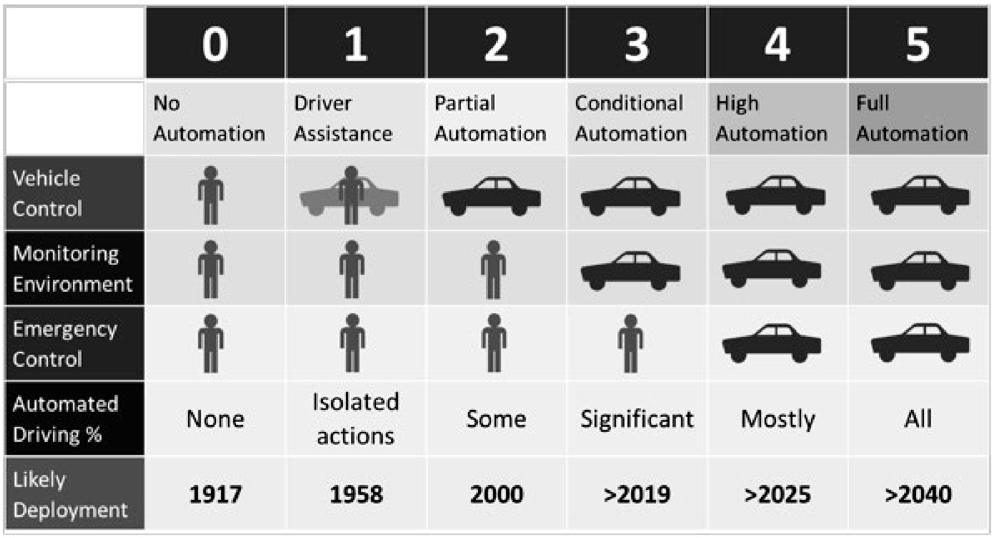

Figure 1. SAE levels of automation and deployment predictions

safe, economical and controlled environment in which to conduct automation research. However, this is an artificial environment and these differences may influence the subject's behaviour. Therefore, to be used in automation research, driving simulators need to reproduce similar driver responses to those occurring on the real road. Every driving simulator has its limitations which are directly related to the cues (visual, auditory tactile and vestibular) it is able to provide. Kaptain et al. (1996), state that if the set of cues important to the subject of the investigation is available in the simulator, the simulator may be as valid as a field experiment.

As research simulators are commonly developed independently of each other and have distinct parameters (Godley et al. 2002), it is necessary to validate them on an individual basis. Driving simulators are commonly validated for various specific aspects such as speed perception, vehicle dynamics, hazard perception and many more. Godley et al. (2002) evaluated a driving simulator for speed research establishing relative behavioural validity and relative validity for mean speed. McGehee et al. (2000) examined driver reaction and performance in an intersection crash scenario in the simulator and on a test track. The study produced statistically equivalent reaction times. Underwood et al. (2011) evaluated hazard perception in the simulator and on the road observing similar patterns in behaviour in both settings.

As automated driving is a new field, a study was needed to establish the behavioural validity of the available driving simulator. Behavioural validation involves:

- Comparison of two systems during identical tasks and circumstances in terms of system performance and/or driver behaviour
- Measurement of physical and/or mental workload (physiological measurements)
- Subjective criteria from drivers
- Evaluation of how well the simulator results align to real-world findings

There are very few studies concerning validity of the driving simulator for research into automated vehicles. Eriksson et al. (2017) explored workload differences between a driving simulator and on-road drives in an automated vehicle. In this validation study the authors argued that a driving simulator can be a valid tool for studying users' interactions with automated driving systems. Pariota et al. (2017) observed the effects of connected automated vehicles on car-following behaviour in driving simulators and an instrumented vehicle. Although there were some differences in behaviour between environments, a consistency in car spacing within each environment has been shown.

The current work is part of a larger investigation of human factors issues associated with automated driving. The overall research program aims to explore drivers' willingness to engage or disengage automated driving system, the perception of safety in automated driving and transfer of control between vehicle control modes. The aim of this study was to validate the use of a driving simulator for research in human factors of automated driving. More specifically, a relative behavioural validation study was conducted which will establish a level of credibility and transferability of the simulator results into the real world. To the knowledge of authors, no other validation study had been conducted to answer this specific question in the context of automated driving.

Method

The study was conducted at the Monash University Accident Research Centre. The data collection was conducted under semi-controlled experimental conditions. The on-road drive was conducted on real roads and in the real traffic but followed a strict route. The simulator drive was programmed to replicate this on-road test route in terms of length, road conditions and other controllable parameters. No safety critical events were part of the experimental drives.

Since an automated vehicle was not available for the study, on-road automated driving had to be controlled by the human driver. Therefore, to keep experimental conditions the same across the settings, participants were aware that a human driver was used to represent automation in both drives. The participants were placed in the passenger seat and did not have access to a steering wheel and control pedals in both conditions. The researcher was in the driver’s seat and controlled the vehicle. Participants were instructed to assume a situation in which they were behind the controls of a level 3 automated vehicle that was operating in an automated mode for the entire duration of the drive and that they could resume manual control of the vehicle at any time, but their task was just to answer the experimenter’s questions.

The same procedure was followed in the simulator. This way, both experimental conditions were kept as similar as possible. This included obstructing speedometer from the participant in the simulator since the speedometer in the car was not visible from the passenger’s seat.

Participants

There were 20 participants, 11 males and 9 females, ranging in age from 21 to 64 years, with an average age of 36.8 years (SD = 11.2). The median number of years of driving experience was 14.5 (IQR: 9-24.75). Participants were recruited from both Monash University (post-graduate and undergraduate students or staff) and outside using personal contacts. Ethics approval was obtained from Monash University Human Research Ethics Committee. Participants were required to have a full driver’s licence and drive at least 6,000 km per year. They were paid $30 for their participation. The total duration of the experiment was between 90 and 105 minutes.

Equipment

Instrumented car

The experimental car was an instrumented Holden Commodore VE. It had rear wheel drive and automatic transmission. In addition to the existing instrumentation, a wide-angle camera was used to record the driving scene and audio cues.

Driving simulator

The MUARC Automation Driving Simulator (Figure 2) consisted of two seats mounted on separate motion bases. Both seats moved in unison. The simulator vehicle represented a car with an automatic transmission. Visuals were presented on three 46” high brightness bezel-less displays. Each display had a resolution of 1080p and the image refresh rate was 60Hz.

The driver and the passenger both had a 140° of horizontal field of view and a 45° vertical field of view. The sound was presented via left, right and centre satellite speakers and a subwoofer. Each motion base produced three degrees of freedom of movement as well as vibration. The same wide-angle camera from the instrumented car was used to record simulator drives and audio cues.

Experimental questions

Figure 2. Automation driving simulator setup

A tablet (iPad) was used to collect answers during both simulator and on-road drives. There were between 20 and 25 questions for each drive and the final overall question completed after the end of drive. Each question consisted of part A and part B. Part A (Figure 3) asked participants to rate willingness to resume control of the vehicle in that situation. The four categories were: very willing, willing, unwilling and very unwilling. Part B (Figure 3) asked participants to rate perception of safety in that situation using a linear scale from 1 to 100 (1 for very unsafe and 100 very safe).

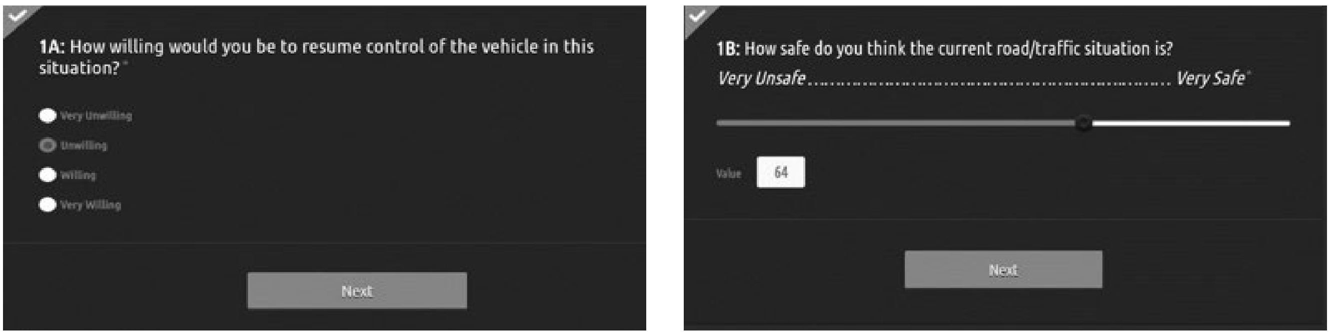

Figure 3. Example of Part A (Willingness to resume control) and B (Perception of safety) question at the decision point

Experimental Drives

The real road and simulator routes were selected to resemble each other as much as possible, taking into account available equipment, time constraints and resources. Overall factors that had to be considered were:

- The total duration of each drive needed to be kept under 30 minutes;
- Total travelled distance during drives needed to be limited to under 20 km;
- The proportion of freeway driving vs urban/residential driving had to be similar;
- Time of the day was between 11:00 and 15:00. This prevented sun glare situations and provided an optimum visibility on the road;
- Peak traffic conditions had to be avoided; and
- Adverse weather conditions had to be avoided (dry roads only).

The following matching criteria between on-road and simulator scenes were used:

- Road lane width;
- Speed limits;
- Number of roundabouts;
- Number of turns;
- Number of freeway entries and exits;
- Number of road bends;
- Traffic density and composition;
- Number of signalised intersections;

The simulator drives were scripted and therefore the same events were presented to each participant. However, during the on-road drives not all events were encountered by every participant. Only events that occurred in both the simulator and on-road drive were analysed.

Experimental Procedure

Participants completed an informed consent form and read the experimental instructions. They were then given a brief introduction to automated vehicles and presented with a definition of willingness:

- Ready of eager to do something;
- Disposed or inclined;
- Prepared, or
- Acting or ready to act gladly.

This was followed by a demographics questionnaire that also included questions about driving habits, subjective driving skills and attitudes toward technologies.

Participants completed the drives in a counterbalanced order. Half of the participants completed the simulator drive first and the other half completed the on-road drive first. Only one researcher was involved in the experiment.

During the drives, participants were given a tablet which was used to record ratings for willingness to resume control (WTRC) and perception of safety (POS). During the drives, participants were instructed to observe the road and wait for the researcher’s verbal instruction: “Ready ... Now!”. The instructions were given with enough lead time for participant to recognise the situation ahead. After hearing this cue, participants were instructed to stop observing the road and quickly complete Part A and Part B of the question. After completing the question, participants would continue observing the road until the next question.

At the end of the drives, participants were asked to rate their overall willingness to engage (WTE) automated driving system as well as their perception of safety of the entire drive.

Data Collection and Processing

During the drives, the following data were collected:

- Video recordings of the road scene;
- Experimental drive questionnaire;
- GPS and vehicle data in on-road drive only;
- Simulator data during simulator drive only;
- Pre-drive and post-drive well-being questionnaires (simulator only).

Using video recording, each decision point was coded for several parameters. They were: time, event name, environment, speed limit, road division, number of lanes, road shape, traffic density, situation complexity and participant comments. These parameters were later used in selecting data for statistical analysis. Traffic density and situation complexity of each event were rated as low, medium and high according to the criteria below.

Traffic density (criteria partially based on Strategic Highway Research Program 2, SHRP2) Levels of Traffic density (VTTI, 2015):

Low:

- Free flow, no lead traffic (0-1 cars ahead within 5s time headway (TH), minimum TH > 3s);
- Freedom to select speed, change lanes and make turns (No vehicles in left or right lanes relative to the participant within 20m radius).

Table 1. Percentages of events with Levels of Traffic Density (TD) and Situation Complexity (SC)

	TD Road	TD Simulator	SC Road	SC Simulator
Low	64.24%	70.45%	56.53%	57.39%
Medium	30.41%	20.34%	40.47%	28.91%
High	5.35%	8.99%	3.00%	13.49%

Medium:

- Free flow with some restriction (1-3 cars ahead within 5sTH, 2-3s TH);
- Freedom to select speed, change lanes and make turns (vehicle or vehicles in left or right lanes relative to the participant, within 10 – 20m radius).

High:

- Forced traffic flow conditions (3+ cars ahead within 5 seconds TH, minimum TH < 2s);
- Limited freedom to select speed, change lanes and make turns (vehicle or vehicles in left or right lanes relative to the participant, within 10m radius).

Situation complexity levels (partially based on Cabral et al., 2016):

Low:

- No significant cognitive processing is required (clear road, smooth and predictable traffic).

Medium:

- Some cognitive processing required (traffic ahead, approaching intersections or turns).

High:

- Medium to intensive cognitive processing required (dealing with vulnerable or unpredictable road users, complex intersections, aggressive drivers, reduced visibility);
- Critical decision making (merging, overtaking, potential emergency braking).

Based on these criteria, levels of traffic density (TD) and situation complexity (SC) were assigned to every individual event. Distributions of these levels across all events are presented in Table 1.

Data Analysis

The purpose of the statistical analysis was to determine whether there were differences between ratings (WTRC/WTE and POS) given for similar decision points in both experimental environments (simulator and on-road). Generalised Estimating Equations model was used for statistical analysis. This model is used to estimate the parameters of the generalised linear model with the possible unknown correlation between outcomes. It can be used for both ordinal (WTRC/WTE) and interval data (POS). The data analysis was done by comparing dependent variables (ratings for WTRC and POS recorded during experimental drives in two environments).

Processing of the data resulted in a single rating for each category (individual events and conditions) per participant. In the GEE models, participants were the subject variable and experimental environment (simulator or on-road) were independent variables. WTRC/WTE and POS were the dependent variables. In cases where multiple records existed for a category, the median value was used for ordinal variables (because the data were non-normally distributed) and the mean for linear variables. The correlation matrix that represented the within-subject dependencies was estimated as part of the model.

Results

Results of the data analysis are presented in Table 2. The table contains a list of all tests conducted on events and driving conditions. Results are primarily expressed as p-values for both WTRC (WTE for the Final question) and POS (Figure 4).

The results for the final questionnaire item, which represents overall WTE and POS ratings for the whole drive revealed that there were no significant differences across the on-road and simulator environments for both WTE (p=0.315) and POS (p=0.324).

There were no significant differences across environments for WTRC and POS ratings for free driving on the freeway, short time headway, left bend, roundabout, give way/stop sign, congestion, stopped bus, and pedestrians.

Mixed results were obtained for free driving on urban roads where POS was significantly different across the environments, while there was no significant statistical difference in WTRC. Events that produced significant statistical differences in both WTRC and POS were uphill road and merging on the freeway.

Statistical test on levels of traffic density (TD) and situation complexity (SC) indicated that there were no significant statistical differences between on-road and simulator environments. The only exceptions were WTRC for medium TD on the freeway where significant differences were found across environments (p=0.018) and POS for medium SC on the freeway (p=0.045).

Table 2. Test results

	Mean POS road	Mean POS simulator	SD road	SD sim	p(POS)	p(WTE/ WTRC)
Final Question	70.75	73.30	3.59	3.89	0.315	0.324
Free Driving (Freeway) ay) Freeway)	71.21	76.26	3.35	3.15	0.053	0.180
Free Driving (Urban)	69.08	75.75	3.29	2.98	**0.000**	0.143
Short Time Headway	48.15	52.35	5.54	5.96	0.517	0.06
Left Bend (Freeway)	75.79	76.51	3.41	3.42	0.811	0.210
Roundabout	67.96	62.84	5.98	5.45	0.340	0.739
Give Way/ Stop Sign	65.36	67.58	4.04	4.60	0.492	0.657
Merging (Freeway)	56.63	74.15	4.20	3.12	**0.000**	**0.002**
Changing Lanes	62.58	51.65	5.17	4.54	**0.033**	0.482
Congestion*	75.93	61.79	7.52	5.96	0.127	0.089
Stopped Bus*	67.73	53.95	6.44	6.56	0.109	0.191
Pedestrians*	56.16	61.45	7.49	5.20	0.309	0.300
Uphill road*	72.43	86.55	4.17	2.38	**0.000**	**0.015**
Low TD (Urban)	68.58	70.47	3.13	3.17	0.371	0.951
Medium TD (Urban)	64.42	63.54	4.05	4.78	0.808	1.000**
Low TD (Freeway)	73.48	72.75	2.67	3.45	0.796	0.065
Medium TD (Freeway)	56.53	55.86	4.54	4.83	0.815	**0.018**
Low SC (Urban)	71.05	73.72	2.90	3.10	0.259	0.191
Medium SC (Urban)	62.98	60.45	3.76	4.70	0.304	0.701
Low SC (Freeway)	73.05	76.40	2.59	3.39	0.125	0.187
Medium SC (Freeway)	56.70	63.38	4.47	3.80	**0.045**	0.216
High SC (Freeway)*	61.33	47.30	8.58	5.15	0.160	0.968

*Events that did not have a full dataset (< 50%)

**Repeated GEE model analysis with only two categories of WTRC (willing and unwilling)

Significant values ($p < 0.05$) are shown in bold.

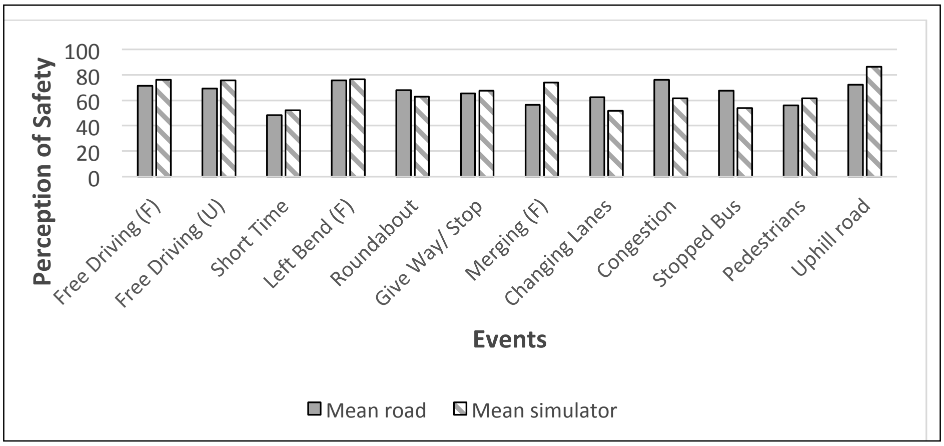

Figure 4. Perception of safety during events

Discussion

The results showed that for the large majority of events, there was no statistical difference ($p > 0.05$) in ratings of WTRC, WTE and POS when comparing the two driving environments. This suggests that these events are well represented in the simulator when compared to the on-road environment in the context of the research question. In their research on driving simulator validity, Kaptain et al. (1996), stated that if the results between the simulator and the field experiment are similar, the simulator is shown to be valid for investigating the studied driving task. Another important element of a succesful behavioural validation study is a carefully designed experimental procedure (Blana, 1996).

From the perspective of further research, it is more interesting to understand what were the differences in experimental conditions that may have contributed to the significant statistical differences. Only two events produced significant statistical differences in ratings for both POS and WTE between experimental conditions. They were merging onto the freeway and to a lesser extent unrestricted driving on an urban road.

Merging onto a freeway could be classified as a high-risk event. This event involved multiple simultaneous manoeuvres (changing lanes, adjusting speed, finding gaps, and continuously scanning the scene) while travelling at a relatively high speed, often in medium or high TD. In comparison with the on-road event, the simulator freeway merging event was simpler (lower TD) and more predictable, therefore demanding less mental workload. Moreover, we speculate that an increase in workload demand exponentially augments perceived risk between the two experimental conditions. Although the merging event in the simulator could be made more demanding by increasing traffic density and speed, further research is needed to answer how exactly perceived risk and mental workload correlate under the simulator and on-road conditions. The exact relationship will, of course, be affected by the specifications of each individual simulator.

Uphill driving on the urban road was intended as a relatively simple and undemanding event so the perceived risk should not be such an important factor. However, statistical test results indicated significant differences in the ratings between environments. Due to limitations in the selection of roads, not all experimental conditions could be accurately matched. In the simulator drive, this event occurred on the four-lane road, while in the on-road drive it occurred on a two-lane road with occasional parked cars on both sides of the road. To participants, the on-road event may have appeared less safe than the simulator event and thus, influenced their WTRC ratings. These observations are supported by Fildes et al. (1989) who found that road width and number of lanes had the strongest influence on judgements of safety and travel speed, while the roadside environment also had an effect but to a lesser degree. Finally, it is believed that the differences in WTRC for Medium TD on the freeway and POS for medium SC on the freeway are due to the challenges in creating a realistic freeway driving environment in the simulator.

It is important to accurately represent an event in the simulator; however, differences between the real and the simulated environments related to simulator measurements and mental workload emerge whatever the cost of a driving simulator is. Harms et al. (1996), observed that increasing the face validity of the VTI driving simulator did not necessarily enhance the overall behavioural validity of the simulator. More research is needed when investigating on-road situations that create a high mental workload and their representation in the simulator. This will be especially important in the case of take-over requests. In addition, it is important to understand the precise conditions under which drivers are willing to engage or disengage an automated driving system. A future study to investigate this is currently being undertaken by the authors.

Given that an automated vehicle was not available for this study and Level 3 Automated vehicles are not legally allowed to travel on Australian roads, we adopted a protocol whereby participants sat in the front passenger seat of the real and simulated vehicles which were driven by an experimenter. Participants were asked to imagine that he or she was in the driver's seat of an automated vehicle and answer the questions from this perspective. This method may, of course, lead to differences in participants' perception of safety and trust in vehicle automation. However, we estimate only a small impact of these limitations because the main task was to enter ratings in the questionnaire (willingness to resume control of the vehicle and perception of safety during the drive) and not to drive or respond to take over requests. We were also interested in comparing ratings across the on-road and simulated environments, which were kept as similar as possible in terms of the automation protocol.

Conclusions

The results confirmed the relative behavioural validity of the MUARC automated driving simulator. We argue that if certain limitations of the driving simulator are taken into account absolute behavioural validity can be confirmed.

These findings will be used for the design of future simulator experiments investigating willingness to resume control or engage an automated driving system, the associated perception of safety and driver behaviour during transfer of control.

Acknowledgements

This work was funded by Monash University research scholarship and RACV scholarship award.

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Road Safety Policy & Practice

Implementation Principles for 30 km/h Speed Limits and Zones

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This peer-reviewed paper was first presented as an Extended Abstract and Oral Presentation at the 2018 Australasian Road Safety Conference (ARSC2018) held in Sydney, NSW, Australia and first published in the ARSC2018 Proceedings in the form of an Extended Abstract. It was expanded into a 'Full Paper' and underwent further peer-review by three independent experts in the field. It is being reproduced here with the kind permission of the authors and is now only available in this edition of the JACRS.

Key Findings

- Implementation principles developed for an Australian state road agency;
- Emphasis on an area-wide 30 km/h practice for improved road safety and environment;
- Unlike New Zealand, Australia has limited experience in 30 km/h implementation;
- 30 km/h speed limit practice aligns well with the Safe System approach and principles.

Abstract

In the context of the Safe System approach for harm minimisation where fatal and serious injuries are not accepted as inevitable costs of mobility in any transport system, there is an increasing need to consider implementing speed limits within the biological tolerance of road users. The need to implement speed limits lower than 40 km/h in an urban area with high pedestrian movement and activity has been recognised by an Australian state road agency. Through a literature review, stakeholder consultation with road transport agencies in Australia and New Zealand and a Safe System analysis, this paper presents the development of guiding principles in implementing 30 km/h speed limits and zones in Australasia. The implementation principles have been developed to inform a revision of the existing speed zoning guidelines and its applications within the jurisdiction, which are also applicable elsewhere across Australasia and internationally.

Keywords

Speed Limit; Speed Zone; 30 km/h; Traffic Calming; Local Area Traffic Management; Speed Management

Introduction

In Australia, current practices and guidelines foster the implementation of a 40 km/h speed limit in high pedestrian activity areas and a 10 km/h limit in designated shared zones. While there are trials and pilot tests in the country, the use of area-wide 30 km/h speed limits are not generally accepted, partly due to regulatory barriers.

Internationally, particularly in Europe, a speed limit of 30 km/h (or 20 mph), by contrast, has long been employed as a measure to reduce vehicular dominance and for improving pedestrian safety and amenity. One early example developed in the 1970s was 'verkehrsberuhigung' (German for 'traffic calming'), which describes speed control measures such as 30 km/h speed zones to improve street environments (Brindle 1992).

In the context of the Safe System and harm minimisation approach where fatal and serious injuries (FSIs) are not accepted as inevitable costs of mobility in any transport system, there is an increasing need to consider implementing speed limits lower than 40 km/h in heavily pedestrianised areas. This situation has been recognised by a state-level transport agency in an Australian jurisdiction. This paper presents the results of a literature review of 30 km/h speed zone implementation and stakeholder consultation. The implementation principles have been prepared to inform a revision of the existing speed zoning guidelines and its applications within the jurisdiction, which are also applicable elsewhere across Australasia and internationally.

Methods

The research methodology included a review of the literature on the 30 km/h speed limits and zones, stakeholder consultation with Australian and New Zealand road transport agencies and a Safe System analysis. The focus of the review of published literature in relation to 30 km/h speed limit practice was on the guidance, policies and criteria for setting 30 km/h speed zones. The review findings, including a comprehensive list of 30 km/h speed limit schemes in various jurisdictions, are documented in Karndacharuk & McTiernan (2017).

Targeted stakeholder consultation with Australian and New Zealand road transport agencies was undertaken to obtain jurisdictional views and practice on the 30 km/h speed limit implementation, including views about the approach, lessons learnt from design and implementation experiences as well as key issues and lessons learnt. For the Safe System analysis, the objective was to identify the extent to which the 30 km/h speed zone implementation requirements align, and are consistent with, the Safe System approach and its pillars.

Discussion of Review Findings

This section offers a discussion of the literature review findings with an aim to inform a development of the guiding principles. It is noted that the speed limit of 20 mph (equivalent to approximately 32 km/h) is used interchangeably with 30 km/h in this paper. Additionally, the 30 km/h speed limits in many European countries are predominantly applied in a residential context rather than an area with high pedestrian activity.

Towards area-wide practice in both residential areas and activity centres

A shift from a linear or 'pockets' implementation towards an area-wide practice can be observed, especially in the UK and Europe, in both residential and mixed-use areas. The 30 km/h speed limit designation is an integrated part of the Netherlands' Sustainable Safety – the precursor to the Safe System approach. The 30 km/h zones are applied principally to urban local roads that serve the dominant access function while facilitating pedestrian and cycle movement as well as allowing stopping and parking of vehicles (Schermers 1999, Schermers & van Vliet 2001).

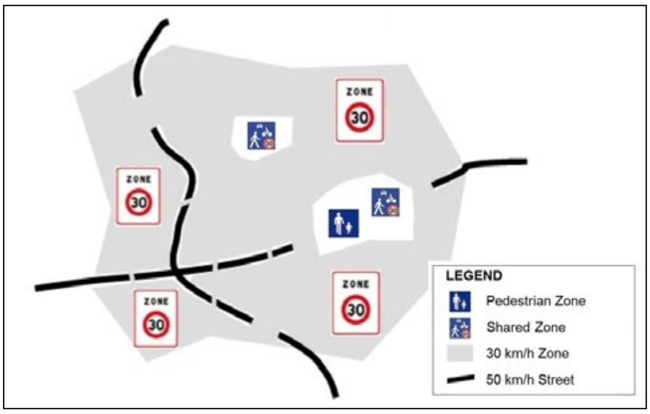

Figure 1. Area-wide 30 km/h speed zone implementation (Based on Nogues 2009)

The extent of an area-wide 30 km/h implementation in relation to linear 50 km/h traffic routes is shown in Figure 1. The 30 km/h zone can be applied to an entire activity centre boundary that incorporates pedestrian and shared zones (Nogues 2009).

Choices of implementation techniques using signs and traffic calming measures

The findings from the literature review reveals a wide range of implementation techniques from using either signs only, or traffic calming measures only, or a combination of both measures. Consistent with the Sustainable Safety concept (Austroads 2005) where speed limits often require engineering support to encourage compliance, many 30 km/h (or 20 mph) speed zones in the UK and Europe utilise both speed limit signs and traffic calming measures to limit high speeds, and reduce speed differences and vehicle conflicts.

The following sections discuss the two unique implementation techniques of signs only and self-explaining roads (traffic calming measures only).

Traffic Signs Only

Setting 30 km/h speed limits by using posted speed signs only has been evaluated by a number of jurisdictions. This method has a cost advantage when compared to the approach of constructing physical traffic calming measures. However, its main disadvantage is the effectiveness on the reduction of vehicle speeds and crashes.

Large-scale implementations of low speed limits using signs only were trialled and implemented in a number of towns and cities in the United Kingdom, including Bristol, Edinburgh, Oxford, Portsmouth and Warrington (20's Plenty for Us 2017). The UK study concluded that signed only speed limits are most appropriate for areas where vehicle speeds are already low (Department for Transport 2013). In many cases, a 30 km/h speed roundel road marking was also used as a repeater sign in addition to post-mounted speed signs to indicate the speed limit.

Signs-only speed limits were used in Alberta, Canada where the legal speed limits around school and playground zones were lowered from 50 km/h to 30 km/h in 2009 (Tay 2009). The Belgian government also lowered the speed limits in school zones to 30 km/h in Flanders (Dreesen & Nuyts 2007). However, the speed limits around school zones are not in full-time operation in Alberta, and only some are full-time in Flanders.

Traffic Calming Measures Only (Self-Explaining Roads)

The Woonerf concept was originally proposed in the Netherlands in the 1960s with the design emphasis on creating an environment in a residential area where vulnerable users can safely share the street with motorists (Karndacharuk 2014). Road design features, including a level, shared surface, traffic calming measures and streetscape elements for pedestrian staying activities, are employed to urge the driver not to drive faster than walking speeds (Karndacharuk et al. 2014). Implemented in this fashion, Woonerf streets do not require sign-posted speed limits to explicitly remind the motorist of safe vehicle speeds.

A similar approach to the Woonerf is Self-Explaining Roads (SER). Also known as a naked street, the SER encourages the driver to adopt safe behaviour and speeds in response to the visual appearance of the roads (Mackie et al. 2013, Theeuwes & Godthelp 1995, Wegman et al. 2005). The SER approach can be applied across all road categories as long as the road design and user behaviour match the intended function and the look and feel of the roads are consistent within each road category.

In the Guide to Traffic Management (Austroads 2016b), the SER concept is recognised as psychological traffic calming within the local area traffic management (LATM) philosophy, where increased uncertainty by design helps drivers to slow down to negotiate the area and become more aware of the surrounding rather than simply moving through the road space.

Accordingly, McTiernan et al. (2015), suggested that the wider application of the SER approach should be considered in the Australasian context to support improved safety and self-regulation of speed by drivers. A trial of SER was undertaken in Auckland, New Zealand (Charlton et al. 2010). Two types of road hierarchy were chosen – local and collector roads. A 30 km/h design speed was applied to the local roads along with the design to reduce forward visibility and to incorporate improved landscaping, community spaces and threshold treatments. Road markings and signage were also removed.

Stakeholder Consultation

Consultation with Australasian transport agencies at both state and local levels was undertaken in August and September 2017 to obtain views and experience on 30 km/h speed limits and zones (Karndacharuk & McTiernan 2017). The task comprised a short email survey asking for feedback on:

- Design, planning and implementation experience
- Outcome and lessons learnt from an evaluation study
- Key issues/complaints, including community perceptions.

The majority of the consultation messages and requests for information were submitted to the road and traffic agencies using the contact details from their website or via an online customer contact form. A follow-up task of a telephone discussion and an examination of relevant documentation available on the agency's official websites was also conducted.

Table 1 presents the outcome of consultation with each of the Australian and New Zealand jurisdictions. None of the road transport authorities in Australia that responded to the survey requests opposed lowering the speed limit to 30 km/h in appropriate locations. Five Australian jurisdictions (i.e. ACT, NSW, Tasmania and Victoria and WA) have either planned or implemented 30 km/h speed zones. Collectively, the 30 km/h area has been or is being applied, albeit on a relatively small scale, to school zones, activity centre areas and residential streets in Australia.

In New Zealand, the majority of the 30 km/h speed zones are implemented on an area-wide basis. More importantly, all the NZ local government jurisdictions under investigation have prioritised the use of 30 km/h zones in the CBD and mixed-use areas.

Table 1. Consultation response from transport agencies in Australia and New Zealand

Jurisdiction	Feedback on 30 km/h Implementation		
	Response	Experience	Discussion
ACT	Yes	Yes	• As part of an Active Streets pilot program (ACT Government 2017), a 30 km/h speed limit was trialled at two primary schools (out of four schools under the pilot scheme). • The 30 km/h school zone was considered an infrastructure intervention to promote safe routes to school via active travel.
NSW	Yes	Yes	• The 30 km/h speed limit was applied on Druitt Street primarily in response to a fatal crash. The other 30 km/h zone within the boundary of the City of Sydney (2017) is in the Royal Botanic Garden. • The general consensus within RMS is that the 30km/h limit on Druitt Street is not successful as it appears anecdotally that most drivers are either unaware or choose to ignore the speed limit. • A trialled 30km/h limit is suggested in a street environment that is obviously different from the standard (higher speed) road environment in order for drivers to feel compelled (be that by geometry, traffic calming or carriageway widths) to drive in accordance with the lower speed limit.

Jurisdiction	Feedback on 30 km/h Implementation		
	Response	**Experience**	**Discussion**
NT	Yes	No	• Department of Infrastructure, Planning and Logistics is not aware of a 30 km/h implementation in the Northern Territory.
Qld	Yes	No	• Department of Transport and Main Roads support, in principle, the use of 30 km/h to improve road safety in an appropriate location. • At the time of writing, there was a plan to implement 30 km/h speed limits across the Brisbane CBD.
SA	No	No	• No response from Department of Planning, Transport and Infrastructure has been provided within the project timeframe.
Tas	Yes	Yes	• 30 km/h zones, forming part of a streetscape upgrade, have been implemented within the City of Hobart to support the Central Bus Interchange. • A 30 km/h speed limit was implemented in 2010 along Hobart waterfront at the Franklin Wharf under the responsibility of TasPorts. A crash data analysis of the before (2003-2009) and after (2011-2017) showed: - 39% reduction of total recorded crashes (from 69 to 42) - No serious and fatal injury post implementation whereas there was one serious injury crash in the before period.
Vic	Yes	Yes	• Yarra City Council (2017) is planning to implement a 12 month trial of area-wide 30 km/h speed limits on residential streets in Fitzroy and Collingwood. • Recognising the benefits of reducing speed limits to 40 km/h on all residential streets in Yarra, the 30 km/h trial forms part of Council's commitment to creating safer streets for all road users. • Based on the review and discussions with the UK's Nottingham City Council and the 20s Plenty for Us program, the following key findings are identified in a pre-trial evaluation (Fildes et al. 2017): - There is a need to carefully stage the introduction of a trial with on-going consultation with key stakeholders and community engagement to maximise its success. - Additional signage to be placed at critical threshold entry points along the trial boundary or where there is no change with new speed limit in order to alert local travellers of the trial in progress and to keep stressing the road safety message • VicRoads is in principle support the use of 30 km/h speed limits in Victoria. To ensure speed compliance, community support and acceptance is considered an important factor in the planning and implementation process.
WA	Yes	Yes	• A 30 km/h speed limit environment exists: - In the high pedestrian activity section of Oxford Street in Leederville and on the Cappuccino Strip (South Terrance) in Fremantle - Along the beach front roads between West Coast Highway and the sea at Scarborough Beach • Main Roads Western Australia further advised that more 30 km/h speed zones are being implemented under the Safe Active Streets (formally called Bike Boulevards) program.

Jurisdiction	Feedback on 30 km/h Implementation		
	Response	Experience	Discussion
NZ	Yes	Yes	• A 30 km/h speed limit environment was implemented in the following two locations in Auckland before 2010. - Queen St in Auckland CBD. The speed within the zone is largely controlled by congestion and the closely spaced signalised intersections. Traffic signal phasings are also set with generous time for pedestrian, which helps restraining traffic volumes and speeds. - Orewa Blvd in Orewa town centre. 30 km/h was originally implemented as a temporary speed limit. The design of the zone was styled similar to a shared zone with a texture, level surface (no kerb). There has been speed compliance issues due to the need to regain sufficient width for over dimension vehicles. • A recent area-wide 30 km/h zone is progressively being implemented in Wynyard Quarter and Viaduct Harbour on Auckland waterfront. Traffic calming measures (e.g. raised platform and special surfaces) are employed to support a credible low speed environment. • With the recent changes to the speed limit guidelines and legislation, Auckland Transport expect to roll out more 30 km/h areas in the next few years, particularly in the CBD and town centres across the region.
			• The majority of streets in the Christchurch CBD have a 30 km/h speed limit, which was imposed through the Recovery Plan post 2011 earthquake. A large proportion of the 30 km/h zones do not have the environmental controls (e.g. traffic calming) that were originally intended to occur at the same time as the 30 km/h implementation. • The average speed is in the order of 35-40 km/h even with traffic signal coordination for 30 km/h progression. • The 30 km/h speed limit has not been well received by the community, although much of the negativity was directed at a few roads due to their arterial nature and the lack of physical changes to the streets. • Christchurch City Council is of the view that regular repeater road markings, which were recently allowed through the change in NZ legislation, would support the 30 km/h operation (by improving conspicuity) along with self-enforcing traffic calming measures.
			• A 30 km/h limit was implemented in 2010 in the Hamilton CBD as part of streetscape improvement in order to improve pedestrian safety. The monitoring of speeds and safety performance showed the work was successful, which paved the way for more introduction in 2013.
			• Started in 2009, Wellington City Council has been progressively implementing 30 km/h limits in the CBD and shopping centres (16 location completed) to support pedestrian and cycling activity. The lower speed limit has been shown to reduce crash rates.

Safe System Analysis

The Safe System concept recognises that humans can only tolerate limited kinetic energy exchange before death or serious injury occurs. Safe System principles aim to manage the energy exchange via the four pillars of safe roads, safe speeds, safe vehicles and safe people to eliminate death and serious injury as a consequence of a road crash. A fifth pillar, involving emergency response and post-crash care is often cited internationally (Austroads 2016c). A Safe System analysis, shown in Table 2, considers the impact of the 30 km/h speed zone implementation against the five Safe System pillars.

Table 2. Safe System analysis of 30 km/h implementation

Safe System Pillar	Assessment Response
Safer roads and roadsides	• With an emphasis of reducing pedestrian deaths and serious injuries, roads and roadsides should be designed to incorporate traffic calming measures, especially in areas where existing speeds are much higher than 30 km/h, to gain compliance with lower speed limit. • Other street and urban design approaches such as provision for the disabled, appropriate lighting as well as Crime Prevention through Environmental Design should be considered in order to: - reduce the risk of crashes occurring, - lessen the severity of injury if a crash does occur - encourage safe behaviour by users
Safer vehicles	• The rapid development of emerging technologies of connected and autonomous vehicles (CAVs) provides an opportunity to promote the use of safer vehicles in crash avoidance and protection for both occupants and people outside the vehicle. • The deployment of CAVs and in-vehicle intelligent systems will assist in ensuring the compliance of 30 km/h speed limits and zones and enabling automated protective systems for vulnerable users when crash risk is elevated.
Safe road users	• In acknowledgment of the fact that people make mistakes and are vulnerable, lowering speed limits to 30 km/h in a highly pedestrianised area will reduce crash energies, and provide a factor of safety in terms of increased driver field of vision, driver's reaction time and breaking distance. • Education campaigns and stakeholder engagement should focus on: - reminding that a successful 30 km/h implementation is a shared responsibility of everyone, including road users. - encouraging safe, consistent and compliant behaviour through well-informed and educated road users. • Enforcement and sanctions are critical to effective implementation, particularly from the outset.
Safer speeds	• Based on the literature review findings, a maximum limit of 30 km/h should be applied principally in an area with high pedestrian activity to manage fatality and serious injury risks to more vulnerable road users. • Credible and consistent 30 km/h speed limit implementation is fundamental to encourage road users to obey and drive to conditions.
Post-crash response and trauma treatment	• The need for access by emergency and medical services should be taken into account during the planning, design and implementation of 30 km/h speed limits and zones.

Implementation Principles

The following guiding principles are proposed to be employed in the process of implementing a 30 km/h speed zone in order to maximise the potential for the zone to operate successfully by ensuring commonality and legibility for the end user. Table 3 shows 12 principles, which can generally be categorised into three groups to address the why, where and how of a potential implementation of 30 km/h as an appropriate, credible and enforceable speed management option.

Table 3. Principles for 30 km/h speed limit implementation

	Principle	Discussion
The 'Why'		
1	Embrace the Safe System approach for harm minimisation.	• In a location with a large number of vulnerable road users and possible vehicle-pedestrian conflicts, a Safe System approach supports the use of speed limits no greater than 30 km/h to manage the potential for fatal and serious injury risk, especially for pedestrians. • A small reduction in mean speed can result in a substantial decrease in FSI crashes. • While a 40 km/h speed zone already provides a degree of support to the harm minimisation approach in high pedestrian activity areas, a 30 km/h environment, implemented in a consistent and credible manner, is expected to further reduce road trauma and social costs of FSIs.
2	Enable a more balanced approach through the creation of a 30 km/h speed environment by taking into account multi-modal and multi-functional objectives for the use of the same road space.	• Roads and speed environments are categorised based on the functions they perform in the context of an integrated road network and land use activities. • Lowering a speed environment from 40 to 30 km/h will improve the mobility and accessibility of non-motorised users as well as enhance environmental amenity within the network and of the surrounding land uses.
The 'Where'		
3	Prioritise a location with strategic place significance in the movement and place framework.	• The classification, taking into account factors such as road design and traffic volumes, is a key input into calculating safe and appropriate travel speeds. The role of road space as a destination (place function) is recognised in the Guide to Traffic Management (Austroads 2016a). • 30 km/h speed limits and zones can be prioritised based on this movement and place functions within the road network.
4	Target activity centres and selective residential areas with a high level presence of vulnerable road users.	• Based on the movement and place framework, the initial focus of employing 30 km/h limits can be activity centres and other high-risk urban areas with high volumes of pedestrians and other vulnerable road users.
The 'How'		
5	Focus on an area-wide implementation in homogeneous road sections.	• Regulatory signs are required at entry points to the designated area. • Attention must be paid to ensure these additional signs (and pavement markings) do not present new hazards to the environment (e.g. issue with skid resistance and impeding sight lines).
6	Employ traffic calming measures for speed management and control.	• Incorporating traffic calming in the 30 km/h implementation at the outset is critical for speed management, especially in an area with existing mean speeds significantly higher than 30 km/h. • While it is relatively costly to retrofit the existing higher-speed streets with traffic calming measures, the SER design of a new road network in greenfield areas can readily incorporate local area traffic management devices to self-regulate speeds.

Principle		Discussion
7	Utilise a mean speed as a primary measure of actual traffic speed for a road section.	• The conventional use of 85th percentile speed to determine speed limits is challenged by the arguments that: - Many drivers are ill equipped to judge road safety risks, and to determine appropriate speeds for the environment. - Many people tend to drive above the speed limit, which gradually increase the 85th percentile speed over time - Many individuals seek to drive faster than the average speed in effect to self-affirm their image of better than average drivers • Setting a speed limit based on a mean speed will achieve a safe distribution of speeds at a lower level than that of the 85th percentile speed. This is more suitable for a lower speed zone of 30 km/h where (vehicle) mobility is not a primary function. • The aim of the 30 km/h zone implementation and monitoring is to ensure a mean speed is appropriate to the prevailing road and traffic environment or otherwise additional traffic calming measures are required. • The use of mean operating speed as a primary measure is reflected in the UK's 2013 *Setting Local Speed Limits* circular and NZ's 2017 *Setting of Speed Limits* rule.
8	Consider residual crash risks associated with road, roadside and traffic characteristics.	• Lowing a speed limit to 30 km/h in itself reduces crash severity and likelihood. • Nonetheless, there are residual risks associated with the road environment (e.g. road geometry, roadside hazards, traffic volume, traffic mix and presence of vulnerable users) that may warrant additional measures to be included as part of a 30 km/h implementation.
9	Manage the impact of the 30 km/h implementation in school zones.	• There is no reason why the maximum speed environment for school zones should not be reduced to 30 km/h during school hours, except for major thoroughfares. • Key factors to be considered are default and full-time speed limits as well as speed management measures during school and non-school hours. • Lowing a general (default) urban speed limit from 50 km/h to 30 km/h would render a school zone designation redundant. • Any safety risk due to children's movement unpredictability can be addressed using the flashing lights as well as school zone signage and marking but as advisory measures instead of a specific enforceable zone. • In any case, legal traffic controls are still required to distinguish the 30 km/h speed environment from the underlying (higher) speed limit outside school hours.
10	Set technical criteria that are consistent with the requirements in the existing guidelines.	• The following criteria should be developed: - A minimum length to avoid too many changes of speed limit along a route or an area. - Repeater signs or markings to serve as an indicator of the speed limit and a reminder for drivers to check whether they are travelling at the maximum safe speed. - Specific provisions for temporary or part-time 30 km/h limits • Once the impact and performance of the 30 km/h implementation is fully understood, the existing criteria of the speed zoning guidelines may require an update to reflect contemporary practice. For example, if a SER design was proven to be successful in speed management, a requirement for regulatory signage may be relaxed.

Principle		Discussion
11	Establish an on-going evaluation and monitoring process.	• An on-going performance evaluation informs policies, guides the investigation of investment options, and assists in estimating the return on investment. • The speed limit review is an iterative process to keep up with a change in road and land-use environments.
12	Engage key stakeholders and communities for support.	• Community support and acceptance is fundamental in the success and compliance of any 30 km/h zone implementation. • Education and communication of the benefits of 30 km/h speed zones is also vital in gaining greater community acceptance.

Conclusions

Guiding principles for implementing 30 km/h speed limits and zones have been developed based on the outcome of a literature review, a consultation survey of Australasian practitioners in road transport agencies and a Safe System analysis of setting a 30 km/h speed limit for harm minimisation.

It is found that the 30 km/h speed limits and zones have been utilised widely in various international jurisdictions outside Australia and New Zealand. The 30 km/h practices identified employ speed management techniques of traffic calming measures, self-explaining roads and regulatory signage to influence safe travelling speeds within the designated 30 km/h zones.

Based on the philosophy of the Safe System approach, which reaffirms an absolute priority to avoid death and serious injury, 30 km/h has been recognised as a safe and appropriate speed limit in an area where there is a high level of vulnerable road users present and a potential for conflict with vehicle traffic. The evidence of 30 km/h practice in Australia and New Zealand highlights the area of focus for the 30 km/h implementation - that is, to prioritise the activity centre areas in an integrated area-wide approach.

Moving forward would require the integration of the principles into to the regulatory speed zoning guidelines to enable a broader introduction of 30 km/h limits and zones. In the longer term, an emphasis should be placed on having 30 km/h as a default urban speed limit in higher-order activity centres (town centres or denser) and designated residential areas serviced by the lowest order roads since there are the areas of greatest pedestrian activity.

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Exploring Local Government Challenges in Effective Road Safety Delivery

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This peer-reviewed paper was first presented as an Extended Abstract and Oral Presentation at the 2018 Australasian Road Safety Conference (ARSC2018) held in Sydney, NSW, Australia and first published in the ARSC2018 Proceedings in the form of an Extended Abstract. It was expanded into a 'Full Paper' and underwent further peer-review by three independent experts in the field. It is being reproduced here with the kind permission of the authors and is now only available in this edition of the JACRS.

Key Findings

- Local government face several challenges in delivering road safety outcomes.
- Road safety outcomes on local roads can be enhanced with central agency assistance.
- Increased funding is only one part of a broader approach needed to assist local government.

Abstract

Half of all vehicle kilometres travelled and 62% of all deaths and serious injuries in New Zealand occur on local government roads. The upward trend in road trauma has revealed a growing disparity in safety performance between locally and centrally managed roads. The increasing gap, which is mirrored by differing levels of investment, was the stimulus behind a national project to understand the dynamics of local government road safety delivery and investment. Engagement workshops with local councils throughout New Zealand uncovered an array of common challenges – some of which were not anticipated when the project commenced.

Keywords

Local Government, Program, Funding, Engagement, Workshop, Road Safety

Glossary

DSi	Deaths and serious injuries
KiwiRAP	New Zealand's Road Assessment Programme that adheres to iRAP protocols
Mega Maps	New Zealand's Online Risk Assessment Tool
Safer Journeys	New Zealand's Road Safety Strategy 2010-20

Introduction

Since 2010, the New Zealand Transport Agency ('the Agency') and their Safer Journeys partners have commissioned the development of a number assessment tools and techniques that move away from traditional methods of identifying high-risk locations. Reliance on total crash numbers and the social cost of crashes have been replaced with approaches based around risk and the likelihood of death and serious casualties occurring in the future.

Increasingly, the assessment tools and techniques have been developed to apply to local roads and not just State Highways that are rich in data. The rationale for the focus towards local roads is that while the vehicle kilometres travelled on local roads is similar to State Highway network; the number of people killed and seriously injured on local roads accounts for 62% of all DSi compared to 38% on State Highways. The local road network is also substantially longer than the State Highway network (approximately 100,000km compared to 11,000). The much longer length combined with lower volumes and a more dispersed pattern of crashes creates another series of issues around the planning of road safety programs.

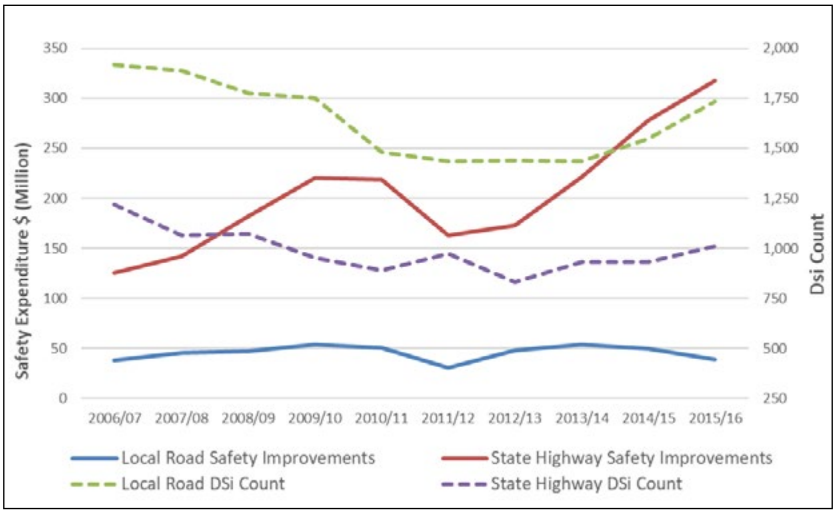

Figure 1. Comparison of Local Road and State Highway DSi and Safety Expenditure

The trend in safety performance is one of growing disparity, with the number of DSi on local roads increasing more rapidly than on State Highways. In part, this may be explained by the growing gap between road safety expenditure on State Highways compared to local government roads, as shown in Figure 1.

Local Road Safety Investment Program

To understand why safety performance on local roads is lagging State Highways, and why investment is static or falling, the Agency commissioned the development of an indicative nationwide program of works to identify if additional infrastructure investment could significantly reduce DSi on local roads. This local road safety investment program (colloquially known as the $800 million program) was developed by collating the results of the following industry recognised risk assessment techniques that have been applied to local road networks:

- Urban KiwiRAP – Collective and Personal Risk maps
- Infrastructure Risk Rating (IRR)[1]
- Intersection Collective and Personal Risk, as per the NZ Transport Agency's High-Risk Intersections Guide[2]
- High-risk rural curves analysis
- High-risk motorcycling routes, as per the NZ Transport Agency's Safer Journeys for Motorcycling in New Zealand guide[3]
- High-benefit speed management opportunities – where infrastructure intervention was identified as an appropriate response, as per the the NZ Transport Agency's Speed Management Guide[4]

Road segments classified as being 'high-risk' by one or more of the assessment methods above were taken through for further assessment and prioritisation. Some 4,000 km of roads, which represent around 4% of the local road network by length and account for 36% of all fatal and serious crashes on local roads over the past 5 years, formed the basis of the local road safety investment program.

Generic treatments were assigned to each corridor or intersection based on the nature of the surrounding land use, functional road classification, and other relevant geometric and operational factors. The DSi reduction potential and implementation cost of each intervention were then assigned to each road segment. Three approaches to prioritisation were then evaluated, as follows:

- Targeted to DSi risk – prioritised based on roads with the highest number of DSi per km.
- Targeted to DSi reduction potential – prioritised based on roads with the greatest DSi reduction potential per km.
- Targeted to DSi reduction per $$ spent – prioritised based on the greatest DSi reduction potential per $100M investment.

The 'Targeted to DSi reduction potential' was selected as the preferred approach to formulating the local road safety investment program. Further analysis found that safety benefits began to diminsh quickly once the program value exceeded $800 million. As such, an $800 million program was identified as an optimal level of investment, which could be expected to generate a reduction of around 169 DSi per annum.

1 https://www.nzta.govt.nz/safety/speed-management-resources/
2 https://www.nzta.govt.nz/resources/high-risk-intersections-guide/
3 https://www.nzta.govt.nz/resources/safer-journeys-motorcyclists/
4 https://www.nzta.govt.nz/safety/speed-management-resources/

The Agency then commissioned a follow-up study to understand the alignment between proposed local government road safety investment and the $800 million program, which is the subject of this paper.

Local Government Engagement

The purpose of local government engagement study was twofold:

1. To identify the extent of alignment between planned local government road safety investment and the $800 million program, and
2. To identify any internal and external factors that represented challenges or impediments to the effective delivery of road safety and ultimately better road safety outcomes.

A cross-section of different local government types, a combination of major and minor metropolitan centres, as well as smaller urban area centres and rural areas were selected for the study to obtain a wide breadth of responses covering different environments. The local governments included in the project were:

- Far North District Council
- Whangarei District Council
- Auckland Transport
- Hamilton City Council
- Waipa District Council
- Palmerston North City Council
- Wellington City Council
- Christchurch City Council

Alignment Method

The starting point of the study was to identify the degree of alignment between proposed local government investment for safety projects (assessed via data input to Transport Investment Online (TIO) for the 2018-21 period) and the $800 million program. This involved extracting all projects from TIO where either Primary Outcome or one of the Multiple Outcomes was identified as 'Safety'. TIO is a repository of activities planned to be delivered by through the National Land Transport Programme (NLTP). The NLTP sets out activities that can receive funding from the National Land Transport Fund (NLTF) under the Land Transport Management Act 2003. The Agency uses an Investment Assessment Framework (IAF), developed in line with the Government Policy Statement on Land Transport Funding (GPS), to prioritise which proposals should receive funding. The NLTP and the Investment Assessment Framework (IAF) are the two key tools the Agency uses to give effect to the GPS.

Each planned safety project in TIO was then compared with the $800 million program and against other parts of the local road network that were identified as high-risk but were not included in the prioritised program. A 'match' was assessed to occur where the planned local government project overlapped with the $800 million program or other high-risk locations.

Alignment Results

Overall, a high degree of matching was found between planned local government safety projects in the 2018-21 program, the $800 million program and other high-risk locations. There was a 52% matching rate between planned local government safety projects and the $800 million program and an additional 33% matching rate with other high risk locations.

None of the smaller district councils included in the study had proposed any individual safety projects in the 2018-21 program at the time of the study i.e. no co-funding was being sought from the Agency for projects exceeding $300,000. For these councils, all safety improvement projects were funnelled through a low risk/low cost program. As the details of smaller projects that comprise the low risk/low cost program were not identifiable in TIO, this precluded the ability to determine if this planned safety investment was targeted at high-risk locations.

Workshops Method

Workshops were held with the local government during December 2017 and January 2018.

Each local government organisation was provided with their high-level matching results as part of the workshop invitation. In advance of each workshop, attendees were also provided with an agenda outlining the purpose of the workshop and a series of questions planned to stimulate discussion for the attendees to consider ahead of time. The list of questions circulated to attendees was:

1. What do you consider to be the biggest safety challenge in your area?
   - On urban roads?
   - On rural roads?
2. What do you consider to be the biggest challenge in delivering your program(s)?
3. What are your processes for developing your program(s)?
4. To what extent is your program(s) informed by your strategic priorities?
5. Does your organisation have a DSi reduction target?
6. Do you have an estimate of the number of DSi your program will save?
7. Has an assessment been undertaken into alignment of investment level and expected outcomes?
8. What engagement do you have with the Agency during development of program?
9. What process do you go through to determine projects in your minor safety program?

10. How do you prioritise your lists?
11. Are all projects prioritised against your priorities?
12. What staff do you have assigned to delivering your program?
13. How would an increase in funding help you deliver road safety more effectively?
14. Are there internal barriers preventing you from delivering effective road safety outcomes?
15. Are there external barriers preventing you from delivering effective road safety outcomes?
16. What would you like to do, but currently don't, and what's holding you back?
17. How could the Agency better assist you to deliver effective road safety outcomes?

Workshops Results

Overall, there was a high level of engagement and participation from local government staff in all workshops. Without exception, local government presented highly motivated staff who wanted to deliver positive road safety outcomes for the networks. Staff could readily identify internal and external factors that were preventing them from being as effective as desired. The challenges faced by local government to achieve better safety outcomes were discussed openly and frankly, and covered a broad spectrum of operational, funding, policy, political, legislative and industry matters. That level of engagement and willingness to share opinions was instrumental in uncovering some key themes can now be explored further to support local government in the development and delivery of their road safety programs.

Table 1. Key themes from local government workshops

Issue	Description
Funding	Increasing the Funding Assistance Rate (FAR) would encourage local government to do more.
Capacity	Most local governments are not adequately resourced to deliver effective road safety programs.
Stakeholder Support	National leadership is required to support local government with the implementation of measures that are unpopular.
Access to Information	Local government noted gaps in data required for decision-making and lacked awareness about where to access information.
Industry Training	Local government noted a lack of ongoing training and development of people in the road safety area.
Program Development	Local government struggle with aspects of program development, including composition, internal priorities and justification.
Enforcement	Local government want a widescale rollout of red-light and speed camera enforcement technology to support road safety efforts.

Minutes were recorded of each workshop and circulated to attendees for review and comment.

The workshop minutes were then analysed individually and collectively to identify key themes, a summary of which is presented in Table 1.

Discussion

Funding

All local governments indicated they could deliver more road safety projects and larger programs if funding was increased.

A challenge noted was that funding for road safety projects competes with other local government activities, both within the wider transport activity class, and with infrastructure projects in general. Because specific delivery areas, such as road safety, compete for budget from the overall fund, most local governments indicated that increasing the Agency's Funding Assistance Rate (FAR) for road safety projects would be very helpful to encouraging local government to do more in the road safety area. This was seen as being particularly helpful for mass-action type projects.

Capacity Constraints

All local governments noted resourcing concerns, both within and external (consultants and contractors) to local government. The shortage of skilled local government staff was noted by most, and while some local governments were able to train staff to roles, staff caps were also identified as a problem. Major projects, such as the Safe Roads Alliance (based in the Waikato) and the North Canterbury Transport Infrastructure Rebuild (NCTIR) project were cited as being resource hungry projects that consumed a lot of resource that would otherwise be available to assist local government.

At a wider industry level, some local governments expressed concern about a lack of national leadership in progressing skilled people through the industry, especially in the road safety area. The fact that some of the key road safety experts at the NZ Transport Agency were at or nearing retirement age was not lost on local governments – citing concern about a potential loss of institutional knowledge. Both factors were identified as being prolonged capacity constraint risks for the industry.

Stakeholder Support

Most local governments identified the lack of support for unpopular measures from either elected officials or the public as being an obstacle to the delivery of some road safety projects. Competing priorities within local governments was also a concern, since some local governments would prioritise other outcomes – for example infrastructure projects – over smaller scale safety improvements.

There was some confusion over ownership for responding to the safety challenge i.e. who should be responsible for effecting change and reducing DSi, and whose responsibility leading the delivery of road safety outcomes is. There was a suggestion that clarity was needed over what goals should be achieved and whose responsibility effecting change is.

Access to Information

Local governments expressed appreciation of the increased road safety guidance and high-risk tools that have been developed nationally for local use. Mega Maps was noted by most, as being their 'go to' place for road safety information. While Mega Maps was seen as a step forward, many local governments said they didn't know where to go to access information and in what situation certain information was best used.

Many local governments mentioned data gaps which were detrimental to delivering programs. A key data gap noted was the lack of pedestrian and cyclist counts, or suitable techniques for estimating these at a network level. This information was considered particularly important, as the absence of count data for active road users was seen as a barrier to justifying safety improvement projects, even though the majority of benefits accrue for health reasons due to the dispersed nature of active road user crashes. There was also a lack of data available on lessons learned and developing trends, which local governments commented they had little time to undertake themselves.

Another common issue related to speed management. Specifically, local governments were looking for assistance, direction and/or reassurance about how they take the nationally available data presented in Mega Maps and develop their speed management implementation plans. The lack of case studies on this was mentioned by most local governments.

Industry Training

Some local governments noted a lack of ongoing training and development of people in the road safety area. The general feeling was that aside from the Safe System Engineering Workshop, ongoing education was achieved by attendance at conferences, rather than through nationally led targeted capability building workshops or training events. The Fundamental and Advanced Cycle Design courses run by the Agency were held-up as an example of something that would probably work well in the road safety area.

The lack of ongoing training at an advanced level meant that some local governments still resorted to reactive decision making when producing road safety projects, even though most acknowledged that proactive approaches were a better approach. This approach appeared to be a result of an incomplete knowledge base of all the recent developments in road safety, and a lack of confidence of how to shift towards a more proactive approach.

Program Development

One of the most common challenges raised by the workshop participants related to the process of developing programs. A range of different issues were identified, although common themes related to the need for safety driven projects to be prioritised against other programmed activities which results in a number of potential obstacles for delivery. Key points taken away from the workshops were:

- The raising of the Low Cost, Low Risk project cap from $300,000 to $1,000,000 was welcomed. This change was expected to enable local government to deliver more by removing the need to go through a business case process.
- Safety projects were often prioritised less highly than other transport or infrastructure projects according to individual local government priorities.
- Projects that generate travel time savings often produced a better Benefit to Cost Ratio (BCR) than safety projects and were therefore prioritised above safety projects. Safety projects may also increase travel times which would bring overall benefits down.
- Some local governments resorted to separating projects into smaller portions to avoid the need for NZ Transport Agency approvals. This approach meant a holistic approach to delivery was lost.
- Local government programs were subject to internal approval processes and political influence, both of which can create delay and result in programs including activities with little safety benefit.
- Local governments noted the fact that operating with fixed internal budgets meant they were unable to respond in an agile way to new challenges. Often relatively small scale and low-cost measures could not be funded because they were not programmed.

Related to this was the challenge of knowing how to produce a balanced safety program across a region. Challenges included balancing safety issues in different contexts e.g. rural v urban (see further explanation below), midblock v intersection etc. as well as safety issues for different user groups and safety themes e.g. speed management v intersection improvements v curve safety v roadside hazard protection/removal. Local governments requested guidance at a strategic level on the composition of their road safety programs. In the absence of that strategic guidance, local governments tended to default to prioritisation based on BCR and with a heavy reliance on delivering via the low-cost, low-risk budget.

Rural Areas

Rural areas face some different challenges to urban areas. A low ratings base and dispersed networks can make funding for safety projects and enforcement of undesirable behaviours challenging. They may also face challenges in finding staff, consultants and contractors to undertake project work.

Widespread speed reduction was seen to be the main tool to address safety concerns in rural areas, but again the issue around public acceptance was noted as a concern. Other approaches to improve safety in rural areas included improving the safety of curves and targeted safety maintenance e.g. improved skid resistance.

Urban Areas

In urban areas, the complex interplay between priorities was noted as causing challenges for local governments. The balance between encouraging walking and cycling and achieving safety outcomes was identified as a particularly challenging issue, with the key point of contention being that active travel is inherently less safe compared to driving. The Agency has already gone a long way to acknowledging the health benefits of active travel outweigh the safety risks through incorporating these benefits in the way projects are assessed. However, in the road safety area, there would appear to be missing metrics and targets related to the broader personal health and environmental benefits of active travel. Retaining a sole focus on active road user safety metrics has the potential to stymie continued improvement of safe infrastructure for active travel unless a broader view is adopted.

Increased Enforcement

Although not a core function of local governments, most indicated that there should be a widescale rollout of red-light and speed camera enforcement technology given its proven effectiveness in addressing unacceptable behaviour that leads to poor road safety outcomes. The consensus view was that the level of enforcement did not match the scale of the road safety problem. The reduction in physical police enforcement presence on roads was also mentioned, but to a lesser extent than the technology-based solutions.

Outcomes of the Study

The study is somewhat unique in that it is rare to formally ask questions and record responses about how a central organisation can better support local government. Now in possession of these responses, the Agency is identifying how it can better assist local government. The study has reinforced to the Agency that it could do more, and gone further by identifying what the challenges, barriers and issues are that need to be focused on to improve local government effectiveness at delivering road safety outcomes.

The feedback has helped the Agency realise how complex the delivery of safety outcomes is at a local government level. Clearly, supporting local government through increased funding or raising the FAR is only one part of a much broader approach need to address the issues. Resolving capacity constraints, providing leadership to garner stakeholder support and upskill the industry, improving access to information and providing assistance with program development are other factors that need attention.

The Agency has started the journey by taking a leadership role in the speed management and program development areas. They are developing nationwide speed management and infrastructure improvement programs and sharing these with local government to help them develop their regionally led programs. This systemic approach effectively treats all roads in New Zealand as one network. In doing so, it is facilitating targeted road safety investment in the areas that need it most, and reducing the need for local government to start from scratch when developing their safety programs. The study has opened the door to a collaborative approach with the ability to cluster and partner as appropriate to share information and grow capability while ensuring safety investment is better targeted.

The study demonstrates the benefit of openly engaging with key stakeholders and provides a strong platform to outline the steps the Agency needs to take to break down the barriers to effective local government road safety delivery. The lessons learnt from this study are expected to be applicable throughout Australasia and therefore be of interest to everyone involved in the delivery of local government road safety programs.

Acknowledgements

The authors acknowledge wish to thank the participating local governments for their high level of engagement in the study and willingness to discuss the challenges and barriers to achieving better safety outcomes in an open and candid manner. That was instrumental in uncovering some key themes can now be explored further by the Agency to better support local government in the development and delivery of their road safety programs.

Contributed articles

Road Safety Case Studies

Safe Pedestrian Behaviours among Children Aged 7 to 9 in Malaysia

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Key Findings

- Less than 30% of surveyed children aged 7 to 9 reported high levels of safe pedestrian behaviours as defined in the Malaysian Road Safety Education module.
- Less than 30% of the children aged 7 to 9 reported to 'always' wear bright clothes, walk against the traffic, and wave at the drivers to cross the road.
- More than 70% of children aged 7 to 9 reported to 'always' hold adult's hand when crossing the street and look left, then right, and then left again before crossing the street.
- A small percentage (9.9-13.6%) of children aged 7 to 9 reported to 'always' wear dark clothes at night, cross the street between parked cars, and run to cross the road.

Abstract

The present study examined safe pedestrian behaviours according to the Malaysian Road Safety Education module among 7-year-old to 9-year-old children in Malaysia. A survey was conducted with a relatively large (n = 1206) random sample of children aged 7 to 9 years old, drawn from 24 selected schools in six states in Malaysia based on the highest numbers of crash cases. Analysis of one-way ANOVA revealed a statistically significant difference in safe pedestrian behaviours between different ages. Post hoc comparisons using the Tukey HSD test indicated that the mean score of safe pedestrian behaviours for 7-year-old children was significantly higher than that of 8-year-old children ($p = .004$) and 9-year-old children ($p = .021$). No statistically significant difference was revealed between the 8-year-olds and 9-year-olds ($p = .859$) at the 0.05 level. Although many children reported safe pedestrian behaviours, low levels of certain safe pedestrian behaviours were also reported – less than 30% of the children aged 7 to 9 reported to 'always' wear bright clothes, walk against the traffic, and wave at the drivers to cross the road. In addition, a small percentage (9.9-13.6%) of children aged 7 to 9 also reported to 'always' wear dark clothes at night, cross the street between parked cars, and run to cross the road. These findings may inform programs to improve children's safe pedestrian behaviours.

Keywords

Safe Pedestrian Behaviour, Children, Malaysia

Introduction

In 2016, 1.4 million people died from road traffic crashes around the world (WHO, 2018). Road traffic injury ranked fourth for causes of death for children, and it was estimated that 186,300 children die from road traffic crashes yearly (WHO, 2015). Meanwhile in Malaysia, road traffic crashes recorded the third highest percentage (7.4%) for premature deaths (Department of Statistics Malaysia, 2017).

A statistic from Royal Malaysia Police stated that 2,248 children aged below 15 were part of road traffic casualties in 2016 (Royal Malaysia Police [PDRM], 2016). Children who were affected by terrible crashes may experience unending suffering and misfortune that also trouble people surrounding them, especially family and relatives. Children are vulnerable on the road due to their limitation in terms of physical, cognitive, and social development (WHO, 2015). Although children are not eligible to drive on the road, they are still part of the road users. Children use the road daily, especially to commute to school as pedestrians, putting them at risk of being a victim of road traffic crash.

With more than 30,000 children killed annually, child pedestrian injuries are an important issue worldwide (Toroyan & Peden, 2007). This trend is very worrying as it has not declined in recent years (WHO, 2008). According to National Centre for Injury Prevention and Control or NCIPC (2013), children in the 5-year-old to 10-year-old age range are at particular risk and account for a disproportionate number of pedestrian injuries. In 2016, a total of 1,040 school children had been involved in pedestrian road crash which was also the third leading cause of casualties in Malaysia (PDRM, 2016). A review revealed that most of the crashes and injuries happened in or near the house, or in few instances, at school (Khamsiah Ismail et al., 2016).

Given road safety is a significant issue for the young children, the objective of this study is to examine the level of safe pedestrian behaviour among 7-year-old to 9-year-old children in several selected districts in Malaysia, and to determine whether a significant difference exists in the pedestrian behaviours according to their age. The paper hypothesised that there will be a significant difference among the age groups, where the older children show better performance on safe pedestrian behaviours than the younger children. Apart from that, the research goal is to identify what kind of safe pedestrian behaviours should be improved in order to create prudent pedestrians among children. Identifying the weakness in the aspects of safe pedestrian behaviours among children is essential for developing effective prevention strategies.

Methods

Research Design and Sampling

This is a quantitative study in which two-stage sampling comprising purposeful random sampling and simple random sampling was applied to gather the data. During the first stage, six states were identified based on the road crash statistics from Royal Malaysia Police. The highest numbers of crash cases involving those aged 6 to 12 years old in six districts were shortlisted, with one district representing one state. During the second stage, four primary schools in each district were randomly selected. At each school, children were randomly selected by the school administrators according to low, medium, and high academic achievements. The study was conducted based on ethical regulation research involving school children and it was approved by Ministry of Education, Ministry of Transport, and other related departments. Consent of participation was obtained from parents of the children.

Participant

A total of 1,206 children were recruited from a total of 2 4 primary schools; 410 were 7 years old, 392 were 8 years old, and 404 were 9 years old.

Instrument

The researchers developed a questionnaire consisting of 9 questions aimed to assess safe pedestrian behaviours among children aged 7 to 9 years old (refer to items listed in Table 2). The questionnaire was developed by the researchers based on the literature review, the Bloom's taxonomy, and the children's psychological development. All of the items were constructed based on the content of the Malaysian Road Safety Education module which was related to children's pedestrian behaviours. Out of the nine items, six items measured safe pedestrian behaviour (Items 1 to 6), whereas three items measured unsafe pedestrian behaviour (Items 7 to 9). A three-point Likert scale of "never", "seldom", and "always" was utilised to measure the frequency of each behaviour. The total scores for this questionnaire ranged from 6 to 27 points, and higher scores indicated better and safer pedestrian behaviours. All items in the questionnaire were pictorially illustrated and the participants answered the questions in a face-to-face interview with the researchers.

Analysis

Data were processed and analysed using SPSS software, and the descriptive and inferential statistics were applied. Simple frequency and percentage were used in order to examine the level of safe pedestrian behaviours among children aged 7 to 9 years old. The extent of safe pedestrian behaviours was categorised into three levels, namely low, moderate, and high, based on the score and data distribution. Percentage was also utilised to present the distribution of data for each item. As for inferential statistics, one-way ANOVA was utilised to determine the mean difference of safe pedestrian behaviours among the children according to their age. The significance levels adopted were 0.01 and 0.05.

Results

Table 1 shows the levels of safe pedestrian behaviours among 7-year-old to 9-year-old children. Most of the 7-year-old children had either low level (37.6%, n = 154) or moderate level (33.7%, n = 138) of safe pedestrian behaviours. Only 28.8% (n = 118) of them showed high level of safe pedestrian behaviours. As for children aged 8 years old, half of them recorded low level (51.0%, n = 200) of safe pedestrian behaviours. Meanwhile, 25.0% (n = 98) and 24.0% (n = 94) of this age group displayed moderate and high levels of safe pedestrian behaviour respectively. Similarly, 47.8% (n = 193) of 9-year-old children reported low level of safe pedestrian behaviours and 28.5% (n = 115) of them demonstrated moderate level of safe pedestrian behaviours. Only 23.8% (n = 96) of them showed high level of safe pedestrian behaviours.

Table 1. Level of safe pedestrian behaviours among the children

Age (years old)	Level	Frequency (n)	Percentage (%)
7	Low	154	37.6
	Moderate	138	33.7
	High	118	28.8
	Total	**410**	**100.0**
8	Low	200	51.0
	Moderate	98	25.0
	High	94	24.0
	Total	**392**	**100.0**
9	Low	193	47.8
	Moderate	115	28.5
	High	96	23.8
	Total	**404**	**100.0**

Table 2 presents the mean differences of safe pedestrian behaviours among 7-year-old to 9-year-old children. One-way ANOVA (F (2,1203) = 5.828, p = .003) showed a statistically significant difference in safe pedestrian behaviours between different ages. Post hoc comparisons using the Tukey HSD test (Table 3) indicated that the mean score of safe pedestrian behaviours for 7-year-old children (M = 21.09, SD = 2.50) was significantly different from 8-year-old children (M = 20.28, SD = 2.87, p = .004) and 9-year-old children (M = 20.65, SD = 2.47, p = .021). However, no statistically significant difference was found between 8-year-olds and 9-year-olds (p = .859) at the 0.05 level. The 7-year-old children recorded the highest mean compared to 8-year-old and 9-year-old children. That is, 7 year old children reported better pedestrian behaviours than 8 and 9 year olds.

Table 2. Mean difference of safe pedestrian behaviours based on age group

Age	Mean	Std. Deviation	F value	Sig.
7 years old (n = 410)	21.0902	2.50264	5.828**	.003
8 years old (n = 392)	20.2781	2.86825		
9 years old (n = 404)	20.6510	2.47157		

*p<.05, **p<.01

Table 4 presents the overall percentage of responses to each item. It was found that less than 30% of the children aged 7 to 9 stated "always" on three out of six safe pedestrian behaviour items (items 1, 3, 6). However, for Items 4 and 5, 77.1% and 73.1% of children reported "always". More than half (53.1%) of the children always used the green man signal to cross the road (item 2).

As for the negative road safety behaviours, Item 7 showed the highest percentage of "never" with 65.0%, suggesting that a majority of children were aware that it is very dangerous to cross the road between parked cars. Only 13.6% of the children reported to "always" wear dark clothes at night, 10.3% to cross the street between parked cars, and 9.9% to run to cross the road.

Discussion

The present study was conducted to assess the level of safe pedestrian behaviours among 7-year-old to 9-year-old children in Malaysia and to identify the aspects of safe pedestrian behaviours that should be strengthened and improved among the children.

The present survey found that less than 30% of surveyed children aged 7 to 9 reported high levels of safe pedestrian behaviours as defined in the Malaysian Road Safety Education module. The possible explanation for this is that children have specific age-related limitations that lead to poor decisions as pedestrians. Their limitations include generally lower cognitive ability as proposed by Piaget's theory on cognitive development (Sandels, 1975); lack of domain-specific knowledge (Bongard & Winterfeld, 1977); perceptual disadvantages (Sandels, 1975); immature visual search strategies (Whitebread & Neilson, 2000); distractibility (Dunbar, Hill, & Lewis, 2001); and inferior physical and motor skills (Briem & Bengtsson, 2000). Studies found that individual children under the age of 9 years old were unable to identify dangerous locations when crossing the road (Dunbar, Lewis & Hill, 1999). The same authors also found considerable age-related variations in attention switching and concentration, both of which are essential for a safe road crossing, with older children being better at both (Dunbar, Lewis & Hill, 2001).

Table 3. Multiple comparisons of safe pedestrian behaviours based on children's age

(I) Age	(J) Age	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
7	8	.18260*	.05760	.004	.0474	.3178
	9	.15229*	.05716	.021	.0182	.2864
8	7	-.18260*	.05760	.004	-.3178	-.0474
	9	-.03031	.05781	.859	-.1660	.1053
9	7	-.15229*	.05716	.021	-.2864	-.0182
	8	.03031	.05781	.859	-.1053	.1660

*The mean difference was significant at the 0.05 level; Tukey HSD; Dependent variable: safe pedestrian behaviour

Table 4. The overall percentage of children's pedestrian behaviour items

Item	Behaviour	Scale	Average (%)
1	Wear bright or white clothes when walking at dusk	Never	30.7
		Seldom	47.1
		Always	**22.2**
2	Cross the street when the green man signal is on	Never	19.3
		Seldom	27.6
		Always	**53.1**
3	Walk down the street, facing the cars and traffic	Never	37.8
		Seldom	40.8
		Always	**21.5**
4	Hold adult's hand when crossing the street	Never	6.8
		Seldom	16.1
		Always	**77.1**
5	Looking left, then right, and then left again before crossing the street	Never	6.2
		Seldom	20.7
		Always	**73.1**
6	Wave at the drivers before crossing the street	Never	43.7
		Seldom	29.7
		Always	**26.6**
7	Crossing the street between parked cars	Never	**65.0**
		Seldom	24.7
		Always	10.3
8	Run when crossing a street to get to the other side fast	Never	**62.9**
		Seldom	27.2
		Always	9.9
9	Wear dark clothes when walking at night	Never	**44.2**
		Seldom	42.2
		Always	13.6

According to Schieber and Thompson (1996) children have not yet developed the necessary motor or complex cognitive skills required to cross a road safely or plan the safest route nor the ability to adequately judge the distance, movement, or speed of a vehicle. Children as young as 6 and 7 years old have been found to have difficulty in interpreting information on the direction and speed of moving vehicles (Joly, Foggin, & Pless, 1991). The Piaget's theory supports this notion by stating that due to cognitive and perceptual limitations of children, their adaptation to traffic before 11 years old is impossible, although they have been educated about road safety (Assailly, 2016).

The present survey also found that 7-year-old children reported safer pedestrian behaviours in their daily life compared to 8-year-old and 9-year-old children. One of the reasons for this finding may be the influence of environmental factors. According to the ecological theory by Bronfenbrenner (1979), child development tends to be influenced by the upbringing process in their environment. Children's interaction with different environments will produce different development for each child. Since 7-year-old children are younger and have limited skill and ability to take good care of themselves, parents and teachers may give more attention and guidance to them compared to 8-year-old and 9-year-old children. Furthermore, in Malaysia, children start to enter primary school at the age of 7. It is the first time that the children will be exposed to road hazard. Therefore, the parents may assume that it is necessary to regularly monitor and remind their 7-year-old children about their safety behaviours. For instance, parents may initiate holding hands with the children and keep reminding their children to be aware of the traffic. Special supervision and treatment given by the parents and teachers may lead the children to be a safer and prudent road user. Researchers recognized that parental involvement is critical to children's behavioural change (Rothengatter, 1981). Moreover, children consider their mother and father as significant safety role models (Quraishi, Mickalide, & Cody, 2005).

Similar studies may be conducted in other educational settings such as preschools and secondary schools, various types of national schools, and higher learning institutions in order to further understand the extent of safe pedestrian behaviours among children in Malaysia. These studies combined may inform ways to improve children's safety on our roads.

Acknowledgements

The authors would like to express their appreciation to Road Safety Department and Malaysian Institute of Road Safety Research (MIROS) for providing the grant to conduct the study on road safety behaviours among primary school children in Malaysia. The authors' gratitude goes out to Ministry of Education, Road Safety Department, and all the stakeholders involved, partners, reviewers, relevant agencies/companies, research participants, and others. The authors would also like to thank research officers, research assistants, and research fellows of MIROS; who have worked hard and contributed their invaluable ideas, input, energy, and time to complete the study on time and finally, to produce the paper.

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Commentary on Road Safety

Tractrix Trajectory with Slip Steering

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Key Findings

The paper considers an urban myth that remedial action for caravan fishtailing is to speed up:

- Using a number of actions that contribute to the fishtailing phenomena the authors highlight the folly of the myth.
- An alternative to the tractrix is presented suggesting scope for adaptation.
- Examples of modified tractrices are presented for two road speeds.
- The results show an earlier cross-over to the next phase of oscillation for the higher speed.
- Angular momentum caused by the tractrix and also windage is greatly affected by vehicle speed.

Abstract

The tractrix curve, sometimes called the pursuit curve has long been the standard used to describe the path of a pig trailer behind a prime mover. This ideal path still has validity today provided the speed is very low and the trailer is unloaded. During a common phenomenon of snaking or fishtailing, the trailer sways back and forth in relation to the prime mover centreline axis. Often regarded as the nightmare of caravanning, the action does not follow the tractrix curve but follows a shorter path to the common centreline of prime mover and trailer. This paper explores the shorter path in response to a tyre reaction to centripetal force causing slip steer. An example derived by drafting progression steps to show quantitatively that speed causes early cross-over carrying more energy into the next fishtailing phase is presented. It is believed the inclusion of slip steering to modify a tractrix curve is a novel development.

Keywords

Tractrix, sideslip, pursuit curve, fishtailing, snaking, caravan.

Introduction

The objective for this paper is to show that when a fishtailing event manifests, where the amplitude of the sway is increasing, speeding up is not a solution to prevent a terminal end. There was scope to choose from a number of causes for the fishtailing and the slip steer modified tractrix posed a particular challenge. Although momentum in the trailer as it rotates from an angle of articulation to zero articulation does not affect slip steering, it is explored to shed more light on the "speeding up" solution.

Highway engineers traditionally used a mechanical device called the Tractrix Integrator or the hatchet planimeter Haynes LC (1931) consisting of a wheel or knife edge at one end of a straightedge and a tracing point at the other end. Historically, famous researchers in the 17th century like Perrault, Newton, Bernoulli, Huygens and Leibnitz amused themselves with a schoolbook tracing a track in the mud, a dog on a leash and a fob watch on a chain. Leibnitz gave the curve the name ***Hundkurve*** translated from German as dog curve. It is believed that Huygens coined the name ***Tractrix***.

Nevertheless, an awkward mathematical expression for the tractrix resulted in the form of ***x = f(y)***, as follows:

$$x = k * \ln\left(\frac{y}{k-\sqrt{k^2-y^2}}\right) - \sqrt{k^2 - y^2}$$

Where k is the length of string. [1]

Attempts have been made to make x the independent variable including a numerical hand-calculator solution by Ross (1987). Sreenavisan et al (2010) present a parametric approach to rotate the axis of hitch point progression by an angle to the x-axis but stop short of integrating the equations needed. Van Aarsen (2018) solved the integration problem and is to be assessed for usefulness in the present context.

It is recognized that the fishtailing phenomenon is complex; involving windage, yaw momentum, centrifugal action and body roll as well as trailer steering of the prime mover. This paper focuses on, and assists in understanding of a limited section of the overall fishtailing cycle.

The objective of this paper is to devise a method to test the trajectory of a trailer on a tractrix path that is modified by slip steering of tyres, in turn influenced by centrifugal action of the trailer mass progressing along a curve. The idea is visualized in Figure 1. In the pursuit of this objective the Van Aarsen (2018) equations are tested to be followed by a tedious manual process of discretizing the trailer path and adding slip steer angles at each step.

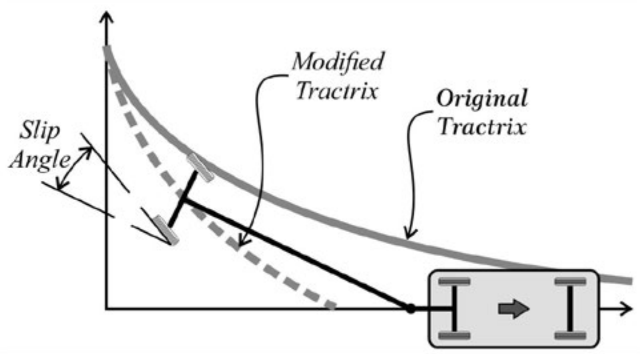

Figure 1. Idea of side slip progression away from original tractrix

Tractrix Curve

Nowadays with modern computers the Equation [1] can be easily plotted. One such plot appears in Figure 2 for a 5.0 m wheelbase trailer.

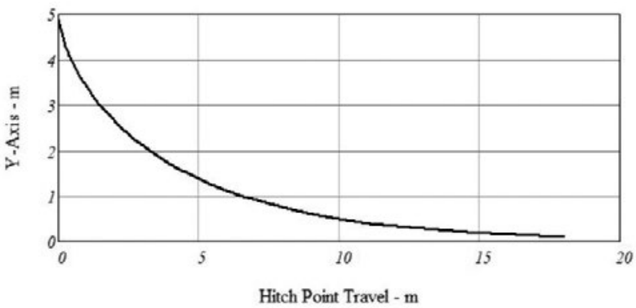

Figure 2. Graph of slow tractrix curve derived from Equation [1]

Beyond the use of the tractrix curve is a swept path analysis. Once hand-drawn using a Runge-Kutta style of piecewise stepping method has evolved to modern computer software such as AutoTURN using similar algorithms (Carrasco, 1992).

To show relevance of modern swept paths with the tractrix curve a typical curve is superimposed on a swept path study of right-angled turn of a car and trailer. This is shown in Figure 3.

To offer context for an overall fishtailing cycle, we visualize the trailer's historical path and identify phases. This is shown in Figure 4 where the cycle is divided into 4 phases on the basis of peak oscillation and cross-over across the centreline. This paper considers Phase 4 only.

It should be noted that in the ideal of Phase 4, the wheelbase centreline remains tangent to the tractrix as the tow vehicle

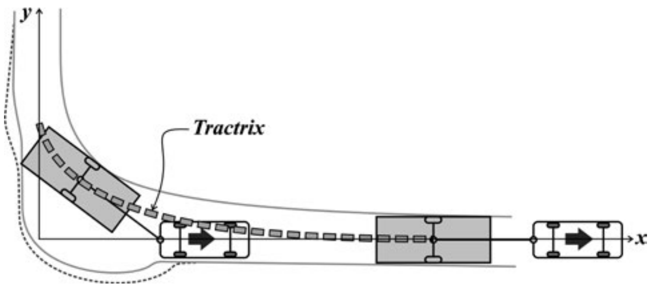

Figure 3. Tractrix superimposed on a conventional swept path analysis

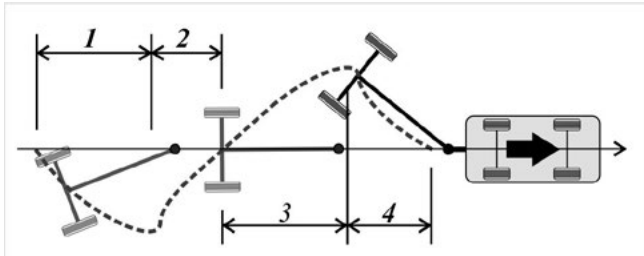

Figure 4. Historical progression showing phases 1 through 4

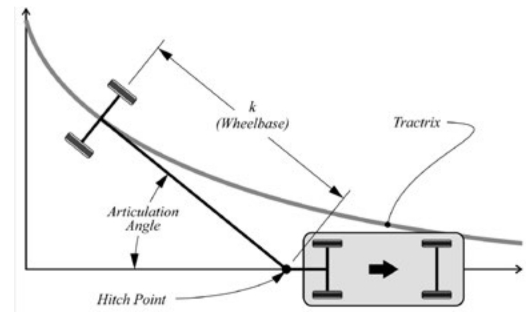

Figure 5. Trailer skeleton and car superimposed on tractrix curve

travels on the x-axis, decreasing the articulation angle, asymptotic to the x-axis. It should also be noted that the wheels in the trailer do not slip or twist but have normal forward rolling friction. More description appears in Figure 5.

Slip steering occurs naturally as the tyre contact patch deflects from its original position as a result of the tyre lateral flexibility. It is to be contra-distinguished from a sliding tyre where the traditional Coulomb friction and also adhesive friction factors apply.

Taking the hitchpoint as the frame of reference and given that oscillation is at a standstill at some angular displacement extreme, the trailer begins to revert back to the x-axis. The aberration history is important as an early departure from the original tractrix is cumulative and will affect all future directions of the trailer path. The net effect of slip steering in an oscillation event is that the modified tractrix brings the trailer axle to the x-axis quicker. Nevertheless, in a very slow progression of the hitch point, the axle centre remains asymptotic to the x-axis.

Alternate Tracking Lines

The modified tractrix idea in Figure 1 on an alternate tracking line held appeal. The authors are indebted to Klaas van Aarsen (2018) for the mathematical gymnastics to produce the following equations:

1. Parallel Tracking Line:

$$x = k * \ln(\frac{y-b}{k\sqrt{k^2-(y-b)^2}}) - \sqrt{k^2-(y-b)^2} \qquad \textbf{Equation [2]}$$

2. Angled Tracking Line:

$$X(t) = x_c + \frac{k}{\sqrt{(1+m^2)}}[t - \tanh(t) - m(\mathrm{sech}(t) - 1]$$

$$Y(t) = y_c + \frac{k}{\sqrt{(1+m^2)}}[m(t - \tanh(t)) - (\mathrm{sech}(t) - 1]$$

Equation [3]

Equations [2] & [3] were developed by Klaas van AArsen (2018) in response to a general enquiry in a mathematics help forum. It was hoped that the equations might find use for trailer articulation.

Equation [2] is merely a tractrix with the hitchpoint following a line parallel to the x-axis. Equation [3] is a tractrix curve with the hitchpoint tracking line at an angle to the x-axis. The visualizations of the new tracking lines appear in Figure 6.

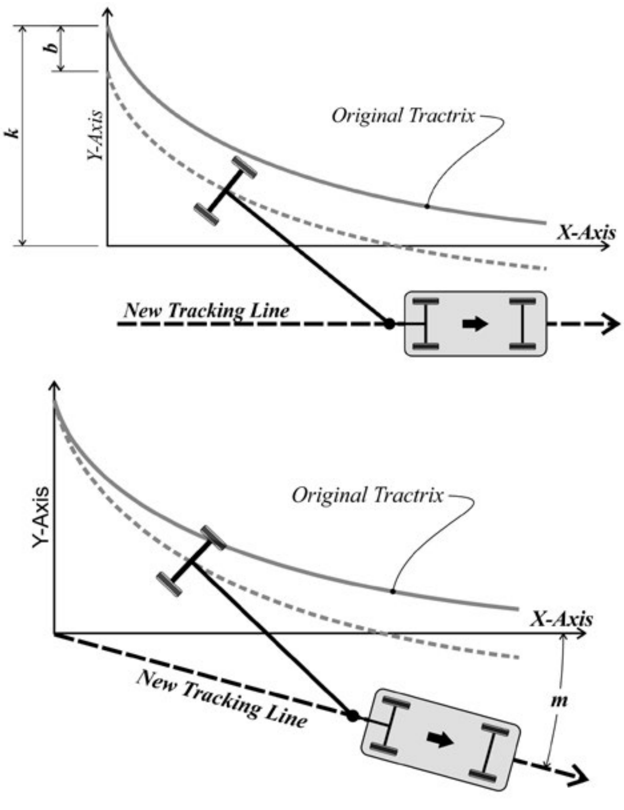

Figure 6. Visualizations of new tracking lines for modified tractrix

The input parameters in Equations [2] and [3] are b and m. The two parameters are entered into Equations [2] and [3] left and right respectively in Figure 7 for values b=-0.5 and m=-0.045.

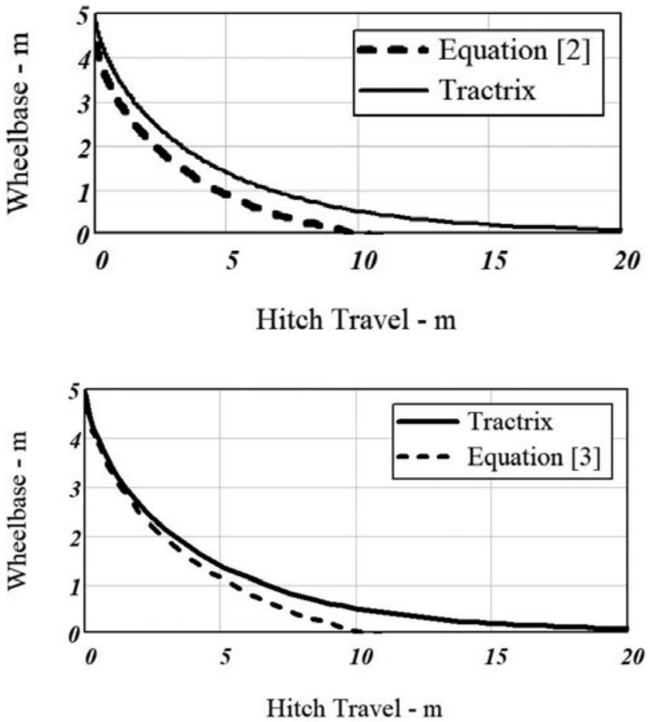

Figure 7. Plot of modified tractrix for Equations [2] and [3] (left & right respectively)

Whilst the modified curves cross the x-axis as hoped, the curves were found to be unsuitable for the objectives of this paper as follows:

- There is currently no nexus between the coefficients ***b*** and ***m*** with slip angles
- The curves cannot reflect prime mover speed change.
- Tractrix curvature increases with progression of hitchpoint and so the slip angle must decrease. The slip angles increase in the modified tractrices.
- The curves suggest starting points are at the y-axis. A trailer at right-angles to prime mover cannot have developed sufficient speed to reflect any tyre side slip.

Work is continuing to determine if the curves can be adapted for the present needs.

Tyre Response

Before we can consider an example of slip steering we must first develop a relationship between lateral tyre force and the angle of slip caused by centrifugal action of the trailer mass following a curved path. For this we use the Pacejka "Magic Formula" (Pacejka, 2012) on a suitable tyre. The well-known formula is shown below:

$$F = F_z * \mathrm{D} * \sin[C * \tan^{-1}(B * slip - E * (B * slip - \tan^{-1}(B - slip)))]$$

Equation [4]

Here, the coefficients ***B, C, D & E*** describe the particular tyre chosen while ***Fz*** is the vertical force on the tyre. The result is shown below for a trailer weighing 1500 kg (750 kg on each wheel).

A high centre of gravity under centrifugal action will shift load from one tyre to another. A heavier loaded tyre will respond with a greater slip angle and vice versa. To assess whether to ignore the shift in vertical load from the inside wheel to the outside wheel as a result of centrifugal action, values were calculated for a nominal transfer of 100 kg. Curves were calculated and posted to Figure 8.

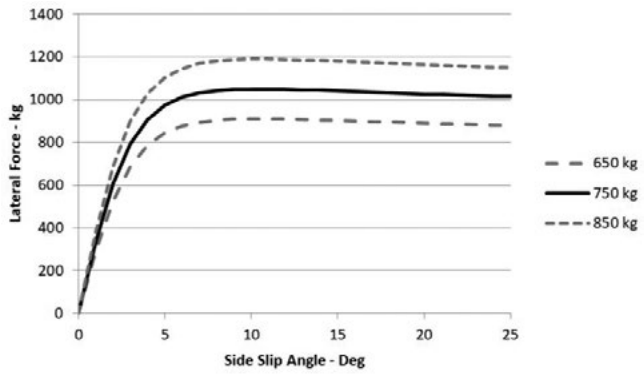

Figure 8. Lateral forces for side slip angles for varying vertical tyre loads

The graphs in Figure 8 display typical characteristics of tyre performance under lateral load, as follows:

- The linear portion up to about 3 degrees slip represents pure slip.
- The curved sections are transitional where pure slip combines with sliding.
- The top of the curves represent the maximum limit of tyre adhesion.
- Beyond the top of the curves the tyres are purely sliding with the lateral force developed by adhesive friction declining in magnitude.

In the light of Figure 8, but subject to future study, the 750 kg curve is assumed to be representative of load shifting, as average. A significant simplification follows as a result.

Graphical Tractrix Modification Example

In the absence of a closed form solution or other suitable mathematical equation that might reflect the effect of slip steering on the path of a vehicle-following trailer, a manual and time-honoured method is employed.

The path of the tow vehicle travels on the x-axis at constant speed. This path is segmented into 0.5 m segments at which calculations are made.

In this analysis, the tow vehicle travels at constant speed. Thus a 90 degree articulation starting point is not practical. The starting point on the tractrix then, is where the oscillation reverses. This nominally occurs at the end of Phase 3 and the start of Phase 4 as shown in Figure 4. Since sideslip history is important, for this example the oscillation is deemed to start at an articulation point having prior developed full centripetal force on the tyres at 10^{O}.

All parts of the tractrix curvature have an instantaneous radius that increases with progression of the hitchpoint. The resulting centrifugal action can thus be calculated and be shown as centripetal force (Arrow in Figure 9) on the tyre contact patch. Such a force gives rise to slip steering where the wheel direction of heading is different to direction of travel. The science of slip steering is mature and needs little elaboration here. Notwithstanding, slip steering applied to the pursuit curve does not appear to have received adequate coverage. The idea of an instantaneous radius along the tractrix is embodied in Figure 9 (Bronshtein et al, 2007).

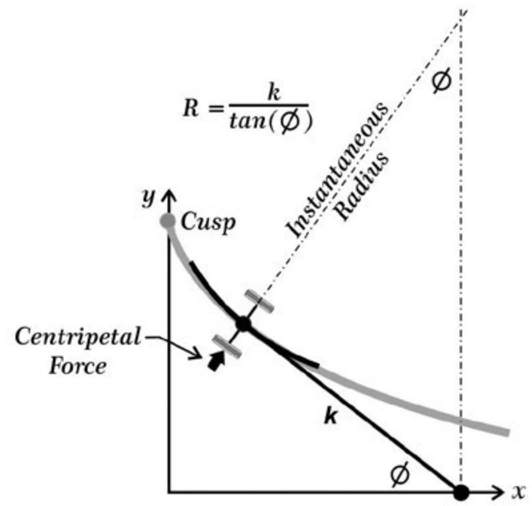

Figure 9. Calculation of instantaneous radius (R) of tractrix curvature

It should be noted that as the hitchpoint travels along the x-axis in Figure 9, the instantaneous radius increases. Similarly, the velocity of the trailer wheels increases approaching the constant forward speed of hitchpoint at the lower articulation angles.

A laborious piece-wise construction using accurate drafting software follows, showing reference steps every 0.5 m calculations at which the curvature radius, instant trailer velocity and the corresponding centripetal force are determined for a 5.0 m trailer wheelbase. The reference points showing articulation angles together with lateral forces caused by the ever-changing radii as well as slip angles in degrees are tabulated for two hitchpoint speeds of 60 & 70 km/h.

Beyond the positions #5 and #6 (60 & 70 km/h respectively) the calculations saw little change and created complexity without significant gain. Accordingly, parts of the original tractrix were graphically tacked on as if beyond the points

Table 1. Tables of lateral force vs. slip angle (degrees) calculated at various trailer positions

Hitch Point Speed @ 70 km/h						Hitch Point Speed @ 60 km/h			
POSN	ARTIC ANG	RAD (m)	Fc (N)	SLIP		ARTIC ANG	RAD (m)	Fc (N)	SLIP
1	10.00	28.356	1020	6.30		10.00	28.356	749	2.70
2	8.56	33.218	857	4.67		8.80	32.298	640	2.15
3	7.29	39.085	728	2.60		7.75	36.739	564	1.82
4	6.37	44.788	635	2.13		6.85	41.622	504	1.58
5	5.56	51.363	558	1.80		6.11	46.709	447	1.38
6	4.86	58.805	488	1.52		-	-	-	-

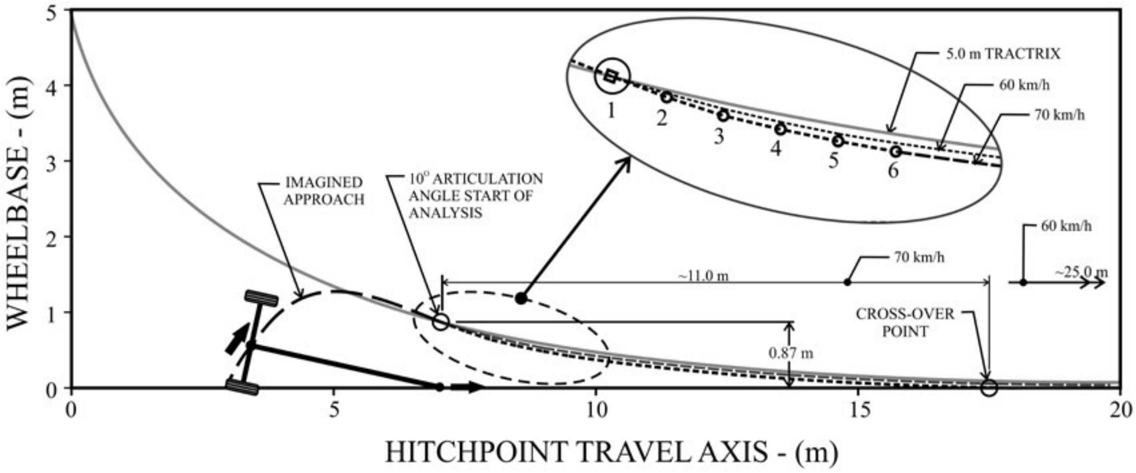

Figure 10. Technical drafting of variance from true tractrix tracking due to slip angles

#5 and #6 no more slip steering was occurring. Thus the results shown in Table 1 are conservative, i.e. the real curve aberration from the original tractrix would be larger beyond the points #5 and #6.

From the 10^{O} articulation point to the cross-over point was measured at 11.0 m of hitchpoint travel for the 70 km/h analysis. Not shown for clarity of presentation, the 60 km/h example crossed over at about 25 m.

Yaw Momentum

As the trailer progresses from the example of 10^{O} articulation angle to the cross-over point, the trailer mass moment of inertia (*I*) gathers momentum. The trailer inertia is acted upon by an inward force at the hitchpoint. The force is impulsive so that acting on the length of wheelbase gives rise to angular momentum, often referred to as yaw momentum.

The trailer mass is assumed to be over the axle and wheelbase intersection. We know from the linear analogue, that:

$$Impulse = Change\ in\ Momentum$$

$$\int Fdt = \Delta(Mv)$$

For the angular equivalent:

$k \int Fdt = \Delta(I * \omega)$ where ω is angular velocity

Mass moment of inertia needs to be calculated. An even distribution of mass on a plane area of a caravan in plan view is assumed for a caravan measurement of 5.0 m long x 2.1 m wide. This was calculated at Ames Web, (2018) to be 3676 kgm2. The calculation steps are set out in Table 2 where angular velocity is taken as a linear average.

Table 2. Calculation of approximate yaw momentum for 60 & 70 km/h analyses

Item	For 60 km/h	For 70 km/h
Hitchpoint Velocity	$Vx = 16.7\frac{m}{s}$	$Vx = 19.4\frac{m}{s}$
Hitchpoint Distance to Cross-over	$D1 = 25m$	$D2 = 11m$
Travel Time from 10^{O} to Cross-over	$T1 = \frac{D1}{Vx} = \frac{25}{16.7} = 1.50s$	$T2 = \frac{D2}{Vx} = \frac{11}{19.4} = 0.57s$
Angular Velocity (Avg.)	$\omega_{avg} = \frac{10°}{T1} = 6.7\ deg/s$	$\omega_{avg} = \frac{10°}{T2} = 17.7\ deg/s$
Angular Momentum	$L = I * \omega_{avg} = 428\frac{kg * m^2}{s}$	$L = I * \omega_{avg} = 1134\frac{kg * m^2}{s}$

The angular momentum calculated in Table 2 is given as a reasonable approximation using a linearized approach. A more accurate account would involve the curved shape of the angular momentum-time graph. The tractrix between 10^{O} and the appropriate value downstream is reasonably flat and thus a linear approximation simplifies greatly with little loss of accuracy.

To summarize Table 2, for a mere increase of about 17% (from 60 to 70 km/h) in hitchpoint speed, more than twice the cross-over momentum was calculated.

Windage

Considerations so far have not taken into account the interaction of stagnant air with the speeding caravan. To gain a quantitative appreciation, the authors performed a Computational Fluid Analysis (CFD). Here the vehicles remain stationary while the air has velocity inside a bounding box. Figure 11 shows such a box together with velocity streamers. The 5m long caravan is set at an angle of 10O to the tow vehicle axis.

The model caravan in Figure 11 comprised 33 surfaces exposed to the wind including radiussed corners as well as

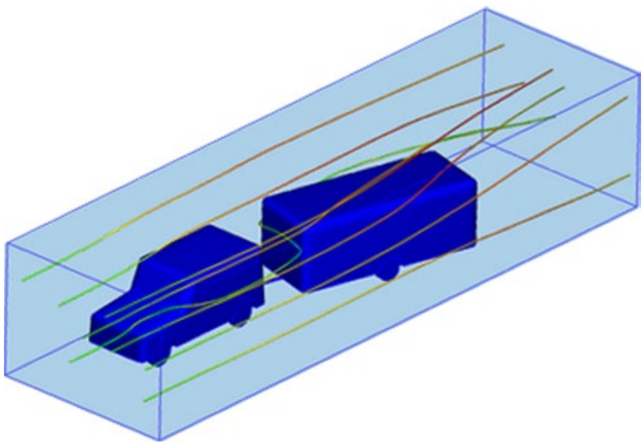

Figure 11. Car and caravan at 10O articulation in a CFD wind tunnel

wheel arches and tyres. The model was set for 60 and 70 km/h wind speed. The spreadsheet output provided forces in the X and Y directions and moment arms about the Z-axis, being the vertically up convention. The forces acting on each surface were resolved into moments about the hitchpoint. The moments about the hitchpoint are reported as follows:

- 60 km/h = 451 kg-m
- 70 km/h = 572 kg-m

These moments acting on a 3.355 m wheelbase offer lateral forces on the tyres at 134 kg and 170 kg for the 60 & 70 km/h respectively. The tyres scoped earlier in this paper for the Pacejka so-called "magic formula" in Figure 8 yielded a modest 0.4 and 0.5 degree slip angle. Whilst modest, they would compound the slip angles calculated to account for the centrifugal actions. Further, laterally softer tyres would provide greater slip angles.

Windage forces causing a moment about the hitch point decrease as the articulation angle decreases. Notwithstanding, these forces acting impulsive over time to zero articulation, add angular momentum to the values listed in Table 2.

To summarise, the computational fluid analysis showed a greater lateral force on the tyres which in turn gave a greater slip angle for the 70 km/h model over the 60 km/h model.

Conclusion

In this paper we have looked at some factors that contribute to fishtailing of a trailer/caravan in isolation of each other. It is recognised that these factors work in concert with each other to potentially bring about the dreaded out-of-control sway. The paper concludes with the following:

1. Some closed form solutions have been assessed for suitability for current objectives and found to be unsuitable to include slip steering and tow vehicle speed as inputs.

2. A graphical solution has been presented to illustrate that slip steering shortens the time for a towed trailer to cross the hitch straight line path.
3. It was shown in that example that for a mere 17% increase in vehicle speed the cross-over momentum increased to more than twice as compared to the lower vehicle speed..
4. The results of a computational fluid dynamics analysis was presented showing a higher lateral forces on tyres with corresponding higher slip angles of steering for the 70 km/h model as compared to the lower speed.

There is an urban myth that to avoid the terminal consequences of a trailer fishtailing event you need to "drive out of it" by speeding up. The myth has intuitive appeal and hence it remains persistent in the caravanning landscape. It was shown in this paper that a higher vehicle speed gives rise to larger tyre slip and higher cross-over momentum, so fuelling the next oscillation cycle.

The work goes some way in dispelling that myth and suggests that accelerating in a fishtailing event merely makes the terminal end happen at a higher speed.

Acknowledgements

The substantial help from Juan Carlos Herrera and Klaas van Aarsen in the mathematical areas is gratefully acknowledged. Thanks too, to John Drake of the Drake Trailer Group for the supply of software to power these analyses.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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