

GUEST EDITORIAL

Road safety in an aging population: risk factors, assessment, interventions, and future directions

Introduction

With the number of older drivers projected to increase by up to 70% over the next 20 years, preventing injury resulting from crashes involving older drivers is a significant concern for both policy-makers and clinicians. While the total number of fatal crashes per annum has steadily decreased since 2005 in Australia, the rate of fatalities has demonstrated an upward trend since 2010 in drivers aged 65 years and above (8.5 per 100,000), such that it is now on par with the fatality rate in drivers aged 17–25 years (8.0 per 100,000) (Austroads, 2015). Similar statistics are reported for the United States (NHTSA, 2012), implying there is a need for better identification of those older drivers who are unsafe and implementation of strategies that can enhance mobility while maximizing road safety.

The responsibility for ensuring older drivers are safe drivers often falls between the health and road safety sectors, with few countries or jurisdictions providing an overall, integrated approach to assessment, reassessment, and management. Prevalent medical conditions among very old adults (over 85) such as dementia, stroke, and eye disease reduce driving safety and in the case of dementia and macular degeneration will inevitably preclude driving with progression of symptoms.

We argue that there is a need for an evidence-based system of assessment, reassessment, intervention, and license review for older adults. An older driver may present to a psychiatrist, neurologist, optometrist, general practitioner, or other health professional. Reliance solely on health professionals to report crash risk based on clinical judgment may result in patients failing to report important symptoms for fear of license implications. Alternatively, physicians, with little training in relevant evidence-based crash risk assessments, may not recognize deficits associated with unsafe driving. In many countries a system to manage older drivers will need to be multi-sectorial and multi-disciplinary, involving a range of clinicians (including driving specialists) and government licensing authorities (Carr and O'Neill, 2015).

Clinical judgment of driving capacity without objective assessment

In most systems, evaluation of fitness to drive (FTD) is largely placed in the hands of physicians. This is consistent across several countries: Canada (Marshall *et al.*, 2012), the United States (American Medical Association, 2014), the United Kingdom, (Hawley and Galbraith, 2008) and Australia (Sims *et al.*, 2012). Given the accessibility of family physicians, and their capacity to screen for a range of medical conditions that potentially impact driving safety, primary care is a logical first point of contact in the process of evaluating FTD. Over the past decade, however, there has been growing recognition that physicians are not confident in making FTD assessments (Lipski, 2002; Jang *et al.*, 2007; Marshall *et al.*, 2012; Sims *et al.*, 2012). Surveys conducted on Canadian physicians from a range of specialties (Jang *et al.*, 2007; Marshall *et al.*, 2012) found that only 33% felt confident in their ability to make FTD assessments, and 73%–88% felt they would benefit from further education. Similarly, in the Australia surveys of general practitioners (GPs) found that only 41%–54% felt confident in their ability to assess FTD, and 59%–74% felt they would benefit from further education in this area (Lipski, 2002; Sims *et al.*, 2012).

Current recommended practice for FTD assessment in the medical/office-based context includes gathering evidence regarding the patient's cognitive status, presence of fluctuating conditions, visual impairment, musculoskeletal conditions, drugs and alcohol, as well as history of traffic infringements and informant report of driving difficulties (Carr and Ott, 2010; Molnar and Simpson, 2010; Carmody *et al.*, 2012). However, most guidelines for applying this type of clinical data collection are based on expert opinion or consensus statements rather than objective evidence. For example, practice parameters provided by the American Academy of Neurology propose the use of global cognitive measures such as the Mini-Mental Status Examination (MMSE) and the Clinical Dementia Rating Scale (CDR), and a family/caregiver questionnaire of driving history,

for identifying patients at risk of unsafe driving (Iverson *et al.*, 2010), with only slightly different protocols suggested by other groups (Canadian Medical Association, 2006; Australian and New Zealand Society for Geriatric Medicine, 2010). Critically, most recommended measures are either not validated against on-road performance, or have poor evidence of association with driving safety risk (Odenheimer *et al.*, 1994; Reger *et al.*, 2004; Crizzle *et al.*, 2012; Joseph *et al.*, 2014). Furthermore, recommendations are not consistent, with some guidelines suggesting a diagnosis of early dementia is sufficient to enforce driving retirement (Iverson *et al.*, 2010; Austroads, 2012), while others suggest this is not sufficient evidence for license cancellation (Australian and New Zealand Society for Geriatric Medicine, 2010).

Few studies have investigated the accuracy or validity of physician assessments of FTD. One study examined the association between physician warnings given to drivers aged over 18 years, and emergency department visits relating to road-traffic incidents in which the patient was a driver ($n = 100,075$) (Redelmeier *et al.*, 2012). Using a self-matching cross-over design, Redelmeier *et al.* found that crash-related injury declined by 45% in the year following the physician warning compared to the three years preceding the warning. Older drivers, who constituted 51% of their sample, showed a similar pattern to the rest of the sample with injury rates declining in those aged 60–75 years (3.39 per 1,000 per annum to 2.29), and in those aged 75 years and above (2.65 per 1,000/pa to 0.93 per 1,000/pa) (Redelmeier *et al.*, 2012). However, the methodology used in this study makes it difficult to determine whether the change was caused by license cancellation (which occurred in 10%–30% of cases) or the warning itself, and how the physician warnings were implemented (e.g. driving cessation, self-regulation, or remediation). Importantly, the false positive rate cannot be determined. In fact, Redelmeier and colleagues report that following the physician warning, the patients' emergency department visits for depression increased from 19 per 1,000/pa to 23 per 1,000/pa, and visits to the responsible physician declined by 29% (Redelmeier *et al.*, 2012) lending some credence to physicians' concerns that FTD assessments have negative impacts on patient-physician relationship and may reduce visitation rates (Lipski, 2002; Jang *et al.*, 2007; Marshall *et al.*, 2012; Sims *et al.*, 2012).

Fox and colleagues (1997) examined the association between physician judgment of FTD in 19 patients with Alzheimer's Dementia (AD) (which included medical exam, MMSE, caregiver report, and vision testing), against an on-

road assessment conducted in traffic by an occupational therapist (OT). They found that physician prediction of driving competence was not associated with on-road performance (Fox *et al.*, 1997). Furthermore, 37% of the AD patients were judged as safe to drive by the on-road assessment, suggesting that AD diagnosis may not be sufficient to recommend driving cessation.

A Delphi study on physician consensus in identifying at-risk older drivers (Rapoport *et al.*, 2014), had 41 physicians rate 26 patient scenarios, and achieved only 27% consensus, which improved to 69% on the fifth iteration. They found the strongest predictors of physician decisions were caregiver concern and abnormal performance on the Clock Drawing Test, and recommended that uncertain cases be referred for on-road assessment (Rapoport *et al.*, 2014). A systematic review of studies on the validity of in-office FTD assessments for a range of chronic diseases (e.g. Parkinson's Disease, AD, Sleep Apnoea, Stroke etc.) concluded that the clinical tests employed in these studies were not consistently related to measures of driving performance (Marino *et al.*, 2013).

Based on current evidence, it is therefore unclear whether physician assessment of FTD provides an accurate prediction of driving safety. Although physician warnings have the potential to influence rates of crash related injury, their specificity, reliability, and accuracy needs to be evaluated in order to minimize negative effects of unnecessary or premature license cancellation. Clear, consistent guidelines and validated in-office screening measures are critical for physicians to not only feel confident in their decision-making for further referral, but to provide an accurate first-tier evaluation of risk in a multi-tiered, multi-disciplinary system for assessing FTD (Carmody *et al.*, 2013).

Risk assessment

Risk assessment for older drivers focusses on cognitive, visual, and motor abilities that are linked to safe driving in large cohort studies (Reger *et al.*, 2004; Mathias and Lucas, 2009; Devos *et al.*, 2011).

Cognitive function

Common risk assessment tools currently widely used to screen for cognitive impairment fail to discriminate safe from unsafe drivers. For example, a large Canadian study ($n = 17,538$) found that the MMSE did not predict crashes over two years of follow-up (Joseph *et al.*, 2014). Generic tools and dementia screening instruments do not assess the

specific deficits that cause drivers to become unsafe. A consistent body of research has demonstrated that memory deficits are not typically associated with unsafe driving (Reger *et al.*, 2004; Anstey *et al.*, 2005; Aksan *et al.*, 2015), which may explain why patients with early AD may continue to drive safely. In contrast, deficits in executive function, visual selective attention, and processing speed predict crashes in older drivers (Ball *et al.*, 2006; Dawson *et al.*, 2010; Anstey *et al.*, 2012). As dementia progresses and multiple domains of cognitive function are affected, driving cessation is inevitable. Some specific types of cognitive deficits in non-AD dementia may also preclude safe driving early in the disease. Cognitive assessment for safe driving focusses on key abilities which are evaluated in most older-driver screening batteries e.g. Wood *et al.* (2008).

Visual function

VISUAL TESTS

Visual acuity (VA) is the most common method employed to assess visual function in clinical practice and by licensing authorities. However, studies using a range of sample sizes and methodologies have found only a weak relationship between VA and crash risk (Hofstetter, 1976; Gresset and Meyer, 1994; Marottoli, 1998; Ivers *et al.*, 1999) or no association (Keeffe *et al.*, 2002; Rubin *et al.*, 2007; Cross *et al.*, 2009). High-contrast static VA is unlikely to represent the normal-driving environment that includes both static and moving objects of different sizes and contrast levels. Tests of contrast and motion sensitivity and visual fields may thus provide better measures of visual performance for driving than VA.

VISUAL AGING AND EYE DISEASE

Population studies consistently demonstrate an increase in the prevalence of visual impairment for those aged 65 years and above (Klein *et al.*, 1991; Attebo *et al.*, 1996; Rubin *et al.*, 1997). For example, the prevalence of bilateral visual impairment, defined as VA worse than the commonly adopted driving standard of 6/12 (or 20/40), increases from 1% for those between 60–69 years, to 26% for those aged 80 years and over (Wang *et al.*, 2000).

An estimated 30% of the older population have significant cataract in at least one eye (Rochtchina *et al.*, 2003). Many people live with cataracts for extended periods before cataract removal (Owsley *et al.*, 1999); with around a quarter of these continuing to drive, even if their vision fails to meet the visual standard for driver licensing (Monestam, 1999; Pager *et al.*, 2004). This has important

ramifications for driving safety, given that older drivers with cataracts have 2.5 times higher crash rates than age-matched controls without cataracts (Owsley *et al.*, 1999).

Glaucoma is one of the leading causes of visual field loss in older adults (Ramrattan *et al.*, 2001) with approximately 60 million people affected by the disease worldwide, with numbers estimated to increase in the aging population (Quigley, 2011). It has been estimated that 20% of those with glaucoma experience progressive loss of their visual fields even with appropriate treatment (Musch *et al.*, 2009) and approximately half of those with glaucoma are not aware that they have the condition (Weih *et al.*, 2001). Numerous studies suggest that glaucoma is associated with higher at-fault crash risk than those without glaucoma (e.g. McGwin *et al.* (2015)).

Finally, age-related macular degeneration (AMD) is the leading cause of irreversible moderate to severe visual impairment in older adults worldwide (Weih *et al.*, 2000; Wang *et al.*, 2000). A retrospective study (McGwin *et al.*, 2013) showed that drivers with intermediate AMD, had significantly lower crash rates than drivers with normal vision. The authors suggest that these drivers self-regulate their driving to avoid challenging situations and exercise greater caution on the road, which is reflected in their lower risk for crashes. In contrast, drivers with early and advanced AMD had similar crash rates to the controls. Drivers with early AMD may be less likely to self-regulate their driving, given their better levels of visual function, and thus show similar driving risk profiles to controls. Interpretation of the findings is also difficult for drivers with advanced AMD due to the low numbers of active drivers, as many cease driving in the advanced stages of the condition (Sengupta *et al.*, 2014).

Approaches to prevention

There is increasing evidence that some interventions, or combinations of interventions, improve the driving safety and mobility of older adults. Adaptive cognitive training programs (i.e. those that systematically increase difficulty level during training), have transferred to both maintained driving mobility and safety. For example, Speed of Processing Training, which focuses on visually-based processing speed and divided and selective attention, has repeatedly been shown to reduce driving cessation risk across three years and maintain driving mobility across five years as compared to both a no-contact and social-contact control groups (Edwards *et al.*, 2009a; 2009b; Ross *et al.*, 2015). Importantly, this training has also

demonstrated transfer to driving safety. Ball and colleagues examined the impact of ten hours of three separate cognitive training interventions (Speed of Processing, Reasoning, and Memory) compared to a no-contact control group on crashes across six years (Ball *et al.*, 2010). Results revealed that the Speed of Processing and Reasoning training interventions resulted in over a 40% reduction in at-fault state-reported crashes. When training focused on memory performance, which is not typically predictive of driving outcomes, there was no impact on driving safety.

In addition to improving cognitive function, there is growing evidence that improving visual function related to eye disease has important benefits for road safety. A growing body of work suggests that cataract removal improves driving safety (Subzwari *et al.*, 2008). In one study, cataract surgery resulted in a 50% reduction in crash rates, compared to those who did not have surgery (Owsley *et al.*, 2002) and an Australian study found that cataract surgery resulted in a 12.7% reduction in crashes corresponding to \$4.3 million in savings (Meuleners *et al.*, 2012). Relatedly, Mennemeyer and colleagues (2013) extended this work using a US data simulation model and found that earlier removal of cataracts, versus current treatment, reduced crashes by 21%, thus illustrating the important, and often under-investigated, impact of the timing of interventions.

Interestingly, educational interventions are one of the most commonly used forms of rehabilitation; however, current evidence suggests that educational interventions alone have a minimal impact on driving safety. Owsley and colleagues found that visually impaired participants reported avoiding more challenging driving situations after an educational intervention (Owsley *et al.*, 2003); however, the intervention had no impact on driving safety (as measured by crashes) two years later (Owsley *et al.*, 2004). Similarly, Bédard and colleagues (2004), examined a widely-used educational intervention and found that the training did not result in significant improvements during an on-road evaluation. There is some evidence that educational programs combined with other components, such as on-road training (Marottoli *et al.*, 2007b; Bédard *et al.*, 2008) may improve on-road driving.

Finally, the improvement of physical abilities related to driving may also be an avenue for improved function. Marottoli and colleagues (2007a) found that a graduated physical therapist-guided exercise program translated to improvement of on-road driving performance. Although not an exhaustive review of driving safety interventions, the studies discussed here provide support that

there are an increasing number of potential domains, and combinations of domains, that may be targeted to enhance driving safety. Further discussions of driving safety and mobility should include not only assessment, but importantly, potential rehabilitation through evidence-based interventions.

Other older road users – pedestrians and cyclists

Discussion of road safety in aging often omits walking and cycling which are cost-effective methods of maintaining mobility and increasing physical activity for older adults. Numerous studies report that older adults have the highest risk of mortality of all pedestrians when involved in vehicle collisions (e.g. Koepsell *et al.*, 2002). While this is partly due to older adults' increased frailty, simulation studies indicate that aging affects gap selection, in particular, the ability to weigh-up estimated vehicle time of arrival and one's own walking speed when selecting a gap in the traffic to cross the road (Oxley *et al.*, 2005; Lobjois and Cavallo, 2009; Holland and Hill, 2010; Dommès and Cavallo, 2011). Mobility-impaired older adults show additional difficulty in judging safe crossing gaps to compensate for their rate of walking (Holland and Hill, 2010). Age-related cognitive changes such as decline in executive functions, including decision making, and attentional control, are speculated to contribute to unsafe crossing behavior in older adults (Oxley *et al.*, 2005; Lobjois and Cavallo, 2009; Dommès and Cavallo, 2011). The effects of neurodegenerative diseases such as AD and Parkinson's disease further increase risk for older pedestrians (Gorrie *et al.*, 2008). Studies suggest that signs of neuropathology (e.g. brain accumulation of neurofibrillary tangles) is associated with risk of older pedestrian crash fatalities (Gorrie *et al.*, 2006), particularly in areas with low complexity traffic (Gorrie *et al.*, 2008).

Cycling in older adults has received very little research interest. However, a Swedish study of older bicyclists ($n = 456$) treated for injury over a ten year period found that the most frequent cause of injury was due to falls when mounting or dismounting the cycle (20%) or due to irregular road surfaces (13%), with only 6% due to vehicle collisions (Scheiman *et al.*, 2010). Interestingly, poor balance and falls risk are also associated with reduced executive function in older adults (e.g. Muir *et al.*, 2012), although no study has yet examined cognitive factors in cycling safety. Along with road safety education, cognitive remediation targeting executive functions may help improve

older adults' safety when cycling or walking within their neighborhoods.

The design of crossings and intersections can also contribute to the elevated risk experienced by older pedestrians (Koepsell *et al.*, 2002). Koepsell and colleagues reported that unless marked crossings are accompanied by traffic signals or signage, they pose much greater risk to older pedestrians relative to un-marked crossings. As such, urban designers may need to take into account how aging affects the ability to safely negotiate traffic, and introduce greater traffic control, separation of pedestrians and vehicles, and pedestrian visibility (Koepsell *et al.*, 2002; Retting *et al.*, 2003; Michael *et al.*, 2006).

Thus, understanding how aging and age-associated disease impacts pedestrian safety is important for effective promotion of health behaviors, encouraging mobility and independence in aging, and designing age-friendly neighborhoods.

Future directions

The range of factors that may impact on the capacity to drive safely spans several disciplines. Future strategies for road safety among older adults need to encompass all types of road users, as neurological and sensory deficits impact on the use of public transport, pedestrian safety, and cycling as well as the capacity to access community transport. In most countries there is currently a shortage of driver-trained OTs, and other medical specialists who may be involved in assessing FTD. The ideal scenario is that evidence-based screening and general assessment methods become available which are inexpensive, culturally appropriate, and can be conducted by health care providers with different discipline backgrounds and in different settings. This will allow specialist driving assessment services to focus on complex cases. Evidence-based screening needs to be part of a framework of older driver safety that includes clear referral pathways to interventions, full assessment, and support for driving cessation and alternative transport. Interventions to improve older driver skill and safety are being developed and future investment in research and implementation of these will enhance the overall mobility and quality of life in our aging population.

Conflict of interest

NT Lautenschlager is the Editor-in-Chief of International Psychogeriatrics and therefore this editorial was assigned to a Deputy Editor of

International Psychogeriatrics for the editorial process.

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