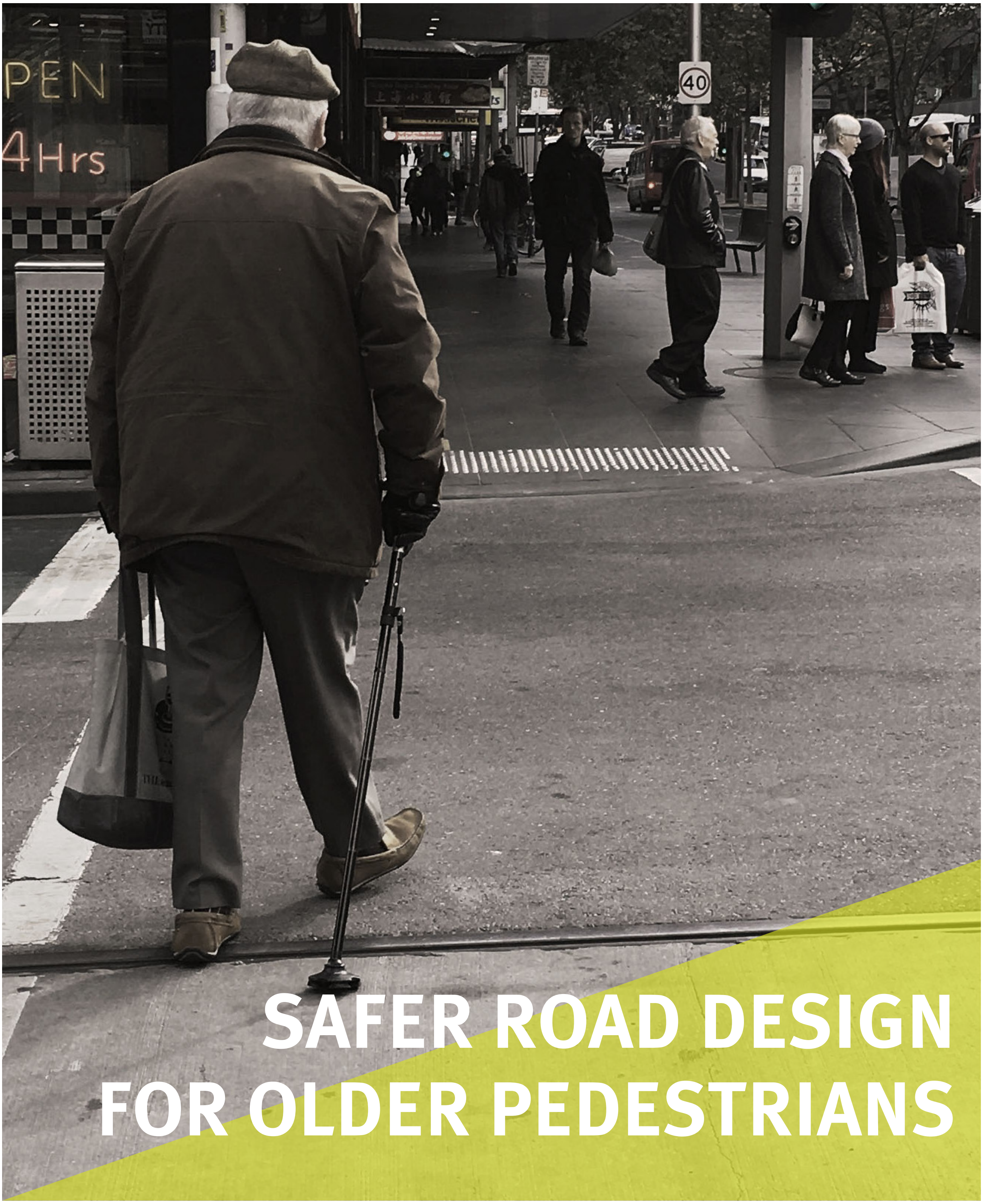
Victoria walks



SAFER ROAD DESIGN FOR OLDER PEDESTRIANS

movendo

VicHealth™

TAC COMMUNITY ROAD SAFETY GRANTS

ACKNOWLEDGEMENTS

This report has been prepared by movendo (lead author Jose Mantilla) and Victoria Walks (Duane Burtt), in collaboration with the Municipal Association of Victoria (MAV). Funding was provided by a Community Road Safety Grant from the Transport Accident Commission (TAC), along with VicHealth's support of Victoria Walks.

Victoria Walks would like to acknowledge and thank the following organisations who provided input to this research:

- Monash University Accident Research Centre (MUARC)
- Council on the Ageing
- Corben Traffic Safety
- VicRoads
- The various local authorities that attended the local government workshop on this project

Acknowledgement of these organisations should not be implied as endorsement of this paper and its recommendations by any of the organisations named.

Recommended citation:

Mantilla, J. and Burtt, D. (2016). *Safer Road Design for Older Pedestrians*. Victoria Walks, Melbourne. Version 1.1. August 2016.

USER GUIDE

This report presents high-level principles and solutions that can assist road managers to provide safer road environments for older pedestrians – people 65 years or older.

- Chapter 1 summarises the importance of walking for seniors and the characteristics of ageing that affect pedestrian safety. It outlines road safety issues for older pedestrians derived from a review of local and international literature.
- Chapter 2 provides analysis of crashes in Victoria involving pedestrians aged 65 years and over, between July 2008 and June 2013.
- Chapter 3 discusses two key issues with road rules affecting older pedestrians – give way rules at intersections and rules for carparks.
- Chapter 4 provides some principles for road design for older pedestrians. It also includes evidence around the effectiveness of different road infrastructure treatments in improving pedestrian safety and associated commentary on the applicability to older pedestrians.
- Chapter 5 sets out recommendations, including:
    - General recommendations for infrastructure and operational treatments to improve road safety for older pedestrians
    - Recommendations for road design at traffic signals, unsignalised intersections, roundabouts, mid-block locations, and footpaths, driveways and carparks
    - Broader recommendations on further research, road safety campaigns, traffic enforcement, changes to road rules and speed limit guidelines
    - Site specific examples of how the recommendations could be applied.

For a quick summary of the issues and design options for key locations, separate factsheets are available for:

- Traffic signals
- Unsignalised intersections
- Roundabouts
- Mid-block locations
- Footpaths, driveways and carparks.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

OVERVIEW

In the ten-year period between 2004 and 2013, people aged 70 years and over represented 10% of the population of Victoria, but 33% of all pedestrian fatalities (Transport Accident Commission 2015). This report provides high-level principles and solutions that can assist road managers to provide safer road environments for older pedestrians – people 65 years or older. The report encompasses:

- A review of the current literature on the importance of walking for older adults, the factors impacting safety for older pedestrians and the changes in capability associated with ageing
- Analysis of crash data for incidents involving older pedestrians in Victoria
- Recommendations to make the road environment safer for older pedestrians to walk.

In Victoria, the number of people aged 65 and over is likely to almost triple from 2011 to 2051 as the population increases and the proportion of older people grows (Department of Transport, Planning and Local Infrastructure 2014). Walking is particularly important for seniors, who are less likely than younger adults to participate in more vigorous forms of physical activity, more likely to experience social isolation and less likely to drive a car (Garrard, 2013). It is well understood that walking has significant physical health benefits for older people, including reduced risk of many chronic diseases such as obesity, heart disease and diabetes. Recent studies suggest it also has an important role in maintaining and even potentially improving brain health in older age.

The importance of enhancing the safety and convenience of walking for older pedestrians will grow as the older population in Victoria continues to increase. *Towards Zero 2016//2020 Victoria's Road Safety Strategy and Action Plan* notes that with the population growing and ageing, "...trauma levels could rise in the next five years unless we take bolder approaches to road safety" (Victorian Government 2016).

VULNERABILITY OF OLDER PEDESTRIANS

The World Health Organisation (WHO) in its 2013 report *Pedestrian Safety - A Road Safety Manual for Decision Makers and Practitioners* states that the combination of the following factors increases the vulnerability of older pedestrians – deterioration in visual acuity, cognitive decline, reduced mobility, frailty and existing health conditions, and slower walking speeds. These factors become increasingly significant as people move through older age and affect women to a greater extent than men.

Notwithstanding the physical impacts of ageing, research suggests that the over-representation of older pedestrians in crash statistics is usually not the result of an error on the part of the pedestrian. A Transport Accident Commission study found that pedestrians 60 years of age and older were at fault in only 12% of crashes affecting them (Nieuwesteeg & McIntyre, 2010), a finding that is verified by the analysis presented in this report. Older pedestrians are not generally 'risk-takers' (Garrard, 2013).

Over-representation of older people in pedestrian crashes and fatalities appears to relate largely to their increased frailty and a reduced capacity to avoid a vehicle that is threatening to collide with them. When involved in a crash, older pedestrians are more likely to sustain fatal or serious injuries than younger pedestrians (even at low impact speeds) and take longer than younger people to recover from their injuries.

Over-representation of older people in pedestrian crashes appears to relate largely to their increased frailty and a reduced capacity to avoid a vehicle.

TRAFFIC SPEED AND OTHER ISSUES

Increased frailty is probably the most significant characteristic of ageing for road safety. Seniors have a much higher injury and fatality risk at all collision speeds.

Traffic speed is determined by the posted speed limit and traffic conditions, but is also a response to road design. Roads are often designed to accommodate people driving above the speed that is intended for the road and the speed limit. Historically, this was thought to be "conservative" and consistent with other engineering disciplines that intentionally "over design" critical components to ensure safety under particularly stringent conditions (Donnell et al., 2009). However, the practical result is that urban roads allow drivers to travel at higher speeds than desirable and safe.

Even though road design and management have changed over time, existing roads are not necessarily updated when these factors change. Most significantly in the Victorian context, the default urban speed limit has been reduced from 60 km/h to 50 km/h, but the configuration of streets did not change with the speed limit. Typically, therefore, the speed limit is 50 km/h on streets that were designed for 60 km/h and usually higher speeds.

The road environment should take account of human fallibility and minimise both the opportunities for errors and the harm done when they occur, consistent with a 'Towards Zero' road safety approach. In other words, when a mistake occurs it should not cause injury or death. Collision speed is even more critical when considering solutions to improve safety for older pedestrians, given their increased frailty.

It is increasingly recognised that 30 km/h is an optimal urban speed limit for road safety, especially pedestrian road safety. Despite this, 30 km/h is not one of the suite of speed limits available to road authorities under applicable Victorian guidelines (VicRoads 2013b).

While this study focuses primarily on collisions with vehicles, as recorded by CrashStats, it is important to understand that this is only one of two key dimensions of pedestrian road safety. Trips, slips and falls in the street are also a major cause of injury, accounting for an average of 1,680 hospital admissions and 3,545 emergency department presentations in Victoria each year (Oxley et al., 2016). While falls in the street affect all age groups, older people (and particularly older women) have the highest rates of serious injury.

Some aspects of the road rules raise issues for pedestrian safety. When turning, drivers are required to give way to pedestrians who are crossing the road the driver is turning into. However, drivers are not required to give way to pedestrians crossing the street as they approach an intersection, even if they are required to stop for opposing traffic. This is potentially confusing for both motorists and pedestrians, and may be reflected in the high proportion of crashes that occur when a vehicle is turning.

The road rules relating to carparks are somewhat unclear, but appear to treat carparks much like streets. Carparks are not designed like streets and seldom have footpaths, so in practice vehicles and pedestrians typically intermingle, albeit at slow speeds. In practical terms, carparking areas are much more like shared zones than conventional streets.

CRASH STATISTICS FOR OLDER PEDESTRIANS IN VICTORIA

A detailed review of the crash information for older pedestrians contained in the VicRoads CrashStats Restricted Access database was undertaken. This analysis included review one-by-one of the descriptions and diagrams in police reports for 1,149 older pedestrian crashes recorded in Victoria between 2008 and 2013. The primary objective was to uncover the circumstances that led to crashes in order to develop practical and effective infrastructure and operational treatments that improve safety for older pedestrians.

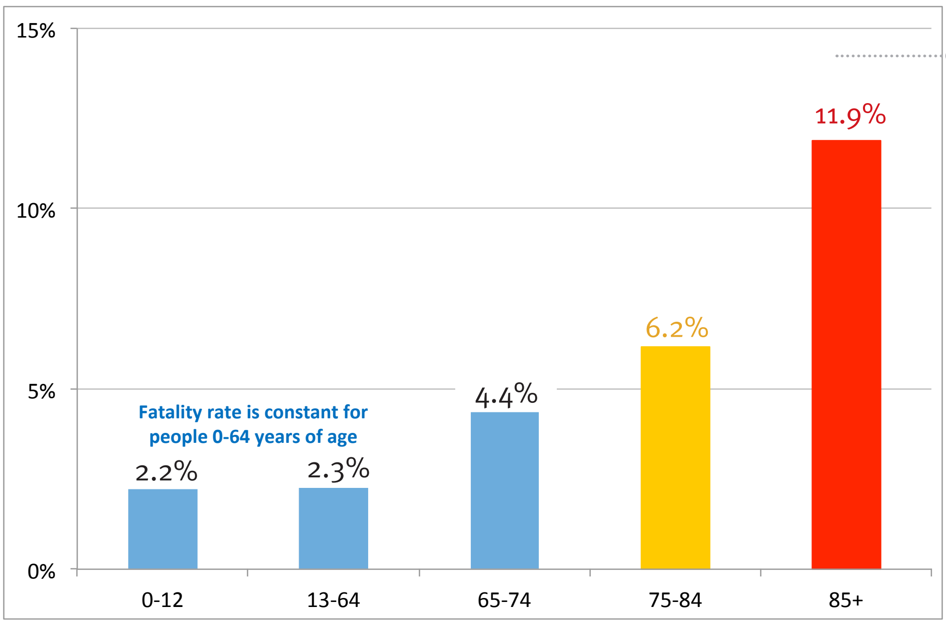
Between 2008 and 2013, Victorian pedestrians aged 65 years or older have experienced an average of 17 fatalities, 147 serious injuries and 114 other injuries per year. Adopting the estimates used by VicRoads for the cost of crashes, this equates to an estimated economic cost of almost $110 million per annum for the State (in 2012 dollar values).

The crash analysis found that, in Victoria, people aged 65 and over represent 14.6% of the population yet accounted for 39% of pedestrian fatalities.

People between 65 and 74 years of age represent 8% of the population and 11% of pedestrian fatalities, while those between 75 and 84 represent 5% of the population and 14% of pedestrian fatalities.

When involved in a crash with a motor vehicle, the fatality rate for those 85 years of age and older is over five times higher than for those aged 64 years or less (see Figure ES 1). This higher fatality rate is reflected in the proportion of pedestrians who are killed – people 85 years of age or older represent only 2% of the population in Victoria, but are 13% of pedestrian victims.

With respect to speed limit zones, and consistent with the TAC findings, around 75% of all crashes involving older pedestrians occur in 50 or 60 km/h zones.



Fatality rate increases dramatically after people reach 65 years of age

Fatality rate (after being involved in a crash) is:

- Around 2% for people from birth to 64 years of age
- Almost two times higher for people 65-74 years of age
- Almost three times higher for people 75-84 years of age
- Over five times higher for people 85 years of age & older

Figure ES 1: Proportion of Pedestrian Crashes Resulting in Fatalities by Age

INTERSECTION CRASHES

Collectively, intersections are the most common crash location, representing 45% of all older pedestrian crashes in Victoria and distributed as follows:

- Signalised intersections – 21%
- Unsignalised intersections – 19%
- Roundabouts – 5%

Most older pedestrian crashes at intersections involve turning vehicles. Evaluation of the signalised and unsignalised intersection data shows that right and left turn manoeuvres respectively account for around 18% and 10% of all the 1,149 older pedestrian crashes analysed.

At signalised intersections, 20% of crashes involve left turns and 55% right turns. At unsignalised intersections, 29% of crashes involve left turns and 35% right turns.

The vast majority of right-turn crashes (96% at signalised intersections and 87% at unsignalised) occur on the departure side of the intersection (where the driver had an obligation to give way to the pedestrian). These right-turn departure side crashes are the most common of all crash scenarios, comprising 17.6% of all older pedestrian crashes. When comparing right-turn departure side crashes by gender, it was notable that at an unsignalised intersection older males were twice as likely to be hit as females.

Virtually all older pedestrian crashes involving a left-turning vehicle at signalised intersections occur on the departure side of the intersection.

In contrast, at unsignalised intersections, 40% of older pedestrian crashes involving a left-turning vehicle occur on the departure side and 60% occur on the approach side.

The crash data showed that, at unsignalised intersections, motorists had an obligation to give way in at least 42% of crashes involving older pedestrians, as they collided with a pedestrian crossing the road the vehicle was entering.
At signalised intersections, motorists had an obligation to yield in at least 72% of crashes.

Around 5% of all older pedestrian crashes (and almost 7% of the 'old-old' pedestrian crashes) occur at roundabouts. Women represented 72% of the 57 older pedestrian crashes at roundabouts.

OTHER CRASH TYPES

While intersections are the key locations for crashes, about half of older pedestrian crashes occur in a range of other locations.

Mid-block locations where there is no control or assistance for pedestrians to cross the road account for 19% of older pedestrian crashes. Very small proportions occur at mid block zebra or signalised pedestrian crossings (2% each).

Vehicles colliding with pedestrians on footpaths, driveways or at entrances to carparks, comprise at least 16% of all older pedestrian crashes. The proportion of older pedestrian crashes on footpaths/driveways is significantly higher than that for younger age groups – five times that for people between 13 and 64 years of age. The incidence of these crashes also increases substantially as people move through older age. The proportion of footpath/driveway crashes for people 85 years of age and older is 23% – more than twice that for people between 65 and 74 years of age and almost eight times the proportion for people between 13 and 64 years of age. This dramatic difference reflects the increased frailty in the old-old population and could also be related to their reduced agility, limiting their ability to take evasive action when a vehicle is entering/exiting a driveway or carpark.

The prevalence of falls in the street environment also emphasises the need to design footpaths, driveways and road interfaces to minimise risk of falls.

Other significant crash circumstances for older pedestrians are vehicles reversing on the roadway (6%) and pedestrians emerging in front of parked vehicles (4%).

INFRASTRUCTURE SOLUTIONS

On the basis of the research and CrashStats analysis, a number of principles of better design for older pedestrian safety are provided in Chapter 4 and summarised below:

1. **Separation from traffic.** Older people need a comprehensive, connected footpath network to allow them to walk comfortably without mixing with traffic when they are not actively crossing a road.
2. **Reduction in vehicle speeds.** This can apply generally, through area wide traffic calming or speed limits, and specifically at crossing points.
3. **Reduction in the complexity of crossing the road.** This includes design that allows older people to stage crossings and deal with one direction of traffic at a time, and signal phasing that avoids conflict with turning traffic.
4. **Reduction in crossing distance.** Design should minimise the distance that pedestrians have to cross while exposed to traffic.
5. **More time to cross.** Signalised pedestrian crossings need to provide adequate phase time to allow older pedestrians walking at slower speeds to complete their crossing.
6. **Increase visibility of pedestrians**. Treatments such as kerb outstands and pedestrian refuges, and signal phasing such as 'head start,' allow pedestrians to safely position themselves where they are visible to drivers.
7. **Reinforce the requirement for vehicles to give way.** Treatments such as zebras and raised thresholds, and visible extension of footpaths over driveways reinforce the legal requirement for vehicles to give way when turning.

8. **Quality surfaces and detailed design.** It is important that footpaths provide level, smooth (but non-slip) surfaces and minimal obstructions, and changes in level at the kerb are minimised, to reduce the risk of falling.

Chapter 4 also includes evidence around the effectiveness of different road infrastructure treatments in improving pedestrian safety and associated commentary on the applicability to older pedestrians.

RECOMMENDATIONS

A range of recommendations are put forward in Chapter 5 to address the most commonly occurring older pedestrian crash types in Victoria. Based on their potential to address the main locations where older pedestrians are involved in crashes, together with their potential for reducing the incidence and/or severity of crashes, the following are proposed as priority infrastructure and operational treatments:

- Safer design standards for driveways to indicate priority for pedestrians and provide physical cues for drivers.
- Mid-block pedestrian crossings (ideally with flashing lights and raised surfaces), particularly in activity centres, in the vicinity of housing and facilities for older people and on routes that have been identified as popular with older pedestrians.
- Raised pedestrian crossings at intersections and roundabouts to reduce vehicle speeds at the crossing point, enhance priority for pedestrians and make them more conspicuous to drivers.
- Raised thresholds, which effectively extend the footpath across an intersection (usually side streets), to emphasise that drivers are required to give way when turning.
- Kerb extensions, median refuges and tighter turn radii at intersections and roundabouts to reduce vehicle speeds, distance of pedestrian exposure and complexity of crossings.
- Fully controlled right turn signal phases and right turn lag signal phases to protect older pedestrians from right-turning vehicles on the departure side of the intersection.
- Early-start signal phases and PUFFIN pedestrian detection signals to adjust phase times and allow older pedestrians to fully clear the intersection.
- Reduced speed limits and area wide traffic calming.

Raised pedestrian crossings at intersections and roundabouts reduce vehicle speeds at the crossing point, enhance priority for pedestrians and make them more conspicuous to drivers.

Chapter 5 also provides recommendations for design at particular types of road environment: traffic signals; unsignalised intersections; roundabouts; mid-block locations; and footpaths, driveways and car parks.

Based on the review of local and international literature, together with the analysis of Victorian crash statistics, it is recommended that road management agencies also consider the following:

- Undertaking research on road users' behaviour and understanding of road rules relevant to pedestrian safety, particularly those concerning vehicles turning into and out of a street at intersections.
- Evaluating the appropriateness of the existing road rules for intersections and potential enhancements to promote pedestrian safety.
- Reviewing the road rules relating to pedestrian safety in carparks, with consideration of classifying carparks as shared zones
- Implementing design speeds that are as low as practicable in areas with current or predicted high levels of pedestrian activity, reinforced by the provision of narrower roads, corners with tighter radii and the introduction of treatments that improve pedestrian safety.
- Providing the capacity for councils to apply 30 km/h speed limits in appropriate circumstances, to reflect the objectives of the *Towards Zero 2016//2020 Victoria's Road Safety Strategy and Action Plan.*

(1)

INTRODUCTION AND LITERATURE REVIEW

This research report presents principles and solutions that can assist road managers to provide safer road environments for older pedestrians.

1.1 STUDY BACKGROUND AND METHODOLOGY

The information collected and analysed throughout this study is summarised in this report, which encompasses:

- A review of the current literature
- Consultation with relevant experts, VicRoads and local councils
- Analysis of crash data for incidents involving older pedestrians in Victoria
- Recommendations on design of road environments to make it safer for older pedestrians to walk.

For the purposes of this report, an older pedestrian is considered to be a person aged 65 years or older. Where relevant, older pedestrians are further classified by age and gender to illustrate crash types and locations for which particular subgroups may be especially vulnerable. For example, the research presented in this report has identified that women are over-represented in roundabout crashes, accounting for over 70% of all older pedestrian crashes in Victoria at this type of intersection.

The report emphasises infrastructure and traffic management solutions that are targeted and practicable in terms of delivery, and effective in promoting walking in older people, enhancing safety and convenience, and promoting positive changes in behaviour.

The recommendations presented in this report concentrate on infrastructure improvements, rather than policy changes. The recommendations are based on a review of local and international literature (including peer reviewed papers, technical documents, and road design and safety guidelines) and detailed analysis of Victorian crash data. Discussions with local experts also contributed to understanding the issues that affect safety for older pedestrians and the optimal treatments which can be implemented to improve their safety. Face-to-face discussions were conducted with key experts from leading organisations and government agencies, including:

- Monash University Accident Research Centre (MUARC)
- Council on the Ageing
- Corben Traffic Safety
- Transport Accident Commission (TAC)
- VicRoads

The recommendations in this report are based on a review of local and international literature, and a detailed analysis of Victorian crash statistics

In order to quantify the magnitude of older pedestrian crashes (and related injuries and fatalities) in Victoria, as well as to identify high risk locations and types of crashes, a detailed review of data from the VicRoads CrashStats Database was undertaken.

A workshop was held in November 2014 with around 40 representatives from local councils, VicRoads and other relevant organisations and interested individuals. The preliminary findings of the literature review and CrashStats analyses were presented and participants were provided with an opportunity to share their opinions on six main areas of relevance for older pedestrian safety: vehicle speeds, intersections, right turns, roundabouts, mid-block crossings and footpaths. The input received during the workshop was used to refine the areas of focus for this report. This report expands on initial research on the importance of walking for older people and the barriers they face when walking, described in the report *Senior Victorians and Walking - Obstacles and Opportunities (Garrad, 2013)*. This study was conducted by Dr Jan Garrard on behalf of Victoria Walks and included a survey of 1,128 senior Victorians.

The 2013 study concluded that older pedestrians are generally not 'risk taking road users' and highlighted the inappropriateness of 'blaming' them for their involvement in crashes. In contrast, the study concluded that road environments must be more carefully designed to promote safer conditions for older pedestrians (both when walking along and when crossing roads) and that motorists must be more mindful of the safety and general needs of vulnerable road users.

1.2 VICTORIA'S AGEING POPULATION AND ROAD SAFETY

In Australia, the proportion of people aged 65 years and over was 14% in 2012 and is expected to rise to 22% by 2061 (Australian Bureau of Statistics 2013). As the general population will be increasing significantly during this period, the growing proportion of seniors represents a very large increase in absolute numbers. The number of people aged 65 years and over in Victoria is likely to almost triple from 2011 to 2051 as the large population currently aged 45 to 65 moves into older age (Department of Transport, Planning and Local Infrastructure, 2014).
Figure 1 shows the proportion of the population in Victoria who were 65 years of age and older in 2011, and the projected proportion up to 2051.

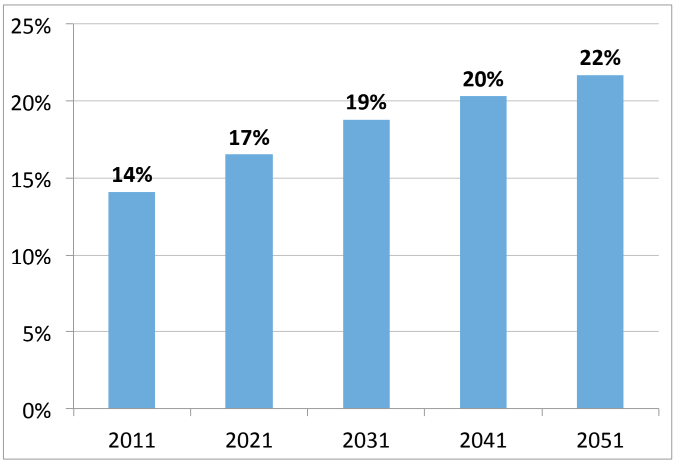


Figure 1: Projected proportion of Older People in Victoria, 2011-2051 (Department of Transport, Planning and Local Infrastructure, 2014)

The ageing population creates a need to understand current road safety conditions and the travel behaviour of older adults, so that measures can be implemented to improve the safe mobility of older road users, thus enabling them to maintain active lifestyles (O'Hern & Oxley, 2015).

Towards Zero 2016//2020 Victoria's Road Safety Strategy and Action Plan states that there will be a focus on people most likely to become road casualties, including both older Victorians and pedestrians generally. The Government will fund safer road infrastructure for pedestrians, as part of a $100 million investment to support walking and cycling (Victorian Government 2016).

The number of people aged 65 years and over in Victoria is likely to almost triple from 2011 to 2051

1.3 THE IMPORTANCE OF WALKING FOR OLDER ADULTS

Walking is particularly important for seniors, who are less likely than younger adults to participate in more vigorous forms of physical activity, more likely to experience social isolation and less likely to drive a car (Garrard, 2013). Walking is highly valued by seniors for a range of reasons, including improved health, wellbeing, independence, personal mobility and social connectedness. Importantly, a significant proportion of older people walk more than 1 hour per week for transport related trips and walking for transport trips becomes even more important for seniors 80 years or older (Garrard, 2013).

Walking is critical to allow older people to conduct day-to-day activities, such as shopping, attending meeting places (sporting clubs, libraries and community centres) and visiting essential services like doctors and hospitals (Garrard, 2013). In addition, the Council for the Ageing (COTA) has collected information that indicates that around 25% of all children aged 12 years or younger in Victoria are cared for by their grandparents on a regular basis, making it increasingly important for there to be safe walking opportunities around schools, as the two most vulnerable road user types are engaging in trips together. Walking for transport can reduce transport-related costs, including lower personal expenditure on fuel and vehicle maintenance. These aspects can be critical to older adults, who generally have lower annual incomes and for whom transport costs may represent a larger component of their expenses. The combination of these factors can result in transport disadvantage and social exclusion, which has been identified as a significant problem facing older adults (O'Hern & Oxley, 2015).

Wider societal benefits are also associated with increased walking (and related reduced motor vehicle use), including improved air quality, reduced greenhouse gas emissions, reduced traffic congestion and maintenance costs, and increased community connectedness and liveability (O'Hern & Oxley, 2015). Walking for transport is also a more socially inclusive form of physical activity than leisure-time activity: while socioeconomically disadvantaged population groups are substantially less likely than advantaged groups to participate in recreational exercise, walking for transport is fairly evenly distributed across the socio-economic spectrum (Garrard, 2013).

The walking networks that support the trips undertaken by older pedestrians (including access to public transport) must be safe, comfortable and responsive to their particular needs.

WALKING AND OLDER ADULTS' HEALTH

It is well understood that walking has significant physical health benefits for older people, including reduced risk of many chronic diseases such as obesity, heart disease and diabetes (O'Hern & Oxley, 2015; Garrard 2013). A well-established finding in the literature is a link between physical activity and decreased risk of many chronic diseases (Bijnen et al., 1998), including cardiovascular disease in people of all ages (Luepker et al., 1994).

Less well understood is that vascular risk factors are linked to many common cognitive disorders associated with aging, including mild cognitive impairment, Alzheimer's disease (the most common cause of dementia) (Gorelick, 2004; Kivipelto et al., 2005; Li et al., 2011) and vascular dementia (Hachinski, Lassen, & Marshall, 1974; Román et al., 1993; Skoog, 1998).

Modifiable lifestyle factors, such as increased physical activity, may prevent or delay cognitive deterioration (DeCarli et al., 2005; Lautenschlager et al., 2008).

Even though there is no specific treatment for those individuals who are at risk of developing dementia, it may be possible to delay or prevent the appearance of the disease symptoms through the increase of physical activity and the implementation of healthy lifestyle changes (Barber, Clegg, & Young, 2011; Lautenschlager et al., 2008; Rolland, van Kan, & Vellas, 2010). It has thus been suggested that individuals at risk of developing dementia, or who exhibit cognitive difficulties, may benefit from some type of physical exercise on a daily basis (Barella, Etnier, & Chang, 2010; Middleton & Yaffe, 2009; Ruthirakuhan et al., 2012). Walking, in particular, has been associated with maintaining brain volume, preventing cognitive impairment, promoting social interaction, and providing higher levels of sensory stimulation (Barella et al., 2010; Middleton & Yaffe, 2009; Stern, 2012).

In summary, increasing physical activity and mobility is a promising area for addressing cognitive decline as well as physical health among older adults.

Unfortunately, 58% of older people in Victoria do not achieve daily recommended levels of physical activity, but walking is clearly their preferred form of exercise (Garrard 2013). For Australians aged 65-74, walking is 71% of their total time spent on physical activity and for those over 75 the proportion is 77%. Older Victorians walk significantly less than their counterparts in European countries, indicating that rates of walking are related more to the nature of the community than any inherent characteristics of ageing (Garrard 2013). Conversely, this also demonstrates the great potential for appropriate design to facilitate walking.

1.4 IMPACTS OF AGEING ON SAFETY OF OLDER PEDESTRIANS

When analysing the vulnerability of older pedestrians, it is important to consider the impact of physiological and cognitive changes that occur as people age. The World Health Organization in its 2013 report *Pedestrian Safety - A Road Safety Manual for Decision Makers and Practitioners* states that the combination of the following factors increases the vulnerability of older pedestrians:

- Deterioration in visual acuity results in older pedestrians accepting significantly smaller gaps in traffic than required when crossing roads
- Cognitive decline results in reduced ability to make safe judgments about walking speed and traffic gaps
- Reduced mobility results in an inability to react quickly and avoid crashes
- Frailty and existing health conditions can result in greater injury severity when a crash does occur
- Slower walking speeds can result in older pedestrians being stranded in the middle of the road when attempting to cross at signalised crossings.

Ageing results in gradual deterioration of agility (walking speed and balance), sensory perception (vision and hearing) and cognitive skills (attention and information processing speed). Older pedestrians can thus experience problems in situations that demand efficient cognitive processing, fast responses and quick actions (Oxley et al. 2006).

Age-related changes reduce people's ability to undertake the many cognitive tasks required when crossing roads, such as finding a place to cross a road, looking for traffic, perceiving traffic, judging vehicle speeds and available gaps, deciding when to cross and then crossing the road (Department for Transport 2004).

Older pedestrians are over-represented in crashes at complex intersections (particularly those with two-way traffic and/or multiple lanes) and when traffic volumes and speeds are high.

Older pedestrians can experience problems in situations that demand efficient cognitive processing, fast responses and quick actions.

VARYING CAPABILITY THROUGH OLDER AGE AND GENDER

While it is easy to discuss older people as a generic group, capability varies significantly between groups within 'older age'. As a result, sub-categories are often used to analyse and report information on older people. The three most commonly used age subcategories in Australia and western countries are:

(1) People 65-74 years of age, referred to as the 'young-old'
(2) Those 75-84 years of age, referred to as the 'old' and
(3) People 85 years of age and older, referred to as the 'old-old'.

The 2008 *Disability in Australia: trends in prevalence, education, employment and community living* study estimated the number of people with severe or profound core activity limitations. Core activities encompass self-care, mobility and communication. Severe and profound core activity limitations are defined as a person always and sometimes "needing assistance from another person to perform a core activity", respectively. As shown in Figure 2, the prevalence of severe or profound core activity limitations increases dramatically with age, despite the relatively small proportion of the population comprised by older people.

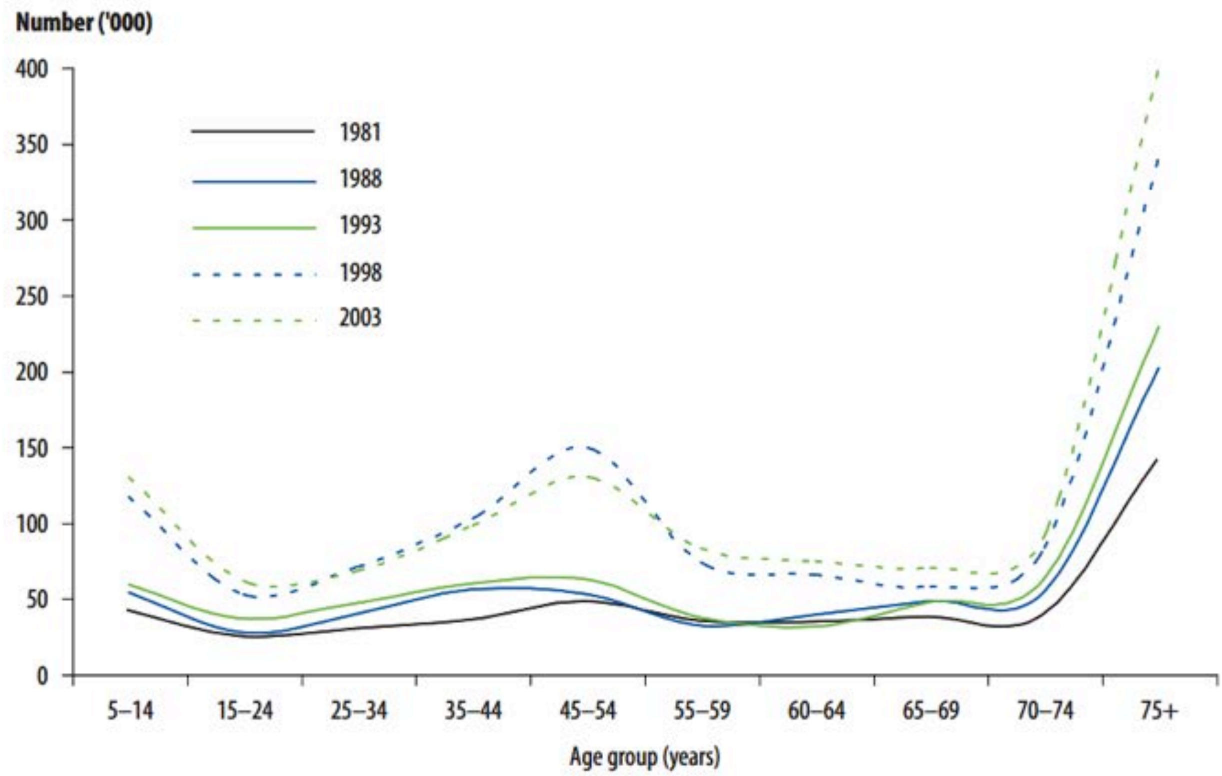


Figure 2: Number of People with Severe or Profound Core Activity Limitations, by Age Group (1981-2003) (Australian Institute of Health and Welfare, 2008)

In terms of road safety, VicRoads states that "to be a safe pedestrian, use your eyes, ears, judgment and common sense". Within this context, it is relevant to evaluate the impact of age and gender on the physical and cognitive abilities required to be a 'safe pedestrian', namely vision, hearing and mental and behavioural aspects. Figure 3 illustrates two of the health conditions most relevant to being a 'safe pedestrian' as defined by VicRoads: vision and hearing.

While the prevalence of severe or profound core activity limitations most relevant to the safety of older pedestrians increases dramatically as people progress through old age, the data also shows that the prevalence of core activity limitations is higher in women than men for all relevant health conditions and the gap tends to widen in the 85+ age group (Australian Institute of Health and Welfare 2008). Within this context, it is apparent that consideration of older pedestrians as a single group, without reference to age and gender differences, may result in either misrepresentation or failure to fully capture relevant trends and areas for improvement.

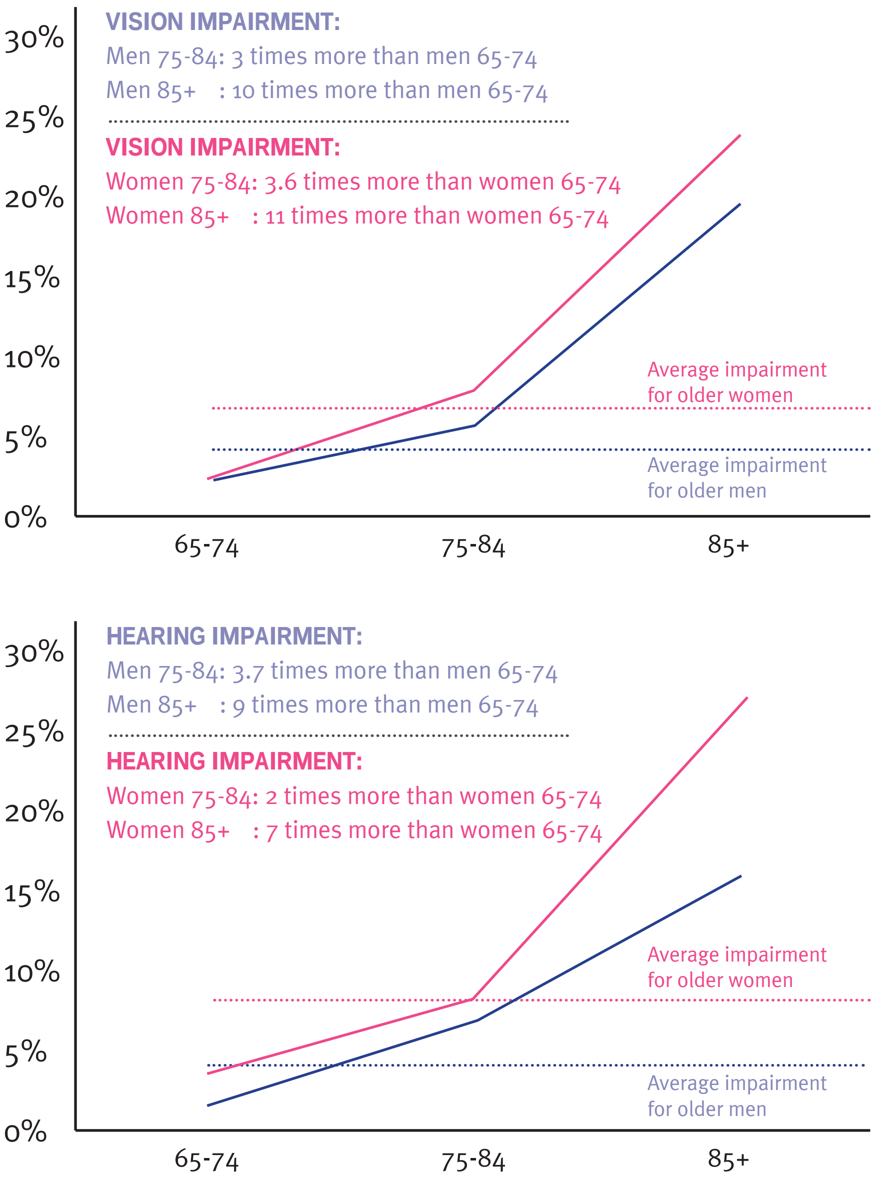


Figure 3: Proportion of People with Severe or Profound Core Activity Limitations, by Age Group and Health Condition (Australian Institute of Health and Welfare 2008)

While the picture of diminishing physical capability as people move through older age is clear, it should not be assumed that this is the cause of crashes affecting older pedestrians. There is evidence to suggest that seniors compensate for their declining capacity by changing when, where and how they walk to minimise their (perceived and real) risk. For example, older pedestrians tend to be more cautious than their younger counterparts in their decision making with respect to where and when to cross a road (Garrard 2013; Oxley et al. 1995). Even though some crashes are caused by older pedestrians misjudging traffic speed and/or their capabilities (which may be related to ageing), evidence suggests that this may not be a primary cause of crashes overall. Victorian studies of crash circumstances for older pedestrians indicate that they are often hit by motorists who fail to give way to them when legally required to do so (see chapter 2).

Older pedestrians are more likely to be injured or die, and less able to recover when hit by a vehicle than younger people. In addition, their diminished capabilities make some older pedestrians less able to identify risk and/or avoid a vehicle in a situation where a younger pedestrian might be able to take evasive action. Together, these two factors appear to be the main reasons that older pedestrians are over-represented in crash statistics.

1.5 CHARACTERISTICS OF TRANSPORT WALKING BY OLDER ADULTS

A recent review of travel behaviour data in Victoria (using the 2009 Victorian Integrated Survey of Travel Activity – VISTA) revealed a number of important aspects with regard to the behaviour and needs of older pedestrians (O'Hern & Oxley, 2015). First, the total number of transport trips undertaken on foot by older adults reduces past the age of 65 years, which could be linked to a reduction in the number of work-related trips and other lifestyle changes, or to age-related changes to health and physical activity. Second, even though the average walking distance between stops (defined as the distance a person can walk without having to rest) is also reduced with age, people over 85 years of age walk on average 520 metres per stop (and longer for each leg of a trip if appropriate infrastructure such as street furniture is provided to help break up trips into smaller components). The Victoria Walks 2013 study identified that the most common distance for transport-related walking trips for older pedestrians is 500 metres to 1 kilometre and that the majority of all walking trips by older pedestrians are less than 2 kilometres. As such, changes to the road environment (infrastructure and operational improvements) to facilitate access to destinations within 500 metres to 1 kilometre may result in increased walking participation among older adults.

The average walking speed of older adults, particularly for those aged 85 years or older, is slower than that for younger adults, reflecting age-related physical changes. Walking speed can have significant impacts on the design of infrastructure to accommodate the needs of older pedestrians.

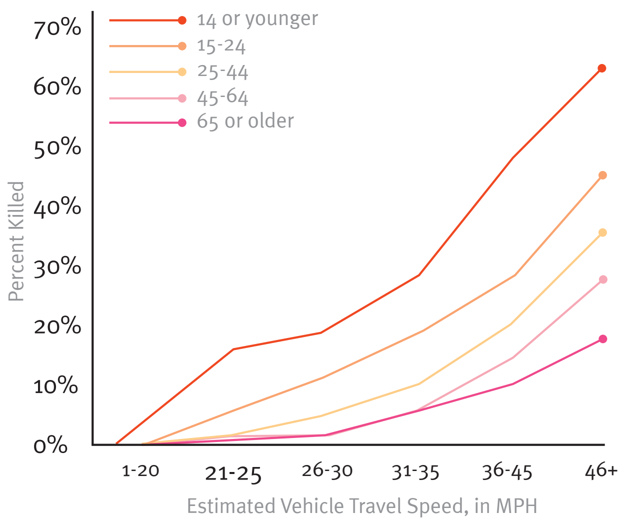
For example, walking speed assumptions used for the design of pedestrian crossing facilities (typically 1.2 m/s – VicRoads) are greater than the average walking speeds recorded in the VISTA survey (O'Hern & Oxley, 2015). Adjustments to design guidelines for pedestrian crossings should be examined to ensure slower walkers are fully able to clear a road during the allocated green and flashing red periods.

The installation of intelligent crossing facilities can assist slower walkers, because they monitor pedestrians as they cross the road and shorten or extend the time allocated to the pedestrian clearance phase, depending on the walking speed of the pedestrian.

Lastly, a high number of the walking trips that older people engage in occur outside of the traditional commuter peak periods. This provides the potential to implement measures such as lower variable speed limits and supporting infrastructure in areas of high pedestrian activity, and reallocating signal time at intersections to better accommodate older pedestrians in off-peak periods (O'Hern & Oxley, 2015).

1.6 OLDER PEDESTRIANS AND TRAFFIC SPEED

The over-representation of older adults in pedestrian crashes reflects, in part, their frailty – once involved in a crash (even a moderate crash) older pedestrians are more likely to sustain fatal or serious injuries than younger pedestrians (even at low impact speeds) and more likely to take longer than younger adults to recover from their injuries (Oxley et al., 2006). Figure 4 highlights the vulnerability of older pedestrians when involved in crashes. At speeds between 58 and 72 km/h an older person is almost five times more likely to die than a person between 25 and 44 years of age. In general, the probability of injury and the severity of injuries that occur in crashes increase exponentially with vehicle speed.



Increased vehicle speed increases risk of death for all pedestrians involved in crashes.

Older pedestrians (65+) have greater chance of death if involved in crashes at any speed.

Figure 4: Traffic Speed and Fatality Risk by Age (U.S. Department of Transportation National Highway Traffic Safety Administration 1999)

In addition to drastically increasing the risk of death and serious injury, higher driving speeds reduce predictability of the vehicle 'behaviour' for pedestrians and reduce a driver's ability to control the vehicle, and negotiate and manoeuvre around obstacles and other road users. Higher speed also increases the distance a vehicle travels while the driver reacts to a potential collision and increases the minimum braking distance, thereby reducing the time available to avoid a collision (Oxley et al., 2006).

Towards Zero 2016//2020 Victoria's Road Safety Strategy and Action Plan states that traffic calming will be used to slow vehicle speeds on local streets and areas with high pedestrian and cyclist activity, such as shops, town centres and transport hubs (Victorian Government 2016). It is increasingly recognised that 30 km/h is an optimal urban speed limit for road safety, especially pedestrian road safety (WHO 2013). Despite this, 30 km/h is not one of the suite of speed limits available to road authorities under applicable Victorian guidelines (VicRoads 2013b). A United States study (Leaf & Preusser 1999) found that even below 30 km/h, the risk of fatality was three times greater for those over 65 than for younger pedestrians. Pedestrians over 45 years old have double the risk of fatality than younger adults have as a result of a crash when the speed limit is 31-50 km/hr. The risk was about five times greater for those over 65 years old. Those over 65 had higher injury rates than younger people at all speeds.

In addition to drastically increasing the risk of death and serious injury, higher driving speeds reduce predictability of the vehicle behaviour for pedestrians.

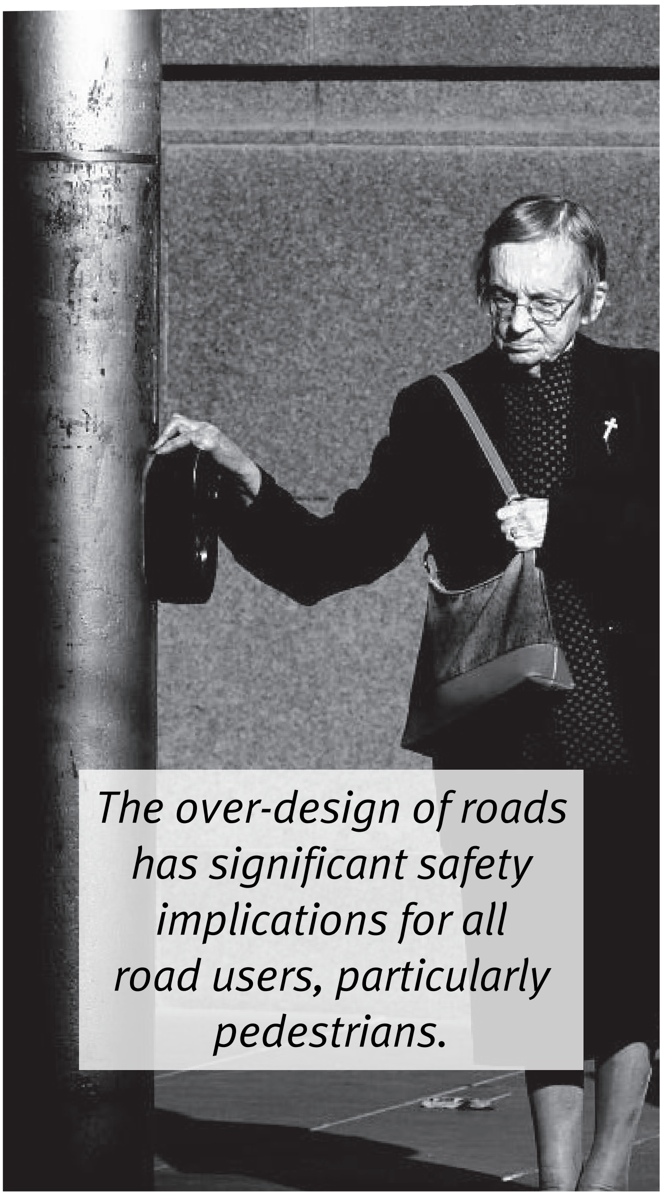
OVER-DESIGN OF ROADS, TRAVEL SPEED AND SAFETY

Traffic speed is well recognised as a major factor in road accidents. Speed is determined by the posted speed limit and traffic conditions, but it is also a response to road design.

Recommendations for the use of “above-minimum design criteria” are common practice in road design across the world (Donnell et al., 2009). The underlying rationale for this guidance is that “above-minimum” features will safely accommodate a condition “beyond the assumed parameters” (National Cooperative Highway Research, 2003; Donnell et al., 2009). In other words, roads are typically designed to accommodate people driving above the speed that is intended for the road and the speed limit. Historically, this was thought to be “conservative” and consistent with other engineering disciplines that intentionally “over design” critical components to ensure safety and/or performance under particularly stringent conditions (Donnell et al., 2009).

The over-design of roads has significant implications for motorist behaviour as research demonstrates that drivers read the road, not the design plans (Donnell et al., 2009). Some roadway segments, such as long straight sections, look the same regardless of designated design (and posted) speed. When these features are combined with over-designed speed sensitive features, the visible cues on appropriate speed may be in sharp contrast to the designated design speed. What was contemplated by the designer as a factor of safety is often negated by driver speed choice (National Cooperative Highway Research 2003; Donnell et al., 2009).

The practical and perverse result of over-design is that roads in residential and other areas where multiple road users interact allow (and perhaps encourage) drivers to travel at higher speeds than initially intended and that are appropriate for the location and context, making the road environment more difficult to navigate and less safe for other (more vulnerable) road users (Donnell et al., 2009). For example, wide roads in residential areas, which are common in many inner, middle, outer and rural areas in Victoria, allow drivers the ability to travel at speeds above the posted speed limit, posing a safety hazard to other road users.



The over-design of roads has significant safety implications for all road users, particularly pedestrians.

Even though road design methods and the management of roads have changed substantially over time, existing roads are not necessarily updated when these factors change (Donnell et al., 2009). Most significantly in the Victorian context, the default urban speed limit has been reduced from 60 km/h to 50 km/h, but the configuration of streets did not change with the speed limit. Typically, therefore, the speed limit is 50 km/h on streets that were designed for at least 60 km/h and, with factors of 'safety', usually more.

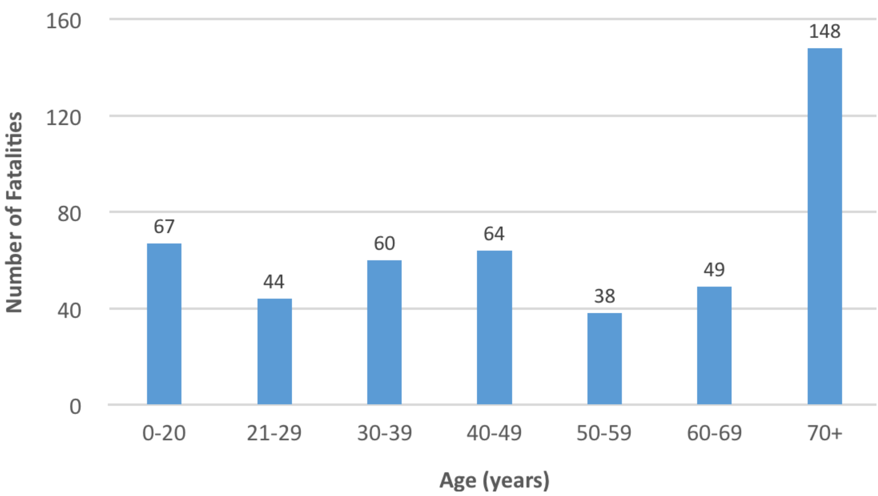
Roads have also been traditionally designed to handle peak period volumes. By designing for the peak period, the roads may be over-designed for most common traffic volumes.

Road designers should adopt modern design methods that obviate in most instances the need for safety factors to be applied, in order to create an environment where drivers read a road that "tells them" to drive at a speed that is appropriate for the context and location. Furthermore, the design speed in areas with current or predicted high levels of pedestrian activity should be as low as possible (30 km/h in residential and sensitive areas) reinforced by the provision of narrower roads, corners with tighter radii and the introduction of treatments that improve pedestrian safety. Lastly, programs should be implemented to retrofit and update existing roads with inappropriate designs for their location and context.

1.7 OLDER PEDESTRIAN CRASHES AND INJURIES

Victorian crash data from the Transport Accident Commission shows that older pedestrians are more likely to be involved in a fatal crash. In the ten-year period between 2004 and 2013, people aged 70 years and over represented 10% of the population of Victoria and 33% of all 470 pedestrian fatalities (Transport Accident Commission 2015). Figure 5 shows the number of fatalities by age group in Victoria (between 2004 and 2013) (Transport Accident Commission 2015).

When normalised by population, the fatality rate for older Victorian pedestrians is over five times higher than that for the overall population. Age-specific rates, based on data for the period January 2006 to December 2008, indicate that older Victorian pedestrians experience a fatality rate five times that of the overall population (4.04 per 100,000 for people 75 years and older, compared to the all-age pedestrian fatality rate of 0.8 per 100,000) (Cassell, Kerr, Reid, Clapperton, & Alavi, 2011).



The fatality rate for older Victorian pedestrians is over five times higher than that for the overall population.

Figure 5: Number of Fatalities by Age Group in Victoria (2004-2013) – Transport Accident Commission

CHARACTERISTICS OF OLDER PEDESTRIAN CRASHES

A survey developed by the TAC (Nieuwesteeg & McIntyre, 2010) sought to collect detailed information to gain a clear picture of crash circumstances and pre-crash pedestrian behaviour. The sample of 200 respondents was drawn from people injured as pedestrians in Victoria who were either 16-39 years of age (n=110) or 60 years and older (n=90).

The main aspects highlighted for those people 60 years and older include:

- The most common crash type involved right turning motorists exiting the intersection
- The majority of crashes occurred in 50 or 60 km/h speed limit zones
- Older pedestrians were considered to be at fault in only 12% of the crashes affecting them
- In terms of location:
  - 45% of crashes occurred when crossing at an intersection
  - 7% occurred when crossing at a roundabout
  - 27% occurred when crossing mid-block

Oxley et al. (2006) found that older pedestrian crashes in Victoria tend to occur on a regular trip, often close to home or at shopping centres or recreational venues; during daylight hours and mostly in urban areas. Similar results have been found in other parts of the world. The 2006 study also found that crashes tend to occur at intersections, particularly unsignalised intersections, which aligns with a study in the United Kingdom that found older pedestrians were up to three times safer when they used a signalised pedestrian crossing facility (Transport for London 2013). However the CrashStats data presented in Chapter 2 shows that in the 5-year period between 2008 and 2013, older pedestrian crashes in Victoria were slightly more common at signalised intersections than unsignalised ones.

A review of United States data showed that 31% of older pedestrian fatalities and 51% of injuries occurred at intersections; most of these crashes occurred while the pedestrian was using a pedestrian facility and half while the pedestrian signal was 'green' (US DOT NHTSA 2008b). A study in the United Kingdom found older pedestrians are particularly at risk crossing wide roads (particularly those with four or more lanes). Even though only 35% of roads crossed by older people are classified as main roads, 85% of injuries occur when crossing these roads (Department for Transport 2004). Another study found that the majority of older pedestrian deaths and serious injuries occurred when crossing roads in areas with no formal crossing facility within 50 metres (Transport for London 2006).

Older pedestrian crashes in Victoria tend to occur on a regular trip, often close to home or at shopping centres or recreational venues.

A 2007 review of safety of older pedestrians in New Zealand concluded that uneven pavements, high kerbs, unsatisfactory access to public transport and dangerous road crossings were the main concerns of older people when walking (Wilton & Davey, 2007).

Road design has a significant influence on the behaviour of motorists and pedestrians, as well as on exposure to risk and safety.

Oxley et al. (2006) identify that safety issues arise from the road system being designed for the needs and priority of vehicles, and mainly for young, fit and healthy road users, resulting in a road environment that is unforgiving for vulnerable road users, including older people. In particular, dominant attitudes by drivers, failure to acknowledge the rights of pedestrians and fast speeds of drivers in areas of high pedestrian activity greatly increase the potential for crashes and the injury consequences once a collision occurs (Oxley et al., 2006).

FOOTPATHS AND FALLS AS A ROAD SAFETY ISSUE

Injuries arising from falls are a major public health and safety issue. A study by the Australian Institute of Health and Welfare determined that in 2010-11 there were 92,150 serious injuries due to falls in people aged 65 years and older, with approximately 30% occurring outside of the home or aged care facilities (Bradley 2013).

The Victoria Walks 2013 seniors research report indicated that the most relevant factors affecting the walking experience (as described by older people) are related to issues which could directly affect their feet, subsequent balance and may lead to a fall. Older pedestrians have a significant fear of falling, either while walking along an inconsistent footpath, crossing a road with inadequate pram ramp crossings or as a result of being startled or bumped by passing cyclists or uncontrolled dogs off leashes (Garrard 2013). The evidence suggests this concern is well founded.

Footpath incidents and falls frequently result in serious injuries for older people. In London, for example, accidents involving falls on footpaths are more common and cause more 'damage' and serious injuries for older pedestrians than collisions with vehicles (Department for Transport 2004).

In the United States falls are responsible for around 78% of all older pedestrian injuries, whereas being hit by a motor vehicle is responsible for 15% of injuries (Transport for London 2013 and Naumann et al., 2011).

A recent study undertaken by the Monash University Accident Research Centre, commissioned by Victoria Walks and funded by VicHealth, is the first Australian research to look at pedestrian falls in detail (Oxley et al 2016). It found that while collisions with vehicles result in about 1,600 pedestrian casualties in Victoria each year, pedestrian falls account for an average of 1,680 hospital admissions and 3,545 emergency department presentations.

The MUARC study found:

"While falls affect all age groups, there is an increased rate of injuries for older pedestrians, especially those older than 75, who were roughly twice as likely to present to hospital emergency departments as people aged 15-64. Moreover, the majority of hospital admissions involved older persons, with pedestrians aged 75-84 having a hospitalisation rate nine times greater than pedestrians in the 35-64 year age group; for those aged 85+, the hospitalisation rate was 14 times greater."

While collisions with vehicles result in about 1,600 pedestrian casualties in Victoria each year, pedestrian falls account for an average of 1,680 hospital admissions and 3,545 emergency department presentations.

Women were particularly affected – females accounted for 55.5% of emergency department presentations and 58.9% of hospitalisations, compared to 44.5 and 41.1% respectively for men.

Hospital admission data did not allow contributing factors to be identified and contributing factors were not recorded for most emergency department presentations. However, for those that did, the most commonly reported were kerbs or gutters (159 incidents), alcohol or drugs (111), and to a lesser extent uneven surfaces (69), dogs (64), potholes (49), tram or train tracks (39), wet surfaces (33) and wearing high heels (24).

In terms of design responses, the authors recommended:

- Footpaths free from tripping hazards with non-slip surfaces, delineation of edges and consideration of impact absorbing materials
- Measures to remove kerbs, such as raised crossings, raised thresholds and shared space
- Use of mountable kerbs, well-designed kerb ramps and good lighting at crossing points.
- Traffic signals that provide more time to cross and pedestrian refuges and kerb outstands at unsignalised crossing points.

Importantly, poor or uneven walking surfaces can also lead to older people being distracted (looking at the ground surface more than observing vehicle traffic) while approaching a crossing, while crossing a road or while walking along roads without adequate footpaths (Transport for London 2013 and Garrard 2013). This highlights the importance of ensuring that walking surfaces are level, continuous and safe in order to encourage older walkers to 'lift their heads' and concentrate more on traffic conditions rather than on the condition of footpaths.

While walking along footpaths, older pedestrians are also more vulnerable to being hit by vehicles reversing from driveways. Research suggests that this may be associated with their lessened ability to get out of the way of even slow moving vehicles and that they tend to concentrate on the quality of the footpath surface and may be less aware of reversing motorists (Oxley et al 2006). These findings indicate that improving safety for older pedestrians requires a reduction in pedestrian falls and not simply of vehicle-pedestrian collisions.

ROAD DESIGN CONCLUSIONS

In summary, our review of the literature suggests the vulnerability of older pedestrians is associated with a number of road design and operational factors, including:

- Inadequate sight distances, lack of refuge islands, lack of signals to control turning movements of vehicles, poor visibility and legibility of signals and signs, and poor channelisation and delineation of travel lanes.
- Wide, multi-lane roads are especially hazardous for older pedestrians, most likely due to their slower walking speeds and diminished abilities to handle complex traffic conditions.
- Few facilities are designed specifically for the special needs and capabilities of older pedestrians.
- Crossing phases (both walk and clearance) at signalised pedestrian crossing facilities are commonly too short for older pedestrians and can be confusing. In Australia, the walking speed used for the design of intersections is 1.2 metres per second (VicRoads 2015b). On average, however, older pedestrians walk at a pace of around 0.9-1.0 metres per second, which means in many cases they are unable to complete a safe crossing.
- Uneven and narrow paths, rough road surfaces, high kerbs, obstacles on footpaths (poles, cars and trees) and poor lighting can all contribute to falls or to increased risk of crashes as they distract older pedestrians from traffic conditions.

(2) CRASH STATISTICS ANALYSIS–OLDER PEDESTRIANS

This Chapter provides an analysis of older pedestrian crashes in Victoria for a five year period between 2008 and 2013. The analysis provides information that helps to answer the fundamental question of where to focus improvement efforts to obtain the largest safety benefits for older pedestrians.

2.1 METHODOLOGY

In order to identify the most common 'causes' of crashes for older pedestrians, a detailed analysis of the VicRoads CrashStats database was undertaken for the five-year period from July 2008 to June 2013. The primary focus was to identify the common older pedestrian crash scenarios, both in terms of numbers and severity, for which infrastructure and operational solutions can be implemented to improve overall safety.

CrashStats is the official Victorian collision statistics and mapping program. Some of the limitations of CrashStats include that it does not account for 'near misses' (which can provide relevant information with respect to risk areas), 'very minor' injuries, or unreported collisions. It therefore provides a good picture of serious crashes but not necessarily low impact collisions. Furthermore, it does not capture falls on the footpath network. As discussed previously, older pedestrians may experience more injuries from falls than from vehicle crashes. Additionally, there are degrees of incompleteness, misreporting and miscoding of crashes in the CrashStats database.

Despite these limitations, CrashStats provides extremely valuable information with respect to the location, type and conditions surrounding crashes, which can assist in determining the types of solutions that may be most effective in improving safety for older pedestrians.

The analysis included review one-by-one of the descriptions and diagrams from the police reports for each of the 1,393 older pedestrians crashes recorded in Victoria between 2008 and 2013.

Examination of the reports revealed that 56 crashes were miscoded, giving a total of 1,337 older pedestrian crashes in this period, encompassing crashes under the Definitions for Classifying Accidents (DCA) 100-109 (Pedestrian) (see Figure 11).

2.2 RESULTS OF CRASHSTATS ANALYSIS

The analysis shows that in the five year study period pedestrians aged 65 years or older have experienced an average of 17 fatalities, 147 serious injuries and 114 other injuries each year.
Aside from the obvious emotional repercussions, these pedestrian deaths and injuries represent a significant cost to the Victorian economy. The VicRoads Submission to the Parliamentary Road Safety Committee Inquiry into Serious Injuries (VicRoads 2013) estimated the economic cost of crashes (in June 2012 prices) as follows:

- Fatality – $2.12 million per person
- Serious injury (person sent to hospital, possibly admitted) – $478,000 per person
- Other injury (typically requiring medical treatment – bruising, contusions, unconscious, pain, etc. or person complaining of pain, soreness, etc.) – $18,310

Using the previous values, older pedestrian crashes represent an average estimated economic cost of almost $110 million for Victoria each year (in 2012 dollars).

The 5-year data also provides information about the temporal and geographic characteristics of crashes involving older pedestrians. It is important to note that the crash occurrence data reflects those times of the day (days of the week) and locations with higher older pedestrian activity. The data shows older pedestrian crashes occur mainly during weekdays, during the daytime hours and when dry conditions prevail – again, the 'typical' times when older pedestrians are walking.

In terms of the general locations of accidents, over three quarters (77%) of crashes involving older pedestrians occur in urban areas within the Melbourne metropolitan region, but outside the central city. This is probably a reflection of the relatively significant levels of older pedestrian activity in these areas, possibly accompanied by lower levels of pedestrian amenity than those experienced in the central city.

With respect to speed limit zones, and consistent with the TAC findings, around 75% of all crashes involving older pedestrians occur in 50 or 60 km/h zones. Lower levels of crashes in higher speed zone areas are likely a reflection of low levels of pedestrian activity. Lower levels of crashes in 40 km/h zones are likely related to safer conditions for pedestrians in these areas and the fact that 40 km/h zones have not been applied across broad areas until recently.

SEVERITY OF CRASHES

With respect to severity of crashes, Figure 6 shows the proportion of crashes that result in fatalities, serious injuries and other injuries by age group in Victoria for the period 2008-2013.

Older pedestrians in Victoria are significantly more likely to die or be seriously injured when involved in a crash with a vehicle than people 64 years of age and younger. Overall, 58.7% of older pedestrian crashes involved death or serious injury, compared to around 37.5% for children 0-12 years of age and 41.2% for people between 13 and 64 years of age.

The increase in vulnerability as people age is illustrated by examining the older pedestrian fatality incidence compared to the population proportion for the three age subcategories described previously: the 'young-old' (65-74 years of age), the 'old' (75-84 years of age) and the 'old-old' (people 85 years of age and older).

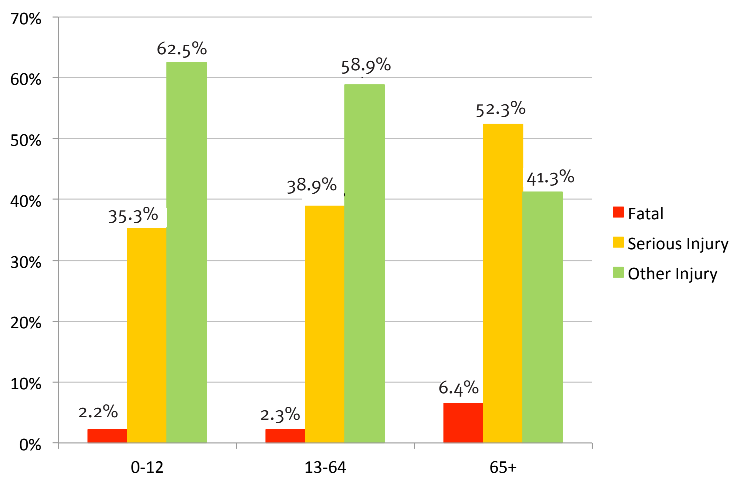


Figure 6: Proportion of Pedestrian Crashes Resulting in Fatalities, Serious Injuries and Other Injuries by Age Group

The data shows older pedestrian crashes occur mainly during weekdays, during the daytime hours and when dry conditions prevail, the typical times when older pedestrians are walking.

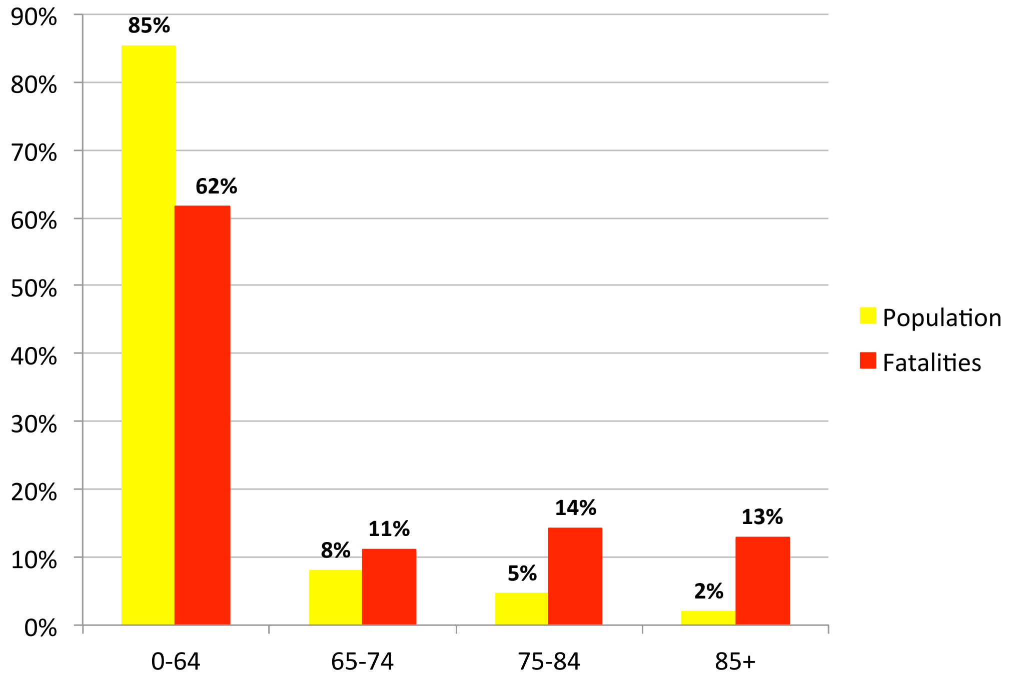


Figure 7: Relationship between Population Proportion and Pedestrian Fatality Incidence by Age

Figure 7 shows that by the time people are 85 years of age or older, even though they represent only 2% of the population in Victoria, they represent 13% of pedestrian fatalities. Similarly, people between 75 and 84 years of age represent 5% of the Victorian population and 14% of pedestrian fatalities, and those 65 to 74 years of age represent 8% of the population and 11% of the pedestrian fatalities.

Collectively, people aged 65 years and over represent around 15% of the Victorian population and 38% of all pedestrian fatalities, highlighting their particular vulnerability and the importance of improving safety for older pedestrians.

Figure 8 shows that the fatality rate (after being involved in a crash) is just over 2% for people between birth and 64 years of age. The fatality rate for all older people (65 years of age and older) is 6.4%, or almost three times higher than for their younger counterparts.

When examining the older adults by age subgroups, the fatality rate is 4.4%, 6.2% and 11.9% for the young-old, old and old-old, respectively, illustrating the increasing frailty associated with the aging process. In practice, this means that while around 1 in 16 older pedestrians involved in a crash will die, almost 1 in 8 pedestrians 85 years of age and older will die if involved in a crash.

The risk of serious injury (after being involved in a crash) is around 36% higher for people 65 years of age and older than for people between 13 and 64 years of age. As shown in Figure 9, the risk of serious injury increases significantly with age, from just under 50% for the young-old to just over 50% for the old to just over 60% for the old-old. Compared to people 13-64 years of age, the old-old are 57% more likely to be seriously injured when involved in a crash as a pedestrian.

Fatality rate is just over 2% for people between birth and 64 years of age, but 6.4% for older adults.

Figures 8 and 9 further illustrate that the risk of serious injury or fatality increases significantly as people progress through older age. For example, the 'old-old' are almost twice as likely to die (after being involved in a crash) than the 'generic' 65 years of age and older category. In fact, the 'old-old' account for only 3.3% of all pedestrian crashes but 13% of all pedestrian fatalities.

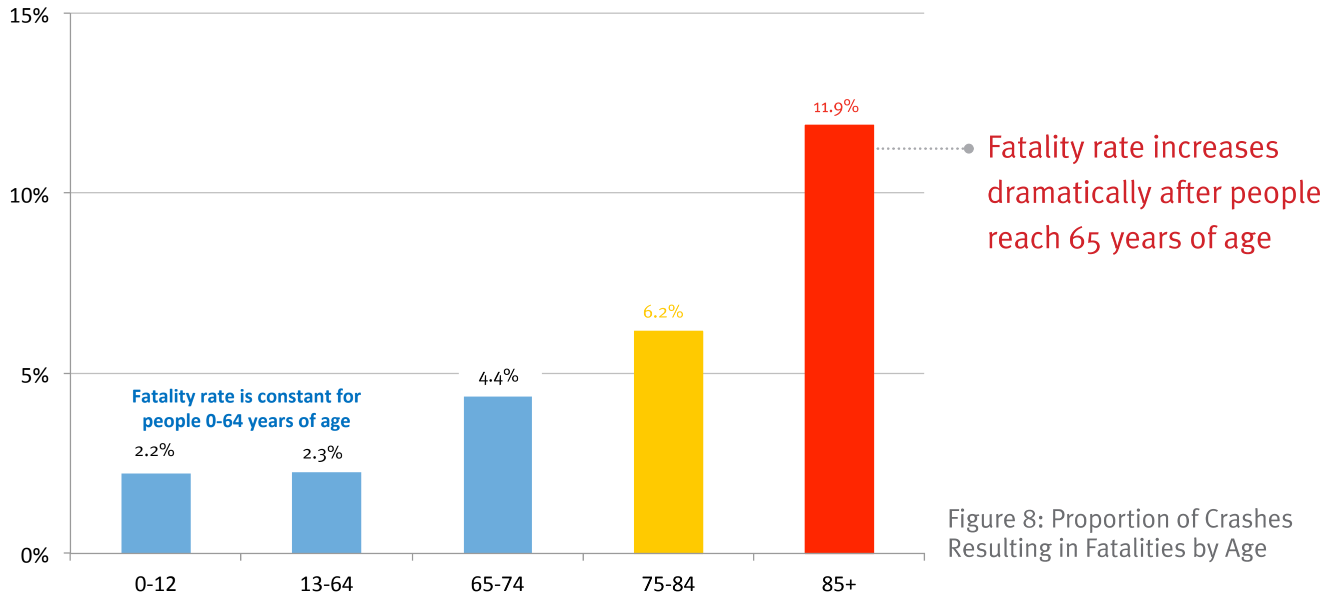


Figure 8: Proportion of Crashes Resulting in Fatalities by Age

Fatality rate (after being involved in a crash) is:
- Around 2% for people from birth to 64 years of age
- Almost two times higher for people 65-74 years of age
- Almost three times higher for people 75-84 years of age
- Over five times higher for people 85 years of age & older

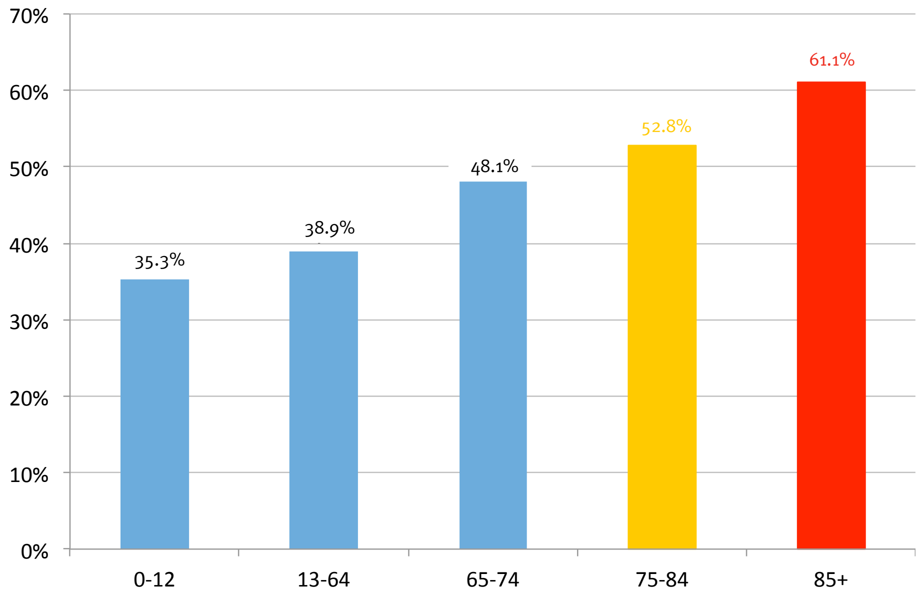


Figure 9: Proportion of Crashes Resulting in Serious Injuries by Age

Relative to people between 13 and 64 years of age,
the risk of serious injury (after being involved in a crash) is:
- 24% higher for people 65-74 years of age
- 36% higher for people 75-84 years of age
- 57% higher for people 85 years of age and older

The death and serious injury risk data shown in Figures 8 and 9 illustrate that the 'young-old' are around two times more likely to die (when involved in a crash) than people 64 years of age and younger, but almost three times less likely than the 'old-old'. Similar (albeit not as dramatic) differences are elucidated when examining the serious injuries data, with the 'young-old' being around 24% more likely to be seriously injured than people between 13 and 64 years of age, but 21% less likely than the 'old-old'.

OLDER PEDESTRIAN CRASHES BY TYPE

The following sections summarise the findings of the detailed analysis of crash statistics by crash type (using the VicRoads DCA Classification) and age. As previously discussed, 1,393 older pedestrian crashes were recorded in Victoria between 2008 and 2013; however, 56 crashes were miscoded, giving a total of 1,337 older pedestrian crashes in this period, encompassing crashes under the Definitions for Classifying Accidents (DCA) 100-109 (Pedestrian).

The young-old (65-74) are around two times more likely to die (when involved in a crash) than people 64 years of age and younger, but almost three times less likely than the old-old (85 and over).

The DCA 109 category (Other Pedestrian) includes rare, random and unusual crash occurrences or unpredictable crashes that exhibit few, if any, of the 'normal' multifactor crash causes captured for other designations. The DCA 109 crashes are largely independent of road conditions and were therefore excluded from more detailed consideration in this analysis. The remaining 1,149 older pedestrian crashes encompass those crashes (DCA 100-108) that are related to the conditions of the road environment and exclude those that were not clearly coded, for which consequences of crashes were indecipherable or that represent unusual or unpredictable circumstances. For the purposes of this analysis, these crashes are the ones analysed as representative for the evaluation of the safety of older pedestrians and the development of infrastructure and operational solutions.

The relevant 1,149 crashes are used for all subsequent sections as the total number of older pedestrian crashes.

Figure 10 shows the proportion of older pedestrian crashes by crash type and age. The DCA Crash Classification Groups 100 and 102 represent 73% (837) of the 1,149 relevant crashes involving older pedestrians between 2008 and 2013 in Victoria. The other significant classification is DCA 107 (on driveway) crashes, which includes crashes where the footpath crosses a driveway and entrances to carparks. DCA 106 is used to classify crashes where a pedestrian is hit on a central median or road centreline; or run-off-road type crashes where a pedestrian is hit on a footpath not at a driveway.

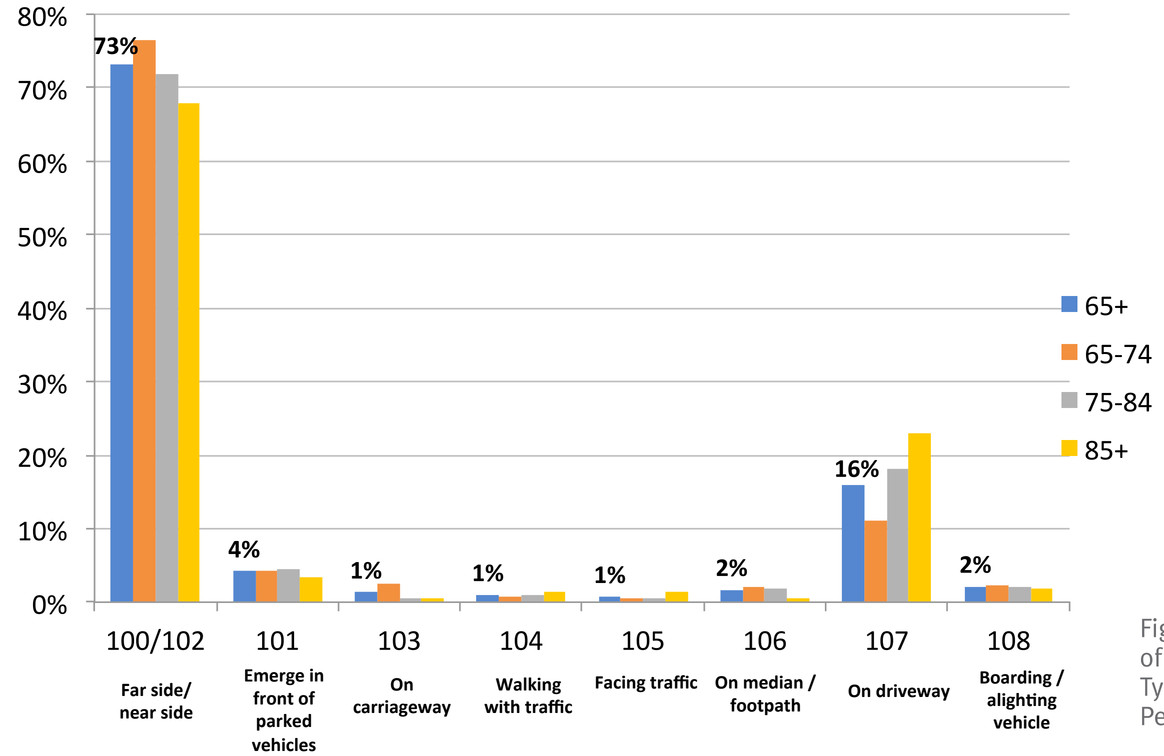
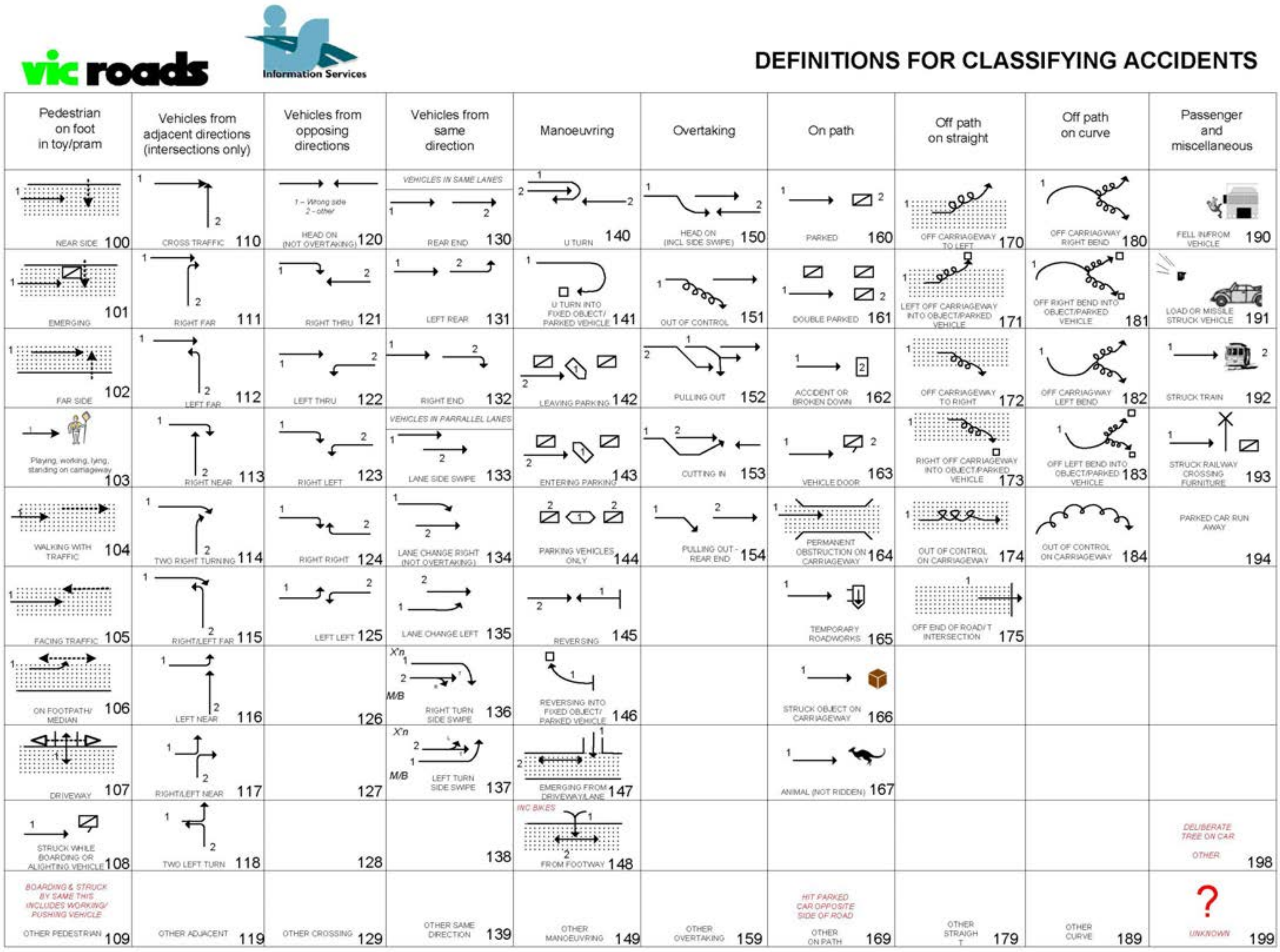


Figure 10: Proportion of Crashes by Crash Type (DCA) and Older Pedestrian Age Group

-100/102 (far side/near side) crashes represent almost 75% of all older pedestrian crashes.
-107 (on driveways) represent around 16% of all older pedestrian crashes.
-100/102 & 107 represent around 90% of all crashes for older pedestrians, as well as for each of the three subgroups (with different relative contributions from each of the two crash categories).



1. DEFINITION FOR CLASSIFYING ACCIDENTS (DCA) SHOULD BE DETERMINED BY FIRST SELECTING A COLUMN USING THE TEXT ABOVE EACH COLUMN AND THEN BY DIAGRAMATIC SUB-DIVIVISION
2. THE SUB-DIVISION CHOSEN SHOULD BE DESCRIBE THE GENERAL MOVEMENT OF VEHICLES INVOLVED IN THE INITIAL EVENT. IT DOES NOT ASSIGN A CAUSE TO THE ACCIDENT
3. SUPPLEMENTARY CODES HAVE BEEN DEFINED FOR MOST SUB-DIVISION. THESE CODES GIVE FURTHER DETAIL OF THE INITIAL EVENT.
4. THE NUMBER 1, 2 INDENTIFY INDIVIDUAL VEHICLES INVOLVED WHEN THE DCA IS LINKED WITH OTHER VEHICLE/DRIVER INFORMATION.
5. THESE CODES WERE USED FOR 1987 ACCIDENTS AND REPLACE THE ROAD MOVEMENT (RUM) CODE.

Figure 11: VicRoads Definitions for Classifying Accidents (DCA) Chart

DCA 100 and 102 are referred to as Near Side and Far Side crashes, and essentially describe whether pedestrians are hit before they get to the middle of the road (near side) or after they pass the centreline (far side) when crossing a road. Importantly, however, these two crash classes aggregate the data for a number of subclasses of crashes. In order to understand the potential solutions that could be implemented to improve safety for older pedestrians, it is crucial to analyse in detail the specific composition of those two classes of crashes and the relative distribution of the crash subclasses.

The disaggregation of the DCA 100 and 102 Classes was undertaken using information obtained from the CrashStats Restricted Access database. These two Classes include the following subclasses of crashes: mid-block location with no control; signalised intersection; unsignalised intersection; roundabout; vehicle reversing on roadway; mid-block zebra crossing; and mid-block signalised pedestrian crossing. Figure 12 shows the proportion of all 1,149 crashes involving older pedestrians for each of the DCA 100 and 102 subclasses. Signalised and unsignalised intersections have the largest proportion, representing 21.1% and 18.5 of all older pedestrian crashes, respectively.

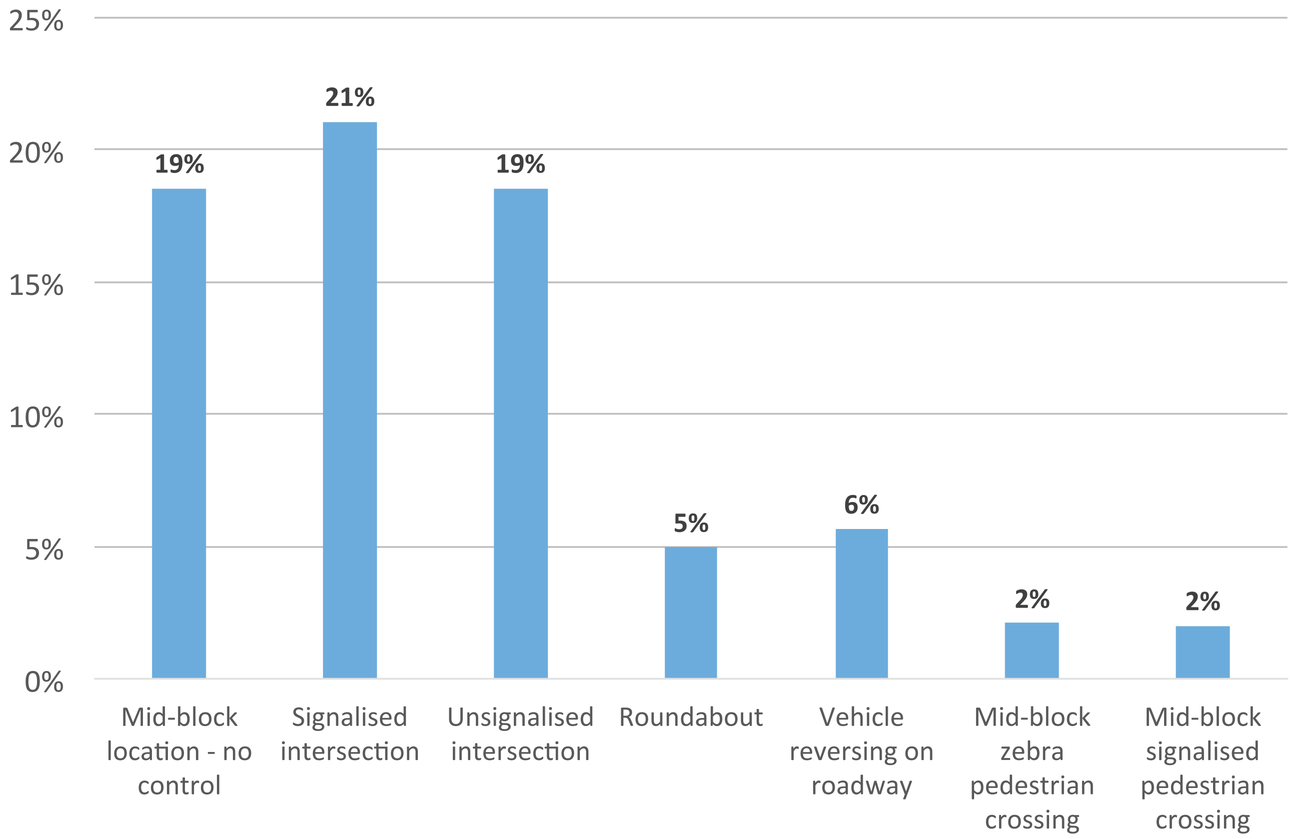


Figure 12: DCA 100 and 102 Crash Subclasses as a Proportion of all Older Pedestrian Crashes (CrashStats Restricted Access Database)

Roundabouts represent around 5% of all older pedestrian crashes (and almost 7% of the 'old-old' pedestrian crashes). Even though overall crashes between male and female older pedestrians are roughly evenly distributed, women represent around 72% of the 57 older pedestrian crashes at roundabouts (there were 2.5 times more crashes for women than men).

Collectively, intersections (signalised, unsignalised and roundabouts) represent around 45% of crashes involving older pedestrians. Mid-block locations with no control also have a relatively large proportion of crashes, with 19% of all older pedestrian crashes. Together, intersection and mid-block (no control) crashes account for approximately 64% of all older pedestrian crashes.

The remaining 36% of crashes involving older pedestrians in Victoria include an additional 10% from the other three DCA 100 and 102 subclasses (the three rightmost bars in Figure 12), on driveway (footpath) crashes (16%), and 10% from Classes 101-106 and 108 (as shown in Figure 10).

In summary, four out of five older pedestrian crashes occur at one of the following 'locations' on the road network:

- 21% at signalised intersections
- 19% at unsignalised intersections
- 19% at mid-block locations with no control
- At least 16% on driveways, footpaths or car park entrances
- 5% at roundabouts

This data suggests that these five 'locations' should be the main areas of focus to improve safety for older pedestrians in Victoria.

INTERSECTION CRASHES

A high proportion of older pedestrian crashes occur at intersections and most involve turning vehicles. Evaluation of the signalised and unsignalised intersection data showed that right and left turn manoeuvres respectively account for around 18% and 10% of all the 1,149 older pedestrian crashes analysed. At signalised intersections, 20% of crashes involve left turns and 55% right turns. At unsignalised intersections, 29% involve left turns and 35% right turns. Virtually all older pedestrian crashes involving a left-turning vehicle at signalised intersections occur on the departure side of the intersection. In contrast, at unsignalised intersections, 40% of older pedestrian crashes involving a left-turning vehicle occur on the departure side (as the vehicle exits the intersection) and 60% occur on the approach side (as the vehicle enters the intersection).

The reasons for this marked difference are not clear. Further research on the circumstances and causes of turning crashes is required.

RIGHT TURNING CRASHES

More than 1 in 6 of the 1,149 older pedestrian crashes analysed involve motorists departing an intersection via right turns, making it the most common form of crash for pedestrians at both signalised and unsignalised intersections. Analysis of the right turn movements by type of intersection control revealed that:

- 96% of the crashes involving a right turning vehicle at a signalised intersection occur on the departure side of the intersection (where the driver had an obligation to give way to the pedestrian, irrespective of the pedestrian signal phase).
- 87% of the crashes involving a right turning vehicle at an unsignalised intersection occur on the departure side.

Right turning motorists have to simultaneously focus on opposing traffic flows and pedestrians crossing the road they are turning into. Previous studies suggest that motorists often concentrate more on opposing traffic flows and subsequently fail to be aware of – and give way to – pedestrians, even when the pedestrian has priority (Lord et al., 1998 and Hurwitz and Monsere 2013). Interestingly, even when opposing traffic flows are low, the risk to pedestrians may not be reduced (Lord et al., 1998). Importantly, from a fatality and injury perspective, right turning motorists can often reach relatively high speeds by the time they reach the pedestrian crossing on the departure side of the intersection.

When comparing right-turn crashes involving motorists departing an intersection by gender, the data shows: (1) 12% of older female pedestrian crashes and 11% of older male pedestrian crashes involve a right turning vehicle entering the road the pedestrian was crossing at a signalised intersection; and (2) 4% of older female pedestrian crashes and 8% of older male pedestrian crashes involve a right turning vehicle entering the road the pedestrian was crossing at an unsignalised intersection.

The reasons for the considerable gender difference in crash incidence at unsignalised intersections (twice as common for males) are not clear.

OLDER PEDESTRIAN CRASHES AND PRIORITY

According to the Victorian road rules, vehicles turning (left or right) into a road must give way to pedestrians crossing the road they are turning into or entering at both unsignalised and signalised intersections (irrespective of the status of the pedestrian signal).

The crash data showed that, at unsignalised intersections, motorists had an obligation to give way in at least 42% of crashes involving older pedestrians, as they collided with a pedestrian crossing the road the vehicle was entering. At signalised intersections, motorists had an obligation to yield in at least 72% of crashes. The difference is largely due to the fact that at unsignalised intersections there is a much higher proportion of crashes: (1) on the approach to the intersection for both left and right turning vehicles; and (2) involving vehicles driving straight through the intersection. Motorists do not have to give way to pedestrians in either of those scenarios.

When examining crashes involving older pedestrians and vehicles performing either a left or right turn at both signalised and unsignalised intersections, the CrashStats data shows that motorists had an obligation to give way in 65% of the 110 crashes involving left turning vehicles and in 93% of the 208 crashes involving right turning vehicles.

OLDER PEDESTRIAN CRASHES ON FOOTPATHS, DRIVEWAYS AND CARPARK ENTRANCES

DCA 107 captures crashes that occur 'on driveway.' Typically this involves a pedestrian walking along a footpath being hit by a vehicle entering or exiting a driveway, including access points to both public and commercial carparks.

DCA 107 does not include crashes on other sections of the footpath, such as those involving 'out of control' vehicles mounting the footpath and striking a pedestrian. Those crashes are included in DCA 106. However, DCA 106 also includes pedestrians hit on a median, so the 2% of older pedestrian crashes in DCA 106 cannot simply be added to DCA 107 to get a 'footpath total.' Crashes that occur within car parking areas (excluding entrances) do not appear to be reliably recorded in CrashStats.

The discussion below applies only to DCA 107 crashes, so does not capture the full extent of older pedestrian crashes on footpaths or in carparks.

Even though they involve vehicles moving at slow speeds, crashes on footpaths or driveways are a major issue for older pedestrians. They represent 16% of all older pedestrian crashes and around 12% (almost 1 in 8) of all older pedestrian fatalities and serious injuries. As shown in Figure 13, the proportion of older pedestrian crashes on driveways is significantly higher than that for younger age groups. Overall, the proportion of on footpath/driveway crashes for older pedestrians is more than twice that of children (0-12 years of age) and over five times that of people between 13 and 64 years of age.

Figure 13 illustrates that the incidence of these crashes increases substantially as people age. More specifically, the proportion of on footpath/driveway crashes for people 85 years of age and older is 23% (nearly 1 in 4 of all the crashes for the 'old-old' age group) – more than twice that for people between 65 and 74 years of age and almost eight times the proportion for people between 13 and 64 years of age.

This dramatic difference is likely to reflect the increased frailty in the old-old population and their reduced agility and/or sensory ability, limiting their ability to take evasive action when a vehicle is entering/exiting a driveway or carpark.

Crashes on footpaths or driveways are a major issue for older pedestrians.

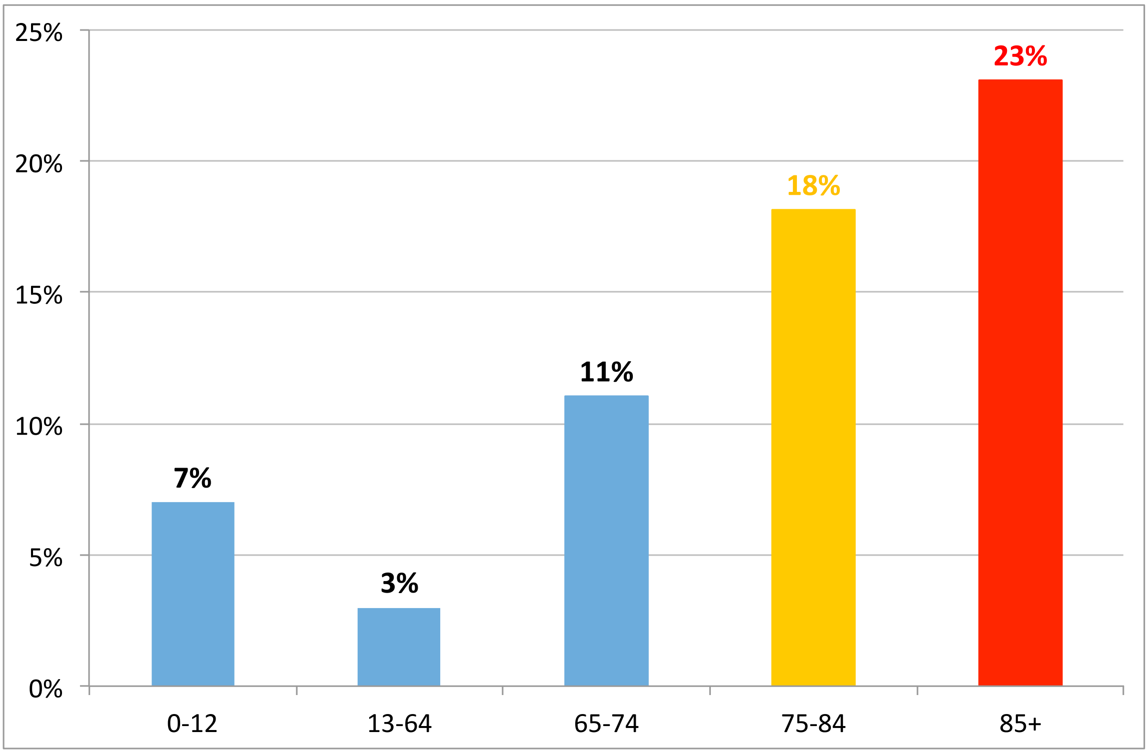


Figure 13: Proportion of Crashes 'On Driveways' by age group

Relative to the proportion of on footpath/driveway crashes for people between 13 and 64 years of age, the proportion for people:
- 65-74 years of age is almost 4 times higher
- 75-84 years of age is 6 times higher
- 85 years of age and over is almost 8 times higher

It is important to remember that this analysis only discusses collisions with vehicles, as recorded by CrashStats, and this is only one dimension of pedestrian road safety. In Victoria each year, pedestrian falls account for an average of 1,680 hospital admissions and 3,545 emergency department presentations (Oxley et al., 2016). While falls in the street affect all age groups, older people and particularly older women have the highest rates of serious injury. The prevalence of falls in the street environment further emphasises the need to design footpaths, driveways and road interfaces to minimise both collisions and falls.

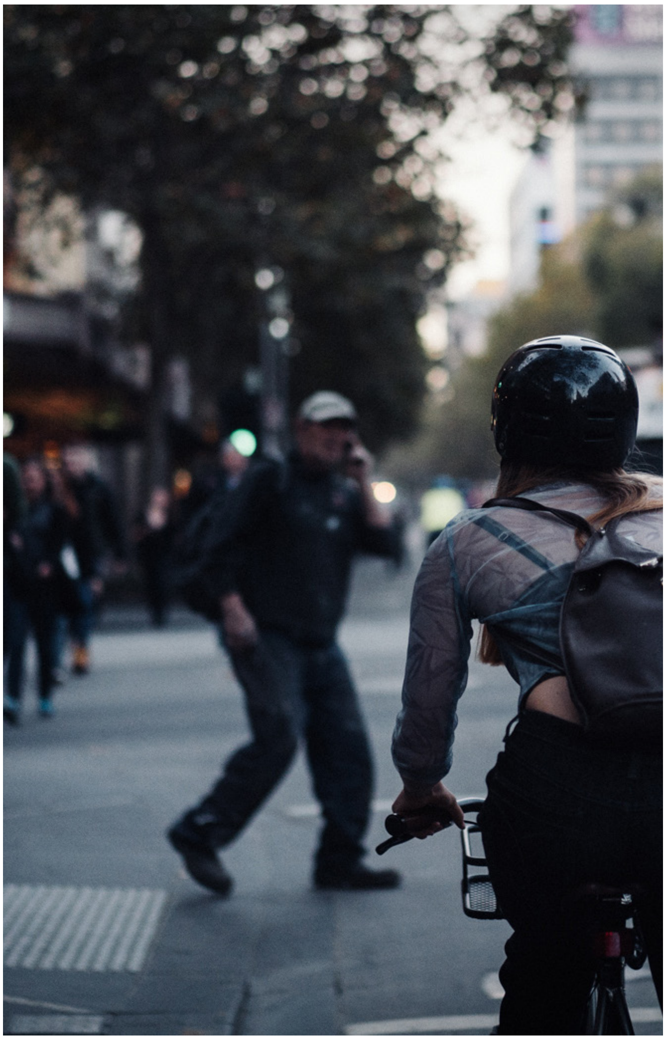
2.2 DESIGNING FOR HUMAN ERROR

When examining the detailed information contained in the crash reports for the key crash types, it is evident that human error is a significant component:

- Mid-block – human error likely from both motorists and pedestrians. Either pedestrians misjudge their ability to cross safely and/or motorists adopt a higher driving speed than appropriate or fail to react to pedestrians.
- Right turns – the crash data shows that older pedestrians had priority in at least 93% of these crashes (an indication that drivers may be focusing their attention on opposing traffic rather than pedestrians crossing the road they are turning into).
- On driveways, carparks and footpaths – half (or around 8% of all older pedestrian crashes) result in either a fatality or a serious injury, despite the fact that by their very nature they are arguably the slowest impact crash type. This highlights the distinct frailty of older people, compared to their younger counterparts, as well as the need for attention by motorists when entering and exiting driveways.
- Left turns – the crash data shows that motorists had an obligation to give way in 65% of the 110 crashes involving left turning vehicles.

The vulnerability of the human body should be a limiting design parameter for the road environment and speed management.

These insights reinforce the simple fact that the road environment should take account of human fallibility and minimise both the opportunities for errors and the harm done when they occur, consistent with a 'Towards Zero' road safety approach. In other words, when a mistake occurs it should not cause injury or death – bearing in mind the disproportionately higher vulnerability and frailty of older pedestrians. Collision speed is even more critical when considering solutions to improve safety for older pedestrians, as when human bodies age their biomechanical tolerance limits are simply not designed to take even low-speed impacts. In summary, the vulnerability of the human body should be a limiting design parameter for the road environment and speed management.



(3)

PEDESTRIAN ROAD RULES : KEY ISSUES

With the benefit of the literature review, expert consultation and CrashStats analysis, this section considers key issues with road rules as they relate to older pedestrians.

3.1 PRIORITY RULES AT INTERSECTIONS

As detailed in the Crashstats analysis, the most common crash scenario is a right-turning vehicle hitting a pedestrian crossing the road into which the vehicle is turning (the driver failing to give way). Similarly, drivers failing to give way when turning left is also a common crash scenario. This raises the question of whether drivers have a good understanding of their obligations to give way to pedestrians and whether the rules themselves are appropriate.

The Victorian Road Rules state:

Unsignalised Intersections
When turning at an intersection, you (the driver) must give way to any pedestrians crossing the road that you are entering.

Signalised Intersections:
A driver turning at an intersection with traffic lights must give way to any pedestrian at or near the intersection who is crossing the road the driver is entering.

Subsequently, motorists turning left or right to enter a road are required to give way to pedestrians crossing that road. Importantly, this applies not only to unsignalised intersections as the 'rules of the game' in the absence of formal signage, but also to signalised intersections regardless of the pedestrian phase displayed while the pedestrian is crossing. However, motorists exiting a public road or laneway are not required to give way to pedestrians crossing that road.

In practice, this means that pedestrians have priority for half of the crossing. Furthermore, the opposite rule applies for motorists exiting a private driveway or carpark access – as these motorists have to give way to pedestrians walking along the footpath.

This complex set of rules is potentially confusing for both motorists and pedestrians, and seems likely to lead to inconsistent behaviour and potential crashes. As previously discussed, 28% of all older pedestrian crashes involve right (18%) and left (10%) turning vehicles at intersections. A further 16% involve motorists entering/exiting driveways and carpark access points, collectively accounting for 44% of all older pedestrian crashes.

Figure 14 provides diagrammatic examples of the existing road rule priorities for motorists and pedestrians. Observations suggest that motorists and pedestrians may be unaware of, or confused by, the priority rules at intersections.

28% of all older pedestrian crashes involve right (18%) and left (10%) turning vehicles at intersections. A further 16% involve motorists entering/exiting driveways and carpark access points, collectively accounting for 44% of all older pedestrian crashes.

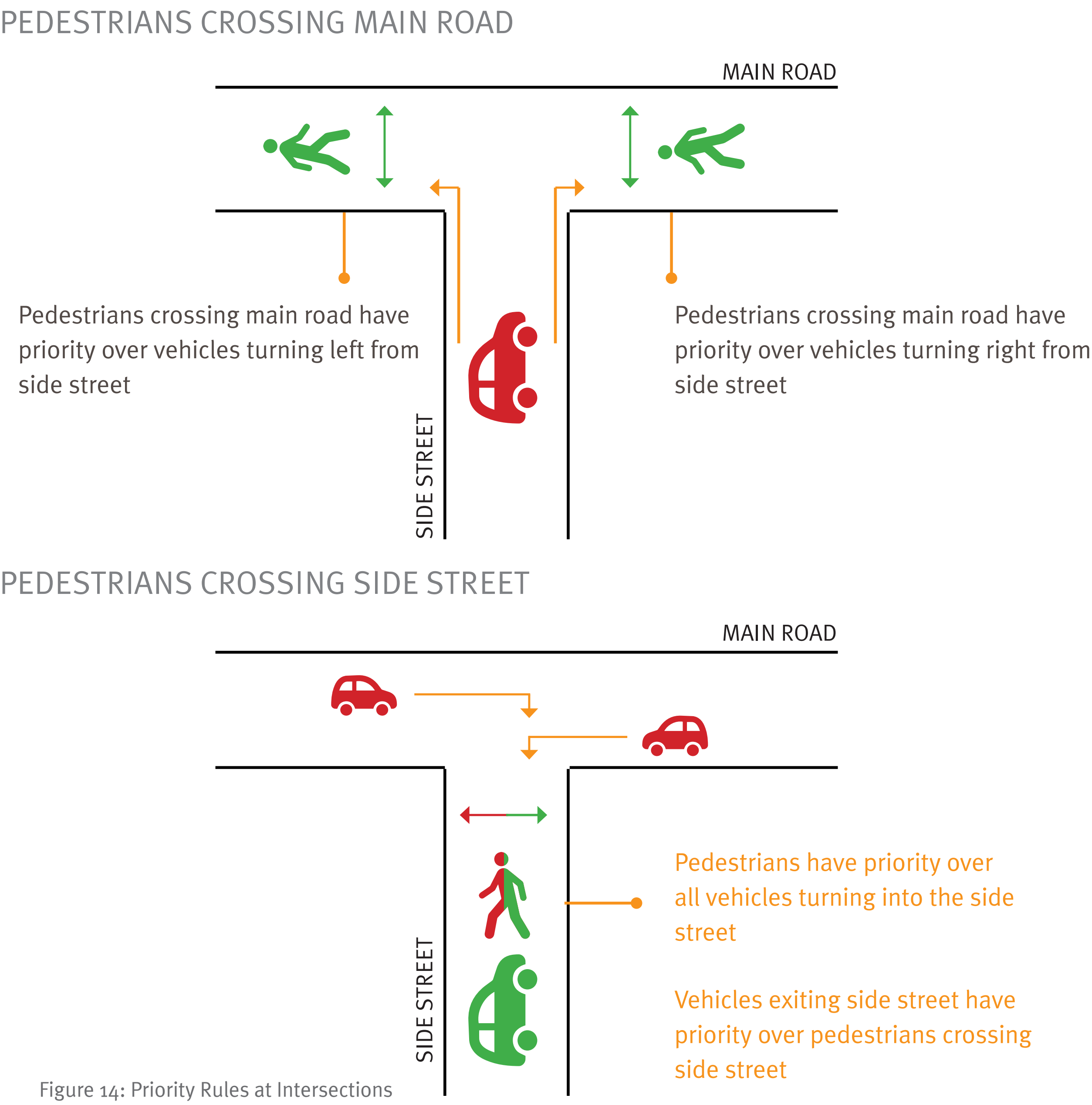


Figure 14: Priority Rules at Intersections

Actions that should arise from this situation include:

- Research on motorists' levels of understanding of the various give way rules to determine the factors that influence failure to give way to pedestrians.
- Research on pedestrians' levels of understanding of the various give way rules to determine the factors that influence their behaviour when crossing at an intersection.

Consideration could also be given to changing road rules to require drivers entering an intersection to give way to pedestrians (as well as vehicles) when the driver is otherwise required to give way to opposing traffic (at a stop or give way sign for example). This might particularly assist in reducing left turn crashes at unsignalised intersections, as 60% of these occur as the vehicle enters the intersection. More broadly however, there would then be a fairly clear requirement for drivers to give way to pedestrians unless on an unrestricted through movement.

This could reduce the possible confusion, promote positive change in motorists' behaviour and help reduce the incidence of pedestrian crashes.

3.2 PRIORITY RULES IN CARPARKS

In Victoria, the road rules apply not only to public roads, but also to areas that are open to, or used by, the public for driving or parking vehicles, legally known as 'road related areas'. Collectively, however, the road rules do not provide a consistent definition for car parking areas that are located off roads. Specifically, the matter of whether a given road related area that is used for car parking is subject to the road rules will depend upon consideration of the degree of access and the circumstances of access to the area in question. While many carparks will be deemed to be 'open to, or used by, the public', others will be not. As such, there is no universal set of road rules that can be applied to all carparks.

In 2010 the Road Safety Committee of the Victorian Parliament conducted an Inquiry into Pedestrian Safety in Carparks (Parliament of Victoria 2010). Some of the factors identified in the report as contributing to the higher risk of older pedestrians being involved in a crash in a carpark include: (1) lower agility to avoid situations that might result in a collision; and (2) decline in perceptual function, such as lower ability to hear approaching vehicles and lower peripheral vision to identify a vehicle that is approaching or is reversing towards them.

The higher incidence of injuries (once a crash occurs) is reflective of the frailty of older pedestrians (Parliament of Victoria 2010).

For older pedestrians, even a slight knock could be enough to cause a fall that results in a severe injury, such as a fractured pelvis or hip (Corben 2009).

The findings of the 2010 Road Safety Committee Inquiry and the analysis of CrashStats contained in this report are consistent with international studies on this subject. For example, a United States Department of Transportation study found that injuries and fatalities resulting from a driver reversing were more likely occur in carparks and disproportionably affected children under five years old and adults aged 70 years and older (US DOT NHTSA 2008a). Furthermore, a large study of carpark crashes in Florida found that older pedestrians were at the greatest risk of being involved in a crash and, once involved in a crash, were at the greatest risk of suffering injury or a fatality (Parliament of Victoria 2010).

The 2010 Road Safety Committee Inquiry into Pedestrian Safety in Carparks (Parliament of Victoria 2010) identified the following as the best practices in carpark design and operation: "appropriate sightlines; lighting; controlling speed through engineering measures and the separation of pedestrians from vehicles and separating loading zones. In addition, declaring small and medium sized car parks as shared zones would formalise a standard 10 km/h speed limit and ensure pedestrians have the right of way. Circulation roads in larger car parks could have higher speed limits in places where there were fewer pedestrians present." The Road Safety Committee determined therefore that small and medium carparks, at least, should be designated as shared zones.

(4)

ROAD DESIGN PRINCIPLES AND INFRASTRUCTURE SOLUTIONS

This Chapter presents a high-level summary of the infrastructure treatments and solutions that can assist road managers to provide safer road environments for older pedestrians.

4.1 ROAD DESIGN PRINCIPLES TO ENHANCE SAFETY FOR OLDER PEDESTRIANS

When considering potential treatments to address the safety of older pedestrians, it is important to consider the many factors that contribute to crashes. These include vehicle speeds, behavioural factors such as lack of compliance with road rules (by pedestrians and motorists alike), street design features and traffic management / operational arrangements. The literature review and crash analysis allows us to establish key principles of street design for the safety of older pedestrians:

1. **Separation from traffic.** Older people need a comprehensive, connected footpath network to allow them to walk comfortably without mixing with traffic when they are not actively crossing a road (unless the street is designed as a shared space). Absence of footpaths remains a problem in many areas – 1,600 bus stops in outer Melbourne do not connect to a footpath (RACV 2009). In addition, many streets, particularly in suburban and rural areas, have footpaths on only side of the road. Austroads' Guide to Road Design Part 6A: Pedestrian and Cyclist Paths offers general principles relating to the provision of footpaths, including that footpaths should be installed on both sides of all new roads. The Precinct Structure Planning Guidelines (Standard S10) also state that all streets should have footpaths on both sides.
2. **Reduction in vehicle speeds.** This can apply generally, through area wide traffic calming or speed limits, and specifically at crossing points through vertical or horizontal deflection.
3. **Reduction in the complexity of crossings.** This includes design that allows older people to stage crossings and deal with one direction of traffic at a time (medians and pedestrian refuges) and signal phasing (controlled right turns) that avoids turning traffic conflicting with pedestrians.
4. **Reduction in crossing distance.** Design should minimise the distance that pedestrians have to cross while exposed to traffic.
5. **More time to cross.** Signalised pedestrian crossings need to provide additional phase time to allow older pedestrians walking at slower speeds to complete their crossing, rather than being stranded in the middle of the road. This could be achieved by designing crossings to accommodate slower walking speeds (0.9 metres per second rather than 1.2 metres per second) or more efficiently by utilising sensor detection technology which can adjust the signal phasing in response to a slower pedestrian.

Design should minimise the distance that pedestrians have to cross while exposed to traffic.

6. **Increase conspicuousness** / visibility of pedestrians, particularly when crossings streets. Treatments such as kerb outstands, pedestrian refuges and zebra crossings, and signal phasing such as 'head start,' allow pedestrians to safely position themselves where they are visible to drivers.
7. **Reinforce requirement for vehicles to give way.** Treatments such as raised thresholds and extension of footpaths over driveways reinforce the legal requirement for vehicles to give way when turning.
8. **Quality surfaces and detailed design.** Older pedestrians are vulnerable to injury from trips and falls when walking. It is important that footpaths provide level, smooth (but non-slip) surfaces, minimal obstructions, and continuous connections. This allows older pedestrians to be confident in lifting their eyes more often away from their feet and observe potential traffic hazards. Trip risk at the kerb should be minimised, including methods that remove a change in level at the kerb such as raised crossings. Lastly, kerb ramps should be provided on both sides of all intersections (VicRoads 2015).

4.2 EVIDENCE OF SAFETY IMPROVEMENTS OF INFRASTRUCTURE TREATMENTS AND OPERATIONAL SOLUTIONS

The table on the following pages summarises the evidence of direct and indirect pedestrian safety benefits associated with infrastructure treatments and operational solutions. The information presented is a summary of the literature review undertaken. Since evidence of direct benefits for older pedestrians is limited, the table also presents a discussion of the particular relevance of the treatments for improving conditions for older pedestrians.

Infrastructure and Operational Solutions	Findings	Relevance for Older Pedestrians
Reduced speed limit	United Kingdom: 20mph (32km/h) zones reduce injury accidents by 64% in town centres and 68% in residential areas (Grundy et al 2009). Netherlands: The introduction of 20mph (32 km/h) speed limit zones resulted in a 42 % decrease in all crashes and a 46 % decrease in crashes that resulted in either a fatality or a serious injury (Grundy et al 2009). London (Department for Transport London 2004): The introduction of 30 km/h zones resulted in • All pedestrian injuries decreasing by 32.4% on roadways with a speed limit of 20mph • A decrease of 34.8% of pedestrians who were killed or seriously injured. A United States study evaluated the effect of motor vehicle speed on yielding rates to pedestrians in marked crosswalks at nine locations (Bertulis and Dulaski 2014). Overall, there was an inverse correlation: the higher the motor vehicle speed was, the lower the yield rate was. At the site with the lowest recorded 85th percentile speed of 20 mph, motorists yielded to crossing pedestrians 75% of the time. At the site with the highest 85th percentile speed of 37 mph, motorists yielded to crossing pedestrians 17% of the time. Motorists yielded to pedestrians almost four times more in the street with a recorded speed of 20 mph than in the one with a recorded speed approaching 40 mph. A study of pedestrian fatalities in Adelaide estimated that a 5km/h vehicle speed reduction would eliminate 30% of pedestrian fatalities (McLean et al 1994).	Older pedestrians are over-represented in crashes at locations with high traffic volumes and vehicle speeds. When involved in a crash, older pedestrians are more likely to sustain fatal or serious injuries than younger pedestrians (even at low impact speeds) and more likely to take longer than younger people to recover from their injuries. Speed limit reduction has demonstrated success as a cost-effective approach to improve safety across broad areas. Speed limit reductions should be targeted to those areas identified as having older pedestrian activity.

Infrastructure and Operational Solutions	Findings	Relevance for Older Pedestrians
Pedestrian refuges or medians	A study sponsored by the Federal Highway Administration (FHWA) evaluated the impact of median types on the safety of vehicles and pedestrians are presented (Bowman and Vecellio 1994). The study included the analysis of 32,894 vehicular and 1,012 pedestrian accidents occurring in three cities on arterials with the following median types: (a) raised, (b) flush, and (c) no existing median (undivided). The study found that raising a 1.8m wide painted median reduced pedestrian crashes by 23%. A 1999 study in Australia found that 3m medians reduced pedestrian crashes by 33 % in comparison to 1.8m painted medians (Mead et al. 2014). The effects of selected traffic calming treatments on pedestrian and motorist behaviour were evaluated at both intersection and midblock locations (Huang and Cynecki 2001). Before and after data were collected in Corvallis, Oregon (pedestrian refuge island) and Sacramento, California (refuge islands). The study found that refuge islands at intersections reduced pedestrian crashes by 73 % and that pedestrians who crossed in the crosswalk increased by 10.4% after refuge islands were installed. The pedestrian crash rate was 0.74 pedestrian crashes per million crossings in crosswalks where there was a raised median and 1.37 pedestrian crashes per million at crossings without a raised median. King et al. 2003 explored the effect of a raised median, signalised and redesigned intersections, curbs, and sidewalks on vehicle speed, pedestrian exposure risk, driver predictability, and vehicle volume along a four-lane suburban roadway in central New Jersey. The installation of refuge islands resulted in a 3km/h decrease in 85% of the vehicle speed and a 28% decrease in pedestrian exposure risk without affecting vehicle volumes. The researchers predicted that $1.7 million would be saved due to avoided collisions over 3 years as a result of the roadway improvements. The World Health Organisation (2013) found evidence that roadway narrowing at sites with pedestrian refuge islands and/or widened footpaths have the double benefit of reducing vehicle speeds and pedestrian crossing distances. WHO states that refuge islands are generally successful in reducing pedestrian crashes by approximately 40%.	Median refuge islands help protect pedestrians who are crossing the road at intersections and mid-block locations. Of particular relevance for older pedestrians is the fact that they reduce the distance of exposure to traffic by breaking up the road into two distinct sections – this is crucial as older pedestrians walk at a lower speed than their younger counterparts. In addition, they allow older pedestrians to focus on one direction of traffic at a time, thereby reducing the complexity of the crossing and allowing older pedestrians to choose safe gaps in traffic more easily. Medians are an option for facilitating crossing at mid-block locations if a formal crossing cannot be provided. This may be critical to the mobility of seniors who would otherwise not have the confidence to cross mid-block. Gaps should be provided in raised medians at crossing points, so that older pedestrians do not have to negotiate a change in level.

Infrastructure and Operational Solutions	Findings	Relevance for Older Pedestrians
Kerb extensions	In Berkeley, California, a "serpentine" streetscape design included the construction of 30 kerb extensions to narrow the street at intersections and mid-block locations (US Department of Transportation 2004). This resulted in: The number of pedestrians increasing by 48% on one block and by 126% on a second block of the street during the afternoon peak. Over 80% of pedestrians feeling that the slow street improved pedestrian safety • Daily motor vehicle volumes were lowered by the project from 540 to 441 (18%) on the first block and 500 to 399 (20%) on the second block. • Mean vehicle speeds were approximately 27 - 32 km/h at the maximum speed locations between the speed humps. A study in New York City found that kerb extensions reduced crash rates at 4 of the 6 intersections examined, leading to increased pedestrian safety and the more widespread use of kerb extensions in New York City (King 1999). A study in Santa Barbara, California found that Installing kerb extensions and refuge islands decreased crossing delay by an average of 4.9 seconds and increased the yielding of motorists (Hengel 2013). A study in Oregon found that with tighter turning geometry there was a 43% reduction in the average number of vehicles that make the turn before a pedestrian can cross. This was accompanied by a 21% increase in the average number of vehicles that give way to pedestrians (US Department of Transportation 2005).	Kerb extensions result in improved visibility between pedestrians and motorists, and reduced crossing distance for pedestrians – the latter is crucial as older pedestrians walk at a lower speed than their younger counterparts. Kerb extensions can also reduce vehicle speeds. In particular, they can reduce turning speeds and force motorists (particularly right turning ones) to turn more carefully as the road they enter is narrower – this can be particularly helpful in reducing the incidence of crashes with turning vehicles, which is the most critical safety issue for older pedestrians.

Infrastructure and Operational Solutions	Findings	Relevance for Older Pedestrians
Raised pedestrian crossings and raised intersections	Raised crossings are generally successful in reducing pedestrian crashes by approximately 40% (World Health Organisation 2013). WHO also found evidence that additional significant benefits to pedestrian safety are likely if other traffic calming devices are installed in advance of the raised crossing. A study by Huang and Cynecki (2001) evaluated the effects of selected traffic calming treatments on pedestrian and motorist behaviour at both intersection and midblock locations. Before and after data were collected in Cambridge, Massachusetts (kerb extensions and raised intersection). The study showed a 26.8% increase in pedestrians who crossed in crosswalk after the intersection was raised. See also roundabouts section below for raised pedestrian crossings at roundabouts.	Raised pedestrian crossings force vehicles to slow to very low speeds at the crossing point and provide a clear indication of priority for pedestrians. They also provide a level surface between the footpath and the crossing, which is of particular importance for older (and disabled) pedestrians. Because raised crossings are both safe and convenient for pedestrians, they are more likely to attract people to use them compared to other crossing options.
Area-wide traffic calming	A study by the City of Cambridge, Massachusetts examined the combined impact of treatments in Granite Street. The improvements included extensions, a raised pedestrian crossing and an entire raised intersection. The results included a reduction in 85th percentile speeds on Granite Street by 15% (from 45km/h to 38.5 km/h). In addition to that, vehicles exceeding 40km/h decreased from 40% to 14%. The traffic volume did not change (US Department of Transportation 2004).	Traffic calming measures help to reduce vehicle speed, with benefits to older pedestrians both in terms of reducing crash incidence and severity. Slower walking speeds, reduced cognitive and physical abilities, and increased frailty make measures that reduce vehicle speeds particularly useful for older pedestrians. Area wide measures have been recognised as being particularly useful as they reduce vehicle speeds over entire sections of roads.

Infrastructure and Operational Solutions	Findings	Relevance for Older Pedestrians
Fully controlled right turn phases	A study in New York evaluated the results of fully controlled left turn phases at 95 intersections. The implementation of this solution resulted in a 45% decrease in pedestrian crashes (Mead et al. 2014).	Being hit by a car turning right into the street they are crossing is the most common crash scenario for older pedestrians. Fully controlled right turn phases allow vehicles to turn right only when they have a green right turn arrow, avoiding the situation where older pedestrians are legally crossing the road the vehicle is entering simultaneously. During the green arrow for right turning vehicles, pedestrians are not allowed to cross.
Longer pedestrian crossing times, including Puffin pedestrian crossings	A study in San Francisco investigated (via a trial) the effect of increasing the length of the pedestrian phase at signalised intersections. Video detection technology was used to provide up to 3 seconds of additional time for late-crossing pedestrians at one intersection. The study showed a 9% reduction in the percentage of cycles where a pedestrian was "trapped" crossing the roadway. No significant effects on pedestrian-vehicle conflicts were measured (Mead et al. 2014). A 2010 study of 50 sites in the United Kingdom which had been installed with PUFFIN technology found a 24 % reduction in all pedestrian accidents.	The average walking speed of older adults is lower than that for younger adults. Older pedestrians may not be able to fully complete crossings within the time allowed by standard signal phasing. PUFFIN pedestrian detection signals adjust phase times when they detect a slower pedestrian crossing the road. Their installation can help older pedestrians (who are generally slower walkers) to fully clear intersections and safely complete crossing movements.
Exclusive pedestrian crossing phases	A study evaluated the effect of exclusive pedestrian crossing phases at six intersections in the 'Business Triangle" of Beverly Hills. The results showed that vehicle/pedestrian crashes reduced by 66% between 1987 and 1996 (US Department of Transportation 2004).	Exclusive pedestrian phases are particularly useful for older pedestrians as they guarantee that no vehicle can legally enter or exit the road that the pedestrian is crossing. When coupled with longer pedestrian crossing times, this (in theory) fully protects older pedestrians. The addition of exclusive phases typically results in longer waiting periods for all road users, so efficiency aspects must be considered.

Infrastructure and Operational Solutions	Findings	Relevance for Older Pedestrians
Pedestrian crossing in-ground flashing lights	In San Francisco, a trial concluded that sensor activated flashing lights resulted in a reduction in vehicle/pedestrian conflicts from 6.1% to 2.9% and an increase in vehicle yielding from 82% to 94%, as well as virtual “elimination” of pedestrians being trapped in the crossing (Hua et al. 2009). A study in two cities in Israel showed that in-ground lighting was effective in reducing vehicle speeds near pedestrian crossings by 2-5km/h, increasing yielding to pedestrians by 35-70% and reducing vehicle-pedestrian conflicts significantly, to less than 1% (Mead et al. 2014). In Clearwater, Florida, the installation of in-ground flashing lights at a pedestrian crossing resulted in motorists yielding to pedestrians 30-40% more frequently during daytime and 8% more during the night. The number of pedestrians who crossed ‘without waiting’ increased by 35%, indicating increased confidence to cross (Mead et al. 2014).	Visual cues to motorists of the presence of a mid-block pedestrian crossing has been generally linked to reduced speeds and increases in yielding, thereby increasing safe crossing opportunities for older pedestrians.
Pedestrian crossing count-down display clocks	A study in Sydney found that 53% of pedestrians felt ‘much safer’ and 25% ‘a little safer’ with the introduction of count-down timers (Cleaver et al 2011). In Detroit USA a study found a 70% reduction in pedestrian crashes (Mead et al. 2014). Despite these findings, it appears that studies of pedestrian count-down timers have found mixed or inconclusive results for pedestrian safety (Cleaver et al 2011).	Given their slower walking speed, the amount of time available to cross is a particularly important issue for older pedestrians. Information about the amount of time left to cross allows older pedestrians to make a judgement before entering the road that reflects their individual capabilities, which may reduce the chances of being stranded and not reaching the other footpath safely. However, the primary advantage of countdown displays is likely to be in efficiency of movement rather than safety.

Infrastructure and Operational Solutions	Findings	Relevance for Older Pedestrians
Road narrowing	The trial of removing half of the traffic lanes along Broadway in New York City resulted in pedestrian volumes increasing, but pedestrian crashes reducing by 35% (US Department of Transportation 2004).	Road narrowing is particularly useful for older people because they have slower walking speeds and less agility, so it is important to reduce crossing distance and exposure to traffic. Road narrowing may reduce the need for formal crossings and has the advantage of providing a safe environment along the entire length of road and not just at intersections or midblock crossing locations.
Footpaths and Walkways	A study conducted in the United States found that pedestrian crashes were more than twice as likely to occur at locations without footpaths than would be expected on the basis of exposure (by number of pedestrians and vehicles) (US Department of Transportation 2004). A study in the United States found that sites with footpaths were 88% less likely to be pedestrian crash sites than those without (McMahon et al. 2002). In a study in Sweden, cracked and uneven pavements were said to be a problem by 52% of women and 39% of men of all ages, and over half of all people over 55. Also, when the mean undulation of a surface exceeded 8mm, 20% of older people reported difficulty in walking safely (Retting et al. 2003).	Given their slower walking speed, the amount of time available to cross is a particularly important issue for older pedestrians. Information about the amount of time left to cross allows older pedestrians to make a judgement before entering the road that reflects their individual capabilities, which may reduce the chances of being stranded and not reaching the other footpath safely. However, the primary advantage of countdown displays is likely to be in efficiency of movement rather than safety. Providing adequate footpath space on both sides of all roads is particularly helpful for older pedestrians as it avoids the need to walk along the roadway, where reduced agility means they are less able to avoid vehicles, or along the nature strip, where older people may be less able to safely negotiate unstable or uneven surfaces or obstacles than younger walkers.

Infrastructure and Operational Solutions	Findings	Relevance for Older Pedestrians
Driveway improvements	A number of studies in the United States have found that footpath improvements such as improved vehicle crossover sections improved priority for pedestrians and reduced the likelihood of driveway crashes (US Department of Transportation 2004, Lindqvist et al. 2001 and Gallon et al. 1995). The studies showed that these improvements were particularly important for the most vulnerable pedestrians, namely children and older adults. In a study in Sweden, the control of vegetation on driveways was identified as one of the key aspects of a community safety intervention after 72% of a sample of visually impaired people of all ages reported problems with overhanging objects when walking (Retting et al. 2003).	In Victoria, 16% of all older pedestrian crashes with motorists occur on footpaths and driveways. Improvements such as continuous footpaths will highlight to motorists that pedestrians have priority over pedestrians at vehicle cross-overs.
Roundabouts	*Evidence of problems at roundabouts:* A review of roundabouts showed that 75% of drivers yielded at less than 15 mph, while less than 50% yielded at speeds greater than 20 mph. In addition, drivers who were entering the roundabout were 6.4 times more likely to yield to pedestrians than drivers who were exiting the roundabouts (US Department of Transportation 2004). Older people have high rates of blindness and vision impairment (see Figure 4). In a number of reviews of the behaviour of pedestrians who are blind, it was identified that they experienced: (1) delays up to 3 times as long in beginning to cross, (2) difficulties perceiving driver yielding, (3) limited ability to gauge crossing opportunities, and (4) greater risk exposure from higher incidence of risky crossing attempts (Harkey and Carter 2006, Guth et al. 2000, Geruschat and Hassan 2005, Ashmead et al. 2005 and Leake et al. 1991). In Sweden, a review of 769 pedestrian crossings at 7 roundabouts showed that: Motorists did not yield to pedestrians upon entry of the roundabout 23% of the time, and 38% upon exiting.	Roundabouts are likely to be particularly difficult to navigate for older pedestrians as, coupled with the lack of priority (unless specifically marked otherwise), they have difficulty judging vehicle speeds and safe crossing gaps and less ability to run or jump out of the way of a vehicle if they judge incorrectly. Improvements such as the ones in the vicinity of the South Melbourne Market in Port Phillip improve priority and safety for all pedestrians.

Infrastructure and Operational Solutions	Findings	Relevance for Older Pedestrians
Roundabouts	Motorists on two-lane roundabouts failed to yield 43% of the time, much higher than motorists on one-lane roundabouts, who failed to yield 17 % of the time (Leden et al. 2006). *Evidence for successful treatment:* In Australia, drivers are not required to give way to pedestrians at roundabouts unless there is a pedestrian crossing. In an attempt to address the safety concerns with roundabouts, the City of Port Phillip installed raised pedestrian crossings on all legs of an intersection in South Melbourne. Mean speeds 5 m from the roundabout were lower in the after period with speeds of 19.10 km/h (before) and 16.31 km/h (after). A survey of those who use the roundabout found that a significantly larger number of respondents believed the roundabout crossing was safe (24% before compared with 64% after), that travel speeds were more acceptable (47%, before and 66% after), and that more drivers were giving way to pedestrians in the after-period (78%) compared to before treatment (30%). 89% of respondents found it easy to cross after treatment, compared with 54% before (Candappa et al. 2005). A study in the United States showed that, following the installation of the raised crosswalk at all legs of a roundabout, opportunities for blind pedestrians to cross both lanes of traffic increased by 20.9%, utilisation of those opportunities increased from 88.3% to 98.1%, and average crossing delay decreased from 17 seconds to 8 seconds (Barlow et al. 2011).	

Infrastructure and Operational Solutions	Findings	Relevance for Older Pedestrians
Shared Zones	A review of the shared zone space in Bendigo, Victoria showed that the average speed in Hargreaves Street reduced from 40km/h to 26km/h (Edquist and Corben 2012). Maynard et al. 2014: A review of shared zones in the Netherlands found: • A decrease in delays at intersections from an average of 50 seconds to between 15 and 30 seconds for the roundabout/ shared zone, depending on entry and exit roads. The number of crashes was not particularly high before reconstruction, and dropped significantly afterwards. • Haren: 1 serious injury, 2 minor injuries and 32 damage only crashes occurred during the three years before conversion. In the three years after reconstruction, there were no injury crashes and 17 damage only crashes, which represents a significant safety improvement. • Makkinga: the redesign reduced the speed limit from 50 km/h to 30 km/h. Follow-up studies would need to be undertaken to determine actual changes in vehicle speeds. • Opeinde village: Collisions decreased from 32 to 6 after redesigning the area. In Christianfeld, Denmark, before conversion, an intersection experienced on average of 3 crashes per year in which someone was killed or seriously injured. However, there were no serious injuries or fatalities in the three years after conversion to a shared zone. A study in Auckland, New Zealand showed that after conversion to a shared space, in 2012 70% of drivers chose to travel at speeds under 10 km/h (the posted speed limit) and less than 5% travelled at speeds over 20 km/h (compared to over 25% in 2011 and over 40% in 2010). During the hours of higher levels of activity, namely between 8am and 7pm, traffic volumes decreased by around 20-40% (Karndacharuk et al. 2013).	The slow speed environment of shared zones can clearly assist pedestrians to walk along and cross roads more safely and conveniently. However, it is possible (but untested) that older pedestrians with reduced agility may have more difficulty safely sharing space with cars. There is also evidence that suggests people with limited hearing and vision may find it difficult to navigate shared zones. It may be possible to overcome these issues by providing dedicated pedestrian areas within a broader shared space, or other design solutions.

Infrastructure and Operational Solutions	Findings	Relevance for Older Pedestrians
Speed Humps	A study in New York City evaluated the impact of installing road humps at 601 roadway segments and 1087 intersection sites (Chen et al. 2012). The study showed that the installation of speed humps resulted in a mid-block decrease in the average pedestrian crash rate almost six times higher at the treatment segments (compared to the reduction at control sites). Overall, the installations resulted in a 42% decrease in pedestrian crashes at roadway segments and a 12% reduction in pedestrian crashes at the intersection sites. A study in Bellevue, Washington resulted in a reduction in the 85% percentile vehicle speed from 58-63 km/h to 39-43km/h after installing 16 speed humps in 5 residential neighbourhoods (Mead et al. 2014).	When involved in a crash, older pedestrians are more likely to sustain fatal or serious injuries than younger pedestrians (even at low impact speeds) and take longer to recover from their injuries. Devices that slow vehicle speeds will help pedestrians cross more safely in areas with no formal crossing facilities. Nonetheless, when considering installation of speed humps, road managers should consider installing raised crossings as an alternative. While they are physically very similar, they will encourage pedestrians to cross at the point where vehicle speeds are slowest.

(5)

RECOMMENDATIONS

The recommendations in this chapter respond to the comprehensive insights into the main crash types that affect older pedestrians in Victoria, identified in chapter 2.

5.1 PRIORITY INFRASTRUCTURE AND OPERATIONAL TREATMENTS

Based on their potential to address the main locations where older pedestrians are involved in crashes with vehicles, together with their potential for reducing the incidence and/or severity of crashes, the following are proposed as priority infrastructure and operational treatments:

- Safer design standards for driveways to indicate priority for pedestrians on the footpath and provide physical cues for drivers.
- Mid-block pedestrian crossings (ideally with flashing lights and raised surfaces), particularly in activity centres, in the vicinity of nursing homes and on routes that have been identified as popular with older pedestrians.
- Raised pedestrian crossings at unsignalised intersections and roundabouts to reduce vehicle speeds at the crossing point, enhance priority for pedestrians and make them more conspicuous to drivers.
- Raised thresholds, which effectively extend the footpath across an intersection (usually side streets), to emphasise that drivers are required to give way when turning.
- Kerb extensions, median refuges and tighter turn radii at intersections and roundabouts to reduce vehicle turning speeds, distance of pedestrian exposure and complexity of crossings.
- Fully controlled right turn signal phases and right turn lag signal phases to protect older pedestrians from right-turning vehicles on the departure side of the intersection.
- Early-start signal phases and PUFFIN pedestrian detection signals to adjust phase times and allow older pedestrians to fully clear the intersection
- Reduced speed limits and area wide traffic calming.

5.2 INFRASTRUCTURE RECOMMENDATIONS FOR KEY LOCATIONS

This section sets out recommended infrastructure and operational treatments for key locations in the road environment. Each section identifies good options to consider – it will not generally be necessary to adopt all of the measures identified at any particular location.

TRAFFIC SIGNALS

- The time provided for pedestrians to cross for every metre of exposure must be at least 1 second of time during the "flashing red man" period. Ideally, the same time should be provided for pedestrians to cross during both the 'green man' and "flashing red" periods.
- Continue the program to retrofit audio-tactile devices at all traffic signals, to assist visually impaired pedestrians.
- Reduce intersection signal cycle times to provide more frequent crossing opportunities.
- Apply exclusive right-turn phases to separate right-turning traffic from pedestrians.
- Install pedestrian early-start signal phases and PUFFIN pedestrian detection signals.
- Install automatically operated pedestrian signals ('pushing the button' not required to get a 'green man'), late introduction pedestrian signals or countdown timers at pedestrian signals.

UNSIGNALISED INTERSECTIONS

- Install formal (ideally raised) pedestrian crossing facilities.
- Install informal pedestrian thresholds (such as raised platforms).
- Install medians or pedestrian refuges to provide the opportunity for staged crossing and reduce the area of exposure for pedestrians.
- Install kerb extensions.
- Alter geometry of intersections to promote the slowest possible turning speeds by all vehicle types and reduce the area in which pedestrians are exposed to vehicles.

ROUNDABOUTS

- Install zebra crossings (ideally raised) or other formal crossing controls and make crossing locations obvious.
- Align crossings to footpaths.
- Increase horizontal/vertical deflection (for vehicles approaching/departing roundabouts) to reduce speeds.
- Provide pedestrian refuges to assist crossing in two stages, thereby reducing distance of exposure to traffic and allowing older pedestrians to focus on one traffic direction at a time.
- Install kerb extensions to reduce distance of exposure to traffic and promote lower vehicle speeds.
- On urban arterial roads, if the measures above are not possible, consider signalised roundabouts.

MID-BLOCK LOCATIONS

- Wider implementation of 40 km/h precincts.
- Install formal pedestrian crossings – either signalised or zebra crossings (preferably raised) – on key desire lines for older pedestrians (e.g., in the vicinity of shops, nursing homes and community centres).
- Install refuge islands and medians to allow staged crossing.
- Install kerb extensions to reduce crossing distances and vehicle speeds.
- Establish more frequent safe informal crossing opportunities, such as paths through medians and pram crossings at mid-block locations that coincide with natural pedestrian desire lines.
- Explore channelisation treatments that incorporate horizontal deflection to slow vehicle speeds.
- Consider speed humps, 'serpentine' designs and other traffic calming methods.
- Avoid over-design of new roads and retrofit/update existing roads with inappropriate designs for their location and context.

FOOTPATHS, DRIVEWAYS AND CARPARKS

- Review footpath design standards to ensure that continuous footpaths are provided across driveways, to highlight to motorists that pedestrians have priority over vehicles.
- Explore use of different surface materials, colouring and grade to reinforce pedestrian priorities and minimise vehicle speeds, particularly at the access points to commercial carparks.
- Avoid multi-lane access points for commercial carparks.
- Design vehicle entry/exit speeds to always achieve the absolute minimum turning radius of relevant vehicle types using the driveway (equivalent to a maximum of 5 km/h).
- Implement signage and audio-signalling devices where necessary.
- Install shared zone signage in carparks.
- Provide new footpaths where absent.
- Ensure footpath surfaces are smooth and slip-resistant. Undertake regular auditing and maintenance of footpaths.
- Where possible, choose options that eliminate kerbs or minimise changes in level between the footpath and the road. Good options include raised crossings, raised thresholds, shared space or rollover kerbs.

5.3 GENERAL RECOMMENDATIONS

Based on the review of local and international literature, together with the analysis of Victorian crash statistics, it is recommended that road management agencies also consider the following:

- Undertaking research on road users' behaviour and understanding of road rules relevant to pedestrian safety, particularly those concerning vehicles turning into and out of a street at intersections.
- Evaluating the appropriateness of the existing road rules for intersections and potential enhancements to promote pedestrian safety.
- Reviewing the road rules relating to pedestrian safety in carparks, with consideration of classifying carparks as shared zones.
- Implementing design speeds that are as low as practicable in areas with current or predicted high levels of pedestrian activity, reinforced by the provision of narrower roads, corners with tighter radii and the introduction of treatments that improve pedestrian safety.
- Providing the capacity for councils to apply 30 km/h speed limits in appropriate circumstances, to reflect the objectives of the *Towards Zero 2016//2020 Victoria's Road Safety Strategy and Action Plan*.

5.4 SAFER ROAD DESIGN EXAMPLES

This section uses specific location examples to illustrate how the infrastructure measures recommended in this report could be applied. It provides selected examples of infrastructure solutions already implemented, or that could be implemented, in particular locations in Victoria.

Figure 15 provides a concept plan example of kerb extensions and pedestrian refuges that have now been constructed at the intersection of Victoria Avenue and Danks Street in Albert Park, City of Port Phillip. The changes tighten roadway openings and subsequently reduce vehicle turning speeds by requiring motorists to turn tightly (at close to 90 degrees). In doing so, the treatments also reduce the complexity of crossing Dank Street; reduce the total crossing distance where pedestrians are exposed to traffic; and make them visible to drivers as they approach crossing points. Unfortunately, the presence of tram tracks prevented construction of medians or pedestrian refuges to facilitate crossing of Victoria Avenue, but the kerb extensions assist by reducing the crossing distance and making pedestrians more conspicuous to vehicles.

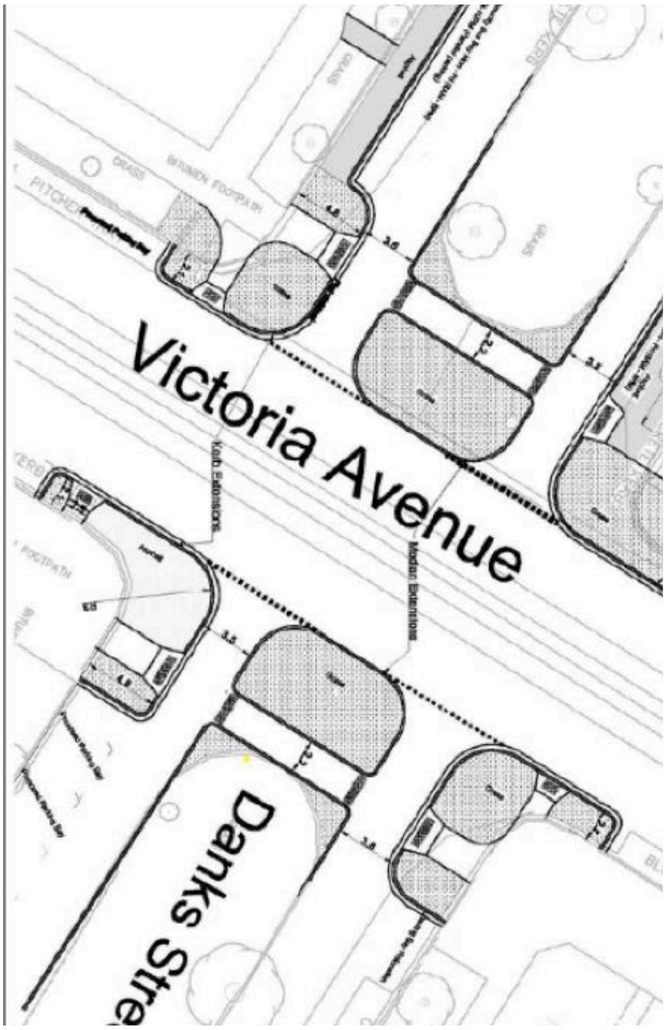


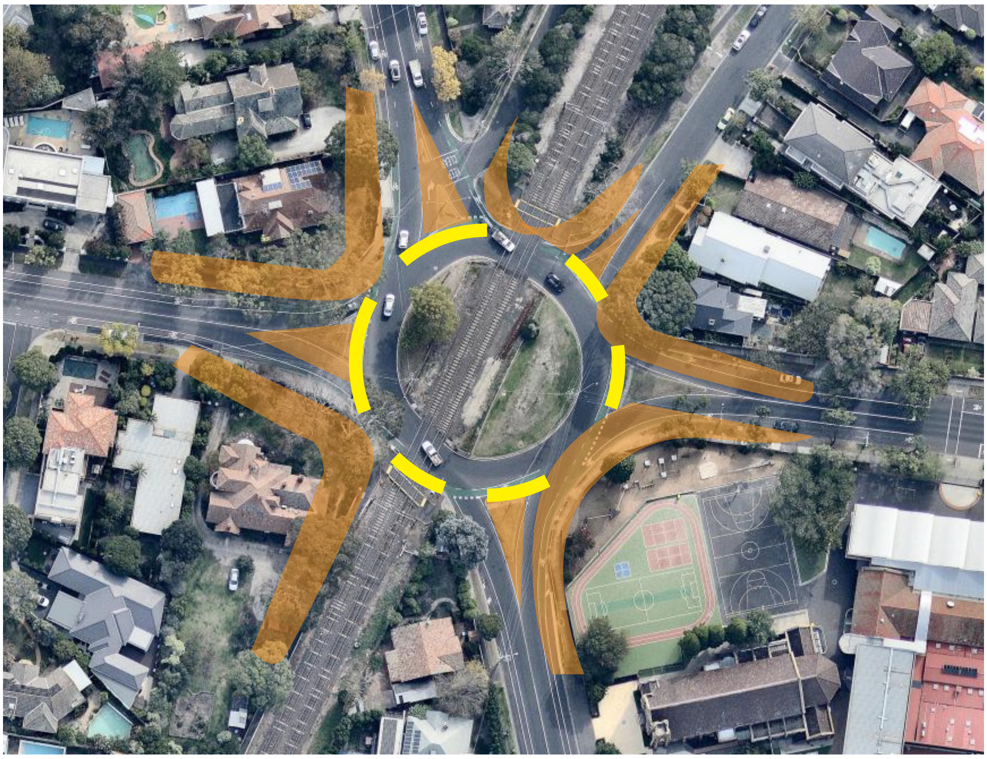
Figure 15: Example: Plan of Kerb Extensions and Pedestrian Refuges at Unsignalised Intersection

Figure 16 provides a concept plan example of how kerb extensions and pedestrian refuges could be utilised to enhance pedestrian safety at an existing unsignalised intersection in Ballarat. This figure shows aerial photos of existing and potentially improved conditions.

Construct kerb extensions and center refuge islands to improve safety for pedestrians crossing Camp Street and crossing on east leg across Mair Street.

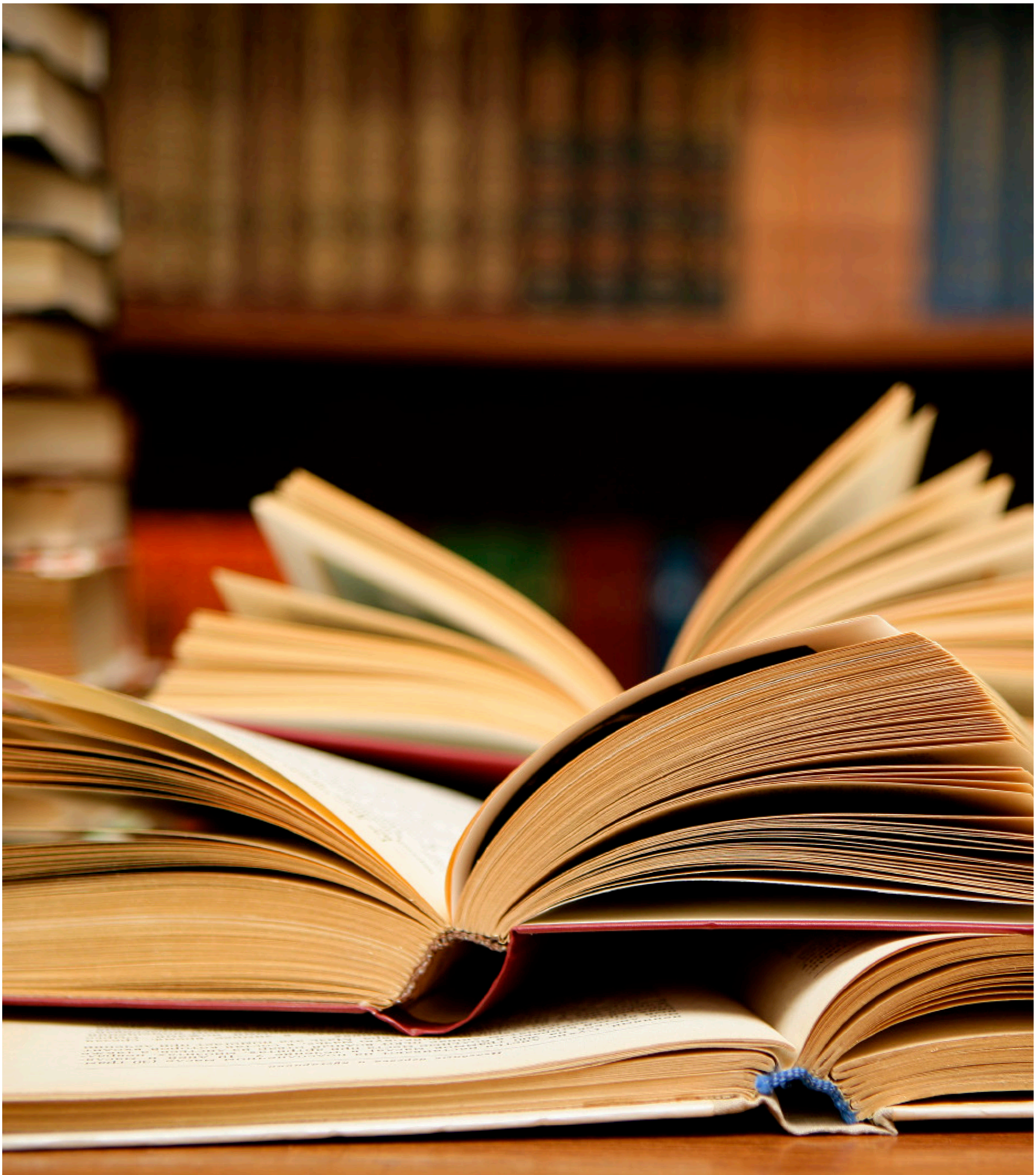
Figure 16: Intersection of Mair and Camp Streets, Ballarat – Proposed Improvement Example

Figure 17 illustrates the existing configuration of a roundabout in Brighton which has been designed to accommodate high vehicular design speeds. This figure provides an alternative design option which includes kerb extensions and tight kerb radii to increase the horizontal deflection of motorists and reduce vehicular speeds. The figure also recommends the installation of formal zebra pedestrian crossing facilities to give priority to pedestrians.



- Increase horizontal deflection of motorists travelling through roundabout.
- Construct kerb extensions to reduce pedestrian crossing distances and narrow circulation lane of roundabout.
- Install raised zebra-pedestrian crossing on all legs - near mouth of roundabout.

Figure 17: Roundabout at New Street and Dendy Street, Brighton – Proposed Improvement Example



REFERENCES

REFERENCES

America Walks. (2012). Steps to a walkable community: A guide for citizens, planners, and engineers.

Ashmead, D.H., Guth, D., Wall, R.S., Long, R.G., & Ponchillia, P. E. (2005). Street crossing by sighted and blind pedestrians at a modern roundabout. Journal of Transportation Engineering, 131(11), 812-821.

Australian Bureau of Statistics. (2013). Population Projections Australia. Retrieved from http://www.abs.gov.au/ausstats/abs@.nsf/mf/3222.0

Australian Institute of Health and Welfare. (2008). Disability in Australia: Trends in prevalence, education, employment and community living. Retrieved from http://www.aihw.gov.au/

Barber, S. E., Clegg, A. P., & Young, J. B. (2011). Is there a role for physical activity in preventing cognitive decline in people with mild cognitive impairment? Age and ageing, afr138.

Barella, L. A., Etnier, J. L., & Chang, Y.-K. (2010). The immediate and delayed effects of an acute bout of exercise on cognitive performance of healthy older adults. Journal of Aging and Physical Activity, 18(1), 87-98.

Barlow, J., Bentzen, B.L., Rodegerdts, L., & Myers, E. (2011). NCHRP Report 674: Crossing solutions at roundabouts and channelized turn lanes for pedestrians with vision disabilities. Transportation Research Board of the National Academies, Washington, D.C.

Bertulis, T., & Dulaski, D.M. (2014). Driver approach speed and its impact on driver yielding to pedestrian behavior at unsignalized crosswalk. Presented at the 93rd Annual Meeting of the Transportation Research Board, Washington, D.C.

Bijnen, F. C., Caspersen, C. J., Feskens, E. J., Saris, W. H., Mosterd, W. L., & Kromhout, D. (1998). Physical activity and 10-year mortality from cardiovascular diseases and all causes: the Zutphen Elderly Study. Archives of Internal Medicine, 158(14), 1499-1505.

Bowman, B. L. & Vecellio, R.L. (1994). Effects of urban and suburban median types on both vehicular and pedestrian safety. Journal of the Transportation Research Board, (1445). Transportation Research Board of the National Academies, Washington, D.C., 169-179.

Bradley, C. (2013). Trends in hospitalisations due to falls by older people, Australia 1999-00 to 2010-11.

Candappa, N; Fotheringham, N; Lenné, M; Corben, B; Johansson, C; and Smith, P (2005). ‘Evaluation of an Alternative Pedestrian Treatment at a Roundabout’, paper presented to Australasian Road Safety Research Policing Education Conference, Wellington, New Zealand, 14-16 November 2005.

Cassell, E., Kerr, E., Reid, N., Clapperton, N., & Alavi, H. (2011). Traffic-related pedestrian injury in Victoria (2): Fatal injury. Hazard: Victorian Injury Surveillance Unit, 72, 1-12.

Chen, L., Chen, C., Ewing, R., McKnight, C., Srinivasan, R., & Roe, M. (2012). Safety countermeasures and crash reduction in New York city- experience and lessons learned. Accident Analysis and Prevention. Retrieved July 23, 2012.

Clarke, A. & Dornfeld, M.J. (1994). Traffic calming, auto-restricted zones and other traffic management techniques: Their effects on bicycling and pedestrians. Case Study No. 19, National Bicycling and Walking Study. Publication No. FHWA-PD-93-028, Federal Highway Administration, Washington, DC.

Cleaver, M. A., Hislop, J., de Roos, M. P., Fernandes, R., Prendergast, M., Brisbane, G., Levasseur, M., McTiernan, D. (2011). 'An evaluation of pedestrian countdown timers in the Sydney CBD,' paper for the Australasian Road Safety Research, Policing and Education Conference 2011

Corben, B. (2009). Monash University Accident Research Centre, Minutes of Evidence, Melbourne, 27 July 2009, p. 23-24.

DeCarli, C., Massaro, J., Harvey, D., Hald, J., Tullberg, M., Au, R., Beiser, A., D'Agostino, R. & Wolf, P. A. (2005). Measures of brain morphology and infarction in the framingham heart study: establishing what is normal. Neurobiology of aging, 26(4), 491-510.

Department for Transport: London (2004). Road Safety Research Report No. 37 – Older Pedestrians: A Critical Review of the Literature.

Department of Transport, Planning and Local Infrastructure. (2014) Victoria in Future 2014: Population and household projections to 2051. Retrieved from http://apo.org.au/research/victoria-future-2014

Donnell, E.T., Hines, S.C., Mahoney K.M., Porter, R.J., & McGee, H. (2009). Speed concepts: Informational guide. (Report no. FHWA-SA-10-001). Retrieved from http://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa10001/

Edquist. J., Corben. B. (2012). Potential application of shared space principles in urban road design: Effects on safety and amenity. Report to the NRMA-ACT Road Safety Trust. Victoia, Australia: Monash University Accident Research Centre.

Fitzpatrick, K., Carlson, P., Brewer, M., Wooldridge, M., & Miaou, S.P. (2003). Design speed, operating speed, and posted speed practices. (Report no. 504). Washington, D.C. Transportation Research Board of the National Academies.

Gallon, C., Fowkes, A., & Edwards, M. (1995). Accidents involving visually impaired people using public transport or walking (Project Report 82). Crowthorne, Berkshire: Transport Research Laboratory.

Garrard, J. (2013). Senior Victorians and walking: Obstacles and opportunities. Summary Report. Melbourne: Victoria Walks.

Geruschat, D. R. & S. E. Hassan. (2005). Driver behavior in yielding to sighted and blind pedestrians at roundabouts. Journal of Visual Impairment and Blindness. 99(5).

Gorelick, P. B. (2004). Risk factors for vascular dementia and Alzheimer disease. Stroke, 35(11 suppl 1), 2620-2622.

Grundy, C., Steinbach,R., Edwards, P., Green, J., Armstrong, B., & Wilkinson, P. (2009). Effect of 20 mph traffic speed zones on road injuries in London, 1986-2006: Controlled interrupted time series analysis. BMJ, 339, 1-6. doi:10.1136/bmj.b4469.

Guth, Long, Ponchillia, Ashmead, & Wall. (2000). Non-visual gap detection at roundabouts by pedestrians who are blind: A summary of the Baltimore roundabouts study. United States Access Board, Washington, D.C.

Hachinski, V. C., Lassen, N. A., & Marshall, J. (1974). Multi-infarct dementia: a cause of mental deterioration in the elderly. The Lancet, 304(7874), 207-209.

Hakkert, A. S., Gitelman, V., & Ben-Shabat, E. (2002). An evaluation of crosswalk warning systems: Effects on pedestrian and vehicle behaviour. Transportation Research Part F: Traffic Psychology and Behaviour, 5(4), 275-292.

Harkey, D. L., & D. L. Carter. (2006). Observational analysis of pedestrian, bicyclist, and motorist behaviors at roundabouts in the United States. Journal of the Transportation Research Board, (1982), Transportation Research Board of the National Academies, Washington, DC, 155-165.

Hengel, D. (2013). Build it and they will yield: Effects of median and curb extension installations on motorist yield compliance. Presented at the 92nd Annual Meeting of the Transportation Research Board, Washington, D.C.

Hua, J., Gutierrez, N., Banerjee, I., Markowitz, F., & Ragland, D.R. (2009). San Francisco Pedsafe II Project Outcomes and Lessons Learned. Presented at the 88th Annual Meeting of the Transportation Research Board, Washington, D.C.

Huang, H.F. & Cynecki, M.J. (2001). The effects of traffic calming measures on pedestrian and motorist behavior. FHWA-RD-00-104, FHWA, U.S. Department of Transportation.

Hurwitz, D. & Monsere, C. (2013). Improved Pedestrian Safety at Signalized Intersections Operating the Flashing Yellow Arrow. Retrieved from https://trid.trb.org/view.aspx?id=1249598

Karndacharuk. A., Wilson. D.J., Dunn. M.C.R. (2013). Safety performance study of a shared pedestrian and vehicle space in New Zealand. New Zealand: Aukland.

King, M. R, Carnegie, J.A., & Ewing, R. (2003). Pedestrian safety through a raised median and redesigned intersections. Journal of the Transportation Research Board, (1828). Transportation Research Board of the National Academies, Washington, D.C., 56-66.

King, M.R. (1999). Calming New York City intersections. Transportation Research Board Circular E-CO19: Urban Street Symposium, (501) Dallas, Texas.

Kivipelto, M., Ngandu, T., Fratiglioni, L., Viitanen, M., Kåreholt, I., Winblad, B., Helkala, E., Tuomilehto, J., Soininen, H. & Nissinen, A. (2005). Obesity and vascular risk factors at midlife and the risk of dementia and Alzheimer disease. Archives of neurology, 62(10), 1556-1560.

Kramarow, E., Chen, L.-H., Hedegaard, H., & Warner, M. (2015). Deaths from unintentional injury among adults aged 65 and over: United States, 2000-2013. NCHS data brief (199), 1-8.

Lautenschlager, N. T., Cox, K. L., Flicker, L., Foster, J. K., van Bockxmeer, F. M., Xiao, J., Greenop, K. & Almeida, O. P. (2008). Effect of physical activity on cognitive function in older adults at risk for Alzheimer disease: a randomized trial. Jama, 300(9), 1027-1037.

Leaf, W. A., & Preusser, D. F. (1999). Literature review on vehicle travel speeds and pedestrian injuries (DOT HS 809 021). U.S. Department of Transportation. NHTSA. Washington, D.C.

Leake, G. R., May, A. D., & Parry, T. (1991). An ergonomic study of pedestrian areas for disabled people (Contract Report 184). Crowthorne: TRRL.

Leden, L., Wikstrom, P. E., Garder, P., & Rosander, P. (2006). Safety and accessibility effects of code modifications and traffic calming of an arterial road. Accident Analysis and Prevention, 38(3) 455-461.

Li, J., Wang, Y., Zhang, M., Xu, Z., Gao, C., Fang, C., Yan, C. & Zhou, H. (2011). Vascular risk factors promote conversion from mild cognitive impairment to Alzheimer disease. Neurology, 76(17), 1485-1491.

Lindqvist, K., Timpka, T., & Schelp, L. (2001). Evaluation of inter-organizational 191 traffic injury prevention in a WHO safe community. Accident Analysis and Prevention, 33, 599-607.

Lord, D., Smiley, A., & Haroun, A. (1998). Pedestrian accidents with left-turning traffic at signalized intersections: characteristics, human factors and unconsidered issues. Retrieved from http://safety.fhwa.dot.gov/ped_bike/docs/00674.pdf

Luepker, R. V., Murray, D. M., Jacobs Jr, D. R., Mittelmark, M. B., Bracht, N., Carlaw, R., Crow, R., Elmer, P., Finnegan, A. & Folsom, A. R. (1994). Community education for cardiovascular disease prevention: risk factor changes in the Minnesota Heart Health Program. American journal of public health, 84(9), 1383-1393.

Maynard, B., McHugh B., Strang, P., & Humphrey-Robinson, B. (2014). Shared spaces for healthy and active places: Can they work in Canberra? AITPM 2014 National Conference.

McLean, A. J., Anderson, R. W., Farmer, M. J. B., Lee, B. H., & Brooks, C. G. (1994). Vehicle travel speeds and the incidence of fatal pedestrian collisions. Canberra: Federal Office of Road Safety.

McMahon, P., Duncan, C., Stewart, J., Zeeger, C. & Khattack, A (2002). An analysis of factors contributing to "walking along roadway" crashes: Research study and guidelines for sidewalks and walkways. Chapel Hill, University of North Carolina Highway Safety Research Center (FHWA-RD-01–101).

Mead, J., Zegeer, C., & Bushell, M. (2014). Evaluation of pedestrian related roadway measures: A summary of available research. Federal Highway Administration USA.

Middleton, L. E., & Yaffe, K. (2009). Promising strategies for the prevention of dementia. Archives of neurology, 66(10), 1210-1215.

National Cooperative Highway Research Program. (2003). Design exception practices: A synthesis of highway practice. Washington, D.C: Transportation Research Board of the National Academies.

Naumann RB, Dellinger AM, Haileyesus T, Ryan GW (2011). Older adult pedestrian injuries in the United States: causes and contributing circumstances. International Journal of Injury Control and Safety Promotion 2011; 18(1):65-73.

Nieuwesteeg, M., & McIntyre, A. (2010) Exploring the pedestrian crash problem from the perspective of injured pedestrians. Canberra: 2010 Australasian Road Safety Research, Policing and Education Conference.

Nitzburg, M., & Knoblauch, R. (2001) An evaluation of high-visibility crosswalk treatments-clearwater, Florida. Publication FHWA-RD-00-105, FHWA, U.S. Department of Transportation.

O'Hern, S., Oxley, J. (2015). Understanding travel patterns to support safe active transport for older adults. Journal of Transport and Health, 2 (1) 79–85 doi:10.1016/j.jth.2014.09.016

Oxley, J., Charlton, J., Corben, B., & Fildes, B. (2006). Crash and injury risk of older pedestrians and identification of measures to meet their mobility and safety needs. The 7th International Conference on Walking and Liveable Communities. Victoria: Monash University.

Oxley, J., Fildes, B., Ihsen, E., Charlton, J., & Day, R. (1997). Differences in traffic judgements between young and older adult pedestrians. Accident Analysis and Prevention, 29(6), 839-847.

Oxley, J., Fildes, B., Ihsen, E., Day, R., & Charlton, J. (1995). An Investigation of Road Crossing Behaviour of Older Pedestrians. Retrieved from http://www.monash.edu.au/miri/research/reports/muarc081.pdf.

Oxley, J., O'Hern, S., Burtt, D., Rossiter, B. (2016). Fall-related Injuries While Walking in Victoria, Victoria Walks, March 2016.

Parliament of Victoria Road Safety Committee (2010). Inquiry into Pedestrian Safety in Carparks. Parliamentary Paper, No.311, Session 2006-10. ISBN 978-0-9807166-0-3.

RACV (2009). Connect Outer Melbourne - Footpaths, Special Report August 2009. Royal Automobile Club of Victoria.

Retting, R., Ferguson, S., McCartt, A. (2003). A review of evidence-based traffic engineering measures designed to reduce pedestrian–motor vehicle crashes. American Journal of Public Health, (93), 1456–1463.

Rolland, Y., van Kan, G. A., & Vellas, B. (2010). Healthy brain aging: role of exercise and physical activity. Clinics in geriatric medicine, 26(1), 75-87.

Román, G. C., Tatemichi, T. K., Erkinjuntti, T., Cummings, J., Masdeu, J., Garcia, J., Amaducci, L., Orgogozo, J., Brun, A., Hofman, A., Moody, D., O'Brien, M., Yamaguchi, T., Grafman, J., Drayer, B., Bennett, D., Fisher, M., Ogata, J., Kokmen, E., Bermejo, F., Wolf, P., Gorelick, P., Bick, K., Pajeau, A., Bell, M., DeCarli, C., Culebras, A., Korczyn, A., Bogousslavsky, J., Hartmann, A. & Scheinberg, P. (1993). Vascular dementia Diagnostic criteria for research studies: Report of the NINDS AIREN International Workshop*. Neurology, 43(2), 250-250.

Ruthirakuhan, M., Luedke, A. C., Tam, A., Goel, A., Kurji, A., & Garcia, A. (2012). Use of physical and intellectual activities and socialization in the management of cognitive decline of aging and in dementia: a review. Journal of aging research, 2012(384875).

Skoog, I. (1998). Status of risk factors for vascular dementia. Neuroepidemiology, 17(1), 2-9.

Stern, Y. (2012). Cognitive reserve in ageing and Alzheimer's disease. The Lancet Neurology, 11(11), 1006-1012.

Transport Accident Commission (2015). Pedestrian Statistics. Retrieved from http://www.tac.vic.gov.au/road-safety/statistics/summaries/pedestrian-statistics

Transport for London (2013). Older Pedestrians and Road Safety: Research Debrief. Retrieved from https://tfl.gov.uk/cdn/static/cms/documents/older-pedestrians-research-report.pdf

Transport for London (2006). Factors Influencing Pedestrian Safety: A Literature Review. Retrieved from https://tfl.gov.uk/cdn/static/cms/documents/Factors-Influencing-pedestrian-safety-literature-review.pdf

US Department of Transportation Federal Highway Administration (2005). Pedestrian safety: Impacts of curb extensions.

US Department of Transportation Federal Highway Administration (2004). PEDSAFE: Pedestrian safety guide and countermeasure selection system.

US Department of Transportation National Highway Traffic Safety Administration (2008a). Fatalities and Injuries in Motor Vehicle Backing Crashes, Report to Congress, DOT HS 811 144, Washington, 2008, p. iv.
US Department of Transportation National Highway Traffic Safety Administration (2008b). National Pedestrian Crash Report, Report to Congress, DOT HS 810 968, Washington, June 2008.

US Department of Transportation National Highway Traffic Safety Administration (1999). Literature Review on Vehicle Travel Speeds and Pedestrian Injuries. DOT HS 809 021. Final Report. http://www.nhtsa.gov/people/injury/research/pub/HS809012.html

VicRoads (2015). Supplement to Austroads Guide to Traffic Management. Part 8: Local Area Traffic Management.

VicRoads (2015b). Supplement to Austroads Guide to Traffic Management, Part 9: Traffic Operations (2014), October 2015.

VicRoads (2013). VicRoads Submission to the Parliamentary Road Safety Committee Inquiry into Serious Injuries. May 2013.

VicRoads (2013b). Traffic Engineering Manual Volume 1: Chapter 7 Speed Zoning Guidelines, Edition 5, November 2013.

Victorian Government (2016) Towards Zero 2016//2020 Victoria's Road Safety Strategy and Action Plan Retrieved from https://www.towardszero.vic.gov.au/what-is-towards-zero/road-safety-action-plan

Wilton, V. & Davey, J.A. (2007). Improving the safety of older pedestrians. New Zealand Institute for Research on Ageing. Retrieved from http://igps.victoria.ac.nz/

World Health Organisation. (2013). Pedestrian safety: A road safety manual for decision-makers and practitioners. Retrieved from http://www.who.int/roadsafety/projects/manuals/pedestrian/en/

Victoria walks

movendo

VicHealth™

TAC COMMUNITY ROAD SAFETY GRANTS