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Journal of the Australasian College of Road Safety

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Special Issue: Road Safety of Older Drivers

Peer-reviewed papers

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Cover image

As people age, sensory, motor and cognitive declines as well as medical conditions common in older adults such as cataract and dementia, can affect driving performance and driving patterns of older adults. This Special Issue guest edited by Professor Lynn Meuleners and Professor Judith Charlton features research studies on older drivers in Australia, Canada and USA, including the analyses of the Australian newspaper coverage of older drivers. See *Original Road Safety Research* article (Harkin, J.M., Charlton, J.L. and Lindgren, M. (2018). Older Drivers in the News: Killer Headlines v Raising Awareness. *Journal of the Australasian College of Road Safety,* 29(4), 72-83).

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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.

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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.

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Editorial Board

From the President

The College celebrated its 30th Anniversary at the recent Australasian Road Safety Conference in Sydney. Reports of the Conference, our Awards, and comments on our 30 years including an address from our first Fellow, Harry Camkin are included. Our first Journal in February 1998, headlined with "Road Trauma is a major public health issue in Australia".

Last year I suggested we needed to uncover the "invisible hand" holding back implementation of good road safety programs and suggested that the then commissioned Independent Inquiry into the National Road Safety Strategy might discover this for us. That Inquiry has concluded and you will find the Deputy Prime Minister's initial positive response made at our recent Conference in Sydney referenced in the news section. Unfortunately road trauma remains an unrecognised major public health issue, although that Inquiry makes 12 very specific recommendations for a step change in road safety management to overcome that "invisible hand". I urge readers to consider them and advocate for their implementation.

This Issue has a focus on road safety for older drivers.

NSW data show that older drivers appear to crash in the oldest cars on our roads. The issues are complex and as our population ages and changes in many ways, exposure rates will change, as will vehicle ownership, and vehicles have also changed radically over the last decade or so. Attention, distraction, mobility needs are key behavioural factors to be addressed for older drivers, and potentially in different ways from other age groups of drivers. While fatality rates for younger drivers are declining considerably, there is only a marginal, if any, change in the rates of older driver fatality rate. With safer roads and safer cars this is unusual. Given the increased frailty of older drivers it is likely then that injuries in that age group have not declined. We need to reduce the risk factors.

The good news is that most vehicles manufactured in the last 20 years are considerably more crashworthy, and in the last decade are less likely to crash, especially for older drivers with features such as brake assist and electronic stability control. Other collision avoidance technologies such as autonomous emergency braking are already in many vehicles and are demonstrating real reductions in crash rates. Encouraging older drivers into these cars is vital.

Ride sharing, alternative mobility and improved public transport can also help reduce risks but we need to communicate all the issues in reducing risks “without adversely affecting the community’s view of older people” (as suggested in Harkin, J.M., Charlton, J.L. and Lindgren, M. (2018). Older Drivers in the News: Killer Headlines v Raising Awareness. *Journal of the Australasian College of Road Safety*, 29(4), 72-83).

Recently I addressed two groups of “older” drivers, who volunteer to raise funds for local hospitals and have appreciation of the impacts of road trauma. The second group was after our recent Conference where the Hon Bella Dinh-Zarr from the US National Transport and Safety Board reminded us of the value of ensuring a balance of the “story with the science” when speaking about road safety in the community. I took the opportunity to ensure that balance in my presentation and subsequent discussion in the context of the many road safety factors, especially for older drivers and vehicle owners.

That is a key challenge for us all.

The recent Sydney Conference provided a wealth of new research results; results which were presented, considered, critiqued, discussed in formal and informal meetings, alongside exhibitors with a range of services and products aimed at supporting our efforts in reducing road trauma (key papers will appear in the future Issues). Communicating those efforts will not be easy, although ensuring the right balance of “the story with the science” will assist us to present the evidence, to lift that “invisible hand”.

Lauchlan McIntosh AM FACRS FAICD
ACRS President

ACRS Chapter reports

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

Australian Capital Territory (ACT) and Region

The ACT & Region Chapter has been very active during the 2018 Winter Quarter. It has begun to address three of the substantial projects nominated for 2018 and 2019. It has also continued to support the Aboriginal Legal Service Driver Licensing Pilot Project for Aboriginal and Torres Islander people in the ACT and surrounding areas.

It must be said that the reason for this activity on a wide range of projects has been the willingness of individual members of our committee to take responsibility for selected projects. The Executive is very grateful for the time, energy and leadership being demonstrated and their ability to draw in other members and external organisations into the discussions and the development of the eventual conclusions and outcomes.

The following is a brief summary of the advances made on the individual projects.

Safe Cycling on Country Roads Forum

The need for the Forum arose from the concerns of road safety officers and cycling representatives about the changing patterns of cycling taking place in the context of growing urbanisation in the region and increasing commercial and general traffic on roads used by cyclists.

The Forum was held in Queanbeyan on 21 September 2018. Around 50 people attended. They included: four local government areas covering a significant proportion of South Eastern New South Wales; NSW Roads & Maritime Safety; ACT directorates associated with road safety, transport & city and roads planning: and cyclists and their representatives from Canberra and rural areas. From feedback received to date, it was considered a great success with potential for cooperative activities between parties.

Together representatives provided the perspectives of State/Territory regulators, local government, and cyclists and their representative bodies. Together they were able to come to understand the issues as perceived from different perspectives and agree to work to improve relationships between cyclists and other road users and the safety of cyclists from a new common understanding.

Some of the issues and possible action outcomes identified were:

Challenges

- Around 75 percent of fatal and serious cycling crashes occur in urban areas, but crashes in rural areas can be serious because of the nature of the roads and vehicle speeds on rural roads;
- *driver behaviour* such as close passing, speeding, distraction and intimidation/abuse;
  lack of standard approval processes for cycling events between local government areas and particularly between NSW & the ACT;
  and
- *cyclist issues* like inexperience, entitlement attitudes, failure to account for weather and poor risk assessments when planning rides;
  Infrastructure short comings including narrow roads, insufficient shoulders, poor road surfaces, and the quality of road side signs and their messages;

Actions

- Road safety organisations and cyclists ad their organisations establish mechanisms to Identify risk areas/pinch points and work together and with involved communities to arrive at mutually agreed effective solutions, which may include reduced speeds at high risk points.
- Consider implementing similar approaches as those adopted for reducing motorcycle crashes in the region;
- Develop programs, or assess what is being done elsewhere, to reduce the current friction that exists between cyclist and motorists. Some cycling organisations in the region have taken positive measures to work socially in communities where they ride regularly in an effort to break down barriers;
- Continue to make the 1 -1.5 metre rules better understood in rural areas as initial results have shown a reduction of up to 15 per cent in the crashes since their introduction in NSW;
- Develop shared regional cycling plans with sharing of data, education programs, effective black spot treatments, and signage;
- Move towards common planning arrangements which will enable cycling organisations to produce well developed cycle activity plans with reduced variability in the requirements.

A comprehensive report is being prepared as a basis of ongoing discussions between the parties.

ACT Graduated Licence Scheme Review

The Chapter is working with the ACT Justice and Community Directorate on its review of the ACT Graduated Licensing Scheme. The Chapter has been asked to manage a forum which will bring together the outcomes of community consultation held mid- year and further consideration of the proposed revised scheme in the light of the consultation.

The forum is scheduled for 12 October 2018.

Wild life collisions in ACT and surrounding area

This is a joint project involving the Chapter, ACT Health and the Royal Australasian College of Surgeons on concerns about the number and seriousness of casualties presenting at Canberra Hospital resulting from crashes with wild life on ACT and surrounding NSW roads.

The objective of the project is to attempt to quantify more accurately the extent and severity of such crashes in the region so that suitable cost effective countermeasures can be developed.

In August the project committee met with interested parties. They included representatives from the insurance industry, the ACT Parks and Conservation Service, and NSW local government.

ACT Parks & Conservation

- Ideal breeding conditions for the Eastern Grey Kangaroo exist in a triangle which includes the ACT and NSW. Breeding numbers are increasing despite some culling. Fertility measures are difficult to implement on such a wide scale.
- High risk periods occur at dawn and dusk (often when traffic levels are high); and in the June- September period when young are being weaned & females and sub adults are stressed, feed is scarce and temperatures are very low.
- The number of incidents that ACT Parks & Conservation responds to seems to have been increasing – 2,881 in 2016, 2,634 in 2017. Between January and July 2018 the number was 2291, and this could reach 4,000 by the end of the year. (These numbers are more than those identified so far in insurance data).
- Fencing is an effective counter measure but is expensive and tends to be used only in very high risk areas.
- Because of the physiology of kangaroos, direct damage is significantly higher in crashes involving cyclists and motorcyclists; trauma to motorists and their passengers tend to result from the secondary impacts after the vehicle hits the wildlife.

Data

Priority should be given to collect quality data from health and insurance industry sources to assist in achieving better outcomes. However, there is a general under-statement of these types of crashes. CTP data does not include crash data where there is no responsible other person, not all minor crashes are reported to police or health authorities and road authority crash data bases on the whole do not specify wildlife incidents but classify them under more general classifications.

Future action

It was agreed to work towards holding a seminar within a reasonable time frame which would involve a wide range of interested parties. It would consider the data available and a robust range of countermeasures based on the data and best current and emerging practice in Australia and overseas. These might include setting criteria for implementing high cost measures, education community & industry programs, and inclusion of advice in licensing programs.

Finally, it was agreed that the involvement of local government in the region is important as would be the need to have the involvement of officials from ACT and NSW. Ministerial involvement from both jurisdictions would cement agreed arrangements and provide long term commitment.

Aboriginal Legal Service Driver Licensing Pilot Project

The Chapter has supported the development of the Aboriginal Legal Service Driver Licensing Project since it was first proposed. Prof Rebecca Ivers also provides continuing advice to the project managers.

Since the project commenced its operations in March 2018, 10 individuals have achieved their probationary licences. It is currently operating with one driving instructor. Currently 20 other people are being trained and considerably more are waiting for lessons. It is anticipated a second driver trainer will be accredited in the near future and a second vehicle is being considered.

Professor Ivers is assisting with the development of an evaluation strategy with some basic data starting to be collected. This project will not only provide safety benefits for young people, but will also expand the social benefits for individual and their families.

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

Victoria (VIC)

Activities are ramping up at the Victoria Chapter.

The AGM in May saw changes in the Chapter Executive. I was honoured to be elected Chapter Chair after Melinda Spiteri stepped down to prepare for maternity leave. As incoming Chair, I am very thankful to Melinda for her leadership in the role and her generous hand over – and delighted to extend our congratulations on the safe arrival of her daughter. We also have new office bearers. Vice Chair, Jeff Potter from the National Transport Commission and Secretary, James Holgate. Thankfully, community road safety advocate Wendy Taylor has agreed to continue to support the Chapter as Treasurer. We also welcome continuing and new members to our Committee, which is open to all Victorian College members.

In August, we hosted a very successful seminar on Drink and Drug Driving. Thanks to our host Dave Shelton from Safe System Solutions, our five speakers covered the topic from front to back. A/Prof Michael Fitzharris from Monash University Accident Research Centre (MUARC) showed us the trends in injury and Dr Morris Odell from Victorian Institute of Forensic Medicine gave us an insider's view of the medical investigation. From Victoria Police, Sergeant Michael Larcart detailed the complex role of police in their work to prevent and respond to drink and drug driving and Sharon Wishart from VicRoads presented the ongoing work from the Victorian State Government regarding the introduction of the new drink and drug-driving laws. Finally, from the Transport Accident Commission (TAC), Helen Redden unpacked the importance of emotion, connection and story in the way we communicate messages of road safety.

In the Victorian Chapter, we are working together to find new and engaging ways to share information. A stellar example is our 'pub quiz' led by Kelly Imberger from Vicroads. This Trojan horse of fun and games is actually jam-packed with information and myth-busting facts and is a great way to get our seminar started. Thank you to Kelly for your work in creating the quizzes and to our seminar audience for getting involved. We are continuing to refine our seminar format and we welcome suggestions about how we can improve the way we share information and help get people together.

Next seminar – Tuesday 27 November (afternoon), Making It Happen in Victoria

Many members of the Victoria Chapter were fortunate to attend this year's Australasian Road Safety Conference in Sydney. The huge conference of almost 700 delegates was an overload of news, action and success in road safety. Our November seminar will bring the key highlights from the conference home to Victoria to share and work out our next steps together.

Finally, two messages to all College members in Victoria.

One, an invitation – you are very welcome to join our regular meetings and we welcome your advice on how we can be smarter, faster and more effective.

Two, a request – please help us connect with your colleagues and friends who share our goal. Please extend an invitation to join our public seminars to add their voice to how we can help make mobility safe for everyone.

VIC Chapter Chair
Dr Marilyn Johnson

Queensland (QLD)

Seminar and meeting, 5 September 2018

The seminar and meeting planned for September had to be cancelled because our guest speaker had a more urgent commitment. As there was insufficient time to organise another speaker, members were invited to attend a Queensland Road Safety Week symposium on older road users that was organised by CARRS-Q, and some were able to attend. A number of Chapter members attended and/or presented at the Australasian Road Safety Conference in Sydney, and participated in a session aimed at providing member feedback and views relevant to the review of the College.

Next meeting scheduled for 4th December 2018

It is hoped the seminar scheduled for 4th December 2018 will be on the National Road Safety Strategy, and will be presented by Austroads Road Safety Manager David Bobbermen. The venue will be room K105 in A Block at QUT Kelvin Grove. This is still to be confirmed.

QLD Chapter Chair
Dr Mark King

ACRS News

DEPUTY PRIME MINISTER MICHAEL MCCORMACK ANNOUNCES NATIONAL ROAD SAFETY GOVERNANCE REVIEW AT ARSC2018 CONFERENCE GALA DINNER AND AWARDS: SYDNEY - 5 OCTOBER 2018

Deputy Prime Minister and Minister for Infrastructure, Transport and Regional Development Michael McCormack has announced a new Review of National Road Safety Governance. The Review is one of 12 recommendations put forward by the independent inquiry into the National Road Safety Strategy (NRSS) 2011–2020, initiated by the Australian Government in September 2017.

Undertaking the Governance Review is an important step in improving capability and accountability, as well as informing how best to implement other recommendations of the NRSS inquiry made by the Independent Panel in their report handed down last month.

Mr McCormack said it was important for work on the Governance Review to start as soon as possible, and that he would be discussing the scope of the review with state and territory ministers when the COAG Transport and Infrastructure Council has its first consideration of the Inquiry Report next month. “I want to ensure broad consultation on the terms of reference, including with the Inquiry Panel and other stakeholders, ahead of release before the end of the year,” he said.

Delivering the Governance Review is a vital first step in following through on the NRSS inquiry’s 12 recommendations and progresses the Australian Government’s agenda to invest strategically in infrastructure, to ensure Australians and their families arrive at their destinations sooner and safer. The first inquiry into progress of the NRSS highlighted areas for potential improvements which can reduce road deaths and trauma such as: road safety leadership; resourcing; performance monitoring; and innovative technology.

Mr McCormack announced the Review of National Road Safety Governance before 600 guests from the industry, at last night’s Australasian Road Safety Conference dinner in Sydney, where major awards were presented honouring road safety achievements. This recognition included Associate Professor Jeremy Woolley, Director of the Centre for Automotive Safety Research, and Dr John Crozier, Chair of the Royal Australasian College of Surgeons Trauma Committee.

Associate Professor Woolley and Dr Crozier—Co-Chairs of the NRSS Inquiry Panel—were presented with the prestigious 2018 Australasian College of Road Safety (ACRS) Fellowship at last night’s awards ceremony. Mr McCormack said Associate Professor Woolley and Dr Crozier are both passionate road safety advocates with great expertise and the Fellowships acknowledged their high-level and ongoing contributions to improve road safety throughout Australia.

“I am particularly delighted to acknowledge Associate Professor Woolley and Dr Crozier for claiming this honour which recognises their outstanding work and leadership over many years to deliver better road safety outcomes, of which they can both be especially proud,” he said. Mr McCormack also presented the major road safety award to a Northern Territory indigenous program which was recognised for changing attitudes and behaviours towards the use of proper child car restraints.

The Northern Territory Motor Accidents Compensation Commission project, led by Team Leader Christine Thiel, won Australasia’s premier road safety award, the 3M-ACRS Diamond Road Safety Award, for exemplary innovation and effectiveness to save lives and injuries on roads. The program has reduced the incidence of death and serious injury of children aged seven and under through the increased use of properly fitted child restraints.

Mr McCormack said the awards showcased the breadth and diversity of the great work being done to reduce road trauma and increase road safety throughout the community. “The Liberals and Nationals’ Government takes road safety seriously and understands the importance of awards such as this to help develop and encourage industry leadership and to deliver better outcomes,” he said.

“I’d especially like to congratulate Christine Thiel and the team from the Northern Territory MACC project for winning the major road safety award which has contributed to a reduction in the number of deaths and serious injuries of indigenous children in regional Australia, through the installation of properly fitted child restraints.”

ACRS 2018 FELLOWSHIP AWARDS - A/PROFESSOR JEREMY WOOLLEY AND DR JOHN CROZIER, RECOGNISED WITH PRESTIGIOUS AUSTRALASIAN ROAD SAFETY FELLOWSHIP AWARDS

Congratulations to leading road safety advocates, A/Professor Jeremy Woolley, Director of the Centre for Automotive Safety Research, and Dr John Crozier, Chair of the Royal Australasian College of Surgeons Trauma Committee, who were presented with prestigious 2018 ACRS Fellowship at last night’s glittering ACRS Award Ceremony at Sydney’s Doltone House. The ceremony took place in front of 600 of Australasia's foremost road safety professionals and advocates, and is deserved recognition of Associate Professor Woolley and Dr Crozier's profound commitment to the reduction of road trauma.

The award was presented by Hon Michael McCormack, Deputy Prime Minister and Minister for Infrastructure, Transport and Regional Development, and ACRS President Mr Lauchlan McIntosh AM, during the 2018 Australasian Road Safety Conference (ARSC2018).

Mr McCormack congratulated Associate Professor Woolley and Dr Crozier for their outstanding commitment and work to reduce fatalities and serious injuries on the national road network. Mr McCormack said Associate Professor Woolley and Dr Crozier are both passionate road safety advocates with great expertise and the Fellowship award acknowledged their high-level and ongoing contributions to improve road safety throughout Australia.

"I am particularly delighted to acknowledge Associate Professor Woolley and Dr Crozier for claiming this honour which recognises their outstanding work and leadership over many years," he said. "A recent example of this contribution includes overseeing the independent inquiry into the National Road Safety Strategy 2011-2020 which was initiated by the Australian Government in September 2017 and saw a report released in September this year."

"This report made a number of evidence-based recommendations, through extensive stakeholder consultations, which will assist governments and agencies throughout Australia with sharing responsibility to deliver better road safety outcomes and for this contribution and so many more, both men can be especially proud."

In detailing the award, ACRS President Mr Lauchlan McIntosh AM said "These two Fellowships demonstrate the broad canvas of road safety, recognising two individuals who have been effectively working from different edges of that canvas; Associate Professor Woolley in research and management, and Dr John Crozier in trauma care of victims.

"Both Jeremy and John continue to be expert contributors and effective advocates for solutions to reducing road crash trauma. Their combined efforts as co-Chairs of the recent Independent Review of the National Road Safety Strategy demonstrate the synergy that can be achieved, as they formulated recommendations to reform the way road safety management is delivered - not only now but for the decades to come".

Above left to right:
Deputy Prime Minister Hon Michael McCormack; Associate Professor Jeremy Woolley FACRS (2018 Fellow); Dr John Crozier FACRS (2018 Fellow); Mr Lauchlan McIntosh AM FACRS (ACRS President)

In receiving the award from the Deputy Prime Minsiter, Dr Crozier said "I am humbled by the honour of receiving this honourary Fellowship of the Australasian College of Road Safety. This will further spur my efforts to help reduce the silent national public health epidemic of serious injury and death, from road crashes on our roads, each year – nothing less than Vision Zero is acceptable."

Associate Professor Woolley said "I am deeply humbled and honoured to receive this award and know that it will further stimulate my efforts to pursue a step change in road safety performance in Australia. It has been a privilege to be in a leadership position striving for better outcomes for society, working with skilled, professional and highly dedicated individuals and organisations across the nation. I hope that the collective efforts of these people can be nurtured and magnified as we work to offset the long term disaster that will burden future generations."

"We must continue to adjust and improve a system that is not well suited to human operation and seek to eliminate the harm being done," said Associate Professor Woolley. "Australia can choose to shape its own future and be world leaders again in road safety. We must explore all options available to us and break away from many historical perspectives that have become entrenched in our organisations and culture. We owe it to current and future generations to begin fixing the problem, not continuing to cope with it."

With the 2018 awards, Associate Professor Woolley and Dr Crozier join an elite group of eminent road safety professionals who have all been bestowed the honour of an ACRS Fellowship. The College first instituted the award of Fellow in 1991 to enable colleagues to nominate a person recognised by their peers as outstanding in terms of their contributions to road safety.

3M-ACRS DIAMOND ROAD SAFETY AWARD: NT'S INDIGENOUS CHILD SAFETY PROGRAM TAKES OUT TOP ROAD SAFETY PRIZE

A Northern Territory indigenous program changing the attitudes and behaviours towards the use of proper child car restraints has taken out Australasia's premier road safety award, the 3M-ACRS Diamond Road Safety Award, recognising exemplary innovation and effectiveness to save lives and injuries on roads. The Northern Territory Motor Accidents (Compensation) Commission (MACC) project, led by Team Leader Christine Thiel, has been developed to reduce the incidence of death and serious injury of children aged 7 and under through the increased use of properly fitted child restraints.

Indigenous children are dying or seriously injured on Northern Territory roads because they are not properly restrained. In regional and remote areas it is "normal" for babies and toddlers to be carried on laps, standing on seats or even riding in the back of a Ute.

Of the 48 Indigenous children killed or seriously injured in a car crash over the past 10 years only 6 were restrained in a baby capsule or child car seat. The personal impact of road trauma to the child, their extended family and community is immense with many children and infants becoming permanently disabled and requiring lifetime care.

Recognising the enormity of the challenge MACC's approach is to make the change one community at a time with a simple program model that is scale-able and easily replicated. The program commenced July 2017 with 630 child restraints distributed/fitted across 9 communities in the first year and is and on track to install a total of 1800 child restraints across 24 communities by 30 June 2019. The program is on-going.

The award was presented last night by the Hon Michael McCormack MP, Deputy Prime Minister and Minister for Infrastructure, Transport and Regional Development, Mr Lauchlan McIntosh AM, President of the Australasian College of Road Safety, and Mr Dan Chen, Vice President & General Manager, 3M's Transportation Safety Division. The award ceremony was attended by over 600 of Australasia's foremost road safety professionals and advocates attending the ARSC2018 Conference Gala Dinner and Awards ceremony at Doltone House in Sydney.

Mr McCormack congratulated all of this year's award winners for their contribution to improving road safety throughout Australia. "These awards showcase the breadth and diversity of the great work that's being done to reduce road trauma and increase road safety in our community," he said.

"I'd like to congratulate all of the winners for their invaluable contributions which have helped to enhance road safety standards in so many different ways. "The Liberals and Nationals' Government takes road safety seriously and understands the importance of awards such as this to help develop and encourage industry leadership and to deliver better outcomes.

"I'd especially like to congratulate Christine Thiel and the team from the Northern Territory MACC project for winning the major road safety award which has contributed to a reduction in the number of deaths and serious injuries of indigenous children in regional Australia, through the installation of properly fitted child restraints."

ACRS President, Mr Lauchlan McIntosh AM, said "Our 2018 winner, the MACC project, led by Christine Thiel, demonstrates a program aimed at bringing about zero road deaths and injuries in the critical under 7 age group." "These Awards have proven to be very successful in helping to transfer the ideas from successful projects to other areas and also to encourage the winners to continue and expand their projects. Reducing the risks for young vulnerable children travelling in cars is essential."

Ms Thiel said, "these awards create the opportunity to shine a spotlight on new and innovative road safety initiatives that we might not otherwise hear about. The awards also provide recognition of those that enable

Above left to right:
Deputy Prime Minister Hon Michael McCormack; Ms Christine Thiel (2018 Grand Prize winner);
Mr Dan Chen (3M); Mr Lauchlan McIntosh AM FACRS (ACRS President)

and support these programs, in our case the NT Motor Accidents (Compensation) Commission (MACC) and of the passionate people who help bring these programs to life such as our delivery partner Kidsafe NT."

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

Finalists for this hotly-contested award came from many areas. These included new ideas and actions from local and state government groups, collaborative programs led by local and regional police groups, individuals passionately pursuing specific projects to reduce risk, industry associations and transport companies implementing programs with targets to ensure safe operations, news programs, and specific education for specialist groups. These are just a few examples of the successful projects awarded as Finalists (15 in total) and Highly Commended (3) winners this year.

Highly Commended winners for 2018 include:

- Trailer Safety Control - **Bosch Australia** - Philipp Frueh
- Crash Investigation Alliance - Fatals & Vulnerable Users(CIA-FV) - **Queensland Police Service (QPS)** - Chris Smith
- Buckle-Up Safely - **The George Institute for Global Health, UNSW Sydney** - Kate Hunter

"3M is very proud to partner with the ACRS on this prestigious award which continues to enable great programs to be shared, celebrated and replicated to reach their potential on road safety", said Dan Chen, Vice President & General Manager, 3M's Transportation Safety Division. "3M is about applying science to life to get every family home safely. Nowhere is the focus more important than saving lives of young children on our roads."

As the winning team leader, Christine Thiel will travel to the USA to attend the 49th ATSSA Annual Convention & Traffic Expo in 2019, and will also visit 3M Global Headquarters in Minnesota.

ACRS 30TH ANNIVERSARY CELEBRATION & GIFT TO ACRS PRESIDENT, MR LAUCHLAN MCINTOSH AM, CELEBRATING OVER A DECADE AS PRESIDENT

The ARSC2018 Welcome Reception included a celebration of the College's 30 year anniversary. Our first awarded Fellow (1992), Harry Camkin FACRS, gave a wonderful speech presenting an overview of the 'birth' of the College. Without Harry and his team of leaders back in 1988 the College wouldn't be where it is today. It was particularly serendipitous that Harry were the head of road safety in the NSW Government back in 1988, and we had the current NSW Road Safety head Bernard joining us and Transport for NSW providing the ARSC2018 Platinum Sponsorship, for this the College's 30th year.

Speakers at the event included:

- Current ACRS President - **Mr Lauchlan McIntosh AM FACRS**
- Our first ever ACRS Fellow (and past President) - **Mr Harry Camkin FACRS**
- Our most recent Fellow - **Ms Sam Cockfield FACRS**
- Our Immediate Past President, & Fellow - **Professor Raphael Grzebieta FACRS**
- Our Fellow (& member of the ACRS sub-Committee overseeing the ACRS Strategic Review) - **Professor Barry Watson FACRS.**

Harry's speech, extract:

I daresay many of you were not working in road safety 30 years ago, so let me quickly paint a small picture of the situation in the 1980's in the lead up to the establishment of the Australian, as it was then, College of Road Safety. I'd like to then tell you a little of how it came to be and pay tribute to some of the major players in its formation and development over its first 5 years or so.

As well as some significant changes since then, you might care to note some disturbing similarities with more recent times.

During the eighties the introduction of compulsory seatbelts and random breath testing was bringing some international recognition to Australia. Our fatality rate per head of population had fallen from 30% higher than the OECD median in 1970 to just under it in1990.

The annual number of fatalities had in fact dropped from a peak of 3800 in the 70's, to around 2800 in the late eighties.

There was a lot of complacency in some quarters as a consequence of this, and little realisation that the population rate of fatalities was closing on an asymptote below the rate of growth of travel, signalling a probable rebound in fatalities within a few years.

Above left to right:
Associate Professor Jeremy Woolley FACRS (ACRS Fellow, 2018); Mr Harry Camkin FACRS (1st ACRS Fellow, 1992); Dr John Crozier AM FACRS (ACRS Fellow, 2018)

The decline in fatalities (and the lack of good data) had masked concern about the number of serious injuries, and even more so, appreciation of the significance of the total social and economic cost of crashes.

The Haddon Matrix was far from in some respects ultimately morphing into the Safe Systems philosophy, and ANCAP and IRAP were still a few years away. As was the practice of road safety auditing.

There was some excellent research in progress at universities and the Australian Road Research Board and in some road and traffic authorities. But nothing approaching AUSTROADS' current guidelines for traffic management and road safety little in the way of strategic thinking about policy development. Nor MUARC's Road Safety Management Leadership program.

There were no endorsed national or state road safety strategies, although there had been an attempt around 1985 by the Federal Office of Road safety to promote one. Sadly this foundered on the all-too-common shoals of federalism and states' rights. As for targets – well the political memory of a certain Prime minister's promise regarding children living in poverty was another obstacle.

I hope you'll all look closely at John Crozier's presentation at the launch of the report on the National Road Safety Strategy Review, because it reminded me very clearly of the part played by the RACS and its Trauma Committee, and particularly by one Gordon Trinca, not only in the formation of our College, but in the promotion of road safety throughout Australia since the 1960's.


More Letters of Note
Letters of Note

ACRS President - Mr Lauchlan McIntosh AM FACRS

A Celebration of inspired leadership!

The 30th Anniversary also marked an appropriate moment to celebrate the growth and achievements of the College under our current ACRS President, Lauchlan McIntosh AM. Lauchlan has led the College since he was elected as President in 2007.

Lauchlan has indicated he will be stepping down as President at our next AGM in May 2019, so, as this will be our final conference with Lauchlan as President, the Executive Committee and Fellows felt it an appropriate time to recognise and celebrate Lauchlan's incredible achievements, and indeed the achievements of the College under his inspiring leadership.

CONGRATULATIONS TO THE ARSC2018 PAPER AWARD WINNERS!

Peter Vulcan Award for Best Research Paper

Dr Vanessa Cattermole-Terzic

Department of Transport and Main Roads Queensland

"Toward a Performance-Based Approach to the Queensland Alcohol Ignition Interlock Program: The Impact of Performance Record on Risk of Recidivism"

Road Safety Practitioners Award

Ms Rae Fry

Transport for NSW, Centre for Road Safety

"Using Evaluation to Drive Program Improvement: Permanent 40 Km/H Speed Limits in High Pedestrian Activity Areas in NSW"

Best Paper by a New Researcher Award

Ms Renee St. Louis

Monash University Accident Research Centre

"Bouncing Back and Maintaining Mobility: The Relationship between Resilience and Driving in the Ozcandrive Study"

Road Safety Poster Award

Dr Herbert Chan

University of British Columbia

"Driving Ability and Transportation Needs of Elderly Drivers: A Prospective from Emergency Department Elderly Patients"

Conference Theme Award

Mr Amir Sobhani

The Safe System Road Infrastructure Program Team

Symposium "Safe System Road Infrastructure Program (SSRIP) I & II

Special mention to:

Bryan Sherritt

Daniel Mustata

John Matta

Nathan Matthews

Dr Johan Strandroth

Shaun Luzan

Best Paper by a New Practitioner Award

Mr Michael Holmes

Sydney Metro

"Managing Vulnerable Road User Safety in Urban Environments during Construction of Major Transport Infrastructure Projects"

Best Paper with Implications for Improving Workplace Road Safety

Dr Sarah Jones

Toll Group

"On-Road and Driver Fatalities at Toll Group: What the Data Reveals about Risk and Opportunity in Our Pursuit of Zero"

People's Choice Award

Lisa Steinmetz

ARRB

"Delivering Safe System Outcomes in Mildura"

Monash University Accident Research Centre PhD student Renée St. Louis was awarded **Best Paper by a New Researcher** at the ARSC2018 for the paper "Bouncing back and maintaining mobility: the relationship between resilience and driving in the Ozcandrive study". It is the first study to link the concept of psychological resilience to self-reported measures of driving-related abilities, perceptions and practices in older adults. Participants of the Ozcandrive cohort study completed a range of functional and health assessments, as well as self-reported driving questionnaires and a 14-item resilience scale. Results show that participants (N = 166; Male: 69.9%; Mean age = 81.74 years, SD = 3.38, Range = 76.00-90.00) had a mean resilience score of 78.97 (SD = 10.53, Range = 52.00-98.00), indicating a moderate level of resilience. Participants with higher resilience scores reported more comfort driving during both the daytime and night-time, more positive perceptions of their driving abilities, and more frequent driving during challenging situations. Future research will investigate for the first time whether resilience scores of older adults change over time, and if they do, whether these changes are associated with major life and health-related events, as well as driving patterns and behaviour.

See a paper in this Issue on the Ozcandrive study: Hua, P., Charlton, J.L., Koppel, S., Griffiths, D., St. Louis, R.M., Di Stefano, M., Darzins, P., Odell, M., Porter, M.M., Myers, A., & Marshall, S. (2018). Characteristics of low and high mileage drivers: Findings from the Ozcandrive older driver cohort study. *Journal of the Australasian College of Road Safety*, 29(4), 53-62.


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Diary

5 – 7 November 2018
Safety 2018 World Conference
Bangkok, Thailand
http://www.worldsafety2018.org/

7-9 November 2018
IRF Global Road R2T Conference
Las Vegas, NV, US
https://www.irf.global/event/grc18-lasvegas/

19-21 November 2018
2018 International Urban Transport Summit and Exhibition
https://www.irfnet.ch/event-info/2018-international-urban-transport-summit-and-exhibition/1/924
Shanghai, China

4 December 2018
IRF & UNECE ITS Summit
https://www.irfnet.ch/event-info/irf-&-unece-its-summit/1/935
Geneva, Switzerland

13-17 January 2019
The Transportation Research Board (TRB)
98th Annual Meeting
http://www.trb.org/AnnualMeeting/AnnualMeeting.aspx
Washington, D.C., USA

8-13 April 2019
Sixth Global Meeting of Nongovernmental Organizations Advocating for Road Safety and Road Victims
http://roadsafetyngos.org/sh_conference/sixth-global-meeting/
Chania, Greece

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

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

6-8 October 2019
25th World Road Congress
http://www.aipcrabudhabi2019.org/events/world-road-congress-2019/event-summary-9cdd9b3dccdc450991da91decda350b4.aspx
Abu Dhabi, United Arab Emirates

Foreword

Older drivers and naturalistic driving research

Professor Lynn Meuleners[1] and Professor Judith Charlton[2]
Guest Editors of the Special Issue: Road Safety of Older Drivers, *Journal of the Australasian College of Road Safety*, 29(4).
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[2] *Monash University Accident Research Centre, Monash University, Victoria*

Demographic changes in the Australian population are leading to an increase in the number of older drivers on our roads.[1] By 2030, approximately 23% of the Australian population will be aged 65 years and older.[2] Research indicates that the risk of fatal and serious injury crashes increases substantially with old age.[3-5] This increased risk has commonly been attributed to frailty and associated injury susceptibility,[6,7] and also to age-related declines in cognition, vision and psychomotor abilities and increased medical conditions and medication use.[8,9] As people age, sensory, motor and cognitive declines as well as medical conditions common in older adults such as cataract and dementia, can affect the ability to safely operate a motor vehicle. For example, older drivers have been found to have more difficulty with merging, negotiating complex intersections, hazard perception, gap selection and slower reaction times than younger drivers.[10]

For people over 65 years, driving is the most common form of transport and is strongly associated with older adults' independence and social inclusion. In contrast, driving cessation has been linked to poorer health, depression[11] loneliness, reduced mobility[12] and a higher risk of institutionalisation. [13] This highlights the importance of understanding driving performance and driving patterns of older adults so that individual autonomy and mobility can be preserved for as long as possible, while ensuring safety on the roads.

This Special Issue includes research into older driver safety that uses a variety of different methodologies, one of these being naturalistic driving research. Naturalistic driving research can provide new insights into the issues affecting older driver safety. Naturalistic driving studies usually involve participants driving an instrumented vehicle/ vehicle fitted with a Data Acquisition System which continuously records their driving behaviour under naturalistic conditions. The systems vary in complexity but may include video cameras, GPS, radar and accelerometers to provide a complete, second-by-second picture of driver behaviour. [14] They also provide in-depth data on everyday driving as well as safety critical incidents including crashes and near-crashes. Quantitative data on outcomes such as speed, steering, braking, acceleration and lane position are fed back to a central system so that objective data on driving performance that is not subject to human bias can be made.

Naturalistic driving research can also provide important insights into the natural driving patterns and driver self-regulation behaviours of older adults by recording kilometres driven, number of trips, duration, average and maximum radius of driving excursions, time of day and type of roads used.[15] This is superior to qualitative, self-reported information which is subject to recall and/or social desirability bias where drivers may not self-regulate as much as they say.

Overall, naturalistic driving research can play an important role in providing in-depth information on the driving patterns and performance of older drivers, how this changes over time and how the experience of medical conditions and treatments affect driving outcomes.

We hope you enjoy this Special Issue on Road Safety of Older Drivers.

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Peer Reviewed Papers

Original Road Safety Research

Distraction and Older Drivers: An Emerging Problem?

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Key Findings

- Distracted driving is predicted to increase in future generations of older drivers;
- Age-related declines make older drivers vulnerable to the risks of distracted driving;
- Australian data shows that older drivers spent 37% of driving time engaged in secondary tasks;
- Evidence suggests older drivers self-regulate the type and timing of secondary task engagement.

Abstract

Distracted driving is widely recognised as a significant threat to the safety of all road users. Age-related declines in a range of sensory, cognitive and physical processes can, however, make older drivers particularly vulnerable to risks associated with distraction. While traditionally viewed as a younger driver issue, distracted driving among the older driver cohort is predicted to increase as future generations of older drivers drive more often, and for longer, and embrace technology in increasing numbers. This paper discusses current knowledge regarding why older drivers are particularly vulnerable to the effects of distracted driving and reviews recent research on older driver distraction engagement and its impact on their driving performance. Also presented, is an Australian case study of older driver secondary task engagement using data from the recently completed Australian Naturalistic Driving Study (ANDS). This case study examined patterns of secondary task engagement during everyday trips among 48 older (60+), middle-aged (43-49 years) and young (22-31 years) drivers. The findings suggest that Australian older drivers do engage in a large number of secondary tasks when driving; however, there is evidence that they self-regulate the type and timing of these tasks.

Keywords

Distracted driving; Older drivers; Ageing; Road safety

Introduction

Older drivers constitute the fastest growing segment of the driving population (FHWA, 2016). Increases in population growth, longevity, licensing rates, and travel frequency and distance will all combine to yield a marked growth in older drivers on the road (Koppel & Berecki-Gisolf, 2015; Koppel & Charlton, 2013). There is strong support for people to maintain independent vehicular mobility as they age to combat issues such as social isolation and depression; however, the safety of older drivers remains a serious public concern (Langford & Koppel, 2006). Current data show that while older drivers have lower crash rates overall than young novice drivers, they represent one of the highest risk groups for fatal and serious injury crashes per number of drivers and distance travelled (Koppel et al., 2011; Langford & Koppel, 2006).

Older drivers' elevated risk for serious injury and fatal crashes can largely be explained by older driver frailty, or their susceptibility to injury in a crash (Li, Braver, & Chen, 2003). Older peoples' biomechanical tolerances to injury are lower than those of younger people (Mackay, 1988; Viano et al., 1990), mainly due to reductions in bone and muscle strength and fracture tolerance (Dejeammes & Ramet, 1996; Padmanaban, 2001).

Declines in a range of sensory, cognitive and physical processes can also place older drivers at an increased risk of crash-related injury and death. Age-related impairments commonly include visual field loss; deteriorated visual acuity and/or contrast sensitivity; reduced dark adaptation and glare recovery; loss of auditory capacity; reduced perceptual performance; diminishing attentional and/or cognitive processing ability; reduced memory function; musculoskeletal declines, strength loss, and slowed reaction time (Janke, 1994; Stelmach & Nahom, 1992). It is these age-related declines that make older drivers particularly vulnerable to any increases in driving complexity, such as occurs with distracted driving. Indeed, a number of studies have shown that older people have a reduced ability to share attention effectively between two concurrent tasks due to declines in vision and cognitive processing (Mourant, 2001; Verhaeghen et al., 2003; Ward et al., 2018) and, thus, may be more susceptible to the distracting effects of engaging in secondary tasks while driving than their younger counterparts.

Distracted driving is defined as "a diversion of attention away from activities critical for safe driving towards a competing activity" (Lee, Young, & Regan, 2009, p. 34) and is acknowledged as a significant threat to road safety (WHO, 2011). While it is difficult to quantify the exact role of distraction in road crashes given a lack of systematic reporting, a growing body of evidence indicates that is an important contributor to both fatal and serious injury crashes. Indeed, distracted driving has been identified as the main contributing factor in approximately 16 percent of serious casualty crashes resulting in hospital attendance in Australia (Beanland et al., 2013) and in 15 percent of injury and 10 percent of fatal crashes in the United States (NHTSA, 2017).

Distracted driving is often thought of as a problem for young novice drivers. While past research has certainly shown that older drivers engage in distracted driving to a lesser extent that their younger counterparts (Sullman, 2012; Young & Lenné, 2010), it is not clear if this will be the case for the upcoming cohort of older drivers – the baby boomers. The baby boomer generation has a number of distinct characteristics that differ from previous generations. In relation to driving, it is predicted that the baby boomers will have higher licensing rates, travel more frequently, travel greater distances, and be more likely to maintain their private vehicle as their primary mode of transport compared to earlier generations (Koppel & Berecki-Gisolf, 2015; OECD, 2001). This increase in motor vehicle use means that the baby boomer generation will be at greater risk of crash involvement and crash-related trauma than previous cohorts (Langford & Koppel, 2006). Furthermore, it is predicted that baby boomers will have higher rates of technology use than previous generations. Despite persistent stereotypes, research has shown that a significant proportion of older adults now utilise mobile technology to send and receive SMS, access the internet and entertainment media and to do on-line shopping (Kuoppamäki, Taipale, & Wilska, 2017; Niemelä-Nyrhinen, 2007). Taken together, these findings suggest that not only will the current and future generations of older drivers drive more, their growing use of mobile technology, coupled with the increasing number and sophistication of on-board technologies, may mean that their engagement in distracted driving may also escalate.

This paper discusses why older drivers are particularly vulnerable to the effects of distracted driving and reviews current knowledge on older driver distraction engagement and its impact on driving performance. The paper also presents an Australian case study of older driver secondary task engagement using data from the recently completed Australian Naturalistic Driving Study (ANDS).

What makes older drivers vulnerable to distracted driving?

Even healthy older adults are likely to experience some level of age-related decline in physical, sensory and cognitive functions. A number of these declines have implications for distracted driving because they increase older drivers' susceptibility to interference from secondary tasks.

Vision

Vision is critical for safe diving. As we age, visual ability declines and older people can experience a range of issues with vision that can impact driving, including a decline in field of view, visual acuity and contrast sensitivity and reduced dark adaptation and glare recovery (Eby & Molnar, 2012). Such declines have implications for safe driving, such as being able to read street and traffic information signs, seeing pedestrians, cyclists and adjacent vehicles, judging gaps in traffic and driving safely at night. Indeed, a range of age-related declines in vision, including those related to poor visual acuity, visual field loss, glare sensitivity and reduced contrast sensitivity have been associated with increased crash risk (Ball et al., 1993; Owsley, 1994; Rubin et al., 2007).

With respect to distracted driving, vision problems can cause older drivers to experience a number of issues with the use of in-vehicle devices, including difficulty seeing small text and discriminating colours, and problems with display glare, particularly at night. This, in turn, could increase the amount of time older drivers have to spend with their eyes off the roadway in order to extract the required information from devices and displays, placing them at greater risk of a distraction-related crash. Research from the 100-car study has shown that glances away from the forward roadway of more than two seconds increases crash and near-crash risk by at least two times that of normal, undistracted driving in a sample of largely young and middle-aged drivers (Klauer et al., 2006). It is not known if older drivers might have an even lower off-road glance threshold before their crash risk is elevated.

Physical ability

Older people often experience a range of physical or psychomotor impairments that can impact their driving.

Physical issues experienced with aging typically include decreased flexibility, strength and endurance, coordination issues, muscle/hand weakness, increased difficulty in moving limbs and extremities, and increased discomfort, pain and fatigue (Anstey et al., 2005). In terms of driver distraction, these physical limitations can affect the ability of older drivers to easily reach device controls and make it difficult for them to manipulate certain control types such as small buttons, turn dials, or steering wheel controls. This can, in turn, result in longer times to complete secondary tasks, increasing older drivers' exposure to the risks associated with distraction engagement. Moreover, difficulty with manipulating buttons and controls could potentially increase the number of errors made, such as selecting the wrong item or under- or over-shooting items in a list. Errors can further increase completion times and result in confusion or frustration, exacerbating the impact of secondary task on driving performance.

Research has shown that older adults have slower and more variable reaction times, particularly when performing complex tasks such as driving (Kaber et al., 2012; Svetina, 2016). While an increase in reaction time is primarily related to age-related changes in cognition, physical limitations resulting from joint stiffness and muscle weakness can also play a role (Godefroy et al., 2010; Klavora & Heslegrave, 2002).

Cognition

The adverse effects of distracted driving reflects a discrepancy between the amount of resources required for the driving task and the amount of resources the driver is devoting to it. Those drivers with lower cognitive capacity, such as older drivers, are particularly susceptible to the risks posed by distracted driving because they have less spare capacity to devote to secondary tasks (Cuenen et al., 2015). As people age, they often experience a range of cognitive declines and a general slowing of processing speed (Eby & Molnar, 2012; Salthouse, 2010; Yang & Coughlin, 2014). Of particular relevance to distracted driving is research showing that ageing leads to declines in divided attention, selective attention and attention switching. Divided attention, or the ability to focus on, or perform, two or more tasks simultaneously diminishes with age (Ponds, Brouwer, & Van Wolffelaar, 1988; Salthouse, Rogan, & Prill, 1984). Therefore, the ability of older drivers to perform even a relatively short and simple secondary task without it impacting driving performance in some way is often limited. Likewise, the ability of older drivers to ignore incoming information from portable or on-board devices, or to select appropriate times to engage in a secondary task may also be diminished.

Age-related declines in information processing speed can also lead to issues in older people processing large amounts of information provided by on-board or portable devices or responding quickly to information or traffic warnings, particularly if these occur simultaneously (West, Crook, & Barron, 1992). Indeed, older drivers have been shown to have a diminished ability to respond to hazardous situations in a timely manner, primarily due to age-related declines in perception and cognition (Ball et al., 1993; Svetina, 2016). Typically, reaction times become longer and are more variable with increasing age, particularly during times of high complexity (Dickerson et al., 2014; Leversen, Hopkins, & Sigmundsson, 2013; Stinchcombe & Gagnon, 2013; Zhang et al., 2007).

Taken together, the observed decline in cognitive abilities with age can place older drivers at particular risk of the dangers of distracted driving because they have less capacity to cope with the added complexity of engaging in secondary tasks and also have less ability to react to hazardous roadway events should these occur while distracted.

A review of distracted driving in the older driver population

Despite the fact that older drivers represent the fastest growing driver population, and they are particularly vulnerable to the negative impacts of distraction, there has been relatively little research specifically focussed on studying distracted driving in this population compared to their younger counterparts. The current literature on older driver engagement in distracted driving and its impact on behaviour and crash risk is reviewed in this section.

Older driver engagement in distracted driving

Research shows that drivers spend a vast amount of driving time engaging in secondary tasks (Dingus et al., 2016). However, willingness to engage in distracted driving varies greatly across different age groups. In general, older drivers have been found to engage less in distracting activities than younger and middle-aged drivers (Gao & Davis, 2017; Huisingh et al., 2018; Lansdown, 2012; Pope, Bell, & Stavrinos, 2017; Young & Lenné, 2010). In a German sample of older (65-83 years) and middle-age drivers (26-61 years), Fofanova and Vollrath (2012) found that the older drivers were significantly less likely than middle-aged drivers to report engaging in certain distracting activities including using in-car devices, self-initiated internal tasks and eating or drinking. Older drivers also rated most of the distracting activities as significantly more dangerous than the middle-aged drivers. Chen and colleagues (2016) also found that, compared to younger drivers, drivers aged 60 years and over reported marginally lower levels of engagement in distracting activities, were less confident about their driving performance while engaging in distractions, and generally held a more negative view of distractions. It is generally concluded that older drivers' reluctance to engage in distracting activities while driving is indicative of a process of self-regulation (e.g., Fofanova & Vollrath, 2012; Lerner, Singer, & Huey, 2008).

It is well acknowledged that older drivers change their driving patterns to avoid complex or high demand driving situations such as driving at night, during bad weather, peak traffic times and on high speed roads (Eby & Molnar, 2012). While some of these changes to driving patterns reflect lifestyle changes, they can also be an adaptive response to a decline in driving ability, termed driver self-regulation. There is also evidence, albeit limited that older drivers self-regulate their behaviour in relation to distracted driving. This self-regulation is not only evident in the relative unwillingness of older drivers to engage in distracting activities overall, but also in the fact that older drivers have been shown to restrict their engagement in certain tasks when driving demands are increased. Charlton and colleagues (2013), for example, examined older driver engagement in distracting activities at intersections using a naturalistic driving study (NDS) method. They found that the most frequently observed secondary activities at intersections were scratching/grooming (42%), talking/singing (30%) and manipulating the control panel (12%). Interestingly, high-risk tasks commonly associated with taking hands off the wheel and eyes off the road, such as reading, phone use and reaching for objects, were all restricted to times when the vehicle was stationary. Older drivers also engaged less in secondary tasks at uncontrolled intersections where the complexity of gap judgements was highest. Such findings are indicative of self-regulation, whereby older drivers chose to perform more demanding secondary tasks when driving demands were lower. While the results from the Charlton et al. (2013) and other studies are encouraging in that they indicate that older drivers attempt to minimise their risk in relation to distracted driving, self-regulation does have its limitations, namely that it relies on drivers being aware of and accurately assess their limitations and risk. In relation to distracted driving, research has shown that drivers have poor awareness of their performance decrements when engaging in secondary tasks and even tend to underestimate both the demands of dual-task engagement the detrimental impact of distraction on their driving performance (Horrey, Lesch, & Garabet, 2008; 2009; Lesch & Hancock, 2004). Further research is needed to examine the nature of older driver self-regulation in relation to distracted driving and how successful these adaptive strategies are likely to be in reducing crash risk.

Research examining the association between driver age and distraction-related crashes confirms the findings of older driver engagement studies by showing that older drivers are significantly less likely to engage in distracting activities at the time of the crash compared to younger age groups. In an analysis of the 1995–1999 Crashworthiness Data System (CDS) data to determine the role of driver distraction in police reported crashes in the United States, Stutts et al. (2001) found that younger drivers aged under 20 years were more likely to be identified as distracted at the time of their crash (11.7%) than drivers aged 65 years and older (7.9%). A later Australian-based study by McEvoy et al. (2007) examining the prevalence and type of distracting activities involved in serious injury crashes showed similar findings. Interviews with hospitalised drivers revealed that younger drivers (17–29 years) were more likely to report being involved in a distraction-related crash (39.1%) than drivers aged 50 years and older (21.9%). With respect to the risks associated with individual secondary tasks, Donmez and Liu (2015) found that dialling or texting on a mobile phone, in-vehicle sources, and talking on a mobile phone were all associated with an increased likelihood of older drivers (65+ years) sustaining a severe injury in a two-vehicle crash.

More recently, Guo et al. (2017) used data from the Second Strategic Highway Research Program Naturalistic Driving Study (SHRP2) to examine the risk of a severe crash associated with distracted driving for four age groups including older drivers (aged 65-98 years). They found that secondary task engagement posed a consistently higher crash risk for drivers aged 30 years and younger and drivers aged 65 years and older when compared to middle-aged drivers, although the older drivers engaged in secondary tasks less frequently than their younger counterparts. One critical finding was that visual-manual phone tasks, texting and phone dialling increased the odds of a crash by 24.5 to 81.5 times for older drivers aged 65 years and older, far exceeding the odds for the same tasks for teenage drivers. Huisingh and colleagues (2018) also used SHRP2 data to examine the association between secondary task involvement and risk of crash and near-crash involvement for older drivers (70+ years). Older drivers engaged in secondary tasks in 40 percent of the driving trips sampled; however, engagement in any secondary task as a combined category was not associated with an increase in crash or near-crash risk. Use of a mobile phone was associated with 3.8 greater odds of being involved in a crash event, while glances to the interior of the vehicle was associated with 2.6 greater odds of near-crash involvement. Interestingly, interacting with passengers and talking/singing were not associated with an increase in crash or near-crash risk. The discrepancy in the crash risk found across the two SHRP2 studies has been attributed to differences in the reference groups used. Specifically, Guo et al. used sober, alert and attentive driving as a reference to compare secondary task involvement, whereas the reference group used by Huisingh et al., while not engaged in secondary tasks, may have had other impairments. The higher odds ratio found by Guo et al. may therefore be attributable to their reference group having a lower risk of crash involvement compared to the reference group used in the Huisingh et al. study.

Overall, the results of research examining older driver distraction engagement and crash risk suggests that older drivers do engage in distracted driving, albeit to a much lesser extent than younger or middle-aged drivers, and that this behaviour can increase their crash risk, particularly if it involves complex visual-manual tasks such as texting or dialling a phone.

Impact of distracted driving on older driver performance and crashes

A review of early research (pre 2008) into the impact of distraction on the driving performance of older drivers has been conducted by Koppel et al. (2009). Since then, there has been an increase in the number of studies examining how distracted driving affects older drivers' performance, although research on this population still lags well behind the number conducted with younger and middle-aged driver cohorts.

Of particular relevance to the topic of distracted driving is how the ability to divide attention and multitask is affected by the aging process. Research has shown that age-related changes in various aspects of cognition can impact older peoples' ability to divide attention across multiple tasks, particularly when the tasks are complex or they require the use of different modalities (Zanto & Gazzaley, 2014). These findings are typically explained in terms of a decline in processing resources that is associated with healthy ageing and not declines specific to attentional resources (Glisky, 2007). Research examining older peoples' divided attention and multitasking ability when driving confirms these general findings. Using a divided-attention task, Mourant et al. (2001) found that older drivers' (aged 58+ years) were less accurate at extracting information from an in-vehicle display and exhibited diminished lane keeping performance during the divided-attention task compared to younger driver group. Comparable results were found by Ward et al. (Ward et al., 2018) using a gaze-contingent useful field of view paradigm, with older drivers exhibiting poorer lateral control and greater following distance variability when multitasking, which declined further with the increased workload and the introduction of wind. Interestingly, they found that visual discrimination performance suffered regardless of eccentricity, supporting a general interference account of multitasking in older drivers rather than multitasking leading to tunnel vision.

Recent research examining the impact of distracted driving on older driver performance has utilised different criteria for defining the 'older driver'. While many studies classify older drivers as 60 or 65 years and older, the starting age for the older driver samples ranged from 55 to 70 years across the studies reviewed. There is also considerable overlap across studies in the age range used for the older and middle-aged driver groups, with some middle-aged samples containing drivers aged up to 65 years. The different age ranges used can make it difficult to elucidate the role of age as a factor moderating the impact of distraction on driving performance. Despite these difficulties, the evidence is fairly compelling that the impact of distracted driving on driving performance is greater for older drivers than it is for other age groups. More specifically, when compared to their younger counterparts, distracted older drivers display a greater level of impairment in longitudinal and lateral control, increased reaction time to expected and unexpected events, a poorer ability to extract information from the driving scene and a higher involvement in crashes (Aksan et al., 2013; Cuenen et al., 2015; Fofanova & Vollrath, 2011; Gao & Davis, 2017; Ortiz et al., 2018; Svetina, 2016; Thompson et al., 2012). For example, in a recent simulator study by Ortiz et al. (2018), texting WhatsApp messages using a smartphone impaired lane keeping performance across all age groups, but particularly among older drivers (55+ years). Notably, crash risk increased by 135 percent for older drivers when sending WhatsApp messages, compared to an 8 percent increase for young drivers.

Despite the age-related declines in driving performance observed in many distraction studies, research has indicated that older drivers may engage in self-regulatory behaviour while engaged in distracted driving. On-road studies by Thompson et al. (2012) and Aksan et al. (2013) demonstrated that older drivers tended to reduce their speed when engaged in a secondary task. Fofanova and Vollrath (2011) also found evidence for task shedding by older drivers under dual-task conditions, whereby they focused on the most relevant part of the driving task, the lane change manoeuvres, and shed lane keeping. All authors explain their results as evidence that older drivers engage in compensatory strategies when distracted. That is, they slow down to increase their margin for error to account for their reduced reaction times, or they shed less relevant driving tasks to reduce the amount of information they have to process. This explanation, however, suggests that these behaviours reflect, at least in part, a conscious decision made by the drivers to mitigate the risks of being distracted and assumes that older drivers are aware of both their cognitive and physical limitations, as well as the risks posed by the distraction task. It is not clear if this is indeed the case, or if the observed changes in drivers' behaviour simply reflect a degradation in driving performance. Further research is required to determine if such behaviour by older drivers is a form of self-regulation and, if it is, whether it is sufficient to off-set the risks posed by engaging in secondary tasks.

While chronological age is used as a common indicator of possible performance deficits, it is not always an accurate reflection of the level of physical, sensory or functional impairment experienced by older people (Koppel et al., 2009). Indeed, some older drivers can perform as well as younger drivers under dual-task conditions (Svetina, 2016). Thus, an older person's functional status, or their level of functional impairment, may be more relevant in understanding the impact of how distracted driving in older drivers. A number of studies have examined how cognitive capacity can moderate the impact of distracted driving on older driver performance. In an on-road study examining the role of visual, motor and cognitive functioning in the distracted driving performance of older and middle-aged drivers, Aksan et al. (2013) found that older drivers (65+ years) identified fewer landmarks and made a higher number of safety errors than middle-aged drivers. Interestingly, for older drivers, functioning in visual cognition predicted both traffic sign identification and safety errors, and executive function predicted variability in traffic sign identification. However, familiarity with the test area and greater exposure to roadway hazards did not benefit the performance for older drivers.

More recently, Cuenen and colleagues (2015) investigated if cognitive capacity has a moderating effect on older drivers' (70+ years) driving performance during visual and cognitive distraction. They found that cognitive capacity moderated the impact of visual and cognitive distraction on lane keeping ability, whereby higher cognitive capacity was associated with better lane keeping performance. Attention capacity was also found to be negatively related to the number of crashes experienced by the older drivers when visually and cognitively distracted. Taken together, the results of these two studies demonstrate that the functional status of older drivers, not just their chronological age, is an important indicator in understanding the extent to which their driving performance may be impacted by distraction.

Case study of older driver engagement in distracted driving from the Australian Naturalistic Driving Study

A large proportion of our knowledge of older drivers' engagement in distracted driving has been informed by self-report surveys (Chen et al., 2016; Fofanova & Vollrath, 2012; Young & Lenné, 2010) and crash data (Donmez & Liu, 2015; Gao & Davis, 2017), both of which are subject to reporting bias. A small number of studies have utilised NDS data to examine older driver engagement in secondary tasks that are unrelated to driving under specific driving conditions, such as when negotiating intersections (Charlton et al., 2013). The recently completed Australian Naturalistic Driving Study (ANDS) offers a unique opportunity to examine older driver engagement in secondary tasks under a wide range of every day, real-world driving conditions in an Australian context.

Using data from the ANDS (Williamson et al., 2015), this case study examined patterns of secondary task engagement during everyday trips among older (60+ years), middle-aged (43-49 years) and younger (22-31 years) drivers. The selection of the age groups examined was constrained by the demographics of the wider ANDS sample (containing drivers aged 20 -70 years) and the small sub-set of coded available at present. The focus of the data analysis was to examine if there are differences across the three age groups in terms of the type and duration of secondary task engagement and the contextual factors that influence drivers' decisions to engage in secondary tasks while driving.

Method

The ANDS comprised 346 privately owned vehicles (n = 185 from New South Wales; n = 161 from Victoria) that were equipped with a data collection system and driven by primary drivers and members of their household for a period of 4 months in real-world, everyday driving. All drivers resided in metropolitan Sydney and Melbourne or in regional areas of New South and Victoria.

The Data Acquisition System (DAS) equipped to each vehicle was supplied by the Virginia Tech Transportation Institute (VTTI) and comprised sensors and data-loggers, allowing the continuous recording of vehicle data and video while the vehicle ignition was on. Variables captured included: acceleration in multiple axes, gyroscopic motion, indicator status, speed and GPS position. A continuous multi–camera video recording system captured the driver's face, forward and rear views, and a view of the dashboard, each at a rate of 15 Hz.

Approximately 1.95 million km of driving was collected during the study from 377 participating drivers. At the time of writing, 185 trips (2,592 minutes of driving) from 117 drivers had been manually coded for secondary task engagement. The data used for this case study comprised 78 trips that were completed by 48 drivers. The 48 drivers were split into three age groups: 16 older (M = 63.4 years, SD = 3.3 years, 68.8% male), 16 middle-aged (M = 46.2 years, SD = 1.7 years, 43.8% males) and 16 younger (M = 27.6 years, SD = 3.1 years, 31.3% males) drivers. For each age group, 16 drivers were randomly selected that fit within each age range and all of their available trip data was used. For a number of drivers, this meant that data was included for multiple trips.

To code the data, two analysts viewed entire driving trips and coded sections where drivers were observed engaging in at least one secondary task. Using a modified version of the coding protocol developed for the SHRP2 project (VTTI, 2015), a range of categorical variables were coded for each secondary task event identified using the video data. These included secondary task type, passenger presence, driving context, self-regulatory behaviour and safety-related incidents occurring while engaged in secondary tasks.

A secondary task was defined as a discretionary task, performed concurrently with driving, but that is not critical to the primary driving task. Secondary tasks therefore did not include interaction with driving related vehicle controls (i.e., gears, indicators), checking the speedometer or mirrors (unless drivers were clearly using the mirrors to perform a non-driving task), or looking out the windows to check traffic or perform head checks. A range of non-critical vehicle tasks are included, however, such as adjusting mirrors, windows, seatbelt and sun visor because these tasks are not directly related to the primary tasks of vehicle control and safe travel. If drivers engaged in additional secondary tasks while already performing a secondary task (e.g., press centre stack button while talking on a hands-free phone), the number and type of additional secondary tasks engaged in were recorded. All variables, apart from self-regulation and incidents, were coded once for each secondary task event, at the point of the secondary task initiation.

Results & Conclusions

A total of 78 trips were analysed, equating to 1,185 minutes of driving time. Across the three age groups, 761 secondary task events were identified, with drivers engaging in a secondary task every 90 seconds, on average. Table 1 displays an overview of secondary task engagement for the older, middle-aged and young drivers. The younger drivers engaged in the highest total number of secondary tasks, followed by older and the middle-aged drivers. However, once total driving duration was taken into account, it was the middle-aged drivers who engaged most frequently in secondary tasks (1 task every 75 seconds), followed by older drivers (1 task every 84 seconds) and, lastly, younger drivers (1 task every 106 seconds).

In terms of the percentage of driving time spent engaged in secondary tasks, older drivers spent less time (23.5%) engaged in secondary tasks than both the younger (38.4%) and middle-aged drivers (32.2%). However, results of a negative binomial regression revealed that these differences were not statistically significant (all p's < .05), most likely due to the large variance in percentage of time engaged within age groups and the small sample size.

The average duration of each of the secondary tasks engaged in when driving was also examined across age groups. The average duration of individual secondary tasks for the younger drivers was 44.5 seconds (SD = 153.0), 35.9 seconds (SD = 91.2) for middle-aged drivers and 30.6 seconds (SD = 129.2) for older drivers. Results of a one-way ANOVA revealed, however, that these differences were not significantly different ($F(2,47) = 0.524$, $p = .596$). The large variance in mean task duration within age groups and across task types and the small sample size is, again, likely to account for this non-significant finding.Taken together, these results suggest that while older drivers' frequency of engagement in secondary tasks was similar to middle-aged drivers and more frequent than younger drivers, the older drivers' secondary task engagement tended to be shorter in duration, meaning that they spent relatively less driving time overall engaged in secondary tasks. There was, however, large variability within all of the age groups in terms of the total driving time spent engaged in secondary tasks and the duration of individual tasks. For the 16 older drivers examined here, for example, the percentage of total driving time spent engaged in secondary tasks by each driver ranged from zero to 99.4 percent. Similar variability was found for

Table 1. Number and mean (SD) total task duration (secs) of secondary tasks in each category

Secondary Task	**Older**		**Middle-age**		**Younger**	
	N	**Duration**	**N**	**Duration**	**N**	**Duration**
All secondary tasks	*214*	*30.6 (129.2)*	*176*	*35.9 (91.2)*	*371*	*44.5 (153.0)*
Adjusting steering wheel buttons	2	1.3 (0.4)	4	4.2 (3.6)	37	2.0 (2.5)
Adjusting centre stack controls (e.g. radio, HVAC)	18	1.7 (1.2)	27	4.9 (8.0)	71	2.4 (4.3)
Adjusting non-critical vehicle devices (e.g. seatbelt)	95	1.5 (2.2)	29	2.6 (3.0)	41	7.4 (30.7)
Drinking	1	12.1	1	91.1	7	16.8 (9.0)
Eating	-	-	2	197.5 (261.1)	4	607.0 (343.0)
Holding object (other than phone)	-	-	3	38.6 (51.1)	7	72.8 (80.2)
Looking at object/event OUTSIDE vehicle	22	7.0 (12.0)	39	11.2 (14.6)	19	8.9 (13.7)
Looking at object INSIDE vehicle (not reaching/touching it)	9	1.6 (1.1)	6	2.8 (1.9)	18	4.5 (7.2)
Manipulating object (other than phone)	-	-	5	27.7 (29.8)	11	123.1 (208.1)
Mobile phone, holding	2	32.6 (32.5)	1	40.0	5	243.8 (324.3)
Manipulating phone (hand-held)	2	5.7 (0.8)	1	11.7	18	18.6 (15.4)
Manipulating phone (hands-free)	-	-	-	-	4	6.3 (8.9)
Mobile phone, talking/listening (hand-held)	-	-	-	-	5	164.7 (118.1)
Mobile phone, talking/listening (hands-free)	-	-	2	69.3 (50.9)	6	543.0 (346.5)
Personal hygiene	2	10.2 (1.3)	22	14.0 (13.6)	30	12.3 (14.1)
Reaching for object/phone (includes moving)	10	4.4 (2.5)	9	5.9 (7.1)	40	5.1 (7.8)
Reading	-	-	-	-	1	9.0
Talking to front passenger	42	142.8 (265.5)	17	170.0 (210.3)	8	484.4 (470.2)
Talking to rear passenger	-	-	2	536.4 (149.4)	-	-
Talking/Singing to self	8	5.3 (4.7)	4	91.9 (135.6)	30	33.7 (59.0)
Other	1	22.8	2	12.7 (14.6)	9	15.7 (17.0)

Note: older = 60+ years, middle-aged = 43-49 years, younger = 22-31 years.

younger and middle-aged drivers. This massive variability likely led to the non-significant findings despite there being large absolute differences across groups in the mean percentage of time engaged. Future work with the ANDS data set will include a larger sample of drivers and also breakdown the secondary tasks into categories, rather than looking at all secondary tasks as a whole.

Older drivers were also found to engage in a smaller range of secondary tasks compared to younger and middle-aged drivers and the types of tasks they engage in most frequently also differed. Almost half (44.4%) of all the secondary tasks engaged in by older drivers involved adjusting/monitoring devices integral to the vehicle, such as their seat belt, window and sun visor. Adjusting/monitoring non-critical vehicle devices made up much smaller percentage of the overall secondary tasks engaged in by middle-aged and younger drivers (22.4% and 11.1%, respectively). Older drivers also interacted with passengers (i.e., talking, touching or giving or receiving objects) more frequently than the middle-aged and younger drivers. Finally, older drivers engaged less in tasks involving holding or using mobile phones than the younger drivers. Indeed, older drivers were only observed on two occasions manipulating a hand-held phone, compared with 18 occasions for younger drivers.

Interestingly, approximately one fifth (20.5%) of all secondary task events identified for the older drivers involved engagement in multiple secondary tasks. This level of engagement in multiple tasks was similar to that found for both middle-aged (20.4%) and younger (18.1%) drivers ($F(2,47) = .473$, $p = .626$). A large majority of multiple task engagement involved drivers talking to passengers while also performing another secondary task.

We also examined if the driving conditions under which drivers chose to engage in secondary tasks differed across age groups (see Table 2). As displayed, compared to the middle-aged and younger driver groups, older drivers engaged in a greater number of secondary tasks when passengers were present in the vehicle. Results of a two-way mixed ANOVA revealed a significant two way interaction ($F(2,45) = 5.85$, $p = .005$), whereby the older drivers engaged in more secondary tasks with passengers present, but the younger and middle-aged drivers engaged in less secondary tasks with passengers present. Given that interacting with passengers made up almost 20 percent of the secondary tasks engaged in by older drivers, the fact that they engaged more in secondary tasks with passengers present is not surprising. Indeed, the older drivers spent more time driving with passengers than the middle-age and younger drivers. It is important to note here that passenger presence has been found to be beneficial for older drivers in terms of reducing their involvement in unsafe driving actions (Michel & Meyers, 2004) and crash risk (Padlo, Aultman-Hall & Stamatiadis, 2005). Rather than being a 'distraction' from safe driving, passenger based secondary tasks could, therefore, have a protective effect for older drivers, at least in some situations. Further research is required to determine the circumstances in which passenger interaction may be beneficial for older drivers.

Older drivers, like both the younger and middle-aged drivers, were also significantly more likely to engage in secondary tasks while maintaining their current speed ($F(4,180) = 7.335$, $p < .001$) and when the traffic was light or there was no other traffic ($F(1,45) = 4.896$, $p = .032$).

Table 2. Percentage of all secondary task engagement as a function of age group, passenger presence and driving context

Driving Context	% Older	% Middle-age	% Younger
Front passengers			
Yes	56.1	41.4	16.7
No	43.9	58.6	83.3
Speed			
Maintaining current speed	73.8	40.3	54.2
Increasing speed	2.3	6.1	7.3
Slowing down to stop	7.9	12.2	15.6
Slowing down to turn	0.5	1.1	1.6
Stationary	15.4	40.3	21.3
Traffic density			
Heavy	2.3	4.9	10.5
Medium	17.3	33.1	24.5
Light	53.7	41.4	45.3
No traffic	26.6	20.4	19.7

Note: older = 60+ years, middle-aged = 43-49 years, younger = 22-31 years.

The fact that the older drivers tended to engage in shorter secondary tasks and at times when the traffic was light or no traffic was present suggests that they do self-regulate their engagement with secondary tasks to some extent. However, almost three quarters of the secondary tasks engaged in by the older drivers were initiated when they were maintaining their current speed. Only 15.4 percent of the secondary tasks engaged in by older drivers were initiated while they were stationary, compared to 40.3 percent of tasks for middle-age drivers and 21.3 percent for younger drivers. This result likely reflects the nature of the secondary tasks most commonly engaged in by older drivers, which were short, discrete tasks involving adjusting vehicle controls or devices or interacting with passengers. However, it is important to note that the older drivers also engaged in a small number of high-risk secondary tasks while travelling at speed, including reaching for objects and holding and manipulating a mobile phone, suggesting that older driver self-regulation of distracted driving behaviours is not always present or sound.

One of the key strengths of the ANDS is the use of naturalistic driving data which allows the examination of the prevalence of drivers' secondary tasks engagement in a natural, real-world driving setting, free from the constraints of traditional experiments. The enormous amount of data collected, however, meant that only a fraction of the available data set was coded and available for analysis in this paper. Future work with NDS data should examine ways to at least partially automate the coding of secondary task events to ensure that larger amounts of data can be analysed. Second, the random selection process used to select trips for coding meant that there was variability in the number of trips analysed for each driver; the number of trips coded for individual drivers ranged from 1 to 12. Thus, individual differences in the propensity to engage in secondary tasks may have had more of an influence on the data for those drivers with a greater number of trips coded. Future analysis of the ANDS data will include a greater number of trips with an even distribution of trips across drivers.

Discussion

This paper has highlighted a number of important issues related to distracted driving among older drivers. The first is that the older driver cohort is growing rapidly and the demographic characteristics of older drivers are changing, most notably in terms of licensing rates, travel patterns and technology use. In recent years, older adults have reported more positive and accepting attitudes towards technology (Mitzner et al., 2010) and this may change the norms in relation to older driver distracted driving behaviour. An increase in the acceptance and use of technology by older people, coupled with the increasing pervasiveness of technology in vehicles, means that the safety risks associated with distracted driving may be further compounded for the upcoming baby boomer cohort of older drivers.

Recent NDS research from the United States and our own case study of Australian older drivers from the ANDS, indicates that the current cohort of older drivers do engage in distracted driving. Indeed, data from the SHRP2 study showed that older drivers engaged in secondary tasks in 40 percent of the driving trips sampled (Huisingh et al., 2018). A small subset of data from the ANDS also showed that older drivers in Australia spent 36.5 percent of their driving time engaged in secondary tasks, a percentage comparable to the younger and middle-aged drivers sampled; however, the nature of the tasks that older drivers engaged in tended to differ. Based on the limited data available in the literature, it is difficult to draw definitive conclusions as to whether engagement in distracted driving is increasing in older drivers. However, given the upward trend in older adult technology uptake and the proliferation of technology into vehicles, older driver engagement in distracted driving should be carefully monitored into the future.

The age-related functional declines discussed in this paper make older drivers particularly susceptible to the risks of distracted driving. Any increase in older driver engagement in distracted driving is therefore likely to have a disproportionally high effect on the crash risks associated with distraction for this population. This is particularly likely to be the case if older drivers increase their engagement with certain technologies such as mobile phones, which has been found to increase the odds of a crash for older drivers by almost four times (Huisingh et al., 2018).

On a more positive note, there is evidence that older drivers engage in self-regulatory behaviour in relation to distracted driving. When engaged in secondary tasks, older drivers have been shown to reduce their speed and shed less relevant driving tasks (Aksan et al., 2013; Fofanova & Vollrath, 2011; Thompson et al., 2012). Data from the ANDS case study also demonstrated that older drivers self-regulate the types of tasks they engage in when driving, as well as the conditions under which they engage. More specifically, the older drivers in the ANDS tended to engage in secondary tasks of relatively short duration and at times when the surrounding traffic was light or no traffic was present, compared to younger and middle-aged drivers. The older drivers in this study did, however, initiate engagement in the majority of the secondary tasks, including some high-risk tasks, while they were maintaining their current speed. These findings suggest that while older drivers do self-regulate their distracted driving behaviours, these self-regulation strategies are not always implemented, nor are they perfect. More research is needed to investigate the self-regulation of distraction behaviours and to determine if the strategies adopted are sufficient to offset the functional limitations of older drivers and the increased risks they face from distracted driving.

As discussed, distracted driving has traditionally been thought of as a younger driver issue and, thus, limited effort has been made to manage driver distraction in older drivers. There are, however, a range of strategies that could be implemented to manage distracted driving in the older population. Koppel et al (2009) provide a review of several potential countermeasures including legislation, licensing, education and training, and vehicle, technology and road design. Those countermeasures that specifically address the functional declines experienced by older drivers that make them more susceptible to the risks of distraction are likely to have the greatest impact. For example, research that has demonstrated that attention capacity training in older adults can have long lasting benefits for road safety (Ball, Edwards, & Ross, 2007; Ball et al., 2010), suggests that this may be one potentially promising countermeasure for older drivers. Given the limited research in this area, however, it is difficult to draw conclusions about the efficacy of any one distraction countermeasure for older drivers; however, as with other driver populations, a systems approach to managing older driver distraction, that contains multiple complementary countermeasures, is likely to yield the highest safety impacts.

Conclusions

Overall, far from being a younger driver problem, this review and the ANDS case study demonstrates that older drivers do indeed engage in distracted driving and that this negatively impacts their driving performance, more so than younger drivers. However, there is evidence that older drivers regulate the type and timing of the tasks they engage in. More specifically, older drivers engage in secondary tasks for shorter durations than younger drivers, engage more often when surrounding traffic is light or not present, and they avoid tasks that have been found in previous research to be high-risk, such as holding or manipulating a mobile phone. Distraction countermeasures should capitalise on the natural self-regulatory tendencies of older drivers by increasing their awareness of dangers of certain secondary tasks and the driving conditions under which they should avoid engagement.

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Driving Ability and Transportation Needs of Older Drivers Treated in an Emergency Department

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Key Findings

- Despite having medical conditions associated with increased crash risk, many older drivers over estimated their driving ability.
- Some older drivers may require further functional assessment upon discharge from an emergency department before resuming their normal driving activity.

Abstract

The number of older Canadians is growing rapidly and many will continue to drive to meet their transportation needs. Most older drivers are safe drivers; however, with advancing age, some develop medical conditions and associated impairment that may affect their driving ability. Often these medical conditions are first recognized when they seek emergency care. In this cross-sectional study, we collected data on a sample of 92 older drivers (57 males and 35 females) aged ≥ 70 years, who were treated in an urban emergency department (ED) for acute illness or injuries. We asked about their perceived driving ability, driving habits, and transportation needs. About one third of respondents had never taken public transit in the past year. Most drove for grocery shopping, visiting family and friends, and medical appointments. Sixty eight drivers also agreed to take tests for cognitive ability, visual acuity and reaction time. All 68 drivers passed vision screening and no drivers showed severe cognitive impairment. However, ten drivers (10/68, 14.7%) failed the Trail Making Test B test and 14 drivers (14/68, 20.6%) had slow reaction time according to a ruler drop test. Medical chart review revealed that close to 40 percent were taking sedating medications that could impair driving and 20 percent had a discharge diagnosis of a medical condition that could potentially affect their driving. In conclusion, many ED older drivers depend on driving to meet their mobility needs. Screening tests and medical chart review suggest that some of these drivers may have conditions that could affect their ability to drive safely.

Keywords

Older drivers, Driving ability, Transportation needs.

Introduction

The most recent Canadian census revealed that the older Canadian population is growing at a faster rate than anticipated (Statistics Canada, 2014). Since older adults are living in their own homes for longer and are staying more active, mobility is important for their quality of life. Many will continue to depend on their own vehicles to meet their mobility needs. Driving however is a complex task requiring a combination of perceptual, cognitive and motor skills. A capable driver must be able to see and hear clearly (perception functioning), interpret the meaning to choose a correct course of action (cognitive functioning), and then execute the action appropriately (motor skills). These skills form the basis of fitness to drive assessment (Devos et al., 2011; Mathias & Lucas, 2009; Reger et al., 2004). As people age, many will experience some decline in the visual, cognitive and/or psychomotor skills that are required to operate a motor vehicle effectively and safely. When functional declines reach a critical point, the individual is deemed unfit to drive. Unfit drivers are found in all age groups but are more common in the older population. This may explains the increased crash risk in some older drivers (Marshall, 2008; Charlton et al. 2004; Vaa, 2003). Many have predicted a large increase in the number of older drivers on the roads as our population continues to age (Meuleners, Harding, Lee, & Legge, 2006; NHTSA, 2008; Sivak & Schoettle, 2012; Statistics Canada, 2010) and it is not unreasonable to suggest that the number of medically unfit drivers will also increase significantly.

The large majority of older drivers are safe drivers and have a low per capita crash rate (Langford, Bohensky, Koppel, & Newstead, 2008b; Lyman, Ferguson, Braver, & Williams, 2002). However, when driving exposure is taken into account, the crash rate (per distance travelled) of drivers aged 70 and above rises steadily and exceeds that of drivers aged below 24 (Langford, Koppel, McCarthy, & Srinivasan, 2008c; Ryan, Legge, & Rosman, 1998). Langford and colleagues (2006, 2008c) noted that the high collision rate per distance travelled seen in older drivers may be explained by "low mileage bias", wherein people of all ages who drive less tend to have more crashes per distance travelled (Langford, Methorst, & Hakamies-Blomqvist, 2006; Langford, Koppel, McCarthy, & Srinivasan, 2008c).

Many older drivers with declining ability will voluntarily limit their road exposure and avoid difficult driving situations, but there is a subset of drivers who do not recognize their reduced driving abilities and do not limit their driving appropriately. This was demonstrated in some studies which showed that a substantial number of older drivers continue driving despite significant cognitive impairment (Carr, Jackson, & Alquire, 1990; Odenheimer, 1993). Older drivers generally tend to reduce their overall amount of driving and modify their driving by avoiding various driving situations such as driving in bad weather or at night. These changes in driving patterns, referred to as self-regulation of driving, are regarded as a strategy for older drivers to continue to drive safely despite functional decline. However the effectiveness of self-regulation of driving in lowering crash rates has yet to be demonstrated (Man-Son-Hing, Marshall, Molnar, & Wilson, 2007). Part of the reason for this inconclusive evidence of effectiveness is that self-awareness of functional decline is often not the main reason for self-regulation of driving (Meng & Siren, 2015). Some drivers who modify their driving behaviours not because of the self-regulation but rather a change in lifestyles or driving preferences (Molnar et al., 2013). Further, some at risk drivers lack insight into the warning signs of cognitive impairment or declining health and may overestimate their driving skills and many would not report problems to their physicians (Carr et al., 1990; Odenheimer, 1993). When drivers overestimate their driving ability, it undermines the ability of self-regulation strategies to reduce crash risk (Horswill, Sullivan, Lurie-Beck, & Smith, 2013). Horswill and colleagues (2013) found that many older drivers have poor judgment regarding their ability to perceive driving hazards.

Another reason that some at risk drivers are reluctant to reduce their driving is related to their transportation needs. The lack of reliable and acceptable alternative modes of transportation can be a barrier of self restriction and driving cessation for many older drivers. This is especially true for older drivers with declining physical strength or with physical impairment that precludes them from walking or taking public transit (Adler & Rottunda, 2006). Fear of losing independence is another reason that some medically at risk drivers continue to drive.

Some older drivers do lose confidence in their ability to drive and tend to avoid difficult situations such as nighttime driving (Baldock, Mathias, McLean, & Berndt, 2006; Betz & Lowenstein, 2010) and some simply stop driving completely. It is important to differentiate general reduction in driving (i.e. fewer trips or shorter distance travelled) from avoidance of certain driving situations (Meng & Siren, 2015; Molnar et al., 2013). Reduction in driving can be a consequence of reduced need for mobility, whereas avoidance of specific driving situations appears to be motivated by negative feelings such as feeling of discomfort or stress when driving in those situations (Hakamies-Blomqvist & Wahlström, 1998; Molnar et al., 2013) and probably not due to self-awareness of functional decline (Meng & Siren, 2015).

Some older drivers have difficulty knowing whether they should continue driving or not. Alonso and colleagues (2017) examined the perception of certain health conditions on driving performance in a group of older drivers in Spain (Alonso, Esteban, Useche, & Serge, 2017). Most participants were not aware that certain common health conditions, such as diabetes, joint pain, or hearing problems, could negatively impact their driving performance. In a study based on interviews and self reporting of 150 older patients (60-95 years of age) from acute care and rehabilitation wards, Kelly and colleagues (1999) concluded that a high proportion (29%) of current older drivers should not be driving at all (6 out of 21 current drivers) and that close to 44 percent of patients who believed that they were eligible to drive were actually under driving restrictions (Kelly, Warke, & Steele, 1999). Despite a very small sample size, the study by Kelly et al. (1999) does highlight that some at risk older drivers may be overly confident in their driving ability and do not feel the need to avoid difficult driving situations. Most commonly, these situations include rush hour driving, parallel parking, driving at night in the rain, and making left-turns across oncoming traffic (right turns in right-hand driving countries).

To keep the public safe and to protect the at-risk drivers themselves, more stringent screening for medically unfit drivers may be helpful. Excessive screening, however, can increase healthcare burden and also act as a barrier to the preservation of independence for older adults. Currently, the provincial government of British Columbia (BC) requires drivers over the age of 80 to be assessed for fitness to drive by a physician every 2 years. No formal assessments are needed for drivers under the age of 80 unless they have been reported to the licensing authority as potentially unfit to drive (for example because of poorly controlled seizures). Although age-based assessments have not been proven to be effective in reducing crash risk (Langford, Fitzharris, Koppel, & Newstead, 2004), many licensing authorities continue to conduct regular age-based assessment using tests that have little or no validity or capability to separate unfit drivers from competent drivers (Fildes, 2008). Futhermore, it is not known how many older drivers actually self-identify as unfit drivers and have stopped driving on their own.

The gold standard for determining fitness to drive is on-road driving performance (Dickerson, Meuel, Ridenour, & Cooper, 2014). Physicians often have knowledge of their patients' medical history and functional limitation, but even so, recognition of medically unfit drivers can be difficult wihout on-road assessment. Previous research, including a survey of BC physicians conducted by our team, has shown that many medical professionals lack training and knowledge of assessing and reporting unfit drivers (Brubacher et al., 2018). In a study comparing physician judgement with on-road test outcomes, Meuser and colleagues (2016) found only a moderate agreement between the two assessments. Of drivers rated by physicians as "likely capable", 27 percent failed the road test (Meuser, Berg-Weger, Carr, Shi, & Stewart, 2016). Conversely, of those rated as "unclear" or "not capable", 62 percent passed the road test. Similarly, Fox and colleagues (1997) found that physician prediction of a patient's driving ability was not associated with patient's on-road performance. In that study, 37 percent of dementia patients were judged as safe to drive by on-road assessment, suggesting that the diagnosis of dementia alone may not be sufficient to recommend driving cessation (Fox, Bowden, Bashford, & Smith, 1997). Currently, many existing guidelines for assessing fitness to drive are not evidence-based (Salmi, Leproust, Helmer, & Lagarde, 2013) and other researchers concluded that no single screening test should be used alone to determine driving fitness based on age (Langford, 2008a). A systematic review of studies on the validity of in-office fitness to drive assessments concluded that the clinical tests employed in these studies were not consistently related to measures of driving performance (Marino et al., 2013) or that they had poor predictive value of true unfit drivers (Bedard, Weaver, Darzins & Porter, 2008; Anstey, Wood, Lord & Walker, 2005) even though there were statistically significant association between test and crash risk. There is still no consensus on the most appropriate in-office screening tools for detecting medically unfit drivers (Carr & Ott, 2010).

Despite these limitations, a wide variety of tools are still being used by driver rehabilition specialists for determining fitness to drive (Dickerson, 2014). A Delphi study by Rapoport et al. 2014 found that the strongest predictors of physician decision in reporting drivers with mild cognitive impairtment and mild dementia were caregiver (family) concern and abnormal performance on the clock drawing test (Rapoport et al., 2014). The authors recommended that all uncertain cases be referred for on-road assessment. Another cognitive test assessing divided attention or cognitive flexibility, the Trail Making Test Part B (TMTB) developed by Reitan (1958), has also been used widely to identify at risk drivers (Classen et al., 2008; Stutts, Stewart, & Martell, 1998). Studies of community dwelling older adults found that results of TMTB were significantly correlated with on-road assessment of driving performance (Wood, Anstey, Kerr, Lacherez, & Lord, 2008), and with recent crash involvement (Edwards et al., 2008). In Canada, TMTB is also recommended in the guidelines from the Canadian Medical Association and the Canadian Council of Motor Transport Administrators as one of the cogntive assessments. In their review of tools predicting fitness to drive in older adults, Dickerson et al. (2014) concluded that no single screening tool should be used in isolation to make decision on whether or not one should stop driving. Dickerson and colleagues (2014) further commented that their findings did not mean that driver fitness screening tools should not be used at all, but merely that careful consideration of why and when these tools are used is important.

Reviews conducted by Marshall (2008), Vaa (2003), and Charlton et al. (2004) concluded that many medical conditions do affect one's driving abilities though some evidence remained inclusive. These reviews suggested that conditions such as vision impairment (e.g. untreated cataracts), cardiovascular diseases, musculoskeletal disorders, cerebrovascular disease/traumatic brain injury and hearing impairment may be associated with a slight increase in crash risk, whereas alcohol dependence, epilepsy, diabetes mellitus, schizophrenia, depression, dementia, medications that affect central nervous system and untreated sleep apnoea may have a moderate to high relative risk of crashing. In an updated review by Charlton and colleagues in 2010 find that there was however no consistent and clinically convincing evidence to link some of the cardiovascular diseases to the risk of crashing (Charlton et al., 2010). Using medical diagnosis alone to determine driving fitness in older drivers is problematic because many older drivers will have multiple conditions with varying degrees of severity. Given the accessibility of family physicians and their capacity to evaluate a range of medical conditions and social supports, primary care is a logical first point of contact in the process of evaluating fitness to drive. However, based on current evidence, it is unclear whether physician assessment in the primary care setting provides an accurate and timely prediction of driving safety, especially when there are no obvious signs of driving impairment. In addition, family physicians may not report potentially unfit drivers to the licensing authorities due to fear of damaging doctor-patient rapport. On the other hand, with advancing age, older adults are likely to develop medical conditions and associated impairments that eventually affect their driving ability. Often these medical conditions are first recognized in the emergency departments (EDs) when patients present with an acute illness or injury from, for example, a fall or driving incidence. In addition, some patients with chronic conditions do not have a primary care physician but seek care in the EDs.

In summary, older drivers who live in their own home are most likely to have access to their own vehicles and are generally safe drivers due to self regulation. However, as these conditions progress, driving cessation may be inevitable. Often these critical stages are first recognized when older patients present at the EDs with injuries or with acute manifestation of a severe underlying medical condition. The objectives of this study are to (1) examine older drivers' awareness of their driving ability, (2) estimate the number of older drivers who may have cognitive decline or conditions that could affect their ability to drive safely, and (3) explore their attitudes towards using public transportation from the perspective of ED older patients.

Methods

This was a cross-sectional study of 92 older drivers aged >70 who were treated in the Vancouver General Hospital Emergency Department (ED), an urban tertiary centre in Vancouver, Canada, between August and September 2017. During times when research assistants were available, we systematically sampled all patients aged > 70 years who registered for treatment. This study was approved by the University of British Columbia Research Ethics Board and by the Vancouver Coastal Health Research Institute.

We recruited patients aged >70 years who live in their own homes and were current drivers. In this study, we defined current drivers as those who hold a valid BC driver's license and reported that they have driven at least once in the past 4 weeks. Patients who came from a nursing facility, were unable to communicate in English effectively, or were unable to be interviewed due to pain or illness were excluded.

We collected data from 3 sources: 1) structured questionnaire interview, 2) medical records and 3) functional screening tests: cognitive screening, reaction time test, and test of visual acuity. The interview asked questions about driving habits, the common purpose(s) of driving trips, awareness of any prescribed medications that could negatively influence driving ability, difficulty driving in certain situations, and opinion regarding alternative forms of transportation. We also obtained patients' consent to review their ED medical record to identify potentially impairing medications and/or medical conditions that may impair driving ability according to the literature (Vaa, 2003, McGwin, Sims, Pulley & Roseman 2000). Specifically, we looked for ED discharge diagnoses such as alcohol dependence, epilepsy, diabetes mellitus, schizophrenia, dementia, cardiovasular diseases, neurological disorders, impaired vision, and sedating medications such as analgesics, antipsychotics, anxiolytics and benozodiazepines. The functional assessment, which included tests of vision, reaction time and cognitive function, was conducted at the end of the interview. Cognitive status was assessed with Trail Making Test B (TMTB) and the Mini-Mental State Examination (MMSE). We chose TMTB test because it measures executive functioning required for driving and has been shown to correlate with driving performance and crash risk in older drivers (Classen et al. 2008, Stutts et al. 1998). The cut-offs of 180 seconds or 3 errors TMTB were commonly used in previous studies by Classen et al. (2008) and Stutts et al. (1998). We chose a score ≤17 for MMSE (indicating severe cognitive impairment) as a cut-off in this study because higher cut-offs are poorly correlated with on-road performance, especially when the MMSE is used in isolation (Crizzle, Classen, Bédard, Lanford, & Winter, 2012). We used the Snellen Eye Test for visual acuity and the timed ruler drop to assess reaction time (Eby, Molnar, Shope, & Dellinger, 2007; Wilson & Pinner, 2013: Dickerson 2014).

For safety reasons, patients who were found to be potentially unsafe to drive were advised to discuss their driving with their family physicians. If patients did not have a family physician or were unwilling to follow up with their family physician, we referred them to the emergency department medical staff for further evaluation.

Statistical Analysis

In this study we divided participants into two age groups: drivers aged 70-79 and drivers aged > 80 because drivers aged 80 or over are required to undergo medical assessment of their fitness to drive in BC. We hypothesized that there would be differences in self-awareness of driving ability, and in driving behaviours between these two age groups . We used cross tabulation to describe the characteristics of participating drivers and their driving abilities. Chi Square test or Fisher's exact test for proportions was used to explore differences in driving abilities, driving habits, medical conditions and transportation needs between the two age groups.

Results

A total of 132 older driver patients met the inclusion criteria and 92 (70% response rate; 57 males and 35 females) agreed to participate as shown in Figure 1. The age and sex distributions of the 40 patients who declined to participate were similar to those of participants. The most common reason for declining to participate was being too tired to answer questions, followed by fear of losing their driver license. The average age of participants was 79.1 (SD=6.4) ranging from 70 to 95 years old with 54.3 percent (50/92) in the younger group (aged 70-79) and 45.7 percent (42/92) in the older group (aged >80) as shown in Table 1. The great majority of participants (n=86, 93.5%) own a vehicle and 55 (59.8%) drove daily or almost daily. The main reasons they drove in past year were grocery shopping (87.0%), visiting relatives or friends (71.7%) and medical appointments (45.7%). There were no statistical differences in the common reasons for driving between the two age groups, although a slightly higher proportion of older age group said grocery shopping was the main reason they drove in past year while slightly more younger age group drivers drove for medical appointments. Overall, most respondents (69/92, 75%) perceived themselves as good to excellent drivers, although 14 (15.2%) had a crash in the past year. A higher proportion of drivers aged 70-79 years considered themselves as "*good to excellent*" drivers (86.0% vs 61.9% of drivers ≥ 80 years, p=0.008).

Overall, 26 drivers (28.3%) had considered giving up driving but few of them had discussed their driving with family members (10/26, 38%) or with their family doctor (2/26, 7.7%). As expected, a higher proportion of drivers aged ≥ 80 considered giving up driving (40.5% vs 18.5% for drivers aged 70-79, p=0.017). Over a third of drivers (36/92, 39.1%) planned to continue driving until they died or were unable to drive, and the percentage of drivers with this response was similar in both age groups. Many drivers (38%) avoided three or more difficult driving conditions

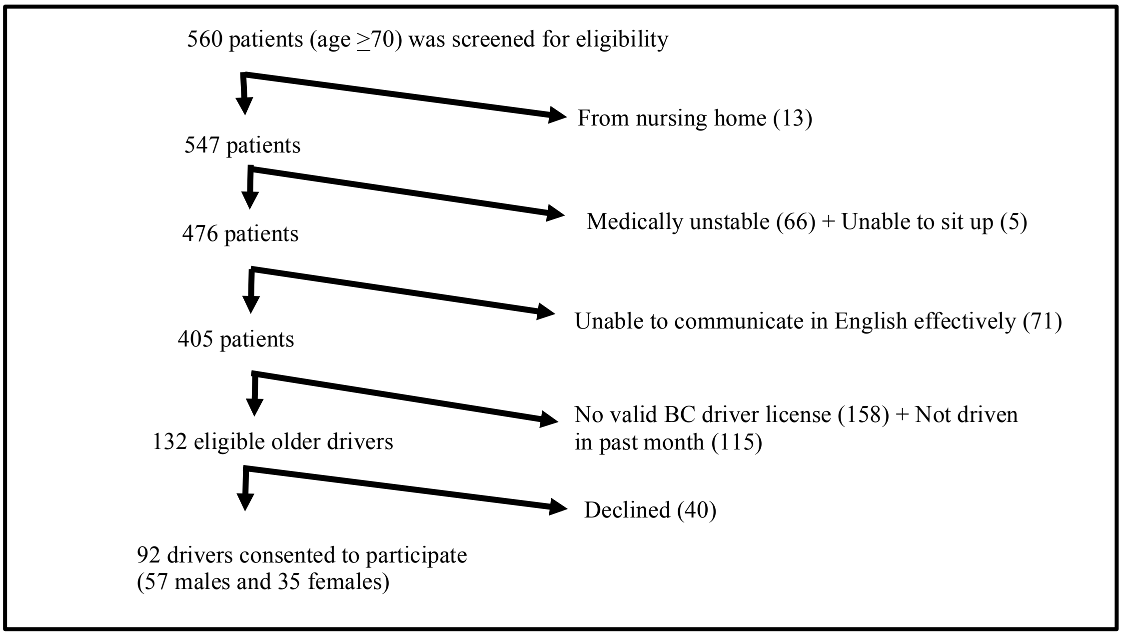

Figure 1. Number of older patients included and excluded

Table 1. Characteristics of participating older drivers

	Total (N=92) n (%)	Age 70 –79 (N=50) n (%)	Age ≥ 80 (N=42) n (%)	p-value
Male	57 (62.0%)	31 (62.0%)	26 (62.0%)	0.993
Own vehicle	86 (93.5%)	46 (92.0%)	40 (95.2%)	0.398
Drove daily in past month	55 (59.8%)	31 (62.0%)	24 (57.1%)	0.636
Most common reasons for driving:				
Grocery shopping	80 (87.0%)	41 (82.0%)	39 (92.9%)	0.124
Visiting relatives/friends	66 (71.7%)	37 (74.0%)	29 (69.0%)	0.599
Medical appointment	42 (45.7%)	25 (50.0%)	17 (40.5%)	0.361
Perceived good to excellent driving skills	69 (75.0%)	43 (86.0%)	26 (61.9%)	**0.008**
Considered giving up driving	26 (28.3%)	9 (18.0%)	17 (40.5%)	**0.017**
Considered continuing driving till unable/death[a]	36 (39.1%)	20 (40.0%)	16 (38.1%)	0.852
Taken public transit in past year	61 (66.3%)	34 (68.0%)	27 (64.3%)	0.707
Preferred public transportation than driving	28 (30.4%)	14 (28.0%)	14 (33.3%)	0.580
Self reported impairing medication uses[b]	15 (16.3%)	10 (20.0%)	5 (11.9%)	0.295
Prescribed impairing medications in last 30 days	39 (42.4%)	21 (42.0%)	18 (42.9%)	0.934
Discharge diagnoses that potentially affect driving skills[c]	19 (20.7%)	10 (20.0%)	9 (21.4%)	0.866
Avoiding three or more difficult driving conditions[d]	35 (38.0%)	19 (38.0%)	16 (38.1%)	0.993

[a] Participants were asked how many more years they will drive.
[b] Self reported medication uses for sleep, anxiety and/or depression.
[c] Discharge diagnoses included cardiac diseases, syncope and anxiety.
[d] Difficult driving conditions included night time driving, rainy or snowy days, high traffic and highway.

Table 2. Results of cognitive function and reaction time tests

	Total n/N (%)	Age 70 – 79 n/N (%)	Age ≥ 80 n/N (%)	p-value
Drivers agreed to screening	68/92 (73.9%)	34/50 (68.0%)	34/42 (81.0%)	0.159
Failed TMTB[a]	10/68 (14.7%)	5/34 (14.7%)	5/34 (14.7%)	0.999
Slow reaction time[b]	14/68 (20.6%)	5/34 (14.7%)	9/34 (26.5%)	0.369
Failed TMTB or reaction time	21/68 (30.9%)	9/34 (26.5%)	12/34 (35.3%)	0.431
Failed both tests	3/68 (4.41%)	1/34 (2.9%)	2/34 (5.9%)	0.999

[a]TMTB=Trail Making Test B

[b] Ruler Drop Reaction Time test

including night time driving, driving in heavy traffic, highway driving, and driving in bad weather.

When asked about public transportation, 61 drivers (66.3%) had taken public transit in the past year. Most (82/92, 89%) knew about special transportation services available for seniors (provided by local transit systems and volunteer driver programs) but only 11/82 (13.4%) had used those services in the past year. Of all the drivers interviewed, only 28 (30.4%) preferred public transportation over driving. For those who preferred driving, many cited convenience as the main reason for their preference. For those who preferred public transportation to driving, only 3 drivers cited safety concern and stress free travel as the reasons. Others indicated difficulty in finding parking in the city, environment (climate changes) and social responsibility, and ease of accessing transit as reasons for their preference. Overall, the responses were similar in the two age groups.

Fifteen drivers (15/92, 16.3%) self-reported using potentially impairing medications such as sleep aids and antidepressants. Slightly more drivers aged 70-79 reported using these medications (20% vs 11.9% drivers aged >80, p=0.295) though the difference was not statistically significant. Medical chart review showed that 19 drivers (20.7%) were diagnosed at ED discharge with medical conditions (including cardiac diseases, syncope/collapse and anxiety attack) which have been shown previously to be associated with higher crash risk (although the severity of the medical condition was generally not described). In addition, on review of recent prescriptions, we found that 42.4 percent (39/92) of all drivers had been prescribed at least one sedating medication in the past 30 days whereas only 16.3 percent patients self-reported taking these types of medications.

Sixty eight drivers (73.9%) agreed to take the functional screening tests. Overall there were no statistically significant differences between the two age groups in all functional screening tests as shown in Table 2. No drivers scored below 17 which indicates severe cognitive impairment in MMSE test. All drivers passed the visual acuity test with their corrective eyeglasses. However, 10 drivers (10/68 14.7%) had poor scores on the TMTB test (requiring >180 seconds or had more than 3 errors). Fourteen drivers (20.6%) had a reaction time over 0.248 second indicating reaction time deficiency in the ruler drop test; a slightly higher proportion of drivers with reaction time deficiency was found in the older age group (26.5% aged > 80 vs 14.7% aged 70-79, p=0.369) though the difference was not statistically significant.

Among these 68 drivers who were screened for functional tests, 54 drivers (31 aged 70-79 and 23 aged >80) self-rated as *good to excellent* drivers. However, among these self rated good-excellent drivers, 29 percent (9/31) drivers aged 70-79 and 21.7 percent (5/23) drivers aged >80 had poor scores on either the Trail Making Test B or on the Ruler Drop Reaction Time test, indicating that some of drivers may have over estimated their driving ability. In particular for the cognitive test, a non-statistically significant higher proportion of young older drivers (aged 70-79) had performed below the cut-offs in Trail Making Test B comparing to old older drivers (aged >80 (16.1% vs 8.7%, p=0.685). For the 21 drivers who performed below the cut-offs in TMTB or reaction time, 5 (24%) had a crash last year and 11 (52%) avoided driving in more than 3 difficult conditions, whereas among the 47 drivers who passed both the TMTB and reaction time tests, 5 (11%) had a crash in the last year and and 15 (32%) avoided driving in more than 3 difficult conditions.

Discussion

Similar to findings from other studies on aging and driving, this study found that driving was the first choice of mode of transportation among the older drivers. However, aging is often associated with the onset of chronic medical conditions that may affect ability to drive. The medical chart reviews showed that at least 20 percent of our sample of older drivers visiting an emergency department had discharge diagnoses which are sometimes reported to be associated with higher crash risk. Overall, 16 percent of drivers in our sample reported using impairing medications, and 42.2 percent drivers had been prescribed sedating medications in the past 30 days. Our findings suggest that ED physicians and nurses should be aware of the driver status of their older patients and, if needed, should provide them with guidance on their driving ability .

We found that a high proportion of participants in our sample had slow reaction time and/or performed below cut-offs in Trail Making Test B. The interpretation of these results requires caution. Although patients were tested at bedside with a privacy barrier (such as curtain), the emergency department is a busy and sometimes distracting environment (with noise and the presence of medical staff). In addition, most patients in the emergency department are there for acute medical conditions or injuries which might affect their performance. Nevertheless, previous researchers have found that the ED environment has a minimal effect on the Trail Making Test B test and suggested that this can be used to screen drivers in the ED setting (Betz and Fisher, 2009). The high proportion of drivers who performed below the cut-offs in the TMTB and/or reaction time tests suggests that the emergency department may be a suitable place to identify (for referral) older drivers with cognitive impairment or slowed reaction time which could potentially put them at increased risk of motor vehicle crashes.

Most older drivers drive because they need to, in particularly for grocery shopping. To reduce reliance on driving for older people, city planners can consider designing more pedestrian friendly communities with higher density of groceries and general stores. However this may not be sufficient because many older adults lack the strength to carry groceries while walking home even while taking public transit home. Home delivery programs should be promoted to help older people get food and household supplies. For medical appointment, less than half of the participants preferred driving. This could be related to the time required for the appointment. Comments from study participants highlight the need for better parking options in clinics or medical facitilies for older drivers who must drive themselves.

Similar to other studies, many older ED drivers in this study report that they avoid driving in difficult situations such as at night, during bad weather condition, or in heavy traffic. Better lighting and line markings on roads may be helpful for older drivers if they need to drive at night or during rainy seasons. In addition, approximately 11 percent of all participants were unaware of the special transportation programs for seniors and people with mobility challenges. Decision makers should promote awareness of these special transportation programs.

Limitations

There are some limitations in this study. First, this sample was recruited during daytime hours in an urban trauma centre and our results may not be generalised to older patients who visit the emergency department during the evening or at night, or to those who live in rural communities. We also excluded patients who were unable to participate because of critical illness or severe cognitive dysfunction. These patients may differ from our participants in terms of driving fitness and baseline health, and those differences could influence their driving patterns. Although this sample was recruited based on the availability of research assistants (RA)s, we screened and approached all eligible patients whenever RAs were available on a 4-hour shift. We believe that the results of this study are generalisable to older drivers with less severe illness treated in an urban emergency department during daytime hours. Second, this study relied on participants' self-reported information which may or may not accurately reflect their true driving behaviours. Third, our findings that a high proportion of older drivers performed below the cut-offs in the TMTB and/or had slow reaction time may not indicate that all of these drivers are unfit to drive. No bedside or office-based screening test is reliably able to detect driving ability in an individual patient, although there is some evidence that the TMTB test correlates with on-road driving performance and with crash risk (Dobbs & Shergill, 2013; Bedard et al., 2008; Langford, 2008). Furthermore, the functional deficiency of study participants who failed the tests could be temporary due to the medical conditions that caused the ED visit. It is also possible that drivers who refused functional testing have different driving abilities than those who participated in this part of the study. We note, however, that the driving patterns and demographic information of drivers who agreed to functional assessment were very similar to that of participants who refused functional assessment.

Conclusions

In this sample of older emergency department patients who were current drivers, we found that the driving abilities and driving needs were similar between the young older (aged 70-79) and the old older (aged ≥80) drivers although the younger age group drivers have not had a formal medical assessment for driving fitness. In this study, we found that close to one third older drivers had never taken public transit and about 60 percent drove daily in past month. Most drivers (75%) perceived themselves as good to excellent drivers and only 38 percent of all drivers said they would avoid driving in more than 3 difficult driving conditions. Functional screening tests indicated that some drivers might have cognitive impairment and slowed reflexes which may impair their ability to drive safely in some situations. Findings from this study may help increase ED physicians' awareness of driving fitness of older adult patients.

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The Association between Visual Abilities and Objectively-Measured Driving Space, Exposure, and Avoidance among Older Drivers: A Preliminary Analysis

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Key Findings

- Study participants had mostly good visual function at the time of their enrollment.
- Poorer visual acuity and perception were related to a smaller driving space.
- Poorer visual acuity and perception were related to a lower driving exposure.
- Poorer visual acuity and perception were related to greater driving avoidance.

Abstract

The objective of the study was to determine if there is a relationship between objective measures of visual function and objective measures of driving habits. The study used data from 2,131 drivers aged 65-79 enrolled in the United States based Longitudinal Research on Aging Drivers (LongROAD) study. Correlational analysis were conducted of three measures of visual function at baseline and six GPS-derived measures of driving averaged over the subsequent year. Results showed that participants had generally good visual function at the time of their enrollment. Analyses found that lower visual acuity and poorer visual perception abilities were related to a smaller driving space, lower driving exposure, and greater driving avoidance, although not for every measure. Poorer contrast sensitivity was associated with avoidance of nighttime driving and driving on high-speed roads, but was not related to driving space or exposure. This study provides evidence about how poor visual abilities can impact subsequent yearly driving. These results support other research evidence that the lower than expected crash-involvement of people with declining visual function may be related to the fact these drivers self-regulate their driving. A limitation of the study was that all significant correlations were relatively small, suggesting that other variables in addition to the ones analyzed may also be important for understanding the relationship between driving habits and visual function scores.

Keywords

Traffic Safety, Mobility, Visual Acuity, Contrast Sensitivity, Visual Perception.

Introduction

The populations of most countries are aging. In the United States (US) for example, the population of older adults (age 65 or older) is expected to grow by 27%, from 431 million older adults in 2012 to a projected 727 million in 2030 (Ortman, Velkoff, & Hogan, 2014). Older adults will also account for a larger percentage of the total population, increasing from 13.7% in 2012 to 20.3% in 2030. It is expected that a large majority of older adults will also retain their driver licenses (Sivak & Schoettle, 2011). At the same time, research has established that visual functioning declines in older adulthood (see Owsley, 2011 for a review) and that many vision-related diseases are more common as one ages (Charlton et al., 2010; Dobbs, 2005).

Good visual function is important for safe driving. Indeed, 100 years ago, researchers were discussing the relationship between visual function and traffic crashes (see e.g., Bonner, 1923; Clements, 1906), yet studies have found mixed results about the effects of visual function declines on crash risk among older adults (see Owsley & McGwin, 1999, 2010 for reviews). For example, in a study of age-related macular degeneration (AMD) researchers found that people with AMD performed worse on driving tasks compared to controls, yet they had fewer crashes than controls (Szlyk, Pizzimenti, & Fishman, 1995). The researchers surmised that this finding resulted from people with AMD restricting their driving and thereby managing their exposure to crashes. There is other evidence in the scientific literature that older adults with certain visual conditions, such as cataracts (Owsley et al., 1999), glaucoma (van Landingham et al., 2013; Ramulu et al., 2009), central vision loss (Sengupta et al., 2014), and maculopathy (DeCarlo et al., 2003) report that they restrict their driving relative to those with normal vision. The literature also shows that people who have documented declines in visual function, such as in visuospatial perception, contrast sensitivity, and acuity, report restricted driving space, reduced driving exposure, and increased driving avoidance (e.g., Baldock et al., 2006; Ball et al., 1998; Brabyn et al., 2005; Freeman et al., 2006; Keay et al., 2009; Lotfipour et al., 2010; Ross et al., 2009; Sandlin, McGwin, & Owsley, 2014; Satariano et al., 2004; Stutts, 1998; West et al., 2003).

Nearly all of these studies, however, rely on participants' self-reporting their driving habits. Recent work with older drivers has found that when subjective estimates of driving over one week were compared to actual driving measured by a global positioning system (GPS) device installed in their vehicles and by driver-completed trip logs, older drivers were inaccurate at estimating their amount of driving and the number of trips they had taken (Blanchard, Myers, & Porter, 2010). There is a lack of research investigating the relationship between objectively measured visual abilities and objectively measured driving habits among older drivers. A study in Maryland explored the relationship among several functional abilities, including several measures of visual function, and driving at night as measured by an in-vehicle monitoring system (Kaleem, et al., 2012). The 990 participants in the study (age 67-87) had a custom data acquisition system installed in their vehicles, and they drove as they normally would for five days. Nighttime driving was defined as any part of a trip occurring during specific hours, and video of the drivers' face was used to determine who was driving the car. Using multivariate analyses, the study found that older drivers with better visual acuity and better contrast sensitivity were more likely to be driving at night when nighttime driving was measured objectively over a 5-day period. The purpose of the present study was to conduct a preliminary examination of an extensive data set of the relationship between measures of visual function at baseline and objective measures of driving habits (space, exposure, and avoidance) averaged over a long period of time among older drivers at five locations in the US.

Methods

The study utilized data from the multi-site Longitudinal Research on Aging Drivers (LongROAD) study. The LongROAD study was designed to explore several areas of older driver safety and mobility, including: protective and risk factors; medications; medical conditions; self-regulation; in-vehicle technologies and aftermarket adaptations; and cessation of driving. Study participants were enrolled in and around five cities across the US (Ann Arbor, MI; Baltimore, MD; Cooperstown, NY; Denver, CO; and San Diego, CA). Participant inclusion criteria were: aged 65-79 years; held a valid driver licence; drove on average at least once per week; had no significant cognitive impairment as determined by a score ≥4 on the Six Item Screener (Callahan et al., 2002) and medical record review; drove a primary vehicle at least 80% of the time that was model year 1996 or newer; planned to reside in the study area 10 months per year; and had no plans to move outside of study area in next five years. Eligible and interested individuals were scheduled for an in-person baseline session. All study protocols were approved by each site's Institutional Review Board.

Data used for this study were baseline measurements of visual function and objective driving data averaged over 12 months following baseline assessment. At baseline, participants completed a set of in-person functional assessments, including vision.

To record objective driving behavior data, a small device called a datalogger was installed in each participant's primary vehicle by plugging it into the on-board diagnostic (OBDII) port. The datalogger recorded GPS information (10 Hz), accelerometer data (4 Hz), and other vehicle data whenever the vehicle ignition was turned on. The datalogger had a built-in cellular system that was used to transmit data at the end of each trip, when the vehicle ignition was turned off. This cellular system was also used to "ping" the datalogger each day to ensure its proper operation. A Bluetooth receiver was used to detect when the study participant was the driver of the vehicle. The receiver detected and recorded the codes and signal strengths of all Bluetooth tags carried by the study participant and any other regular user of the participant's primary vehicle once per minute. This allowed us to determine the driver of the vehicle and remove any trips made by a non-participant. Further details of the data collection system, study methods, and power analysis to determine sample size can be found elsewhere (Li et al., 2017).

Driving data were filtered to identify participants who had been in the study for at least a 12 full months of participation at the time of analysis (n=2,131) and the remaining participants were excluded. For participants with more than 1 year of participation, only the first 12 months were analyzed. The objective driving habit measures were based on previous work (Molnar et al., 2013) and were conceptualized based on three components of the Driving Habits Questionnaire (DHQ, Owsley et al., 1999): driving space, driving exposure, and driving avoidance. The objective driving habit measures used were similar to the self-reported topics addressed in the DHQ, but derived from data recorded from the datalogger device installed in each participant's vehicle. The driving habit measures used in this study were: two measures of driving space (percent of trips within 15 miles [24 km] of home; percent of trips within 25 miles [40 km] of home); two measures of driving exposure (average miles driving per month; average days driving per month); and two measures of driving avoidance (average percent of trips at night; average percent of trips on high speed roads). Definitions of these measures are shown in Table 1. The monthly driving habit measures were averaged for each participant's year of data to obtain a mean and standard deviation (sd) for each measure.

The baseline assessment data for three measures of visual function were extracted for these participants from the LongROAD data. Visual function was measured with glasses or contact lenses being worn if they were used for driving. The measures of visual function were: Tumbling E (visual acuity), Pelli-Robson (contrast sensitivity; Pelli et al., 1988), and the Motor Free Visual Perception Test (MVPT-3) (overall visual perception ability, Colarusso & Hammill, 2003). The visual acuity analyses used measures for both eyes. Because of a problem with measuring visual acuity at one of the data collection sites, visual acuity data from this site are excluded from analysis. Tumbling E scores were converted to logarithm of the Minimum Angle of Resolution (logMAR). Scores could range from -0.10 to 0.70, with a score of 0 being average, scores greater than 0 representing increasingly worse acuity relative to average, and scores less than 0 being acuity that was increasingly better than average. The World Health Organization (WHO) and others (Dandona & Dandona, 206; WHO, 2012; West et al., 1997) define mild vision loss as logMAR scores in the range of 0.18 to 0.48 in the better eye. Visual acuity was converted to a binary variable that consisted of non-impaired acuity (scores of -0.10 to 0.18, n=1,949) and impaired acuity (scores of 0.30 or greater, n=168). This cut-off was selected in order to have a large enough sample of people with vision loss while still being in the range of mild vision loss or worse defined by the WHO. This binary variable was used in analyses. The analyses of contrast sensitivity used results from only the better eye. Scores on this test could range from 0 to 2.2 with higher scores indicating better contrast sensitivity. Scores on the overall measure of visual perception were based on the number of correct answers for test items 22-34 of the MVPT-3. Scores, therefore, could range from 0-13, with higher scores indicating better visual perception. Spearman correlations were calculated to compare driving habits and visual function measures.

Results

The 2,131 participants included in these analyses were 48.6% male, 85.7% White Non-Hispanic (6.8% Black Non-Hispanic, 2.6% Hispanic, and 2.3% Asian), and had a mean age of 71.2 years. Participants were well educated: 13.3% had a high school/trade degree or less, 21.2% had some college or an associate degree, 23.8% had a bachelor degree, and 41.7% had an advanced college degree. Annual household incomes were relatively high: 4.3% reported less than $20,000, 21.0% reported $20,000-$49.999,

Table 1. Means, standard deviations, definitions, and categories for each driving habit measure

Driving Habit Measure	Mean Median (sd)	Definition for the Monthly Variable (Trip is defined as ignition-on to ignition-off)	Category
Average monthly % trips within 15 miles (24 km) of home	64.1 67.2 (22.4)	Percent of trips traveled in month within 15 miles (24 km) of home.	Driving Space
Average monthly % trips within 25 (40 km) miles of home	75.8 80.8 (18.9)	Percent of trips traveled in month within 25 miles (40 km) of home.	Driving Space
Average miles [km] per month	791.4 [1273.6] 705.4 [1135.2] (444.2) [714.9]	Total number of miles driven in month.	Driving Exposure
Average days driving per month	22.5 23.3 (5.0)	Total number of days in month with at least one trip.	Driving Exposure
Average monthly % of trips at night	6.7 5.6 (5.1)	Percent of trips in month during which at least 80% of trip was during nighttime, with nighttime defined as end of evening civil twilight to beginning of morning civil twilight or a solar angle greater than 96 degrees.	Driving Avoidance
Average monthly % of trips on high speed roads	12.9 9.9 (10.9)	Percent of trips in month during which at least 20% of distance travelled was at a speed of 60 MPH (97 km/h) or greater (a proxy for travel on high speed roads).	Driving Avoidance

24.8% reported $50,000-$79,999, 15.0% reported $80,000-$99,999, and 31.4% reported $100,000 or more.

The means, medians, and standard deviations of the six driving habit outcomes measures are shown in Table 1. The means scores, standard deviations (sd), and number of participants (n) for the visual function measures were: visual acuity (0.09, sd=0.12, n=1,509), contrast sensitivity (1.61, sd=0.14, n=2,117), and visual perception (11.6, sd=1.7, n=2,127). Figures 1-3 show the distributions of scores across the participants for visual acuity (Figure 1), contrast sensitivity (Figure 2), and visual perception (Figure 3).

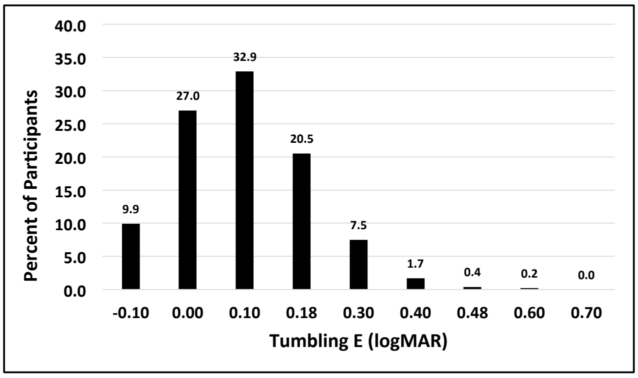

Figure 1. Distribution of logMAR scores for the Tumbling E test of visual acuity

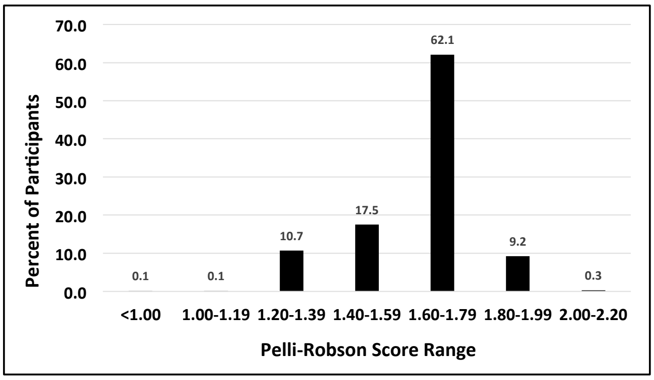

Figure 2. Distribution of scores for the Pelli-Robson test of contrast sensitivity (best eye)

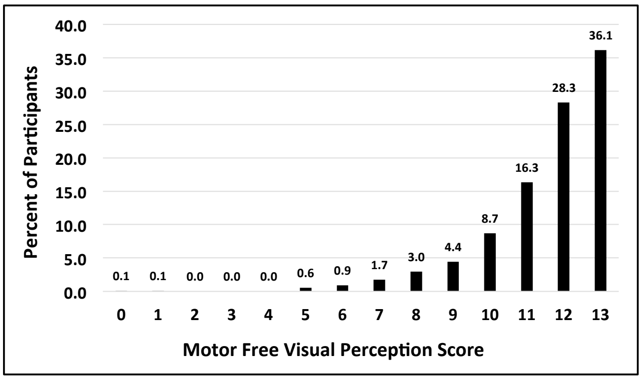

Figure 3. Distribution of scores for the Motor Free Visual Perception Test

Table 2 shows results of the correlation analysis (coefficient and p-value) across each driving habit/visual function comparison. The study found that both measures of driving space were significantly associated with visual acuity and visual perception scores, with worse scores being associated with a higher percentage of trips close to home: average monthly % trips within 15 miles (24 km) of home (67.2% for acuity impaired vs 73.5% for acuity not impaired; and 81.2% for the worse visual perception to 63.7% for the best visual perception); average monthly % trips within 25 (40 km) miles of home (78.0% for acuity impaired vs 83.0% for acuity not impaired; and 87.9% for the worse visual perception to 75.0% for the best visual perception). Contrast sensitivity was not associated with these measures of driving space. Analysis of the two driving exposure measures showed that average miles driven per month was significantly lower in the group with impaired acuity (765.3 miles [1231.6 km] vs 650.1 miles [1046.2 km]). Contrast sensitivity and visual perception scores were not statistically associated with this measure, but lower visual perception scores were associated with greater average number of days driving per month (number of days ranged from 23.8 for the worst visual perception to 22.4 for the best). To explore this finding further, we divided the average monthly days of driving scores into quartiles and determined the average MVPT-3 scores for each quartile. The results showed the following average scores by quartile from least days driving per month to the most: 11.6, 11.8, 11.5, and 11.4. These averages showed that there was little difference from the overall mean of 11.6 for any quartile and that there was no evident trend that explained the significant but small correlation. Both driving avoidance measures were associated with all three visual function measures, except that percentage of trips on high speed roads was not associated with visual acuity. For all statistically significant correlations, better visual function scores were associated with increasing average percentages of trips at night and on high speed roads: average monthly % trips at night (7.2% not impaired acuity vs 6.3% impaired acuity; percentages on contrast sensitivity ranged from 5.3% for the worse to 10.6% for the best; percentages on visual perception ranged from 5.7% for the worst to 7.2% for the best); and average monthly % of trips on high speed roads (percentages on contrast sensitivity ranged from 5.7% for the worse to 13.1% for the best and percentages on visual perception ranged from 11.1% for the worst to 14.6% for the best).

Discussion

This study sought to answer the question of whether there was a significant relationship between baseline measures of visual function and objective measures of driving habits averaged over a 1-year follow-up period after visual function assessment. The study found that, in general, lower visual acuity and poorer visual perception abilities among this cohort of older drivers were related to a smaller driving space, lower driving exposure, and greater driving avoidance. Poorer contrast sensitivity, which is related to one's ability to see in low light conditions, was associated with avoidance of night time driving (in agreement with the results reported by Kaleem, et al., 2012) and driving on

Table 2. Spearman correlations and p-values across each driving space/visual function comparison, with statistically significant differences shown in bold

Driving Habit Measure	**Visual Acuity (Tumbling E, LogMAR) n=1,509**	**Contrast Sensitivity (Pelli-Robson) n=2,117**	**Visual Perception (MVPT-3) n=2,127**
Average monthly % trips within 15 miles (24 km) of home	**0.09138 p=.0002**	0.01242 p=.5679	**-0.05029 p=.0204**
Average monthly % trips within 25 miles (40 km) of home	**0.08536 p<.0005**	0.00232 p=.9149	**-0.08076 p=.0002**
Average miles driven per month	**-0.09121 p=.0002**	-0.00684 p=0.7532	0.02556 p=.2397
Average days driving per month	-0.01305 p=.5937	-0.00159 p=.9416	**-0.04550 p=.0360**
Average monthly % of trips at night	-0.07812 p=.0014	.07880 p=.0003	0.08199 p=.0002
Average monthly % of trips on high speed roads	-0.04368 p=.0741	**0.12199 p<.0001**	**0.14885 p<.0001**

high speed roads, but was not related to measures of driving space or exposure. Thus, at least among the LongROAD cohort of older drivers, poorer visual function was generally related to the three categories of driving habits investigated in the study, as measured over a full year post visual function measurement.

Study results showed that most LongROAD participants included in these analyses had relatively good visual function at the time of their enrollment in the study, yet some had poor visual function. A binocular visual acuity score of 0 or less is considered normal or better than normal visual acuity, while mild visual impairment is considered to occur starting at a score of 0.18 or worse (see e.g., WHO, 2012). As shown in Figure 1, about 70% of the participants had scores better (lower) than 0.18 on the test of visual acuity. Older adult population norms for contrast sensitivity measured by the Pelli-Robson test average about 1.85 and range from about 1.70 -2.00 (see e.g., Mäntyjävi & Laitinen, 2001). The average score in the present study was 1.61, with about 90% of the sample scoring better (lower) than 1.80. No published norms for MVPT-3 scores (test items 22-34) for older adults could be found to which to compare the present study results. However, three large samples of healthy older drivers (787 adults age 55 and older, Ross et al., 2009; 697 older adults age 55-92, Vance et al., 2006; 1,910 adults age 55 and older, Ball et al., 2005) found average numbers of incorrect responses of 1.4, 1.5, and 1.7 (non-crash involved adults)/2.2 (crash-involved adults), respectively. The average number of incorrect items among the LongROAD participants in this study was 1.4, which is the same or better than these other studies. The high visual functioning of the LongROAD cohort is likely related to the inclusion criteria used for the study which required people to be active drivers and to be willing to have their driving monitored over several years (Li et al., 2017). We anticipate that visual function measures will show overall declines compared to the present results in the second in-person assessment, taking place between late 2017 and early 2019.

This study provides further evidence about how poor visual abilities can impact driving in the year following assessment when objective measures of driving, rather than self-reported driving, are considered. Scores on the MVPT-3 test, in particular, were related to restricted driving for all but one of the driving habit measures. These results also provide further evidence that the lower than expected crash involvement of people with declining visual function may be related to the fact the these drivers self-regulate their driving. By reducing their driving space and exposure, and avoiding challenging driving situations, older drivers may be able to lower their risk of a crash.

The strengths of this study include the use of a large sample of older drivers recruited from five distinct geographic locations in the US, and the use of objective driving data collected over an entire year. A limitation of the study was that all significant correlations were relatively small, suggesting that other variables in addition to the ones analyzed may also be important for understanding the relationship between driving habits and visual function scores. Nevertheless, we believe that the practical significance of these results is high. For example, the study found that those with impaired visual acuity drove an average of 14% less distance per month as compared to those with non-impaired acuity (a difference of nearly 100 miles [161 km]). Over the course of 12 months, this equates to an important reduction in exposure. As this longitudinal study continues, and the visual function of a greater number of participants declines, multivariate analyses will explore in greater depth the effects of visual function loss on driving space, exposure, and avoidance. Finally, the LongROAD cohort is relatively well-educated with high household incomes and, therefore, not necessarily representative of all older adult drivers. As such, these results may not generalize to all older driver populations.

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Driving-related Attitudes among Older Adults in Australia

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Key Findings

- The Decisional Balance Scale can be used to assess driving-related attitudes among older adults
- Changes in attitudes covaried with changes in self-regulatory driving practices across six annual assessments in a sample of Australian older drivers.
- Attitudes related to driving may facilitate self-regulatory driving practices among older adults.

Abstract

The Decisional Balance Scale (DBS) was developed to assess older adults' attitudes related to driving and includes both intra- and inter-personal motivations for driving. The current study examines the DBS in a sample of older drivers from Australia ($n = 257$). Longitudinal evaluation of the DBS subscales revealed that changes in attitudes covary with changes in self-regulatory driving practices across 6 annual assessments. Specifically, negative attitudes related to inter-personal motivations for driving (*con-other*) were associated with participants' scores on the Situational Driving Frequency (SDF) scale. Negative attitudes related to intra-personal motivations for driving (*con-self*) were associated with participants' scores on the Situational Driving Avoidance (SDA) scale. These findings highlight the importance of considering attitudes in understanding older drivers' decisions to regulate their driving practices.

Keywords

Driving, Attitudes, Beliefs, Older driver

Introduction

For many older adults, driving provides a sense of independence. However, age-related declines in cognition and physical health can impair driving ability (Anstey, Wood, Lord & Walker, 2005; Babulal et al., 2017; Roe e al., 2017). The number and proportion of individuals aged 65 and older in Australia is expected to double over the next 30 years along with the percentage of older drivers who remain on the road (Australian Bureau of Statistics, 2013). Self-regulation can facilitate safe driving practices. Driving self-regulation refers to the ability to use compensatory strategies, such as reducing driving exposure, and avoiding challenging driving situations to accommodate age-related declines and to better adapt to the driving environment (Molnar & Eby, 2008; Sullivan, Smith, Horswill, & Lurie-Beck, 2011).

Reviews of the literature on older drivers calls for the consideration of attitudes in assessing cognitive processes that promote behaviours related to driving self-regulation (Wong, Smith, Sullivan, & Allen, 2014). However, the association between attitudes and driving practices has primarily been examined in North American samples. The current study specifically examines driving-related attitudes and associations with driving self-regulation in a sample of older drivers from Australia who participated in the Candrive II/Ozcandrive study, a multi-centre prospective cohort study examining the predictive validity of tools for assessing fitness to drive in a cohort of older drivers in seven cities in four Canadian provinces, as well as in two sites in Melbourne, Australia and Wellington, New Zealand (Marshall et al., 2013).

Various approaches have been used to assess driving-related attitudes among older adults. For example, the Day and Night Driving Comfort Scales (DCS-D and DCS-N, respectively) were developed to assess older adults'

Table 1. Number and percent of participants with data at each annual assessment

	Assessment Period					
	T1	T2	T3	T4	T5	T6
Number (% of original sample)	257	241 (94%)	225 (86%)	215 (84%)	197 (77%)	180 (70%)

Note. T = Time point

perceived driving confidence (Myers et al., 2008) and are based on the Social Cognitive Theory construct of self-efficacy (Bandura, 1986). Ratings on the DCS-D and DCS-N scales have been shown to be related to both self-reported (MacDonald, Myers, & Blanchard, 2008; Myers et al., 2008) and objectively measured self-regulatory driving practices in older drivers residing in Canada (Blanchard & Myers, 2010; Crizzle & Myers, 2013; Myers, Trang, & Crizzle, 2011). Another measure, the Decisional Balance scale (DBS) derived from the Transtheoretical Model of Behavior Change (Prochaska & DiClemente, 1982), was developed to assess positive and negative driving attitudes concerning intrapersonal (i.e., attitudes concerning one's driving) and interpersonal (i.e., attitudes concerning one's driving in relation to others) motivations for driving (Tuokko, et al., 2006). Previous studies involving Canadian older drivers have reported that individuals who possessed more positive attitudes about how their driving impacted others were less likely to restrict their driving (measured by self-reported driving frequency), whereas those who held more negative attitudes toward how their driving impacted others were more likely to active restrict their driving (Jouk et al., 2013; Jouk et al., 2016; Tuokko et al., 2006; Tuokko et al., 2016). Similarly, in a cross-sectional study on Australian older drivers, negative attitudes towards driving have been shown to predict more driving self-regulation, particularly among women (Conlan et al., 2017).

To our knowledge, to date, no longitudinal studies of the relationship between attitudes and self-regulatory driving practices have been reported among older drivers in Australia. The DBS is one of the instruments included in the Candrive II/Ozcandrive study (Marshall et al., 2013). The longitudinal associations between driving-related attitudes (measured by the DBS) and self-regulatory driving practices have previously been examined in the Canadian sample (Sukhawathanakul et al., 2015, Tuokko et al., 2016), but not in the Australian sample. The primary objective of the current study was to examine whether changes in the attitudinal subscales covary with changes in self-regulatory driving behaviours (situational driving frequency and avoidance) across 6 periods of assessment.

Methods

Participants

Participants (n = 257) were recruited from Melbourne, Australia. At baseline, participants ranged in age from 75 to 94 years (M = 79.74, SD = 3.51); 71% (n = 182) were men. Twenty-one percent of individuals completed some post-secondary education, 44% had obtained a diploma or a trade/technical certificate beyond high school, 11% completed high school, and 24% did not continue beyond grade school.

The number and percent of participants with data at each assessment is provided in Table 1. By the last assessment of the study, 70% of the original sample had been retained. Selective attrition was assessed by testing for differences at T1 on demographics variables (sex, age, education) and number of medical conditions between participants who remained in the longitudinal study (n = 180) and those who did not participate at the last time point in T6 (n = 77). No significant sex or educational differences were found. Participants who dropped out of the study also did not have more medical conditions at baseline. However, participants who remained in the study were slightly younger at baseline (M = 79.33, SD = 3.12) than participants who dropped out of the study (M = 80.69; SD = 4.17), $t(255) = 2.88$, $p = .004$.

Procedure

All participants provided written informed consent and underwent 6 annual comprehensive evaluations of their health status, functioning, driving habits, and intentions. Psychosocial scales and measures of driving restrictions were completed at home and returned by mail. Marshall et al. (2013) provides detailed information outlining the procedures of the Ozcandrive studies.

Measures

Decisional Balance. The DBS scale asks participants to rate their responses on a 5-point scale ranging from "Strongly Agree" to "Strongly Disagree" to statements concerning attitudes towards driving that comprise four subscales, each with seven items. Specifically, the DBS examines positive aspects of driving relevant for the individual (Pro-self), positive aspects of driving relevant for others (Pro-other), negative aspects of driving relevant for the individual (Con-self), and negative aspects of driving relevant to others (Con-other). Specific descriptions of each subscale are presented in Table 2. Measurement invariance across multiple time points for the DBS has been established previously (Sukhawathanakul et al., 2015).

Driving Self-regulation. The Situational Driving Frequency (SDF) and Situational Driving Avoidance (SDA) scales were developed for older adults to assess self-reported practices (frequency and avoidance, respectively) concerning driving in challenging situations such as driving at night and on highways. On the 14-item SDF scale, respondents rated how frequently they engage in challenging driving situations (such as at night, in new or unfamiliar areas) on a 5-point scale ranging from "Never" to "Very Often." Scores ranged

Table 2. Description of the Decisional Balance Subscale

Decisional Balance Subscale	Example and Scoring of Items
Pro-self: positive perceptions of the self in relation to driving.	e.g., "Driving a vehicle is pleasurable"; higher scores indicate fewer positive perceptions of the respondent's own driving
Pro-other: positive perceptions of driving in relation to others	e.g., "Others count on me being able to drive"; higher scores indicate fewer positive perceptions of the respondent's driving in relation to others
Con-self: negative perceptions of the self in relation to driving.	e.g., "The financial cost of maintaining a vehicle is an increasing concern of mine"; higher scores indicate fewer negative perceptions of the respondent's own driving
Con-other: negative perceptions of driving in relation to others	e.g., "My driving bothers other people"; higher scores indicate fewer negative perceptions of the respondent's driving in relation to others

from 0 – 56 with higher scores indicating greater frequency of driving in challenging situations. On the 20-item SDA scale, participants were asked to indicate which challenging situations, if any, they try to avoid (such as bad weather or heavy traffic). Possible SDA scores range from 0 to 20, with higher scores indicating greater avoidance of challenging situations. Both the SDF and SDA have shown good test-retest reliability with multiple samples (Blanchard & Myers, 2010; MacDonald et al., 2008). The two constructs are moderately negatively correlated concurrently across time (rs = -.47 at T1; -.44 at T2; -.52 at T3; -.40 at T4; -.51 at T5; and -.51 at T6) suggesting that while driving frequency and avoidance are related, the constructs are not multicollinear.

Data Analytic Strategy

Multilevel models were used to assess time-varying associations between the DBS self and other subscales with driving self-regulation across 6 annual assessments. Situational Driving Frequency (SDF) and Situational Driving Avoidance (SDA) were assessed separately. All models were estimated in MPlus 7.1 using a full-information maximum likelihood estimator (FIML) with robust standard errors (MLR) to correct bias due to missingness, which uses all available data (Little & Rubin, 2014; Muthen & Muthen, 2012). Multilevel modelling procedures handle the hierarchical structure of the data in which yearly measurement occasions are nested within individuals. Multilevel models allow for individual changes to be modelled at the within-person level and the individual differences in these changes to be modelled at between-person level.

First, a time-based model estimated individual rates of driving self-regulation as a function of time across the 6-year period. DBS subscales were then included in the longitudinal models as within-person predictors of driving self-regulation. Age, sex, and level of education were added in the intercept and slope parameters to examine between-person differences in initial levels of driving self-regulation and in rates of change over time.

Results

Means and standard deviations for the DBS, SDA, and SDF scales across the 6 annual assessments are provided in Table 3. An unconditional time-based model that excluded demographic predictors was first examined with the SDA and SDF outcomes in order to determine their longitudinal trajectories. Findings from the multilevel analyses revealed that on average, SDF increased over the 6 annual assessment periods (β = .795; SE = .072; p <.001). That is, older drivers report engaging in more challenging driving situations over time. SDA did not change over time (β = .083; SE = .051; p = .099), suggesting that the frequency of avoiding challenging situations remained stable.

Demographic variables (age, sex, education) were added as between-person predictors of baseline levels and changes in SDA and SDF over time. The DBS subscales were included as within-person predictors to determine their time-varying effects on SDA and SDF over time. The subscales were estimated simultaneously in the models in order to assess their independent effects. Table 4 provides results of the multilevel models for SDF and SDA.

Situational Driving Frequency

Age and sex predicted between-person differences at baseline. Specifically, women who were older reported lower SDF at baseline (βs = -.430 and -3.031; SEs =.118 and .984; ps < .001). None of the demographic variables moderated changes in SDF over time. At the within-person level, the con-other subscale was associated with SDF after accounting for the independent effects of the other subscales (β = .215; SE = .099; p = .029). Specifically, individuals engaged in greater SDF during years when they held less negative attitudes regarding their driving in relation to others (con-other) relative to their average yearly attitudinal levels.

Situational Driving Avoidance

None of the demographic variables predicted between-person differences at baseline. However, age and sex moderated changes in SDA over time. Specifically, individuals who were older and women increased their SDA strategies over time at a faster rate than individuals who were younger and men (βs = .036 and .333; SEs = .016 and

Table 3. Means and standard deviations of study variables

	Waves					
	1	2	3	4	5	6
Decisional Balance Subscales						
Pro-self	21.28(5.27)	21.42(5.27)	21.18(5.64)	21.18(5.49)	21.17(5.82)	21.07(5.61)
Con-self	34.19(4.94)	34.47(4.85)	34.77(4.83)	34.51(5.03)	34.35(5.18)	34.65(7.70)
Pro-other	13.93(3.07)	14.23(3.02)	14.15(3.44)	13.95(3.36)	14.79(7.72)	14.16(3.59)
Con-other	30.44(3.28)	30.40(3.54)	30.43(3.47)	30.44(3.56)	30.27(3.61)	30.03(3.64)
Driving Self-regulation						
Situational Driving Frequency	32.89(6.71)	32.99(6.92)	32.71(6.92)	32.44(9.70)	45.48(6.45)	31.28(6.82)
Situational Driving Avoidance	5.33(3.77)	5.39(3.60)	5.67(3.82)	4.67(3.84)	4.57(3.92)	5.04(4.35)

Note. Standard deviations provided in parentheses.

Table 4. Multilevel models of the self-regulatory driving practices

	Situational Driving Frequency		Situational Driving Avoidance	
	β	SE	β	SE
Intercept	58.924***	9.918	6.655	6.102
Age	-0.430***	0.118	0.046	0.071
Sex	-3.031**	0.984	0.890	0.560
Education	-0.084	0.263	0.122	0.153
Time Slope	1.580	1.973	-2.691*	1.307
Age	-0.007	0.025	0.036*	0.016
Sex	-0.179	0.158	0.333**	0.108
Education	-0.030	0.044	-0.047	0.030
Time-varying Effects				
Pro-self	0.024	0.060	-0.014	0.024
Con-self	0.099	0.088	-0.129**	0.047
Pro-other	-0.161	0.124	-0.002	0.034
Con-other	0.215*	0.099	-0.054	0.043
Variances				
Intercept	15.977	24.101	5.552	7.457
Time Slope	0.005	0.832	0.133**	0.040
Pro-self	0.001	0.018	<.001	0.005
Con-self	0.001	0.004	0.001	<.001
Pro-other	0.018	0.017	0.006	0.020
Con-other	0.002	0.015	<.001	0.006

Note. $*p < .05$; $**p < .01$; $**p < .001$

.108; *p*s = .027 and .002 respectively). At the within-person, con-self was associated with SDA after adjusting for the effects of the other DBS subscales (β = -.129; SE =.047; p = .006). Specifically, during the years when individuals reported more negative attitudes about their own driving relative to their average yearly level of negative attitudes, they engaged in more driving avoidance behaviours.

Discussion

The DBS is an established scale that provides insights into driving-related attitudes that may affect older driver's decisions to regulate their driving. The DBS captures the multidimensional construct of driving-related attitudes that acknowledges the influence of both intrapersonal and interpersonal factors. This study assessed the DBS in a sample of Australian older drivers. Examination of the longitudinal associations between the DBS subscales and self-regulatory driving practices revealed that both negative and positive attitudes covary with changes in situational driving frequency and avoidance across 6 annual assessments.

On average, older adults in this sample report engaging in more challenging driving situations over time while avoidance behaviours remained stable. This finding is surprising and is in contrast to what is reported in previous studies with Canadian samples (e.g., Jouk et al., 2016) where SDF tends to decrease and SDA increases over time. However, previous studies have examined SDF and SDA over a shorter time frame of three or fewer years. It may be that over a longer period of time, older adults who remain on the road increasingly encounter more challenging driving situations. Participants who remain in the study may also be more comfortable with driving in challenging situations relative to participants who do not remain in the study. However, these average SDF and SDA levels are moderated by changes in attitudes related to driving.

Significant longitudinal associations between the DBS subscales and frequency of driving in and avoiding challenging situations (SDF and SDA) suggest that changes in older adults' attitudes correspond with self-regulatory driving practices over time. With regards to situational driving frequency, individuals who reported fewer negative attitudes of their driving in relation to others (con-other) drove more frequently in challenging situations. These findings portray a complex relationship between negative attitudes and older adults' driving behaviours, particularly concerning attitudes that value relationships with other people (e.g., when others count on you to drive, driving as an important part of one's community, concern when others are critical of your driving). On the other hand, negative attitudes in relation to the self (con-self) were most predictive of situational driving avoidance. Specifically, individuals who held more negative attitudes towards their own driving engaged in more driving avoidance behaviours. This finding suggest that actively avoiding certain driving situations may depend on the appraisal of one's own driving ability and comfort (e.g., increasing apprehensions about driving, concerns about own driving ability) rather than positive attitudes or attitudes related to interpersonal relationships.

Taken together, these findings suggest that driving-related attitudes consisting of both intra- and interpersonal motivational components have implications for driving self-regulatory behaviours. The longitudinal associations between the DBS subscales and driving self-regulation are consistent with previous studies. In particular, in the Canadian Candrive sample of older drivers, individuals whose attitudes towards their own driving (con-self) became more negative over time were increasingly restricting their driving by avoiding more challenging driving situations compared to individuals whose attitudes towards driving remained stable across a three-year period (Tuokko et al., 2016). The positive association between con-other and SDF has also been reported in a three-year longitudinal psychometric examination of the Decisional Balance Scale (Sukhawathanakul et al., 2015). Results of this study further support the utility of the DBS in assessing attitudes with older drivers from Australia. Specifically, findings from this study, examined over a longer assessment period across six years than was previously reported in the Canadian studies, suggests that changes in attitudes can have enduring associations with driving self-regulatory practices. As older adults increasingly adopt more self-regulatory practices as they age (D'Ambrosio, Donorfio, Coughlin, Mohyde, & Meyer, 2008; Donorfio, Mohyde, Coughlin, & D'Ambrosio, 2008), it is possible that attitudinal changes can facilitate or deter self-regulatory driving practices over time. Future research is needed to understand the underlying mechanisms between driving attitudes and self-regulatory driving practices, as well as how these mechanisms change over time.

Limitations

Findings from this study highlight the longitudinal relationship between driving-related attitudes and self-regulatory driving practices. However, causal conclusions cannot be made due to the limits of the analyses. It is unclear whether shifts in attitudes promote the use of self-regulatory driving strategies or whether it is the increasing use of compensatory strategies that spur a change in attitudes. Future studies that test these directional pathways are needed.

Moreover, measures of self-regulatory driving practices used in this study were limited to self-reports. Although the SDF and SDA scales have good psychometric properties and provide an indication of self-regulation, studies have shown that older adults may drive more in challenging situations and avoid such situations less than they report (Blanchard, Myers & Porter, 2010; Crizzle, Myers & Almeida, 2013). Future examinations of their associations with objective driving measures (e.g., mileage driven) may yield different information about how attitudes shape driving practices.

Despite these limitations, our study demonstrates that the DBS can be used as an instrument for measuring attitudes toward driving among Australian older drivers. Continued use of this scale in future studies is warranted to better understand how self-regulatory behaviours develop in older adulthood, including corresponding decisions to restrict and cease driving.

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Characteristics of low and high mileage drivers: Findings from the Ozcandrive older driver cohort study

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Key Findings

- Low mileage group had proportionally more female than male drivers
- Low mileage group drove most trips within 5 km and fewest trips beyond 20 km
- High mileage group drove least trips within 5 km and most trips beyond 20 km
- No significant group differences on all functional outcomes or crash/citation data
- Low mileage group reported lowest scores on Driving Comfort Scale

Abstract

This study used real-world driving data from the Ozcandrive older driver cohort study to examine the relationship between annual mileage driven and a range of demographic and functional factors, self-reported driving comfort, real-world driving patterns and self-reported crashes and citations. Driving data for a subset of Australian participants of the Candrive/Ozcandrive study (n = 183), aged 75-94 years were included in the analysis. Participants' real-world annual mileage distances were recorded through an in-car recording device (ICRD) installed in participants' own vehicles. Participants' annual mileage distances were grouped into three categories (low: ≤ 5,000 km, middle: > 5,000 - < 13,000 km, and high: ≥ 13,000 km). Preliminary results showed females were more likely to be in the low mileage group compared to male drivers. Additionally, the low mileage group drove significantly more trips 5 km or less compared to the middle and high mileage groups, while the high mileage group drove the greatest percentage of trips beyond 20 km compared to the low and middle mileage groups. On average, the low mileage group reported the lowest total scores on the Driving Comfort Scale compared to the high mileage group which reported the highest total score. However, there were no significant group differences on any tests of cognitive/functional ability or crash and citation rates. Findings suggest that older adults who drive lower annual mileages may engage in some driving practices that are suggestive of self-regulation. However, a larger-scale study using official crash data is needed to establish whether the low mileage bias is pertinent to older drivers.

Keywords

Older drivers, Low Mileage Bias, Crash risk, Functional ability, Real-world driving

Introduction

Older drivers represent one of the highest risk groups for crash-related deaths and serious injuries per number of drivers and per distance travelled (Koppel, Bohensky, Langford, & Taranto, 2011; Langford & Koppel, 2006). Although there is support for the assertion that older drivers are overrepresented in crashes (OECD., 2001), previous research has found that when annual mileage driven is accounted for, only older drivers with low annual mileages show a heightened crash risk per unit of distance travelled compared to older drivers with higher annual mileages (Janke, 1991). This is consistent with the notion that irrespective of age, drivers who travel shorter distances per trip will have greater crash involvement per unit of distance in comparison to drivers who travel longer driving distances per trip (Alvarez & Fierro, 2008).

The term 'low mileage bias' (LMB) has been used to describe the phenomenon that drivers with lower annual mileages have increased crash rates (Alvarez & Fierro, 2008; Hakamies-Blomqvist, Raitanen, & O'Neill, 2002; Langford, Methorst, & Hakamies-Blomqvist, 2006). The LMB was first demonstrated by Hakamies-Blomqvist et al. (2002)

in a survey of 1,869 drivers within two age groups (26-40 years; 65+ years) who were divided into low, medium and high annual mileage groups (<3,000 km, 3,000 -14,000 km, >14,000 km per year, respectively). The authors found small or no differences in crash rates between the two age groups for those in medium or high mileage groups. However, they found an increase in crash rate per mile driven for older drivers in the low mileage group. Similar studies were later conducted by Langford et al. (2006) and Alvarez and Fierro (2008) among drivers aged 75 years and older who were grouped into the same annual mileage categories as Hakamies-Blomqvist et al. (2002). The authors found further support for the LMB, demonstrating elevated crash rates for drivers with lower annual mileages relative to drivers with higher annual mileages.This effect was evident in both older (i.e., 75+ years) and younger age groups (18 -75 years). Specifically, Langford et al. (2006) found only older drivers travelling less than 3,000 km per year (roughly 10% of older drivers in the survey) had heightened crash rates compared to younger drivers.

A potential explanation for the LMB is that low mileage drivers tend to drive primarily in urban areas with complex traffic situations and intersections which increase their crash risk, or number of crashes per mile of driving (Janke, 1991; Langford & Koppel, 2005). Janke (1991) found that the crash risk on non-freeways was 2.75 times higher than on freeways, likely due to difficulties in negotiating intersections. Conversely, middle and high mileage drivers may conduct more of their driving trips on controlled-access highways and multi-lane divided roadways which are associated with a lower crash risk (Langford et al., 2005).

Another possible explanation for the LMB is that low mileage drivers may have a higher crash risk due to poorer perceived or actual declines in driving ability compared to high mileage drivers. This is consistent with findings that an increased number of medical conditions, known to impair driving ability, tend to be associated with advanced age and lower mileages (Alvarez et al., 2008). Indeed, several studies have reported that low mileage drivers perform significantly worse on functional assessments and across a range of physical/sensory and cognitive tests, as well as relicensing driving examinations compared to high mileage drivers (Koppel et al., 2005; Langford et al., 2013). Similarly, low mileage older drivers have reported lower levels of comfort in challenging road situations, including at night and on freeways, had poorer perceptions of their driving abilities and reported more restrictions to their driving compared to high mileage drivers (Blanchard & Myers, 2010; Langford et al., 2013; Myers, Trang, & Crizzle, 2011). It may be that cognitive and/or physical health status is the mediating factor that both reduces annual mileages and increases crash risk (Ball et al., 1998; Owsley et al., 1998).

Although there is considerable evidence to support the LMB, most studies have examined per-mileage crash rates among older drivers using self-reported driving data and crash frequencies (Hakamies-Blomqvist et al., 2002; Langford et al., 2006; Alvarez & Fierro, 2008). However, several authors have suggested that the subjective methods used to validate the LMB may not be reliable particularly as older drivers' self-estimates of annual driving distance may be inaccurate (Langford et al., 2013; Langford, Koppel, Charlton, Fildes, & Newstead, 2006; Staplin, Gish, & Joyce, 2008). A preferred approach is to use objective data sources to measure both annual mileages and crash rates to further validate the LMB and guide improvements to roadway safety and mobility for older drivers (Langford et al., 2008).

The current study aimed to use real-world driving data from the Ozcandrive prospective study of older drivers (Marshall et al., 2013) to investigate associations between annual mileages and:

- Demographic and functional factors;
- Self-reported day-time and night-time driving comfort;
- Annual naturalistic driving patterns, and
- Self-reported crashes and driving citations.

Methods

Candrive/Ozcandrive Project

The Candrive/Ozcandrive study is a multicentre, prospective cohort study which involves a total of 1,230 older drivers from Canada, Australia and New Zealand. In addition to the naturalistic driving data collected, participants completed annual assessments, which included demographic and driving-history questions, measures of functional performance, medications and medical conditions, and self-reported information on driving-related comfort, abilities and practices. Full details on sample recruitment and annual assessment protocols can be found elsewhere (Marshall et al., 2013). All data used in the current study were from the Year 1 assessment protocols (Marshall et al., 2013).

Participants

The Australian subset of the Candrive/Ozcandrive study comprised 257 participants living in the greater Melbourne area in Victoria, Australia. Participants, ranging in age from 75 to 94 years, were recruited into the study on a rolling basis between June 2010 and June 2011. Drivers' first year of data, collected during the period June 2010 - June 2012 was included in the current study. All participants were required to meet the following inclusion criteria: (a) aged 75 years or older; (b) held a valid driver's license; (c) drove at least four times per week; (d) drove a 2003 model vehicle or newer, and (e) did not have an absolute contraindication to driving, as defined by the Austroads Fitness to Drive Guidelines (Austroads, 2013).

Measures

Naturalistic driving data

Monitoring of participants' driving patterns occurred throughout the study using a custom-designed in-car recording device (ICRD; OttoView-CD autonomous data logging device) and software suite that was developed for Candrive II/Ozcandrive by Persen Technologies Inc. (Winnipeg, Manitoba). The ICRD was powered through the on-board diagnostic port of the participants' primary vehicle. The ICRD collected information from the vehicle (e.g., time/date of trip, speed, distance travelled and vehicle parameters) and vehicle location was registered using the Global Positioning System (GPS). Data were saved at a rate of 1 Hz onto a Secure Digital (SD) card that was changed approximately every 4 months to ensure adequate storage space. For participants who shared their vehicle with another driver, a radio frequency identifier system (RFID) was attached to the study participants' car keys. The RFID signals marked the study participants' driving data, thus allowing other driver data to be disregarded. A log book was also provided for shared vehicles for the purpose of recording details for all non-participant driving trips. Additionally, in the event that participants changed their primary vehicle, every effort was made to transfer the ICRD device into the new vehicles on the same day the vehicles were acquired.

Demographic and functional performance measures

Relevant demographic characteristics (age and gender), as well as scores on a range of functional performance measures were selected for analysis. These functional performance measures are described in more detail below.

Functional Performance measures

The MoCA (Nasreddine et al., 2005) and MMSE (Folstein, Folstein & McHugh, 1975) are brief cognitive assessments with total scores ranging from 0 to 30. Scores below 26 on the MoCA and 24 on the MMSE indicate cognitive impairment.

Trail Making Test –Trails B (Moses, 2004) is a timed measure of general cognitive function and executive functioning which involves connecting 25 numbers and letters in alternating order (i.e., 1 to A to 2 to B, etc.). The score is the overall time in seconds required to complete the connections, where a time in excess of 180 seconds may indicate increased risk of crash (Staplin, Gish & Wagner, 2003).

Rapid Pace Walk is a timed measure of motor speed, balance and coordination (Carr, Schwartzberg, Manning & Sempek, 2010). A time in excess of 10 seconds may indicate increased crash risk (Staplin et al., 2003).

The Snellen eye chart provides a measure of visual acuity. Visual acuity scores obtained from the Snellen eye chart were converted to the logarithm of the minimum angle of resolution (LogMAR) (McGwin & Brown, 1999). A LogMAR score of 0.0 is considered normal vision, whereas a score of +0.3 is considered reduced vision and is the Australian legal driving limit (Austroads, 2013).

The Older Americans Resources and Services (OARS) activities of daily living scale (McCusker et al., 1999) includes 14 items; seven items assess biological functions (BADL) including eating, dressing, undressing, grooming, walking, getting in and out of bed, bathing and continence and the other seven items assess instrumental functions (IADL) including using the telephone, travel, shopping, meal preparation, housework, taking medicine and management of finances. The total score is the sum of all 14 items and ranges from 0 to 28 with higher scores indicating greater independence.

Driving Comfort

Self-reported driving comfort was measured using two scales that assess comfort of driving in various situations during the day and at night. The 13-item daytime and 16-item night-time Driving Comfort Scales (DCS-D, and DCS-N, respectively) ask participants to rate their comfort while driving in a range of driving situations. Possible scores range from 0 to 100 per cent, with higher scores indicating greater driving comfort (Blanchard & Myers, 2010; MacDonald, Myers & Blanchard, 2008).

Real-world driving patterns

The real-world driving patterns, as measured by the ICRD, that were selected for analysis are described in Table 1.

Self-reported crashes and citations

The number of self-reported crashes and citations across Year 1 for each participant was collected including overall crashes and at-fault crashes only. A crash was identified as 'at-fault' if the participant was responsible for the damage, including both single-vehicle and two-vehicle collisions.

As per Langford et al. (2013), the crash risk for each driving distance group was defined as the number of crashes per

Table 1. Description of Real-world Driving Variables

Driving Patterns	Outcome Variable	Definition
Annual Mileage	Annual distance (km)	Total annual kilometers driven
Number of Trips	Total trips	Total number of annual trips driven
Night-Time Driving	% Night	Percentage of total annual trips driven at night (i.e., between 1800 to 0600 hours)
Peak Hour Driving	% Peak hour	Percentage of total annual trips driven during peak traffic hours (i.e., weekday periods between 0700 to 0930 hours or between 1600 to 1800 hours)
Shorter/ Longer Trips	% ≤ 5 km / > 20 km	Percentage of trips falling into the following trip length categories: ≤ 5 km and > 20 km

million kilometres driven. The crash risk for each driving distance group was calculated by expressing the number of crash-involved drivers in each group as a ratio of the total distance for all drivers in each group, with the rate then standardised to represent one million kilometres of driving.

Data Analyses

Driving data were cleaned and filtered against trip criteria, yielding a total of 183 participants included for analysis. Participants' data were excluded from the analysis if any of the following criteria were met: a) withdrawn from the study before Year 1 was completed and therefore had missing data; b) unexplained interruptions in their driving (i.e., defined as breaks in driving of one month, or greater, that did not coincide with interruptions recorded in the participant's secondary driver's log book); c) data that was affected by RFID fob detection issues (i.e., defined as periods of one month, or greater, during which no RFID fob was detected); d) driven a secondary vehicle for more than 30 percent of their total distance (i.e., calculated based on participant's annual estimates of primary and secondary vehicle usage); e) entries in their secondary driver's log book that differed significantly from driving data (i.e., mismatch between dates/times recorded in log book and ICRD recording on at least 28 days in total), or f) recorded secondary driver trip times as 'unknown' on at least 28 days in total. In addition to these criteria, driving trips were excluded from analysis if the ICRD data indicated that no RFID fob was detected for that trip, or if trip times overlapped by at least 50 percent with an entry in the secondary driver's log book. Altogether, there were 74 participants whose data were not included in the current analyses.

Statistical Analyses

Included participants were allocated to one of three groups according to their annual milage. Annual driving distances were categorised as ≤ 5,000 km, > 5,000 and < 13,000 km and ≥ 13,000 km, corresponding to the 20-60-20 percentiles of the older driver cohort. Similar parameters have been used in previous studies (see Hakamies-Blomqvist et al., 2002; Langford et al., 2006a; Alvarez & Fierro, 2008). The group sizes are shown in Table 2. The low mileage group represented 18 percent of the total sample.

To test the association between the annual mileage categories and demographic variables, Chi Square Tests of Independence were conducted using SPSS version 23 (IBM Corp., 2015).

To examine the association between the annual mileage groups and functional performance variables, self-reported driving comfort scores, real-world driving behaviour and crash/citation rates, separate non-parametric Kruskal-Wallis H tests were performed. Given that numerous tests were conducted, a Bonferroni correction was applied to reduce the rate of Type I error (Field, 2013). The threshold of statistical significance was set, conservatively, to $p < 0.01$.

Results

Demographic characteristics and annual mileage groups

Table 2 shows the demographic characteristics for each of the annual mileage groups.

There was no significant association between the annual mileage groups and age group, $\chi^2(2) = 4.5$, $p = 0.1$. There was a significant association between annual mileage groups and gender, $\chi^2(2) = 11.0$, $p = 0.004$, Cramer's V = 0.2, representing a small association. Female drivers were more likely to be in the low mileage group compared to male drivers, whereas male drivers were more likely to be in the high mileage group compared to female drivers.

Functional performance and annual mileage groups

Table 3 summarises participants' performance on the functional measures across the annual mileage groups.

Table 2. Demographic Characteristics across Annual Mileage Groups

			Low annual mileage (≤ 5000 km)	Middle annual mileage (> 5000 - < 13,000 km)	High annual mileage (≥ 13000 km)
Total		***N***	33	113	37
		%	18	61.7	20.2
Gender	**Male**	***N***	19	78	34
		%	57.6	69.0	91.9
	Female	***N***	14	35	3
		%	42.4	31.0	8.1
Age	**< 80 years**	***N***	14	62	25
		%	42.4	54.9	67.6
	≥ 80 years	***N***	19	51	12
		%	57.6	45.1	32.4

Table 3. Functional Performance across Annual Mileage Groups

Functional Measure (Criterion for Impairment)		Low annual mileage (≤ 5,000 km)	Middle annual mileage (> 5,000 - < 13,000 km)	High annual mileage (≥ 13,000 km)
	% (N) Unimpaired	Mean (SD) Median (IQR)	Mean (SD) Median (IQR)	Mean (SD) Median (IQR)
Rapid Pace Walk (≤ 10s)	97.3 (178)	7.2 (1.7) 7.0 (6.0-8.0)	7.0 (1.4) 7.0 (6.0-8.0)	6.7 (1.2) 7.0 (6.0-7.0)
LogMAR Visual Acuity Test (≤ + 0.30)	(178)	0.1 (0.1) 0.1 (0-0.2)	0.1 (0.2) 0.1 (0-0.2)	0.1 (0.1) 0.1 (0-0.2)
MMSE (≥ 30)	100.0 (183)	28.9 (1.2) 29.0 (28.0-30.0)	29.0 (1.1) 29.0 (28.0-30.0)	29.2 (1.1) 30.0 (28.5-30.0)
MoCA (≥ 26)	72.7 (133)	25.9 (2.6) 26.0 (23.8-28.0)	26.7 (2.2) 27.0 (25.0-28.0)	26.9 (1.6) 27.0 (26.0-28.0)
Trail Making Test- Trails B (≤ 180s)	93.4 (171)	114.2 (38.6) 104.0 (90.5-140.5)	115.2 (48.1) 108.0 (82.3-137.0)	96.4 (34.8) 86.0 (72.0-124.5)
OARS Activities of Daily Living (Min/Max: 0 – 28)	N/A	27.6 (0.9) 28.0 (27.0-28.0)	27.9 (0.4) 28.0 (28.0-28.0)	27.9 (0.2) 28.0 (28.0-28.0)

Note. Rapid Pace Walk score ≤ 10s indicates unimpairment. LogMAR Visual Acuity test score ≤ + 0.30 indicates unimpairment. MMSE = Mini-Mental State Examination. MMSE score ≥ 30 indicates no cognitive impairment (score of 24 or above indicates mild cognitive impairment); MoCA = Montreal Cognitive Assessment. MoCA score ≥ 26 indicates unimpairment; Trail Making Test-Trails B score ≤ 180s indicates unimpairment. OARS = Older Americans Resources and Services. Range of scores on OARS Activities of Daily Living = 0-28.

There were no significant differences across annual mileage groups in terms of participants' scores on the Rapid Pace Walk, $H(2) = 1.9$, $p = 0.4$, LogMAR Visual Acuity Test, $H(2) = 1.6$, $p = 0.4$, MMSE, $H(2) = 1.4$, $p = 0.5$, MoCA, $H(2) = 2.5$, $p = 0.3$, TMT-B, $H(2) = 6.6$, $p = 0.04$ or OARS activities of daily living scale $H(2) = 8.7$, $p = 0.01$.

Driving comfort and annual mileage group

Table 4 summarises participants' performance on the Driving Comfort Scale across the annual mileage groups.

The results of analyses for the Driving Comfort Scale showed significant differences across annual mileage groups for both day-time driving, $H(2) = 12.6$, $p = 0.002$ and night-time driving, $H(2) = 10.6$, $p = 0.005$. Pairwise comparisons with adjusted *p*-values showed that the low mileage group scored significantly lower than the middle mileage group ($p = .004.$, $r = 0.2$) and high mileage group ($p = .001$, $r = 0.3$) on the DCS-Daytime scale.

Real-world driving patterns and annual mileage group

Table 5 summarises the real-world driving patterns across annual mileage groups.

A Kruskal Wallis test showed a significant difference in the total number of trips driven, $H(2) = 51.2$, $p < 0.001$. Pairwise comparisons with adjusted *p*-values showed that the high mileage group had a significantly greater number of trips per year compared to the middle mileage ($p < .001$, $r = 0.3$) and low mileage group ($p < .001$, $r = 0.6$). The middle mileage group also had a greater number of trips per year compared to the low mileage group, ($p < .001$, $r = 0.4$).

There was a statistically significant difference in the proportion of driving trips that were 5 km or less across annual mileage groups, $H(2) = 20.4$, $p < .001$. Pairwise comparisons with adjusted *p*-values showed that the low mileage group drove a significantly higher proportion of trips that were 5 km or less compared to the high mileage group ($p < .001.$, $r = 0.3$) and middle mileage group ($p = .002$, $r = 0.3$).

The groups also differed in terms of the proportion of driving trips that were greater than 20 km, $H(2) = 73.6$, $p < 0.001$. Pairwise comparisons with adjusted *p*-values showed that the high mileage group drove a significant greater proportion of trips beyond 20km compared to the middle mileage group ($p < .001.$, $r = 0.4$) and low mileage group ($p < .001.$, $r = 0.6$). The middle mileage group also drove a significantly greater proportion of trips beyond 20km compared to the low mileage group ($p < .001.$, $r = 0.3$).

There were no significant differences across the annual mileage groups in terms of their proportion of driving trips at night, $H(2) = 3.7$, $p = 0.2$ or their proportion of driving trips during peak hour, $H(2) = 3.9$, $p = 0.1$.

Annual driving distance groups and annual crash and citation rates

Table 6 summarises the participants' Year 1 self-reported crashes, at-fault crashes and driving citations across the annual mileage groups. Participants self-reported 41 Year

Table 4. Scores on Driving Comfort Scale across Annual Mileage Groups

	Low annual mileage (≤ 5,000 km)	**Middle annual mileage (> 5,000 - < 13,000 km)**	**High annual mileage (≥ 13,000 km)**
	Mean (SD) Range Median (IQR)	Mean (SD) Range Median (IQR)	Mean (SD) Range Median (IQR)
Driving Comfort Scale – Daytime	68.6 (19.0) 76.9 (61.1-84.6)	77.1 (12.8) 78.8 (68.8-86.5)	82.6 (11.9) 85.6 (75.0-89.9)
Driving Comfort Scale – Nighttime	59.6 (22.6) 59.4 (51.2-85.9)	70.0 (18.3) 73.4 (57.8-82.8)	75.8 (14.9) 78.1 (62.9-88.7)

Table 5. Real-world Driving Patterns across Annual Mileage Groups

Real-world driving behaviour	**Low mileage group (≤ 5,000 km)**	**Middle mileage group (> 5000 - < 13,000 km)**	**High mileage group (≥ 13,000 km)**
	Mean (SD) Median (IQR)	Mean (SD) Median (IQR)	Mean (SD) Median (IQR)
Total Trips	849.1 (329.3) 806.0 (480.3-1027.0)	1252.8 (386.8) 1163.0 (960.3-1492.8)	1627.1 (551.7) 1548.0 (1304.0-1791.0)
% Night Time Driving	7.3 (7.0) 6.0 (2.1-9.9)	8.7 (5.8) 8.0 (3.8-11.7)	9.6 (6.5) 7.9 (4.5-13.6)
% Peak Hour Driving	15.4 (7.4) 15.2 (10.8-18.2)	17.5 (5.7) 17.3 (13.4-21.6)	16.1 (5.8) 16.3 (11.8-18.3)
% Trips ≤ 5 km	71.2 (13.2) 73.7 (61.0-83.3)	62.7 (12.4) 63.8 (55.5-71.7)	59.1 (7.9) 57.0 (53.2-64.7)
% Trips > 20 km	2.5 (2.4) 1.5 (0.9-3.6)	5.8 (5.0) 4.5 (2.2-7.4)	12.8 (5.3) 11.1 (9.4-16.0)

Table 6. Self-reported Crash and Citation involvement across Annual Driving Distance groups

		Low annual mileage (≤ 5,000 km)	**Middle annual mileage (> 5 000 - <13,000 km)**	**High annual mileage (≥ 13,000 km)**
		***N* (%)**	***N* (%)**	***N* (%)**
Crash involvement during Year 1	No crashes	26 (78.8)	90 (79.6)	30 (81.1)
	1 or more crashes	7 (21.2)	23 (20.4)	7 (18.9)
At-fault crash involvement during Year 1	No at-fault crashes	27 (81.8)	97 (85.8)	33 (89.2)
	1 or more at-fault crashes	6 (18.2)	16 (14.2)	4 (10.8)
Citation involvement during Year 1	No citations	28 (75.7)	94 (83.2)	28 (75.7)
	1 or more citations	5 (24.3)	19 (16.8)	9 (24.3)

1 crashes - 28 of which were reported as at-fault crashes. In addition, participants self-reported 41 driving citations during Year 1. Four participants had been involved in more than one crash (i.e., 2 crashes in Year 1) and six participants had received more than one driving citation (i.e., 4 participants with 2 citations, 2 participants with 3 citations).

Participants drove a total of 1,690,696 km during Year 1. The annual crash and citation rates per million kilometres driven for each annual mileage group are displayed in Table 7. Most participants did not report any crashes, at-fault crashes or citations: 31 participants, 93 participants and 30 participants for the low, middle and high mileage groups respectively. Likewise, 32 participants, 100 and 33 participants from the low, middle and high mileage groups respectively did not report any at-fault crashes. Finally, 32 participants, 97 participants and 28 participants from the low, middle and high mileage groups respectively did not report any citations.

Table 7. Annual Crash and Citation Rates per Million Kilometres Driven across Annual Mileage Groups

	Low annual mileage (≤ 5,000 km)	**Middle annual mileage (> 5 000 - <13,000 km)**	**High annual mileage (≥ 13,000 km)**
	Mean (SD) Median (IQR)	Mean (SD) Median (IQR)	Mean (SD) Median (IQR)
Crash rate per million km driven	54.0 (121.2) 0.0 (0.0-0.0)	27.7 (59.0) 0.0 (0.0-0.0)	11.2 (24.1) 0.0 (0.0-0.0)
At-fault crash rate per million km driven	48.5 (118.8) 0.0 (0.0-0.0)	18.5 (48.3) 0.0 (0.0-0.0)	6.2 (18.8) 0.0 (0.0-0.0)
Citation rate per million km driven	0.2 (0.6) 0.0 (0.0-0.0)	0.2 (0.5) 0.0 (0.0-0.0)	0.3 (0.7) 0.0 (0.0-0.5)

There was no significant association between the annual mileage groups and annual rates for crashes, $H(2) = 0.8$, $p = 0.7$, at-fault crashes $H(2) = 1.6$, $p = 0.4$, or driving citations $H(2) = 0.5$, $p = 0.8$.

Discussion

The aim of the current study was to examine the relationship between objective measures of annual mileage and a range of functional performance factors, self-reported driving comfort, as well as real-world driving patterns and self-reported crashes and driving citations. The findings showed that there were no significant differences across annual mileage groups in terms of their functional performance or independence in performing everyday activities, suggesting the cohort were relatively healthy in the first year of the longitudinal study presented here. However, it was interesting to note that self-reported day-time and night-time driving comfort levels were lowest in the low mileage group suggests that these drivers may have made restrictions to their driving distance in response to poorer perceived driver comfort and confidence in certain driving situations compared to the higher mileage groups. This is consistent with previous research by Alvarez and colleagues (2008) and Blanchard and Myers (2010).

Annual mileage groups also differed with respect to their real-world driving patterns. Specifically, low mileage drivers drove significantly more short trips (i.e., < 5km) and fewer long distance trips (i., > 20 km). It is possible that these differences reflect differences in life choices and/or employment circumstances (Molnar et al., 2013). For instance, work commitments, proximity of recreation clubs, and availability of alternative transportation options for participants in the low mileage group may be such that they do not need to travel greater distances or more than 20 km from home (Charlton et al., 2006).

Interestingly, while the groups differed with respect to total trips driven and relative numbers of short (and long) distance trips, there were no differences evident in other driving patterns indicative of self-regulation. Across all groups, driving in peak traffic was recorded for only 15-17 percent of all trips and night-time driving represented less than 10 percent of all trips. This is in contrast to findings reported by Langford et al. (2013) which showed that low mileage drivers were more likely to report that they restricted their driving at night and in heavy traffic comapred with high mileage drivers. Notwithstanding the differences observed in drivers' perceived comfort in night-time driving in the current study, the absence of evidence from the objective driving data for differences in challenging driving situations may reflect the relatively homogeneous and healthy level of drivers' functional abilities.

Another potential explanation for the discrepant findings in the current study is that slightly different distance parameters were used to define middle and high mileage groups. Several previous studies (Hakamies-Blomqvist et al., 2002; Langford et al., 2006; Alvarez & Fierro, 2008) used the following distance parameters: low mileage = < 3,000 km, middle mileage = 3,000 - 14,000 km and high mileage = > 14,000 km. Langford et al. (2013) applied slightly higher parameters (low mileage = < 5,001 km, middle mileage = > 5,001 - < 15,000km, and high mileage = ≥ 15,000 km for high mileage). Furthermore, in the current study, driving patterns were measured using naturalistic methods and in-vehicle devices while the majority of previous studies have relied on self-reported annual mileage which the authors acknowledged may be inaccurate (Langford et al., 2013; Langford et al., 2006; Alvarez & Fierro, 2008; Hakamies-Blomqvist et al., 2002).

A key finding of this study was that crash rates did not differ across the annual mileage groups. This is in spite of the finding that drivers with low annual mileage drove proportionately more short distance trips than high annual mileage drivers which are likely to have been in high-risk urban areas. It is acknowledged that crashes are infrequent events as reflected by the low number of at-fault crashes in the current study (n = 28). This may explain the absence of a significant LMB effect. This finding is in contrast to recent findings reported by Antin et al. (2017) using real-world driving data, as well as several previous findings from self-report studies which have shown increased crash rates among low annual mileage drivers (Langford et al., 2006; Alvarez & Fierro, 2008; Hakamies-Blomqvist et al., 2002). Furthermore, the discrepancy between the current findings and the findings from Antin et al. (2017) may be explained by differences in the way crashes were measured. The current study relied on self-reported crashes and citations, while Antin et al. (2017) used crash data from the Strategic Highway Research Program NDS study. Furthermore, several authors (Janke et al., 1991; Antin et al., 2017) have suggested that functional impairment profiles may mediate the association between annual mileage and crash rate. Therefore, it is likely that the older driver cohort, including the low mileage group, in the current study had relatively good functional abilities and any age-related declines in their functional performance were either not sufficient to have impaired their driving ability, or they were able to adapt their driving to compensate. Antin and colleagues (2017) have also made the point that older adults who voluntarily participate in a naturalistic driving study may have higher levels of driving fitness and confidence which could explain the lack of significant group differences on crash risk. Indeed, participants's average scores (for all annual mileage groups) on the MMSE and TMT-B test indicate unimpaired cognitive status.

An important finding shown in the current study was that the low mileage group drove the fewest number of total trips, as well as the greatest proportion of short trips (i.e., within 5 km) and the lowest proportion of trips beyond 20 km compared to the higher mileage groups. Conversely, the high mileage group drove the greatest number of trips over one year, with the lowest percentage of those trips being within 5 km and the greatest proportion of trips beyond 20 km. This is a new finding and provides some useful insights into real-world driving patterns of those drivers who typically drive less in terms of annual mileage. It is reasonable to expect that the predominantly short distance trips driven by the low mileage group are more likely to have been in high-risk urban areas, rather than on highways or divided roads which carry a lower crash risk and tend to be associated with greater travel distances (Janke et al., 1991). This hypothesis remains to be explored in future analyses of road types used. There was also evidence of a gender effect, specifically that the low mileage group had proportionally more female drivers than male drivers. This is in alignment with findings from self report studies (Charlton et al., 2006; Kostyniuk & Molnar, 2008) which showed that female drivers drove shorter trip distances and had a smaller number of total trips compared to male drivers.

Despite the advantages of using real-world driving data in the current study, crash and citation rates, as well as at-fault status of crashes, were self-reported and there is a possibility that some drivers may over- or under-report their crash involvement (McGwin Jr, Owsley, & Ball, 1998). Although several authors have suggested that self-report and authority records can provide complementary information (McGwin et al., 1998), many studies have shown low agreement between the two data sources (Ball, Owsley, Sloane, Roenker, & Bruni, 1993; Owsley, Ball, Sloane, Roenker, & Bruni, 1991). This includes the observation that self-reports tend to identify more crashes than state records particularly given that participants tend to report even minor crashes (Owsley et al., 1991). This is consistent with findings from a recent study among participants at the University of Manitoba site of the Candrive study (Porter et al., 2018) which compared self-reported crashes with official insurance claims or driver records. The authors found a higher frequency of crashes reported to study staff compared to those recorded in official jurisdictional record. On the other hand, crashes may be under-reported if participants fail to recall when the crash occurred or choose not to disclose this information due to social desirability bias (Blanchard & Myers, 2010; McGwin et al., 1998).

Future studies may benefit from analysing official crash data from licensing authorities.

Another limitation of the current study is that the cohort of older drivers was relatively small for the conclusions drawn and only one year of data for crashes and citations was collected. Therefore, the results may not be generalisable to all older drivers, particularly given their relatively high functional performance and voluntary participation in a longitudinal study. However it is likely that their functional performance and real-world driving patterns will decline with age, potentially affecting crash involvement. One of the strengths of the longitudinal design is that as the cohort of Ozcandrive participants ages, follow-up analyses will be conducted to monitor potential changes in the relationship between older drivers' annual mileage and functional performance or crash rates across the eight-year study period. An additional limitation is that data in the current study were analysed using simple bivariate analyses. In order to examine complex interactions between the relevant demographic, functional and driving-related variables, more advanced statistical modeling will be conducted using Ozcandrive data across the entire study period.

Conclusions

Using real-world driving data, the current study has provided preliminary evidence of a relationship between annual mileage and select real-world driving patterns. Larger-scale follow-up research with official crash data are required to further examine the relationships between annual mileage, functional abilities and crash and citation rates. Such findings can be used to inform stakeholders involved in research, policy-making and services for older drivers, particularly regarding the issue of safe mobility and licensing options.

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An Examination of Driving Exposure, Habits and Harsh Braking Events in Older Drivers with Bilateral Cataract Using Naturalistic Driving Data

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Key Findings

- Poorer contrast sensitivity associated with fewer kilometres travelled per week while waiting for first eye cataract surgery;
- Driving at night was avoided by those with poorer binocular contrast sensitivity;
- Binocular visual acuity and stereopsis were not associated with driving exposure.

Abstract

The aim of this study was to examine driving exposure, habits and harsh braking events in older drivers with bilateral cataract using naturalistic driving data. Ninety six older drivers aged 55+ years were assessed in the month prior to first eye cataract surgery. Data collection consisted of a researcher administered questionnaire, a cognitive test and visual measures including visual acuity, contrast sensitivity and stereopsis. Participants' driving exposure, driving habits and harsh braking events were measured using an objective in-vehicle driver monitoring device. A multiple linear regression model was undertaken to examine predictors of driving exposure in older drivers with bilateral cataract. After controlling for potential confounding factors, only binocular contrast sensitivity ($p<0.05$) and gender ($p<0.05$) were significantly associated with kilometres travelled in a seven day period. One log unit increase in contrast sensitivity score was associated with an increase of 163 kilometres driven during the study period. Males drove an average of 50 kilometres more per week than women. Only eleven participants experienced a harsh braking event during the driving monitoring period. The study provides a better understanding of the driving exposure, habits and harsh braking events of bilateral cataract patients while waiting for first eye cataract surgery. Contrast sensitivity is an important measure to consider when determining the impact of cataract on driving. Further longitudinal research is required to examine changes in visual measures, driving exposure, habits and harsh braking events after first eye surgery and whether second eye surgery provides additional benefits for driving.

Keywords

Bilateral Cataract, Contrast Sensitivity, Driver Self-Regulation, Naturalistic Data, Older Drivers

Introduction

Cataract is one of the leading causes of visual impairment worldwide. It is the main cause of blindness (51%) and accounts for 33 percent of visual impairment globally (Pascolini & Mariotti, 2012). Approximately 50% of older people will develop cataract by their seventies and this increases to around 90% by their eighties (McCarty, Keeffe, & Taylor, 1999). The incidence of cataract worldwide has increased rapidly over the past 20 years and this is expected to continue as the population ages (Rochtchina et al., 2003).

Cataract can affect multiple aspects of vision and a growing body of evidence suggests that older drivers with cataract are less safe to drive (Owsley, Stalvey, Wells, & Sloane, 1999; Owsley et al., 2001). However, unlike other conditions of ageing, cataract can be easily corrected by surgery, which has been shown to reduce crash risk by thirteen percent one year after first eye surgery (Meuleners, Hendrie, Lee, Ng, & Morlet, 2012). In Australia however, public hospital patients often wait long periods of up to 12 months before cataract surgery (Meuleners et al., 2012), generating concern among road safety and licensing authorities about the impact of un-operated cataract on driving exposure and ability.

Previous research examining the effect of cataract surgery on driving outcomes has focused on self-reported driving difficulty. A meta-analysis of five studies found that the risk of driving difficulty reduced by 88% after cataract surgery (OR 0.12, 95% CI 0.10 to 0.16; Subzwari et al., 2008). There has also been limited research investigating driving exposure and habits among cataract patients and the research to date has used self-report measures only (Fraser, Meuleners, Lee, Ng, & Morlet, 2013; Owsley et al., 1999). These studies found that older drivers with cataract self-reported that they reduced their driving exposure in terms of number of days, trips and distance travelled per week prior to surgery, compared to before they had cataract (Fraser et al., 2013; Owsley et al., 1999). However, driving exposure was assessed using a self-reported questionnaire which has inherent biases and limitations. Previous research has found self-reported measures of driving outcomes may be less reliable than naturalistic data collection methods (Blanchard, Myers, & Porter, 2010; Molnar et al., 2013a).

Naturalistic studies which collect detailed GPS information allow an accurate and objective examination of driving outcomes such as driving exposure as well as events including harsh braking. This rich source of information provides a means for assessing the safety impact of driving behaviours in an unobtrusive manner. Several studies to date have used in-vehicle devices to measure rapid deceleration events and have used them as a surrogate measure for near crashes (Af Wåhlberg, 2008; Chevalier et al., 2017) with positive correlations found between incidents, near crashes and actual crashes (Wu, Aguero-Valverde, & Jovanis, 2014). The deceleration and acceleration behaviour of drivers specifically has also been shown to predict at-fault crash involvement (Af Wåhlberg, 2008).

To date, no published study has used naturalistic data to explore driving exposure, habits and harsh braking events for older drivers with bilateral cataract. This information is of relevance to licensing authorities and clinicians in terms of understanding cataract patients' driving habits in the waiting period for cataract surgery and the frequency of harsh braking events experienced. This would allow older drivers with cataract to be appropriately advised on driving risks they could face while awaiting first eye surgery and assist them in making an informed decision on whether they continue to drive or not during this wait time. Furthermore, the identification of participants whose driving performance would most benefit from cataract surgery would be useful in the prioritisation for surgery. Therefore, the aim of this study was to describe the naturalistic driving exposure, habits and harsh braking events of older drivers with bilateral cataract who were awaiting surgery and to determine factors associated with driving exposure (kilometres travelled).

Methods

Participants

Participants awaiting first eye cataract surgery were recruited from three public hospital eye clinics in Western Australia either by an invitation letter or a direct approach made by clinicians at the hospitals. Inclusion criteria stipulated that participants were aged 55+ years, drove at least twice a week, had bilateral cataract and had no other significant eye conditions, such as glaucoma, macular degeneration or diabetic retinopathy. Participants were excluded from the study if they were wheelchair-bound, diagnosed with dementia, Alzheimer's disease, Parkinson's disease, were non-English speaking or had cataract surgery previously. A total of 645 cataract patients were reviewed for inclusion in the study with 381 being excluded (predominantly due to being non-drivers, already had one cataract surgery and severe health issues). Of the 264 eligible patients, 111 (42%) agreed to participate in the study.

Data Collection

Participants were recruited between December 2014 and February 2017. Data collection took place during the month before first eye cataract surgery. Data collection consisted of a researcher administered questionnaire, a cognitive test, the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) and three objective visual assessments, which were administered at Curtin University. Participants were also provided with an in-vehicle monitoring device at the end of the assessment. Informed written consent was obtained from each participant before any information was collected, following the tenets of the Declaration of Helsinki. Ethics approval was obtained from the three participating hospitals (Fremantle Hospital, Royal Perth Hospital and Sir Charles Gairdner Hospital) and the Curtin University Human Research Ethics Committee.

Questionnaires

Socio-demographic data

Information on age, gender, marital status, country of birth, level of education, employment status, living arrangements, medications, comorbidities, driver's licence and years of driving experience were collected via a researcher administered questionnaire.

Driving Habits Questionnaire (DHQ)

All participants completed the Driving Habit Questionnaire (DHQ; Owsley et al., 1999). It includes questions about actual driving, driving exposure, dependence, avoidance, crashes and driving space. This questionnaire has been previously validated for use with a Western Australian population of older drivers with bilateral cataract (Fraser et al., 2013).

Mini-Mental State Examination (MMSE)

The MMSE (Folstein et al., 1975) was administered to all participants. It assesses general cognitive function and is used as a screening tool for cognitive impairment. Scores range from 0 to 30 with a higher score indicating better cognitive functioning. The inclusion criterion was a score ≥ 24 on the MMSE which indicates normal cognitive function.

Measures of Vision

Three objective visual measures were administered under the guidance of an ophthalmologist under standard conditions, constant luminance and without mydriasis. Participants wore their habitual correction for visual testing.

Visual acuity: Monocular and binocular visual acuity were assessed using an Early Treatment Diabetic Retinopathy Study acuity chart (ETDRS), calibrated for a 3 metre distance (Ferris, Kassoff, Bresnick, & Bailey, 1982). A letter by letter scoring method was used and scores were expressed as a logarithm of the minimum angle of resolution (logMAR). In WA, drivers must have visual acuity of 0.30 logMAR or better with their better eye or binocularly for unconditional licensing. For visual acuity, lower scores indicate better vision.

Contrast sensitivity: Monocular and binocular contrast sensitivity were measured using the Mars Letter Contrast Sensitivity Test, at a distance of 50 centimetres (Mars Perceptrix ©) and expressed as log units. Normal contrast sensitivity for adults aged over 60 ranges from 1.52 to 1.76 log units. For contrast sensitivity, higher scores indicate better vision.

Stereopsis: Stereopsis was assessed using the Titmus Fly Stereotest (Stereo Optical Co., Inc.) and scores were expressed as log seconds of arc. Average stereopsis for people aged over 60 is approximately 1.97 log seconds of arc. For stereopsis, lower scores indicate better vision.

In-Vehicle Monitoring Device

All participants were provided with an in-vehicle monitoring device and instructed to use it for a period of seven days. Participants were instructed to only use it when they were driving their motor vehicle. They were also provided with a travel diary that they were asked to complete each time they drove their motor vehicle. The diary recorded the model, make and year of their vehicle, number, age and position of passengers, time, date, start and end time of the trip and distance travelled. At the conclusion of the monitoring period, a researcher interviewed participants to identify any issues with the devices and to confirm no one else drove the vehicle while the device was connected. Instructions were provided to all participants regarding the use of the device in the participant information sheet. They had to plug the device into their car's On Board Diagnostic II (OBD II) port for vehicles manufactured after January 2006 or the cigarette lighter prior to 2006 (Figure 1). The in-vehicle monitoring GPS system transmitted time stamped second-by-second data of speed and location for all trips and collected information on real-time driving exposure, time, date of travel and harsh braking events. The GPS data was cleaned to exclude "false trips" of less than 200 meters or which lasted less than 10 seconds. Trips made from the University after the assessments were excluded, as they were not representative of the participants' habitual driving behaviour.

Operational Definitions

Harsh braking episodes were defined as G-force exertion more harsh than -0.61G (Geotab©).

Day time driving was defined as the period from sunrise to sunset and night time driving as the period from sunset to sunrise, for each day. Specific times of sunrise and sunset for each day of the year were obtained from the Australian

Figure 1. In-vehicle driver monitoring device

Government's Bureau of Meteorology website (www.bom.gov.au).

Driving between the hours of 6 and 9 a.m. or from 4 to 7 p.m. on weekdays was defined as peak hour driving.

The mean excursion radius for a driver was calculated as the mean distance (km) of the vehicle from the home of the driver (Keay et al., 2013), scaled to the amount of time the vehicle was present at each location away from home while the vehicle was in motion (i.e. speed > 0), with the moments in time the vehicle was stationary (i.e. speed = 0) excluded from the calculations.

Statistical Analysis

Descriptive statistics were used to summarise the socio-demographic and visual characteristics of the cohort. Driving exposure, habits and harsh braking events were also described in detail. Since the number of participants experiencing harsh braking events was low, only descriptive statistics were calculated. The primary outcome of interest was driving exposure as measured by total number of kilometres travelled in a seven day period prior to first eye cataract surgery. A multiple linear regression model was undertaken to determine the association between three objective visual measures (binocular visual acuity, binocular contrast sensitivity and stereopsis) and driving exposure in a seven day period. Binocular visual measures were chosen since these take into account how better and worse eye vision interact when undertaking tasks in the real world. The three objective measures of vision were entered as explanatory variables in the models and potential confounding factors such as age, gender, the number of comorbidities, cognitive status, retirement status and whether the participant lived alone were controlled for. All variables were entered into the model simultaneously. All statistical analyses were performed using SPSS statistical software, version 22 (SPSS Inc., Chicago, IL, USA).

Results

One hundred and eleven participants with bilateral cataract who were waiting for first eye cataract surgery were recruited into the study. Fifteen participants were excluded from the analysis due to poor data integrity from the in-vehicle monitoring device which was caused by faulty cigarette lighters and/or the loss of the monitoring devices. The final sample consisted of 96 participants (including eight who did not drive during the monitoring period).

The ninety six participants ranged in age from 55 to 91 years old, with a mean age of 73.4 years (SD=8.6). The mean number of years driving was 51.4 years (SD=10.6). As illustrated in Table 1, 18.8% of the sample were aged between 55 and 64 years, 35.4% between 65 and 74, 36.5% between 75 and 84 and 9.4% were 85 or older. The majority of participants were male (52.1%), married or in a de facto relationship (57.3%), were retired (72.9%) and did not live alone (58.3%). Forty-five percent (44.8%) were born in Australia, 60.4% had completed a higher degree and 43.8% wore bifocal or multifocal glasses. Ninety-eight percent (97.9%) of the participants reported at least one comorbid medical condition in addition to cataract, with a mean of 5.4 comorbid medical conditions per participant (SD=2.8). These conditions included musculoskeletal, circulatory, respiratory and endocrine conditions. Eighty-nine percent of participants were also taking prescribed medications, with a mean of 3.4 (SD=3.0) medications taken per participant. All participants had normal cognitive function according to the MMSE, with an overall mean for the sample of 27.7 (SD=2.1).

Responses to the self-reported DHQ questionnaire found that approximately half of the sample (51.1%) reported that cataract did not affect their driving. However, 10.6% of participants (n=10) reported that someone suggested that they stop or limit their driving in the past year. Among the participants who were told that they should stop or limit their driving, four participants did not drive at all during the seven day period. Eighty-one percent of participants (80.9%) preferred to drive themselves rather than being driven by someone else and the majority of participants considered themselves to be good (46.8%), excellent (24.5%) or average drivers (25.5%). Only few participants considered themselves to be a fair (2.1%) or poor drivers (1.1%). All but two of the 96 study participants owned their own car and all but one used their seatbelt while driving. Participants self-reported that in a normal week they drove an average of 5.1 days (SD: 2.0), an average of 170.1 km (SD: 243.9) and made an average of 12.9 trips (SD: 16.1).

Table 1. Demographic characteristics of older drivers with bilateral cataract aged 55+ (n=96)

	Number	Percent
Gender		
Male	50	52.08
Female	46	47.92
Marital status		
De facto/ married	55	57.29
Single/Separated Divorced/ Widowed	41	42.71
Age group		
55-64	18	18.75
65-74	34	35.42
75-84	35	36.46
>=85	9	9.38
Highest educational level		
Primary or Secondary School	38	39.58
Higher Education (University/ TAFE)	58	60.42
Country of birth		
Australia	43	44.79
Other	53	55.51
Employment status		
Retired	70	72.92
Employed/self-employed	18	18.75
Unemployed	6	6.25
Medical disability pension	2	2.08
Living arrangements		
Lives alone	40	41.67
Lives with other people	56	58.33
Habitual correction		
No correction	41	42.71
Single vision spectacles	12	12.50
Bifocals or multifocals	42	43.75
Contact lenses	1	1.04
Presence of comorbidities		
No	2	2.08
Yes	94	97.92
Prescription medication		
No	11	11.46
Yes	85	88.54

The results of the visual measurements prior to first eye cataract surgery are shown in Table 2. Mean binocular visual acuity, as measured by the ETDRS chart, was 0.14 logMAR (SD=0.16). Mean binocular contrast sensitivity, as measured by the MARS contrast sensitivity chart was 1.65 log units

(SD=0.15) and mean stereopsis as measured by the Titmus Fly test was 2.32 log seconds of arc (SD=0.72). Average visual acuity was better than the minimum required for licensing in WA (0.30 logMAR). However, average contrast sensitivity and stereopsis was poorer than normal levels for older adults but not severely impaired.

Table 2. Visual characteristics of older drivers with bilateral cataract aged 55+ (n=96)

Visual tests	Mean	SD
Visual acuity (logMAR)		
Better eye	0.19	0.15
Worse eye	0.43	0.29
Both eyes	0.14	0.16
Log contrast sensitivity		
Better eye	1.57	0.15
Worse eye	1.37	0.34
Both eyes	1.65	0.15
Stereopsis (log seconds of arc)		
Both eyes	2.32	0.72

In-Vehicle Monitoring Devices

The final sample used for the analysis of the in-vehicle monitoring device was 96 participants. No significant difference was found between the 96 participants who undertook the in-vehicle monitoring and the 15 who were excluded from this analysis due to poor data integrity in terms of gender (p=0.77), age (p=0.45), visual acuity (p=0.65), contrast sensitivity (p=0.74), and stereopsis (p=0.62). A total of eight participants (8.3%) did not drive at all during the study period but they were still included in all results. Reasons for this included "difficulties driving at night", "in the rain", or participants were told by someone else that "they should stop or limit their driving".

Overall Driving Exposure and Naturalistic Driving Patterns

Ninety-two percent of participants (n=88) drove during the 7 day period. As illustrated in Table 3, participants, overall, undertook an average of 15.6 trips (SD=10.5), drove an average distance of 115.8 kilometers per week (SD=99.0), and drove an average of 4.40 days (SD=2.1) in a seven day period. The maximum distance that participants travelled from home was 14.1 (SD=11.9) kilometres. Compared to the self-reported DHQ, participants actually drove less days and kilometres per week but made more trips per week than they reported.

Table 3. Naturalistic driving patterns of older drivers with bilateral cataract aged 55+ over a seven day period (n=96)

	Mean	SD
Overall driving (n=88)		
Kilometres travelled	115.77	98.97
Number of trips	15.56	10.51
Driving duration per week (minutes)	186.51	149.03
Number of days driving	4.40	2.06
Maximum excursion radius from home (km)	14.08	11.87
Day time driving (n=88)		
Kilometres travelled	101.27	87.45
Number of trips	14.04	9.15
Driving duration during day time (minutes)	165.00	127.82
Number of days driving	4.32	2.02
Night time driving (n=43)		
Kilometres travelled	14.50	29.47
Number of trips	1.52	3.49
Driving duration during night time (minutes)	21.51	47.37
Number of days driving	0.93	1.41
Weekday driving (n=88)		
Kilometres travelled	86.10	72.56
Number of trips	12.00	8.38
Driving duration per weekday (minutes)	142.48	113.13
Number of days driving	3.23	1.50
Weekend driving (n=72)		
Kilometres travelled	29.67	42.67
Number of trips	3.56	3.64
Driving duration per weekend (minutes)	44.03	55.85
Number of days driving	1.17	0.80
Peak hour driving (n=75)		
Kilometres travelled	33.97	38.48
Number of trips	4.56	4.39
Driving duration during peak hours (minutes)	57.84	61.38
Number of days driving	2.19	1.59

Daytime driving

Ninety-two percent of participants (n=88) drove during the daytime. Participants undertook an average of 14.0 trips (SD=9.2), drove an average distance of 101.3 kilometres per week (SD=87.5), and drove an average of 4.3 days (SD=2.0) during daytime in a seven day period.

Night time driving

Slightly less than half of the sample (45%) drove at night-time (n=43). Participants undertook an average of 1.52 trips (SD=3.49), drove an average distance of 14.50 kilometers (SD=29.47), and drove an average of 0.93 days (SD=1.41) during the night in a seven day period.

Weekday driving

Ninety-two percent of participants (n=88) drove during the week (Monday to Friday). Participants undertook an average of 12.0 trips (SD=8.4), drove an average distance of 86.1 kilometers (SD=72.6), and drove an average of 3.2 days (SD=1.5) during the work week.

Weekend driving

Seventy-five percent of participants (n=72) drove during the weekend. Participants undertook an average of 3.6 trips (SD=3.6), drove an average distance of 29.7 kilometers (SD=42.7), and drove an average of 1.2 days (SD=0.8) during the weekend.

Peak hour driving

Seventy-eight percent of participants (n=75) drove during peak hour traffic. Participants undertook an average of 4.6 trips (SD=4.4), drove an average distance of 34.0 kilometers (SD= 38.5), and drove an average of 2.2 days (SD=1.6) during peak hour traffic.

Table 4. Frequency of harsh braking events

Harsh braking events	**n=12**	**%**
Time of the day:		
Day time	10	83.3
Night time	2	16.7
Traffic:		
Peak hour	5	41.7
Non-peak hour	7	58.3
Type of road:		
Highway/freeway	2	16.7
Local roads	10	83.3

Harsh braking events

Ten participants recorded one episode of harsh braking during the seven day period and one recorded two episodes of harsh braking.

Ten harsh braking events occurred during the day, two occurred during night time driving, while five occurred while driving during peak hour traffic (Table 4). Ten harsh braking events occurred while the participants were travelling on local roads and two events occurred while they were driving on a freeway or highway. There was no significant differences between the participants who did and did not record any harsh braking events in terms of age (p=0.15), gender (p=0.68), binocular contrast sensitivity (p=0.73), binocular visual acuity (p=0.80) or stereopsis (p=0.79).

Table 5. Factors associated with total kilometres travelled for bilateral cataract patients waiting for first eye surgery (n=96)

Predictor	**B**	**Standard Error**	**95% CI**		**p value**
Age	-2.60	1.65	-5.88	0.68	0.12
Gender: (male)	50.49	21.85	7.05	93.94	0.02*
Number of comorbidities	1.93	3.55	-5.13	9.00	0.59
Living situation: (not alone)	13.43	21.27	-28.86	55.72	0.53
Employment status: (retired)	-18.32	29.91	-77.78	41.14	0.54
Binocular visual acuity	10.15	72.17	-133.32	153.62	0.89
Binocular contrast sensitivity	163.41	74.83	14.66	312.16	0.03*
Stereopsis	-14.52	13.92	-42.19	13.15	0.30
Cognition (MMSE[a] score)	1.52	4.91	-8.23	11.28	0.76

[a] MMSE: Mini-Mental State Examination
*p<0.05

Association between visual mesaures and driving exposure

The results of the multiple linear regression model examining the association between visual measures and the total kilometres travelled in a seven day period are presented in Table 5. Binocular contrast sensitivity ($p<0.05$) and gender ($p<0.05$) were the only variables significantly associated with driving exposure (total kilometres travelled) after controlling for potential confounding factors. Neither binocular visual acuity ($p=0.89$) nor stereopsis ($p=0.30$) were significantly associated with driving exposure. Participants with better contrast sensitivity scores drove more kilometres than those who had poorer contrast sensitivity scores. More specifically, one log unit increase in contrast sensitivity score was associated with an increase of 163 kilometres per week driven during the seven day study period. Males drove an average of 50 kilometres more per week than females.

Discussion

This is one of the first studies to specifically examine the driving exposure, habits and harsh braking events of older drivers with bilateral cataract, using objective naturalistic driving data as they wait for first eye cataract surgery. Driving is a complex task and cataract can negatively affect aspects of vision such as visual acuity, contrast sensitivity and stereopsis which can have a serious impact on driving ability (Fraser et al., 2013; West et al., 2003). The results of the study found that older drivers with poorer binocular contrast sensitivity drove significantly fewer kilometres per week prior to first eye cataract surgery than those with better contrast sensitivity. This is consistent with findings from the general older driver population (Sandlin, McGwin, & Owsley, 2014); however, that research used self-reported driving exposure, which is subject to bias. Visual acuity was not significantly associated with driving exposure in this study and inconsistent findings have been reported on this relationship in the literature (Owsley & McGwin, 2010). However, this study confirms previous findings that contrast sensitivity may be a more important measure related to a range of driving outcomes than visual acuity among cataract patients (Fraser et al., 2013; Owsley et al., 2001; Wood & Carberry, 2006).

Gender was significantly associated with driving exposure with males driving more kilometers per week than females. Previous research also found that females report poorer driving confidence, greater driving difficulty and more negative attitudes to driving than males (Conlon, Rahaley, & Davis, 2017; Wong, Smith, & Sullivan, 2015). Females are also less likely than males to be the principal driver (Conlon et al., 2017) which may explain the results of our study as 57% of participants were married.

Previous research has consistently found that as drivers' age, they report driving fewer kilometres per week (Braitman & Williams, 2011; Sandlin et al., 2014). This may be due to a variety of reasons which include older drivers having poorer health, mobility issues and being more frail (Meuleners, Harding, Lee, & Legge, 2006). However, the cohort in our study travelled fewer kilometres in a typical week than reported in previous older driver studies (Blanchard & Myers, 2010; Molnar et al., 2013a). They also appeared to restrict their driving to their local neighbourhood with the mean distance travelled from home being fourteen kilometres. This restriction of driving to the local neighbourhood is consistent with other research among older drivers (Keay et al., 2009). Eight participants did not drive at all during the seven day monitoring period while waiting for cataract surgery, due to driving difficulties or suggestions from others to stop or limit their driving. Overall, these findings may be indicative of participants acknowledging their driving limitations due to cataract and reducing their driving exposure. This reduction in travel by cataract participants as they wait for first eye surgery can be viewed as a positive safety response as it reduces their exposure on the road and the possible risk of crash involvement. It is also acknowledged however, that older drivers may participate in fewer activities that require driving due to changes in lifestyle or retirement (Molnar et al., 2013b). Therefore it should be noted that approximately 80% of participants in this study were retired or unemployed, which may have limited the need for travel by this group and contributed to the results.

Despite the overall low driving exposure observed, 81% of participants in this study still preferred to drive themselves rather than being driven by someone else, almost half of the cohort (n=43) drove at night time and 75 participants drove during peak hour, both of which have been found to be challenging driving situations for older drivers with cataract (Owsley et al., 1999). This raises concerns about fitness to drive while waiting for cataract surgery. Previous research has found that older drivers with cataracts, despite limiting their driving exposure, have an increased risk for at-fault crashes compared to age-matched controls without cataract (Owsley et al., 1999). This has also been confirmed in previous research which examined the impact of simulated cataract on driving performance (Wood & Troutbeck, 1994, 1995). Therefore, ophthalmologists could play an important role in ensuring that cataract patients are provided with adequate information about driving difficulties and risks they may experience due to cataract and how to limit their exposure to these while waiting for cataract surgery. They could then make an informed decision on whether they continue to drive during this period.

Previous research has found that drivers who brake rapidly may be at a greater risk for a crash or a near miss (Chevalier et al., 2017). In particular, a sudden stop has been shown to be associated with rear end crashes (Harb, Radwan, Yan, & Abdel-Aty, 2007). While only eleven participants (11%) in this study recorded at least one episode of harsh braking, this is comparatively high considering driving was only monitored for one week. For example, a previous study found that 64% of participants were involved in at least one episode over a much longer 12 month period (Chevalier et al., 2017). Further research using a larger sample size over a longer period of time is required to explore this issue further and determine whether cataract patients are in fact, at higher risk of harsh braking events.

A major strength of this study is that naturalistic driving behaviour was measured using objective in-vehicle monitoring devices in the participants' own vehicle. However there are several limitations to this study. The strict inclusion criteria may have impacted on the generalisability of the results. Furthermore, participants' naturalistic driving behaviour was only measured over a period of seven days, which may have limited driving exposure and the number of harsh braking events that were recorded. However, the choice of a seven day timeframe is consistent with previous naturalistic studies which has found this time frame to be representative of older drivers' patterns and habits (Blanchard & Myers, 2010; Blanchard et al., 2010; Thompson, Baldock, Mathias, & Wundersitz, 2016). In addition, participants may have modified their driving behaviour while using the devices, due to the fact that their driving behaviour was monitored. A further limitation is that 14% of participants were excluded from the study, due to missing information related to the devices. It should be noted however there was no significant difference between the two groups in terms of gender and age and visual impairment. Other visual measures such as visual field and disability glare were also not collected in this study. We also did not collect video footage of driving which would provide more in depth information regarding driving events. Further monitoring of driving exposure over a longer period of time before first eye cataract surgery and a larger sample is warranted. In addition, future research should examine how driving exposure changes after first and second eye cataract surgery. Despite these limitations, this study controlled for a wide range of potential confounding factors when examining the driving patterns, harsh braking events and exposure of older drivers while waiting for first eye cataract surgery.

Conclusions

The results of this study provide a better understanding of driving exposure, habits and harsh braking events of bilateral cataract patients while waiting for first eye cataract surgery. It also substantiates previous research that contrast sensitivity is an important visual measure to consider when determining the impact of cataract on driving. Cataract patients with poor contrast sensitivity drive fewer kilometres while waiting for surgery, meaning their mobility in the community is negatively affected. Therefore, clinicians should consider contrast sensitivity scores in their assessment and prioritisation for surgery of cataract patients who drive. Further longitudinal research is required to determine the impact of first and second eye cataract surgery on the objective driving exposure, habits and harsh braking events of bilateral cataract patients, particularly as information on the impact of second eye cataract surgery on driving outcomes is lacking.

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Older Drivers in the News: Killer Headlines v Raising Awareness

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Key Findings

- Calls for mass age-based testing persisted despite contra-indicative research outcomes
- Reporting unusual driving incidents reinforced negative images of older drivers
- In-depth coverage of the complex issues involved in ageing and driving was rare

Keywords

Print Media, Newspaper, Headlines, Stereotypes, Ageing, Older Driver

Abstract

The daily print media continues to be an important political and social influence, shaping opinions and setting agendas. Yet few studies have examined Australian newspaper coverage of older drivers, despite researchers calling for increased public awareness of issues related to the growing number of older drivers on Australian roads. This study analyses the content and discourse of articles on older drivers and issues related to them from 11 Australian metropolitan daily newspapers, representing all state and territory capitals, over three periods: 2010-2014 (inclusive), 2016 and 2017. It focuses on three main areas: the topics covered; keywords, stock phrases and stereotypes used; and attributed sources, including who is quoted and where. Several patterns were apparent from the qualitative and quantitative analysis. Articles appeared sporadically but tended to cluster around reports of serious crashes where at least one driver was aged over 60 years. The debate was focused on age, with calls for testing and compulsory age-based restrictions common but few articles mentioned the contribution of the 'frailty bias' to the over-representation of older people in fatality and serious injury crash statistics. A better understanding of the way newspapers present such issues has much potential to identify and address misperceptions around safe driving and ageing.

Introduction

The ability to remain mobile as people age is recognised as important to healthy ageing (WHO, 2015). Maintaining this ability, however, presents serious challenges in car-dependent societies, such as Australia. Ceasing to drive in older age is recognised as 'a key determinant of declines in mobility' (WHO, 2015, p. 180), alternative transport options may not necessarily be 'available, accessible or safer than driving' (Charlton et al., 2010, p. 557) and the population is ageing (Odell, 2009).

The United Nations highlighted the importance of transport and mobility in its 2015 Sustainable Development Goals (UN, 2015). The goals set out to make 'cities and human settlements inclusive, safe, resilient and sustainable' (Goal 11). Clause 11.2, for example, pledged to work towards the provision by 2030 of transport systems for all 'with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons' (UN, 2015, p. 21). The year 2030 is significant. The last of the 'Baby Boomers', those born between 1946 and 1964, turns 65 in 2030 (ABS, 2003). By then almost a quarter of Australia's population is expected to be aged 65 and over (Odell, 2009; OECD, 2001). Most adults walk and drive (Satariano et al., 2012) but driving remains important for older people as they age. The conditions that increase an older person's risk of death or serious injury as a driver – such as age-related frailty and slower recovery from injury (Li et al., 2003; Oxley, 2009) – also increase vulnerability as a pedestrian (Oxley, 2009). Giving up driving is associated with significant adverse effects on older adults' physical and mental health, such as feelings of loss and dependence (Mullen & Bédard (2009), increased social isolation (Ragland et al., 2004), depression (Caragata et al., 2009; Fildes, 1997; Marattoli et al., 2000; Unsworth, 2009), and an increased risk of moving to an aged care facility (Freeman et al., 2006, cited in Caragata et al., 2009).

Authorities have called for communication campaigns to raise public awareness of issues related to safe driving and ageing (WHO, 2015; OECD, 2001) but such campaigns present a key challenge: how to raise public awareness of issues related to road safety and ageing without adversely affecting the community's view of older people. The World Health Authority's 2015 *Report on Ageing and Health* warned that stereotypes of older people as forgetful and less able to learn and make decisions are prevalent in society, including among older people themselves, their families and health and other care providers (WHO, 2015). The organisation (2015, p. 175) highlighted the importance of challenging stereotypes by improving 'knowledge of and understanding about' the process of ageing.

Journalism is a disseminator of information (Tuchman, 1978) and, as such, has the potential to play an important role. Journalism can enhance public awareness by providing medical information in an easily understood form, disseminating public health messages and creating forums for people to share their stories (Phillips & Lindgren, 2010). 'Personal stories, which engage listeners and readers in an immediate and emotional way, can provide a more telling warning than impersonal health messages.' (Phillips & Lindgren, 2010, p. 200). The daily print media, however, focuses more on action than reflection and seldom has space to explore complex issues in detail (Ricketson, 2014). Equally, journalistic stories have the potential to impact negatively on issues.

Researchers in the fields of road safety and ageing have argued that the media contributes to public misconceptions about the risk posed by older drivers through its high level of attention on road fatalities involving this age group (Langford, 2009; OECD, 2001). Bureau of Infrastructure, Transport and Regional Economics (BITRE) statistics reveal that road deaths for the over 65 age groups increased significantly between 2008 and 2017 but the increase was 'consistent with a growing older population as there has been a slight decline over the decade in the rate per 100,000 population'. (BITRE, 2018). In the same period total deaths for all road users in Australia fell from 1437 in 2008 to 1226 in 2017 (BITRE, 2018a), with significant decreases in deaths for age groups under 40 years. However, analysis of the statistics reveals that 24% of fatalities for those aged 75 and over were pedestrians, compared to 18% for the 65-74 age group and 7% for those aged 17-25. Passengers made up 20% of fatalities in the two older age groups and 25% for the youngest; and drivers represented 51% of fatalities for those aged 75 and over, 40% for the 65-74 age group and 49% for those aged 17-25. Decreasing the number of older drivers may not necessarily decrease total fatalities if the safety of older people as passengers and pedestrians does not improve.

Road safety researchers have also pointed to the disjunct between the media's calls for increased restrictions on older drivers (Charlton et al., 2009; OECD, 2001) and advice from road transport and medical experts that compulsory age-based assessment does not improve road safety (Hakamies-Blomqvist, 2004; Langford, 2009; Langford et al., 2008a; Langford et al., 2008b; OECD, 2001) and may be discriminatory (Charlton et al., 2009).

This paper is based on a study of how older drivers and issues relevant to them were presented in Australia's mainstream print media. The aim was to see what issues related to driving and ageing were covered, from what angle and who was quoted. The study formed part of a larger PhD research project on older drivers. The aim of the PhD project is to produce a non-fiction book as a resource for older drivers, their families and those working with them. The book will include experiences related to driving and ageing from these groups to help broaden awareness of issues around safe driving for an ageing population.

Methods

The study involved qualitative and quantitative analyses of 11 daily newspapers: *The Australian*; *The Canberra Times* (ACT); *Adelaide Advertiser* (South Australia); *Courier-Mail* (Brisbane); *Hobart Mercury* (Tasmania); *Daily Telegraph* and *The Sydney Morning Herald* (New South Wales); *The Age* and *Herald Sun* (Victoria); *Northern Territory News* (Northern Territory); and *West Australian* (Western Australia). Articles were selected using the Factiva and Newsbank databases and four search terms: 'older driver', 'older drivers', 'elderly driver' and 'elderly drivers'.

The study covered four periods: 2010-2014 (inclusive), 2015, 2016 and 2017. The period 2010-2014 included several high-profile fatality and serious injury crashes involving older drivers in Queensland, which introduced mandatory medical examinations for drivers aged 75 and over from January 1, 2014. Another fatality crash involving an elderly driver occurred in NSW in 2016. The search was repeated for the periods 2015, 2016 and 2017 to see if newspaper coverage changed following Queensland's adoption of tighter regulations for older drivers in 2014 and changes to licensing regulations in South Australia and Tasmania in the same year.

South Australia abolished compulsory medical tests from September 1, 2014 for drivers aged 70 and over who held car licences only. The state introduced a self-assessed annual medical form from July 2015, to be completed by drivers at age 75, to notify the Transport Department of medical conditions such as arthritis, eye problems, diabetes and mental health issues. Tasmania abolished compulsory annual medical tests for drivers aged 75 and over, who did not have a pre-existing condition affecting driving, from October 2014.

The 11 newspapers analysed, represented all Australian state and territory capitals. The study examined how issues related to older drivers were framed, the sources quoted and use of keywords, stock phrases and stereotypes. Framing involves selecting some aspects of an issue or situation and making them 'more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described' (Entman, 1993, p. 52).

Such an examination is important. Framing affects whether information about an issue is considered newsworthy or not: the 'principles of selection and rejection ensure that only information material seen as legitimate within the conventions of newsworthiness appears in the account'

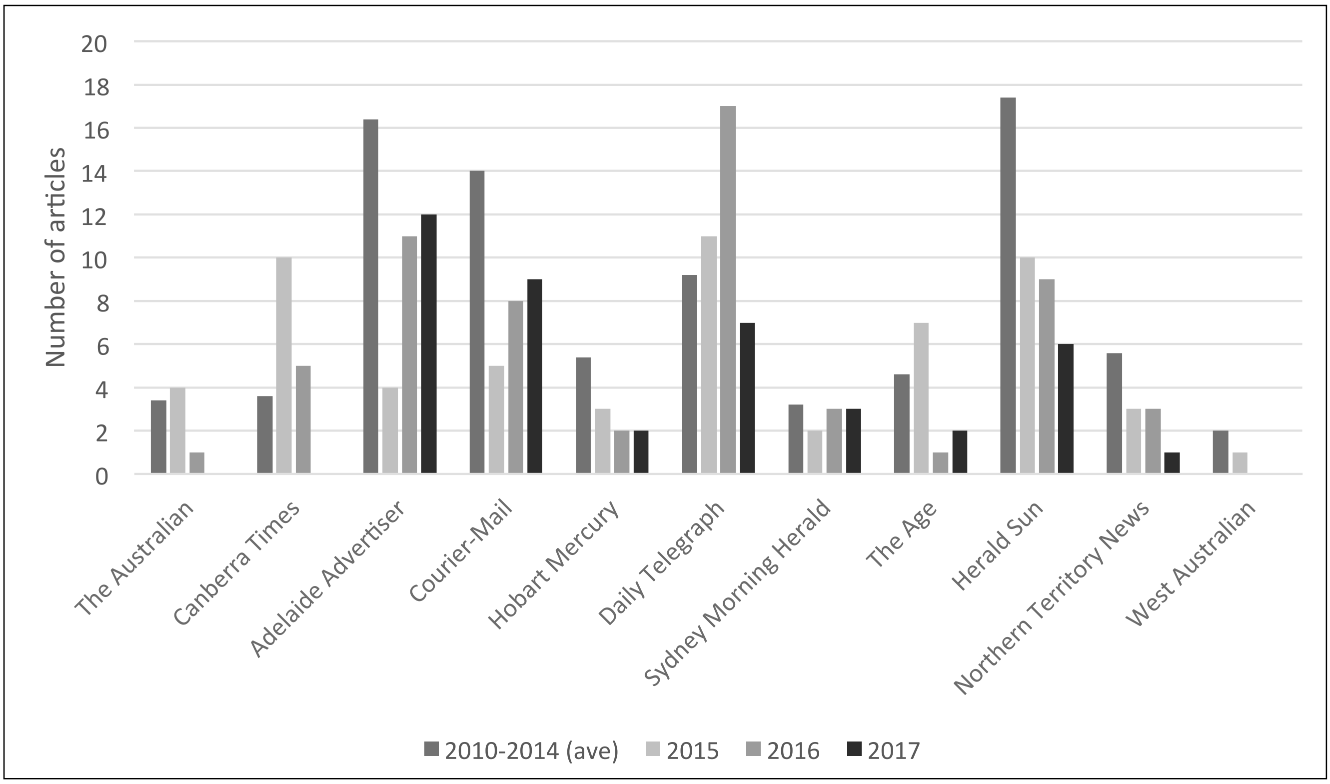

Figure 1. Number of articles, by newspaper, 2010-2014 (average p.a.), 2016, 2017

(Zelizer & Allan, 2010, p. 48). Repeated association of negative images with a community group can impact on the way issues affecting them are viewed (Gerbner et al, 1986, cited in Baker et al.). Such negative images ‘influence decision-making, choices about public policy and public attitudes and behaviours’ (WHO, 2015, p. 159). The sources journalists choose to quote are also important. Citing outside sources allows journalists to ‘borrow from the credibility of others and to demonstrate they have done their due diligence in seeking out relevant interviewees’ (Benson & Wood, 20015, p. 805).

News stories, features and commentary were included. Most linguistic analysis of print newspapers includes the ‘news’ section (Bednarek & Caple, 2012). Examples include Baker et al.’s (2013) study of representations of Muslims and Islam in the British national press (2013) and Blood et al.’s (2003) analysis of representations of illegal drugs in the Australian press. Larkin et al’s (2008) study – of media coverage of crashes which left a child, Sophie Delezio, seriously injured – omitted from analysis of news stories text that repeated details of the child’s injuries and crash location (Larkin et al, 2008). This research project has taken a different approach, retaining similar repetition in the texts analysed as repetition reinforced the representation of older drivers presented. News stories provide prominent coverage of issues related to older drivers and as such are potentially an important source of influence on society’s perception of older people.

Commentary was included as it was an important part of the debate about older drivers. Car reviews were also retained as they indicated the aspect of the car that the journalist was suggesting as relevant to older drivers. Reader comments, such as letters to the editor, were excluded, as were articles that clearly were not about drivers aged 60 and over, such as those on motor racing.

The search returned 424 relevant articles (172,870 words) from 2010-2014 (inclusive), an average of 85 articles per year; 60 articles (29,347 words) from 2015; 60 articles (29,966 words) from 2016; and 42 articles (22,671 words) from 2017. Figure 1 summarises the data for 2010-2014 (average per year), 2015, 2016 and 2017. Content analysed included headlines and text but not graphic elements such as photographs and diagrams. The unit of analysis was the article, as analysis in discourse studies usually focuses on the ‘structures and strategies of a whole event’ rather than the word or sentence (van Dijk, 2009a, p. 192).

A random sample of 10% of the articles from 2010-2014 was produced. Topics present and sources directly and indirectly quoted in the random sample were coded by the first author and her two PhD supervisors to calculate inter-coder reliability. The inter-coder reliability results for the coding of topics from the random sample are summarised in Table 1. The inter-coder reliability results for the coding of sources are summarised in Table 2.

The first author re-coded the random sample to calculate the intra-coder reliability, which was 100% for all topics except ‘solution’ (97%). The intra-coder reliability for sources was lower: Source 1, 82%; Source 2, 85%; Quote 1, 87%; Quote 2, 92%. The first author reviewed the random sample, listing

Table 1. Inter-coder reliability for cross-coding of 40-article random sample

Topics	Road safety risk	Assessment	Regulation	Incident	Solution	Effect on older drivers	Discrimination	Frailty
	%	%	%	%	%	%	%	%
Inter-coder reliability	82	97	87	85	82	68	97	100

all sources named and researched to clarify which category they represented. Similar source categories were grouped together, reducing the categories from 15 to the seven used for the full analysis. These were based on those used in similar studies, such as Benson & Wood (2015).

The source coding exercise was repeated, resulting in intra-coder reliability of 100%.

Six topics were added for the final analysis: (6) fatality and serious injury crash statistics; (7) advice on suitable cars for older drivers; (11) taking away the keys; (12) using the accelerator instead of the brakes; (13) road rage; (14) the role of family and friends. The first author then coded the full database for 2010-2014 (inclusive) and the databases for 2015, 2016 and 2017. Results were recorded in Excel spreadsheets using binary coding, allowing use of Pivot tables to aid interpretation. The coding produced descriptive statistics to report frequencies for each of the relevant variables.

Coding of topics

A list of topics relevant to older drivers was produced from analysis of peer-reviewed journal articles on older drivers from researchers in fields such as gerontology and road safety as well as initial reading of the 424 articles from 2010-2014. The articles were coded according to the presence or absence of these topics.

The topics were: (1) whether older drivers were a road safety risk or not; (2) assessment of driving competency; (3) driving regulation, both by licensing authorities and older drivers themselves (self-regulation); (4) specific driving incidents involving older drivers; (5) solutions, other than punitive measures, such as improved road infrastructure and older driver education; (6) fatality and serious injury crash statistics; (7) advice on suitable cars for older drivers; (8) effect of driving cessation on older drivers; (9) discrimination; (10) frailty; (11) taking away the keys; (12) using the accelerator instead of the brakes; (13) road rage; (14) the role of family and friends.

Coding of sources

Sources can range from government officials to ordinary citizens or official records (Harrower, 2013). Direct quotes present exactly what the person said; indirect quotes summarise or paraphrase what the person said but must retain the source's meaning and sentiment (Lamble, 2011).

Sources included (1) government-related representatives, such as politicians, bureaucrats and other official spokespeople; (2) legal sources, including police, judges and lawyers; (3) experts, including academics and medical spokespersons; (4) influence or lobby groups representatives; (5) business representatives; (6) media; and (7) ordinary citizens (unaffiliated individuals). The source was coded as 'media' when opinions were clearly presented as the views of the editor or journalist, such as in editorials, car reviews and commentary. Where sources fitted more than one category they were recorded in the category that best summed up the capacity in which they were represented in the article. Where the source category was unclear, no category was recorded.

The analysis of articles from 2010-2014 included quotes from official reports as sources. To gain a clearer view of the voices heard, the analyses of articles from 2015, 2016 and 2017 only included people who were quoted, not reports and similar published texts. Coding of legal and political sources and ordinary citizens was straightforward but coding of representatives of semi-government bodies, lobby groups and some business associations was more problematic as it required detailed knowledge of the sector the organisation represented. The first author overcame this difficulty by recording sources' names and affiliated organisations and researching online to clarify the category the source represented where this was unclear. Readers may also have difficulty recognising the sector such sources represent, particularly when a source is affiliated with more than one organisation. For example, Val French was the spokesperson for Queensland lobby group Older People Speak Out but was also a member of the Queensland Government's Ministerial Road Safety Advisory Committee.

Results

Articles on older drivers appeared sporadically in all four

Table 2. Inter-coder reliability for cross-coding of 40-article random sample

Sources	First source mentioned	Second source mentioned	First source directly quoted	Second source directly quoted
	%	%	%	%
Inter-coder reliability	45	55	80	85

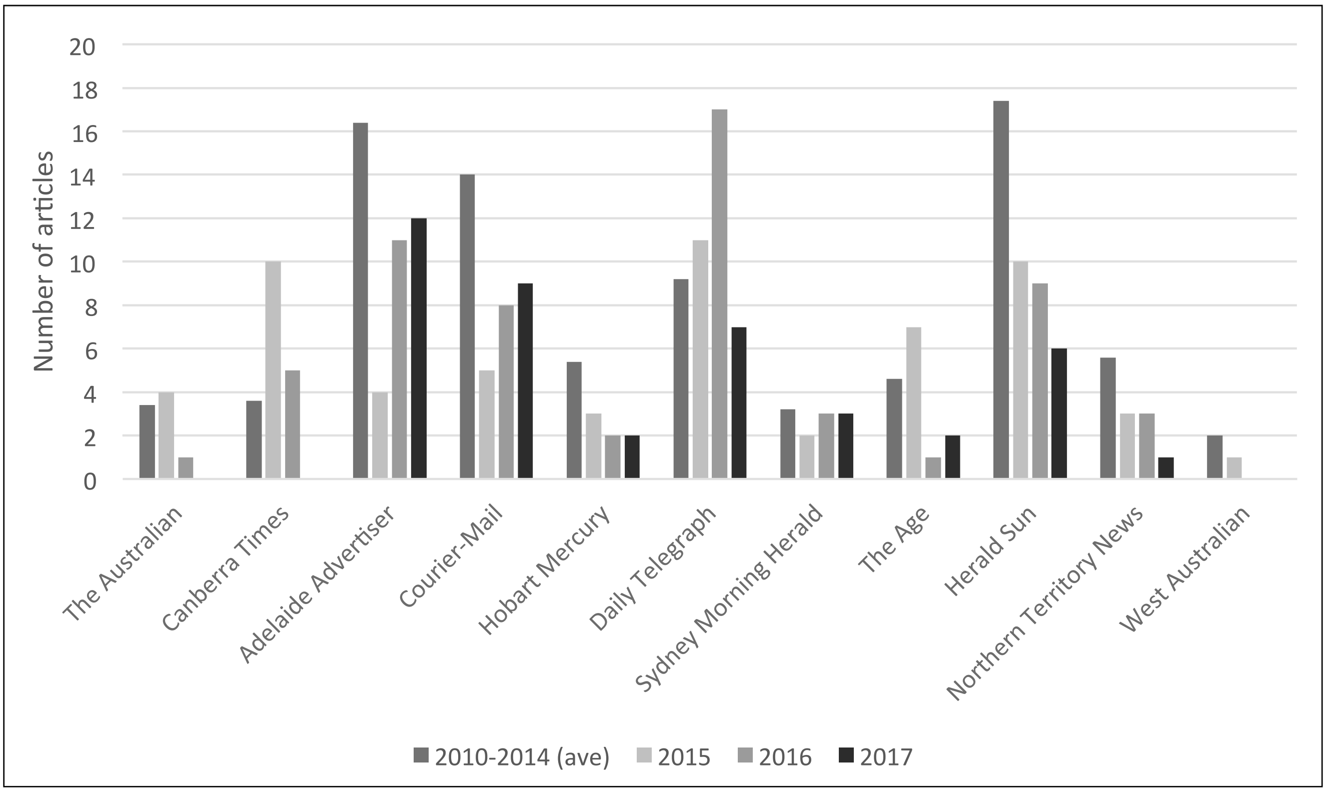

Figure 2. Content topics, by article, 2010-2014; 2015; 2016; 2017

periods. Use of pivot tables in Excel revealed articles clustered in the *Courier-Mail* (Queensland), *Advertiser* (South Australia) and *Herald Sun* (Victoria) in response to fatality and serious injury crashes in 2010-2014. Similar clustering occurred in the *Advertiser* and *Daily Telegraph* (NSW) in 2016 but was not apparent in content analysis results for 2015 and 2017. The search returned fewer articles in 2015, 2016 and 2017 than the average for 2010-2014 but the decline was not uniform across the newspapers. *Herald Sun* articles fell from an average of 17 in 2010-2014 to 10 in 2015, 9 in 2016 and 6 in 2017; *Daily Telegraph* articles increased from an average of 9 in 2010-2014 to 11 in 2015 and 17 in 2016 before falling to 7 in 2017. The 2017 search returned no articles from *The Australian*, *Canberra Times* and *West Australian*. Figure 1 summarises the number of articles, by newspaper, for the four periods, including the average per year for the period 2010-2014 to facilitate comparison of the three period. Articles appeared most frequently in the *Daily Telegraph*, *Herald Sun* and *Canberra Times* (10 articles) in 2015 but in the other three periods, the *Advertiser*, *Courier-Mail*, *Herald-Sun* and *Daily Telegraph* topped the list.

Topics

Whether older drivers posed a threat to public safety on the roads or not was the most common topic in all four periods, appearing in almost two-thirds of articles in 2010-2014 and more than three-quarters in 2015, 2016 and 2017. About a third discussed assessment of older drivers in 2010-2014, 2015 and 2016, although this fell to just under a quarter in 2017. Regulation of drivers' licences was mentioned in more than a quarter of articles in 2015 and about a third in the other three periods. These three topics appeared together in 25% of articles in 2010-2014 and 2015, 32% in 2016 and 24% in 2017.

About a quarter of the articles referred to specific driving incidents involving older drivers in 2010-2014, rising to close to half in 2015 before dropping to a third in 2016 and slightly more than a fifth in 2017. Almost a quarter of the articles from 2010-2014 mentioned fatality and serious injury crash statistics but only 8% mentioned the 'frailty bias' – the contribution of frailty to the over-representation of older people in those statistics. About a third of articles mentioned crash statistics in 2015 and 2016 and more than a quarter in 2017 but references to frailty fell to 3% of articles in 2015, 5% in 2016 and 2% in 2017.

Stock phrases about taking 'the keys' off older drivers appeared in less than 3% of the articles in 2010-2014 and 2% of articles in 2015, 2016 and 2017. Use of catch phrases related to hitting the accelerator instead of the brake occurred in less than 5% of articles in 2010-2014 but rose to

13% of articles in 2015, fell to less than 2% in 2016 and rose again to 7% in 2017. References to older driver car choice were rare in 2010-2014, occurring in just 8% of articles but this category has increased steadily through the periods analysed, rising to 12% of articles in 2015, 23% in 2016 and 26% in 2017. However, most were car reviews involving brief mentions of older drivers in very long articles. Other topics were noted but occurred in too few articles to be recorded as separate categories, including calls for special plates for older drivers' cars. Figure 2 shows the topics most frequently present in articles for the four periods plus the topic 'frailty'.

The newspapers publishing most articles on road incidents involving older drivers were all tabloids. These included the *Courier-Mail* (31 articles), *Herald Sun* (23), *Daily Telegraph* (17) and *Adelaide Advertiser* (12) in the five-year period 2010-2014; *Herald Sun* (7 articles) and *Daily Telegraph* (6) in 2015; *Daily Telegraph* (8), *Adelaide Advertiser* (3) and *Herald Sun* (3) in 2016; and *Courier-Mail* (3) in 2017. Those publishing most articles on assessment of older drivers were also tabloids: the *Courier-Mail* (31), *Adelaide Advertiser* (28) and *Herald Sun* (27) in the five-year period 2010-2014; *Herald Sun* (7) and *Daily Telegraph* (6) in 2015; *Daily Telegraph* (8), *Adelaide Advertiser* (3) and *Herald Sun* (3) in 2016; and *Courier-Mail* (3) and *Adelaide Advertiser* (2) in 2017.

Sources

In the five-year period 2010-2014, 367 articles (87%) indirectly quoted at least one source and 285 articles (67%) used at least one direct quote. In 2015, 58 articles (97%) used at least one indirect quote and 39 (65%) had at least one direct quote from a source. In 2016, 54 articles (90%) used at least one indirect quote and 38 (63%) had at least one direct quote from a source. In 2017, 35 articles (83%) included at least one indirect quote and 27 articles (64%) included at least one direct quote.

The first source indirectly quoted in each article was tallied. The top groups for 2010-2014 were legal sources such as police (74 articles, 17%) and ordinary citizens (73 articles, 17%), which included witnesses to crashes and other driving incidents as well as crash victims and their family and friends, and drivers of various ages. In 2015, legal sources, specifically police, topped the list (23 articles, 40%), followed by the media (8 articles, 14%), academic and other expert sources (7 articles, 12%), government and other official sources, such as emergency service representatives (7 articles, 12%). Legal sources topped the list again in 2016 (15 articles, 25%) followed by ordinary citizens (11 articles, 18%), which included witnesses and others. In 2017, however, the top group was the media. The first statement of opinion was from a journalist or editor in 13 articles (31%). This total included eight car reviews by the newspapers' motoring writers. Academics and other experts (5 articles, 12%) followed with ordinary citizens, business representatives, legal sources and government sources each the first indirectly quoted source in 4 articles (10%).

Ordinary citizens were the first source directly quoted in 74 articles (17%) from 2010-2014, followed by government sources (46 articles, 11%). In 2015, legal sources were quoted first in 13 articles (33%), followed by government and emergency service representatives (7 articles, 18%) and academics and other experts (6 articles). In 2016, legal sources were quoted first in 10 articles (17%), followed by ordinary citizens and representatives of lobby groups, both of which were the first quoted sources in 7 articles (12%). In 2017, ordinary citizens were the first sources directly quoted in 10 articles (24%), followed by business sources (8 articles, 19%).

Headlines

Use of age-related keywords in headlines was recorded. The term 'older drivers' appeared 48 times in headlines in 2010-2014, 3 times in 2015, 8 times in 2016 and 3 times in 2017. The results for use of the other search terms in headlines were: 'elderly drivers' 12, 2, 0, 1; 'older driver' 1, 0, 0, 0; and 'elderly driver' 22, 3, 1, 1. Use of other age-related keywords in headlines was also noted, including 'elderly motorists', 'old drivers' and 'seniors'. Table 3 includes examples of headlines that drew a clear link between age and risk.

Articles were analysed qualitatively but not classified quantitatively as positive, negative or neutral. Quantitative classification of the whole article would involve analysing each sentence and including a weighting for its position in the article. Position is important in journalism. Headlines and the largest image are the first things readers notice on the printed page, followed by captions, then finally an article's text; few people read articles to the end (Stark, 2012; Paul, 2007). Headlines were analysed quantitatively according to how older and elderly drivers were portrayed, with neutral the default if the headline was not clearly positive or negative. Most headlines were neutral across all four periods. The percentage of negative headlines peaked in 2010-2014 and 2016 but they outnumbered positive ones in all four periods. The results were neutral 75%, negative 22% and positive 3% in 2010-2014; neutral 88%, negative 12% and positive zero in 2015; neutral 77%, negative 23% and positive zero in 2016; and neutral 88%, negative 5% and positive 7% in 2017. Negative headlines occurred most frequently in the *Courier-Mail* in 2010-2014, particularly in 2011. Examples included 'Seniors in denial over driver risk' (4/12/11), 'Elderly driver of crash car escapes jail – No recollection of hitting woman who had to have leg amputated' (30/6/11), and 'Senior drivers again under scrutiny as toll overtakes last year's figure (3/10/11). However, negative headlines were not restricted to the tabloids. 'Elderly dying like teens used to' (*The Age*, 2/1/14), 'Elderly drivers as dangerous as young hoons because cognitive, physical abilities diminish' (*The Age*, 4/5/15) and 'Elderly drivers as dangerous as hoons' (*Canberra Times*, 4/5/15) were published in former broadsheets. The *Daily Telegraph* used neutral headlines to represent older drivers in 2016 despite publishing more articles on road incidents involving the cohort than any of the other newspapers.

Table 3. Some headlines drew a clear link between age and risk

Headline	Newspaper	Date
Too many old drivers have a licence to kill	*Daily Telegraph*	4/12/11
Seniors in denial over road risk	*Courier-Mail*	4/12/11
Older drivers a road menace	*Herald Sun*	19/8/14
Elderly drivers as dangerous as young hoons because cognitive, physical abilities diminish	*The Age*	4/5/15
Elderly drivers as dangerous as hoons	*Canberra Times*	4/5/15
For safety's sake, test older drivers	*Herald Sun*	19/2/16
Safety focus needs to shift to older drivers	*Sydney Morning Herald*	15/9/16
Driving is a privilege. Many older drivers have lost their ability and are a danger to themselves and others	*Advertiser*	22/9/16
Elderly drivers on the nose	*Herald Sun*	9/12/17
Put brakes on old drivers	*Courier Mail*	3/12/17
Can't teach an old biker new tricks	*Sun Herald*	24/12/17

Discussion

The newspaper analysis supported concerns that the media inflated the risk posed by older drivers through its attention on road fatalities (Langford, 2009; OECD, 2001). However, the attention to road incidents went beyond news stories on fatality crashes, as qualitative analysis revealed. Newspaper editors make choices in the way a particular topic is presented. The choices can result in overstatement for dramatic effect and impact the way information is emphasised or de-emphasised, what van Dijk (2009a, p. 195) terms 'structural transformations'. Such effects contribute to the way an article is framed, using Entman's definition of framing as selecting 'some aspects of a perceived reality and making them more salient in a communicating text' (Entman, 1993, p. 52).

The media commonly presents issues in terms of problems, causes and solutions. Benson & Wood (2015), for example, noted 'problem' frames, 'causal' frames and 'solution' frames in their study of British press coverage of immigration. However, one frame or aspect of the issue dominated the articles analysed on older drivers: representations of older drivers as a problem for society in terms of safety. Almost two-thirds of the articles discussed older drivers and issues related to them in terms of a safety risk to other road users or themselves in 2010-2014, increasing to more than three-quarters of articles in 2015, 2016 and 2017. Mandatory age-based assessment of older drivers was the most frequently presented solution, as road safety researchers had earlier noted (Charlton et al., 2009; OECD, 2001) but few articles specified appropriate tests. About a third of the articles discussed assessment of older drivers in 2010-2014, 2015 and 2016, falling to just under a quarter in 2017. Regulation of where and when people drove, predominantly focused on legislative regulation, was mentioned in about a third of articles in all periods except 2015 when slightly more than a quarter raised this issue. These three topics appeared together in 25% of articles in 2010-2014 and 2015, 32% in 2016 and 24% in 2017, more frequently than any other cluster of topics, indicating application of a public risk frame for coverage of issues related to older drivers, rather than frames focusing on causes or less punitive solutions.

More than a quarter of articles in 2010-2014 referred to specific driving incidents involving older drivers, rising to almost half in 2015, before falling to a third in 2016 and less than a quarter in 2017. Three crashes involving elderly drivers dominated coverage in 2010-2014 and 2016, igniting calls for tougher restrictions on older drivers. Two resulted in the death and serious injury of pedestrians in Queensland; the third involved the death of a cyclist in NSW. Pedestrian Ali France sustained serious injuries that resulted in the amputation of part of one leg when she was hit by a car in a car park in Queensland in 2011. France was a former *Courier-Mail* journalist and the daughter of then-Queensland state MP Peter Lawlor. Kerryn Blucher and her unborn child died when the young mother was hit by a car in Queensland in 2012. Cyclist Maria Defino died after she was hit by a car in NSW in 2013. Newspaper reports at the time quoted police stating the elderly driver had lost control of her car after suffering a seizure. Several articles included summaries of traffic incidents involving elderly drivers, including 'Leadfoot oldie, Spate of car accidents triggers a caution for the elderly' (*Herald Sun*, 17/7/13). Aggregating traffic incidents reminded readers of the events but the repetition also exaggerated the danger posed by older drivers. Repetition strengthens an image until it becomes the commonly held view, having a long-term effect that begins small but compounds over time 'as a result of the repetition of images and concepts' (Baker et al, 2013).

The risk posed by older drivers to themselves and other road users was further distorted by reporting of traffic incidents involving older drivers even when no fatality or serious injury occurred. When a man, 90, lost control of his car at Sydney's Bondi Beach in February 2014, for example, the story appeared in *The Australian* ('Rain saves the day as elderly driver avoids Bondi Beach crowds', 5/2/14), Sydney's *Daily Telegraph* ('Bondi beached', 5/2/14) and Brisbane's *Courier-Mail* ('Beachfront park sparks panic, foreshore', 5/2/14). The Brisbane headline gave no indication that the incident was not local. Another incident involved an elderly woman in Victoria, who became lost after dropping her son at Melbourne Airport in 2012 and ended up sitting in her car, teetering above a ravine almost 200km from home. The incident was reported in the *Herald Sun* ('A woman on the edge, Elderly driver's wrong turns almost end in disaster'16/8/12). The headline's keywords – 'woman', 'elderly driver', 'wrong turns' and 'disaster' – emphasised age, gender and cognitive decline. The article included no expert opinion or advice. The unusual nature of an elderly woman's predicament became news to entertain rather than inform.

Traffic incidents and crashes involving older drivers sparked interest in testing the cohort, despite research suggesting that compulsory age-based assessment does not improve road safety (Hakamies-Blomqvist, 2004; Langford, 2009; Langford et al., 2008a; Langford et al., 2008b; OECD, 2001). A *Courier-Mail* article ('Car crashes into fence' (22/9/12), for example, stated that an elderly driver had lost control of her car and crashed through a fence while following an ambulance taking her husband to hospital. Readers were not told until paragraph four that the crash occurred as the driver was backing out of her carport and the fence she hit was her side fence. The second paragraph had reminded readers of the death of Queensland pedestrian Kerryn Blucher and her unborn child several weeks before. The third paragraph had called for more rigorous tests for older drivers. A crash in which no-one was injured was linked to an on-going campaign for tighter age-based assessment of older drivers. One elderly driver crashed into her own side fence. Another pleaded guilty to dangerous operation of a vehicle causing death (ABC, 2014). Linking such events suggested the crashes had a common cause – the drivers' ages – misrepresenting the risk posed by older drivers. The headlines used, the way stories were told, the types of words repeatedly associated with older or elderly drivers in news articles, features and opinion pieces contributed to a perception that the cohort was a threat to community safety.

In-depth articles discussing issues related to driving and ageing appeared most frequently in 2010-2014, when 14 articles included at least eight of the topic categories, compared to six articles in 2015, two in 2016 and three in 2017. They included 'In for the long haul' (*Sydney Morning Herald*, 8/1/10)and 'Who will be driving Mrs Davis' (*Courier-Mail*, 5/11/13), which mentioned the effect of frailty on older people in crashes and featured a 100-year-old driver and her son. The *Sydney Morning Herald* article also discussed the effect of frailty, as well as health issues affecting driving ability, the need to retain mobility where possible as people age and the economic cost to society of restrictions on older drivers.

Comprehensive articles, however, were not always so positive in their depiction of older drivers. 'No need for speed – Ageing population forces rethink on road' (*Courier-Mail*, 7/10/12) focused on a recently released Queensland Government's Older Driver Safety Advisory Committee report. Its lead (in this case the opening sentence) stated that the government was reviewing speed limits because older people 'like to drive slowly'. Such an explanation would hardly endear older drivers to the broader population. The article further stated that 'experts' had given the government recommendations to prepare for a 'tsunami of ageing motorists', clearly presenting the ageing population as an impending disaster.

Articles that stood out from the basic news stories on crashes and road incidents included 'Some models more prone to prangs' (*The Australian*, 10/1/15), which reported on the over-representation in crashes of small cars, such as those popular with older and younger drivers; and 'GPs wary on drive bans' (*Herald Sun,* 7/2/12), which presented the results of a survey of general practitioners on medical tests for older drivers. This was an aspect of the assessment debate that most articles ignored. The *Herald Sun* also published articles from road safety experts, such as 'Keeping older drivers on the road is the test', (Charlton, *Herald Sun*, 18/7/13) and 'Should there be mandatory testing for older drivers?', (Congiu, *Sunday Herald Sun*, 24/6/12). Such articles highlighted important information that was under-represented in most of the articles analysed.

Frailty of older people is acknowledged as a major contributor to death and serious injury in crashes for the age group (Li, 2003; Langford, 2009; Whelan, et al., 2006) yet the number of articles referring to the effect of frailty on crash outcome fell from 8% in 2010-2014 to 2% in 2017, despite an increase in the number of articles discussing road fatality and serious injury crash statistics. Failing to acknowledge the frailty bias may contribute to the public's distorted view of older drivers and the risk they pose for other road users. Articles on road fatality statistics focused on drivers, particularly the older and youngest age groups. However, statistics present total fatalities for drivers, pedestrians, passengers, motor cyclists, bicyclists and their pillion passengers. Table 4 shows 2017 statistics for driver,

Table 4. Road fatalities by road user, 2017, based on analysis of BITRE (2018a)

Road user	Drivers	Passengers	Pedestrians	Total
	n (%)	n (%)	n (%)	n (%)
Age 75 and over	89 (51)	34 (20)	41 (24)	174 (100)
Age 65-74	47 (40)	24 (20)	21 (18)	118 (100)
Age 17-25	112 (49)	57 (25)	15 (7)	230 (100)

passenger and pedestrian fatalities in the youngest and oldest age groups. Almost a quarter of elderly road fatalities were pedestrians.

Headlines may further contribute to distorted public perceptions of the risk posed by older drivers, as well as contributing to an ‘us’ and ‘them’ division. The succinct summaries at the top of articles are among the tools newspapers use to attract readers. Most people read headlines before captions and the article’s text (Stark, 2012; Paul, 2007). Verbs are ‘the headline writer’s friend’ and those used in headlines should not only describe an action but also ‘demonstrate a mood, an emotion and a characteristic’ (Downman, 2008, p. 76). However, such newspaper conventions aimed at attracting readers to an article have the potential to promote social division, particularly when verbs such as ‘kill’ are used in headlines that focus on the age of drivers. Two headlines from the same newspaper illustrated the difference between a headline focused on a driver’s age and one focused on a specific crash: ‘Elderly driver on trial for killing’ (*Courier-Mail*, 7/6/13) and ‘Death driver walks free’ (*Courier-Mail*, 12/2/14). Both described actions related to the same fatal crash. The first drew attention to the driver’s age, the second did not.

Pronouns used in headlines may imply division of a newspaper’s readership. ‘Get them off the road – Seniors fight push for elderly drivers to hand licences in’ (Herald Sun, 20/2/12), for example, divided readers into ‘them’ (seniors) and an implied ‘us’. ‘Brakes on our oldies – 80 seniors a week forced to surrender licences – Families, doctors urged to dob in seniors’ (Herald Sun, 12/8/13) implied responsibility for ‘our oldies’ in a way that disempowers them. The verb ‘dob’ in the headline is also an example of how word-choice can derail a message.

Newspaper headlines tend to include short words, active verbs and references to people (Layton, 2011). Short verbs can convey meaning precisely but take up little space. They are used in body text for the same reason. An article in 2016 informed readers that VicRoads wanted families, doctors and carers to ‘dob in anyone they know whose faculties are failing’ (For safety’s sake, test older drivers, *Herald Sun*, February 19, 2016). The verb ‘dob’ has negative cultural overtones, making its use to describe the process for reporting at-risk drivers to licensing authorities problematic.

Researchers argued that comprehensive assessment of driving requires specialised training (Dickerson, 2014) but there was a shortage of trained assessors (Charlton et al., 2009). They further reported that common tests to screen drivers were unable to predict driving performance and future crash risk with sufficient accuracy to be reliable mass screening tools (Bedard, 2008). Such issues received scant coverage. When governments proposed changing licensing regulations to reflect published research results, however, the issue became newsworthy.

The South Australian government’s proposal to ease medical requirements for drivers aged 70 and over in 2014 was front page news in *The Adelaide Advertiser* (‘New drive for elderly to self test’, 3/9/14) and discussed further on page 4 (‘No tests for old drivers’). The proposed change also allowed self-assessment of driving capability if a driver had no relevant pre-diagnosed medical conditions. The headline above an opinion piece – ‘We can’t rely on safety of test-yourself drivers’ (5/9/14) – was consistent with the ‘older driver risk’ frame noted above, despite the proposal reflecting Austroads’ guidelines suggesting all drivers notify their licensing authority of medical conditions likely to affect their safe driving (Austroads, 2016). News about bad aspects of ‘them’, particularly against people like ‘us’, are considered more salient than the reverse (van Dijk, 2009a). The article focused on *older drivers* rather than *all* drivers with notifiable medical conditions and presented a stereotyped image of old people with poor motor skills, slow reaction times and vision that was ‘kaput’.

Use of ‘older drivers’ and similar terms as keywords or labels linked incidents to more serious crashes and contributed to the perception of older people as incompetent, unpredictable and dangerous. Treating them as a homogeneous group also ignored differences in age, gender, level of physical and mental capacity, and socioeconomic status as well as the effects of environmental factors, such as differences in road infrastructure and transport depending on where they live.

Stereotyping for dramatic effect

The representation of older drivers depends, however, not just on the topics discussed but on how the discussion unfolds. Discourse analysis revealed significant differences between two articles – ‘Still here, still driving’ (*The Age*, 13/3/14) and ‘Too many old drivers have a licence to kill’ (*Sunday Telegraph*, 4/12/11) – both of which included in-depth coverage of issues related to driving and ageing. The *Age* article focused on an older driver who was ‘mindful of the responsibility of being an older driver’; the *Sunday Telegraph* article presented an anecdote from the columnist about being missed ‘by inches’ by a car driven by a man ‘so old he possibly didn’t even know he was in a car’. The columnist wrote about an elderly driver who ‘looked like he was 90 in the shade’, wore thick glasses and drove with ‘his neck stuck forward’ and ‘squinting through the windscreen’, and about a second ‘old man, face pressed up against the glass again’ who ‘happily coasted through’ a pedestrian crossing while the journalist waited to cross.

Such descriptions are examples of overstatement for dramatic effect, one of the structural transformations discussed by van Dijk (2009a). The overstatement emphasised poor cognitive skills and bad eyesight, details about the drivers that the journalist could not actually know. Such anecdotes present negative personal experiences as ‘objective proof’ (van Dijk, 2009b, p. 207), promoting a stereotype of elderly drivers as poor decision-makers with poor eyesight, reminiscent of the cartoon character Mr Magoo, as noted by Larkin et al. (2008).

Qualitative analysis revealed the difference in tone between the two articles, quantitative analysis did not. *The Age* article presented a series of quotes from expert sources, including a comment from MUARC spokesman Brian Fildes that age-based testing of drivers is discriminatory. The statement was offered without direct response from the journalist. The *Sunday Telegraph* article, by contrast, quoted a comment from Older People Speak Out spokeswoman Val French from a report on driver's licence regulations in Queensland, in which Ms French expressed frustration with discrimination against older people. The quote was followed by a comment from the journalist that 'Val should look up from her knitting' and read a paragraph from a NSW study on car driver fatalities. The journalist treated her in the way Tuchman et al. (1978) noted that the US media treated women in the 1970s – trivialising them and dismissing them 'to the protective confines of the home' (Tuchman et al., 1978). Such gender-based and ageist stereotyping was not indicative of all newspapers analysed. The *Sunday Telegraph* article ran in other states ('Seniors in denial over road risk', *Sunday Courier*, 4/12/11); 'Seniors can't all be allowed at wheel', *Sunday Herald Sun*, 4/12/11) but the versions published in the *Sunday Herald Sun* and *Sunday Mail* omitted the Val French quote and the knitting reference.

Conclusion

The driver licensing system in most Australian states relies on families, police and medical professionals notifying the driver licensing authority of at-risk drivers, although it is not compulsory for third parties to do so (Charlton et al, 2009). Public education is needed to raise community awareness of the importance of identifying at-risk drivers. The challenge is to raise awareness without adversely affecting the mobility of safe drivers. Reducing the number of at-risk drivers is a whole-community task, requiring respectful treatment of older people whose skill set makes driving a danger to them and other road users.

This study is the first to focus broadly on Australian mainstream print media coverage of older drivers and issues related to them, rather than on coverage of specific high profile crashes involving the cohort. It included commentary as well as news and features, as print media commentators were an important part of the debate about mass age-based screening of drivers. Its results suggest that the decline in negative headlines from 2016 to 2017 is a step towards improving social cohesion. The study has also shown that articles in mainstream newspapers in Australia appear too infrequently to address adequately the identified need for community education. Analysis revealed that the newspapers that published the most articles on older drivers were also those most likely to report crashes and other road incidents involving the cohort. The predicted increase in older drivers was predominantly framed as a risk to public and individual safety, to be tackled through punitive measures rather than through economic or social measures, resulting in coverage of a narrow range of information.

The study did not examine representations of older drivers and issues related to them in other forms of traditional media, such as radio and televion. Nor did it explore portrayal of the cohort online, such as on the websites of mainstram media organisations, in social media and in podcasts. Googling 'older driver shop window', however, in October 2018 produced more than 5 million results in less than a minute, indicating at least one aspect of ageing and mobility is receiving attention online. Examining what sort of attention is fertile ground for further research.

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