MONASH University
Accident Research Centre

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FALL-RELATED INJURIES WHILE WALKING IN VICTORIA

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Executive Summary

Globally, falls are a major public health problem. Each year an estimated 37.3 million falls are severe enough to require medical attention and 424,000 fatal falls occur.

Falls and fall-related injuries can occur in various places and during a range of activities, including walking in public spaces. However, the majority of research addresses falls in and around the home and in supported aged-care facilities (for older populations), and while engaging in sport and recreational activities (for children and youth). To date there have been no Australian studies addressing falls and fall-related injuries while walking in public spaces. Further, crash-based data sources most commonly used to understand road-related injuries may be limited in their ability to provide an understanding of falls and fall-related incidents and so do not provide a full picture of injury risk in the road environment. Consequently, there is very little understanding of the nature and extent of falling and fall-related injury while walking in public spaces in Australia, and therefore little consideration of this issue in the larger road safety debate.

This Australian-first study was undertaken to bridge the gap in our knowledge regarding some of the issues surrounding falls while walking. A three-phased study methodology was used, and included:

- A rapid targeted review of national and international literature;
- Examination of Victorian Police-reported crash and hospital-based injury data to quantify and describe prevalence, characteristics and injury outcomes of falls while walking in the street environment; and
- Synthesis of findings and provision of recommendations for policy, practice and areas for further research.

Study Findings

Literature review: The review revealed that, despite the prevalence of falls and fall-related injuries, particularly amongst older populations, and despite the severity of outcomes (particularly for hip fractures), there is relatively little literature addressing the issues surrounding falls while walking in public spaces. Moreover, there appears to be a lack of understanding regarding falls and their consequences amongst younger adults and children. The review revealed a number of contributing factors to falls including socio-demographic characteristics (gender, socio-economic status), age-related changes in physical, visual and cognitive domains individual behaviour; and a range of environmental characteristics. Only a handful of articles addressed falls while using the transport system, and risk factors were generally environmental. These included slippery, uneven and poorly maintained footpaths and road surfaces, poorly designed access to crossings and kerbs, and inadequate street lighting. Few interventions to prevent falls in public spaces were identified, beyond a broad discussion of provision of good roadway design and land-use planning.

Data analysis: Analyses of injury data was undertaken at two levels of severity – Emergency Department (ED) presentations and hospital admissions – over a five-year period. The findings highlight the substantial and increasing number of pedestrian fall injuries while walking in the street environment.

While collisions with vehicles result in approximately 1,600 pedestrian casualties each year, pedestrian falls while walking in the street or transport environments account for an average of 1,680 hospital admissions and 3,545 ED presentations, and this number is increasing. These figures exclude immediate fatalities, which are not captured

by hospital data. The most common injuries sustained were fractures, most likely a reflection of the hard surfaces associated with public spaces and the pedestrian environment.

Key characteristics of fall injury cases by injury severity level and Police-reported crashes are summarised below.

	ED presentations July 1st, 2009 to June 30th, 2014	Hospital admissions July 1st, 2009 to June 30th, 2014	Police-reported incidents January 1st, 2009 to December 31st, 2013
Number of all transport-related falls	17,727	8,436	85
Gender (female)	56%	59%	N/A
Most common body region injured	Upper and lower extremities	Head, face, neck	N/A
Nature of injury	Fracture	Fracture	N/A

A notable finding is that falls in the street environment affected all age groups, although children sustained a relatively low level of injury compared to adults. For younger and middle-aged adults, the proportion of ED presentations is relatively consistent with their proportion of the population.

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 9 times greater than pedestrians in the 35-64 year age group, and for those aged 85+ the hospitalisation rate was 14 times greater.

Overall, these findings suggest that while ageing results in an increased risk of falling for many older people, the primary impact of ageing is that they are much more likely to sustain an injury in the event that they do fall, and less able to recover from an injury when it occurs.

The burden of injury for older pedestrians is made more apparent when considering the length of hospital stays, with an increasing trend of longer hospital stays for older pedestrians. Older patients are also less likely to be released back to private accommodation following a fall while walking and instead are increasingly transferred to acute hospital care, extended care or aged care facilities. This highlights the significance of injuries sustained from falls, with many older persons unable to make a full recovery.

Women are particularly affected by falls in the street environment. Females accounted for 55.5 percent of ED presentations and 58.9 percent of hospitalisations, compared to 44.5 and 41.1 percent respectively for men.

The hospital data does not readily allow analysis of the detailed circumstances of falls – whether they occur crossing the road, at kerbs or on footpaths; or whether they result from interaction with other road users. To gain greater understanding of fall circumstances, emergency department presentation text narratives were extracted for the most recent year of available data. The most commonly reported contributing factors 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). It should be noted that there may be variations between age groups and between different levels of injury severity.

Analysis of Victorian Police data (Crashstats) confirmed that fall injuries are not captured in the road environment, providing information only on pedestrian injury and mortality arising from vehicle collisions.

Opportunities for reducing falls in public spaces

Utilising successful strategies aimed at reducing falls in the home environment and within a Safe System approach, there are a range of opportunities to address pedestrian falls while walking in public spaces, as detailed below.

Key Areas	Recommendations
Safer People	Consider: • Incorporating the increased risk of fall injuries into public health and road safety campaigns around the risks of drug and alcohol impairment. • Community education programs, particularly for groups who may be concerned about falls, that raise awareness of the risks and provide tips/strategies for safer walking (including vision checks, wearing appropriate footwear, medication reviews). • Promoting exercise interventions, particularly for older adults, to improve muscle strength and balance. • Promoting driver awareness programs to encourage drivers to 'share the road', particularly at conflict points.
Safer Environment	Consider: • Improvements to footpaths: Installation of footpaths with level surfaces that are free from tripping hazards, and include non-slip surfaces, particularly in wet conditions, and impact absorbing surfaces. Edges and potential hazards could be delineated through the use of tactile paving or colour markings so that they are conspicuous. Adequate widths must be provided to allow mobility for all users and benches or other types of rest areas should be provided in areas with high numbers of walkers, particularly older people. Good street lighting should be provided, particularly at crossing points. • Measures to remove kerbs: At crossing locations on minor roads, design should consider raised crossings, raised thresholds so that the footpath is at the same level as the street crossing. In suitable locations, shared space design can be used to reduce the need for changes in grade between the roadway and the footpath and can provide increased priority for pedestrians. • Improvements to transitions to the roadway: Where kerbs are required, they should be designed to minimise fall risk. Use of mountable kerbs rather than traditional kerbs that involve a significant step up from the roadway can be expected to reduce fall risk. Appropriately located, aligned and graded pram ramps should be installed that allow pedestrians to transition onto the roadway. Well-designed ramps help to minimise the need for pedestrians to negotiate kerbs and reduce the occurrence of having to step up and down from heights, which is commonly associated with pedestrian injuries • Improvements to crossing facilities: Crossing facilities need to provide adequate time for pedestrians to cross the carriageway, including older pedestrians, who often have a slower walking speed than that which is assumed in traffic light phasing. Adaptive signal systems such as puffin crossings can provide increased walk times to accommodate older pedestrians' slower walking speeds. At un-signalised locations pedestrian refuges and kerb outstands can reduce the total crossing distance for pedestrians or allow them to stage their crossing.
Further research and development	Consider: • Extract additional detailed information from the narratives contained in the Victorian Emergency Minimum Dataset (VEMD) to understand the contributing factors to fall-related injuries among Emergency Department presentations. • Examine contributing factors to fall-related injuries among Hospital Admission patients – this could involve an in-depth survey or interview. • Translate the recommendations into actions and programs, and evaluate the potential benefits. • Explore the potential for more comprehensive collection of detailed information regarding the circumstances of falls in public spaces through emergency department, trauma registry, coronial data systems and crash data systems.

Conclusion

The issue of pedestrian falls while walking is significant and unless actions are taken it is likely that the rates of pedestrian fall-related injuries will continue to grow with the expanding and ageing population. This study has provided a valuable starting point that highlights the extent of the problem, and the significant limitations associated with traditional Police crash data sources that are typically used for investigating injuries that occur within the road environment. The findings provide a basis on which we can better address the risk of falls in public space management, ensure that road safety does not only consider vehicle-related incidents, and that fall incidents are considered as an important part of the road safety debate.

Walking is the most important source of exercise for seniors – to maintain and enhance physical activity in the population it is critical to keep people walking well into old age. Given older people's concern with the risk of falling, if these risks are better understood and addressed by road management agencies, this can be expected to encourage physical activity by older people and improve community safety and mobility.

1 INTRODUCTION

Victoria Walks has commissioned the Monash University Accident Research Centre (MUARC) to undertake research investigating fall-related injuries that occur while walking in Victoria. Fall-related injuries are a poorly understood public safety issue and understanding of these injuries will enable a broader consideration of pedestrian safety by public authorities in Victoria and Australia.

This study builds on previous research commissioned by Victoria Walks investigating the issues affecting walking by older Victorians. The resulting report *Senior Victorians and Walking: Obstacles and Opportunities* (Garrard, 2013) confirmed that walking is particularly important for senior's exercise, recreation and to access shops and services. Focus groups conducted as part of that study highlighted in particular seniors' concerns about slips and falls while walking, which inter-related with concerns regarding difficult interactions that might cause them to fall, such as out of control dogs and cyclists failing to give way on shared paths. This finding may have significant implications – the risk of falling may deter them from walking, particularly in areas with poor surfaces or where they may face difficult interactions. A fear of falling and focusing on surfaces may also distract them from vehicle hazards when crossing roads. Despite the implications for older people in particular and some limited international research that suggests falls in public space are a major cause of injury, this issue is seldom studied and poorly understood. Indeed, to date, there have been no Australian studies addressing falls and fall-related injuries while walking in public spaces. The limited understanding of falls in public space and the focus of road safety professionals on crash statistics, which seldom record falls, means that the risk of falls is almost entirely overlooked in public space management and road safety discourse.

Victoria Walks

Victoria Walks is a not-for-profit walking promotion body, largely funded by VicHealth and the Department of Health and Human Services to get more Victorians walking every day. Our vision is for vibrant, supportive and strong neighbourhoods and communities where people can and do choose to walk wherever possible. Victoria Walks is a member of international organisations including the International Federation of Pedestrians.

Walking is clearly the most important source of exercise for seniors and walking for transport in particular remains largely constant through older age, while other forms of exercise decline (Garrard, 2013). To maintain and enhance physical activity in the population it is critical to keep people walking well into old age. Given older people's concern with the risk of falling, if fall risks are better understood and addressed by road management agencies, this can be expected to encourage physical activity by older people, as well as improving safety.

Globally, falls represent a major public health problem (WHO, 2014). Each year an estimated 424,000 fatal falls occur, making it the second leading cause of unintentional injury death (WHO, 2014). Furthermore it is estimated that approximately 37.3 million falls occur annually that are severe enough to require medical attention, with the largest morbidity occurring in people over the age of 65 years (WHO, 2014).

Fall-related injuries can occur in various places and during most activities, including walking. While all people who fall are at risk of injury, the age, gender and health of the individual can affect the incidence, type and severity of injury (WHO, 2014). It is important to note that many studies focus on hospitalisations due to falls without specifically considering falls in public space or the street environment. As a consequence, there is very little known about the incidence, contributing factors and injury outcomes of fall-related injuries while walking.

The overall objective of this research, therefore, is to improve our understanding of the issues surrounding fall-related incidents, including injury outcomes. Specifically, the project aims to:

1. Provide a brief literature review of previous studies that have investigated pedestrian safety overall, the issues surrounding falls while walking and potential risk factors;

2. Examine both Police-reported crash and hospital-based injury data to quantify and describe the prevalence, contributing factors and injury outcome of fall-related injuries when walking; and

3. Provide a set of recommendations for research, policy and practice to address the issues of fall-related injuries while walking.

2 LITERATURE REVIEW

A targeted literature review was undertaken to gain a stronger understanding of the issues surrounding pedestrian injury generally, with a focus on falls while walking, including the prevalence of injuries, the injury outcomes and the potential risk factors associated with falls while walking.

2.1 Methodology

An extensive range of search engines and databases, available through Monash University library services, was utilised to source relevant published scientific literature. The main databases and search engines that were used included: Embase, SafetyLit, ScienceDirect, Ingentaconnect, Tandfonline, CRCNetbase, and other relevant databases including PsychInfo, Medline, Cochrane Library and Scopus. In addition, unpublished academic literature and government reports were sourced addressing pedestrians, injury and injury prevention. Key words included: 'fall', 'pedestrian' 'safety', 'injury'.

The findings of the review are presented in the following sections:

- Pedestrian collision statistics;
- Prevalence of falls while walking; and
- Factors associated with risk of falling while walking.

2.2 Background

Walking is a sustainable mode of transportation which is beneficial to both individuals and to the broader community (Kingham & Ussher, 2007). Walking trips form a significant component of daily travel, contributing to almost all daily trips. Walking also results in significant personal benefits which include health, economic and social, while walking trips have also been shown to generate significant positive externalities (PWC, 2010).

Despite the many benefits associated with walking, it is essential that initiatives to promote increased walking include safety considerations, ensuring a safe environment is provided. With an increased focus on active transportation by governments in Australia and elsewhere, there is growing awareness within the road safety community of the potential for an increase in pedestrian serious casualties over the coming years and the need to address the specific needs of vulnerable road users when interacting with the transport network.

In Victoria, there has been a significant reduction in pedestrian deaths, from approximately 160 deaths per annum in the late 1980's to 44 deaths in 2014 (Figure 1).

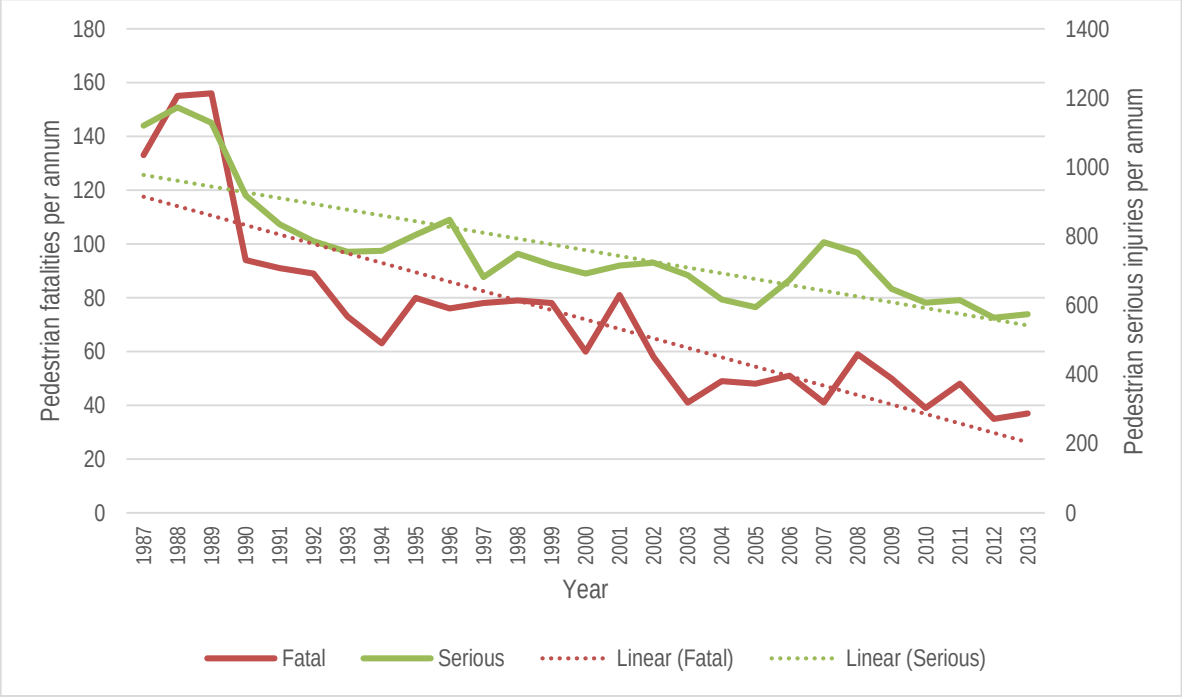

Figure 1: Pedestrian crashes, Victoria 1987-2013

Following the introduction of speed cameras and a boost in random breath testing in 1989/90 (Corben & Duarte, 2000) and the introduction of the 50km/h default urban speed limit in 2001/02 (D'Elia et al., 2007), two large step reductions in the number of pedestrian deaths were achieved. Additional environmental and behavioural programs have also contributed to these reductions.

Subsequent to these countermeasures, pedestrian deaths have plateaued. This inability in recent years to reduce pedestrian trauma further is of concern, given the increasing use of walking for transport, health, leisure and environmental purposes. In Victoria, pedestrians represent one of the most vulnerable road user groups. On average there are approximately 50 fatal traffic-related pedestrian injuries annually and a further 1,100 hospital admissions and emergency department presentations (Cassell et al., 2010; Cassell et al., 2011). These figures largely represent injuries where the pedestrian has been struck by a vehicle, with the extent of pedestrian only injuries largely under-reported.

Previous research in Victoria has established that children, the elderly and the intoxicated are typically the most vulnerable sub-groups of pedestrians (Oxley et al., 2013). Young children are high risk pedestrians because of lack of experience in traffic situations and restricted development of those skills needed to be safe road users. Adults older than 60 years may be at high risk because of changes in their mobility and deteriorating functional performance, especially memory, eyesight and hearing, which makes it harder for them to judge distances and the speed of oncoming traffic. Their increased frailty makes them particularly susceptible to injury in the event of a collision or fall. Intoxicated pedestrians are at risk because of issues similar to intoxicated drivers: their judgment is impaired and reflexes are slowed after consuming alcohol or drugs (Oxley et al., 2006).

Not surprisingly, serious injury pedestrian collisions tend to occur when they share space with other road users, for example while crossing the road, at intersections at driveways and in carparks. The most common collisions types for all pedestrians are associated with pedestrians colliding with vehicles while crossing the road, both at intersections and while crossing mid-block road sections (Oxley et al., 2013). Older pedestrians have also been

found to have an increased prevalence of crashes occurring at driveways and on footpaths (O'Hern et al., 2015). There are a wide range of contributing factors associated with pedestrian traffic-related injuries including, alcohol consumption, pedestrian and driver behaviours and characteristics and design of the roadway and the surrounding built environment (Oxley et al., 2013).

While there has been substantial research into the field of pedestrian traffic-related injuries, much less has been undertaken to understand the issues surrounding pedestrian only injuries and in particular injury-related falls while walking.

2.3 Pedestrian falls

The World Health Organisation has identified falls as the second leading cause of unintentional injury death (WHO, 2014). Globally, it is estimated that approximately 37.3 million falls occur each year that are severe enough to require medical attention, with an estimated 424,000 falls occurring that result in fatal injuries (WHO, 2014). While it is estimated that only approximately 10 percent of falls among younger adults result in injuries that require medical attention (Li et al., 2006), the Centre for Disease Control (CDC) ranks falls as the number one cause of unintentional deaths for persons over the age of 65 years (Kramarow et al., 2015). In the USA between 2012–2013, it was reported that 55 percent of all unintentional injury deaths among adults aged 65 years and over were due to falls (Kramarow et al., 2015).

Falls and fall-related injuries amongst older people continue to be a long-term population health issue worldwide, often resulting in significant mortality and morbidity, including decreases in functional status (Wagner et al., 2011). Major falls are a significant cause of increased utilization of medical services, hospitalization, institutionalization and functional dependency among older adults (Azidah et al., 2012; Fonad et al., 2008; Yarmo-Roberts et al., 2010). Falls and fall-related injuries also impose a heavy burden in terms of social, medical, and financial outcomes (Bradley, 2013; Roudsari et al., 2005). While a high proportion of Australian fall-related hospitalisations result from injuries in the home (49.1%) or in an aged care facility (22.8%), a substantial proportion also occur outside the home (approx. 30%) (Bradley, 2013).

Falls are associated with a range of injury outcomes from minor bruises to intracranial and spinal injuries (Li et al., 2006). It is estimated that most falls result in minor soft tissue injuries, but between 10 and 15 percent result in fracture, and 5 percent result in more serious soft tissue injury or head trauma (Tinetti et al., 1995). Previous research has also found that, when analysed by body region, traumatic brain injuries and injuries to the lower extremities account for up to 78 percent of fall-related fatalities, with fractures and internal injuries the most common types of fatal injuries (Stevens et al., 2006). Approximately 40 percent of older people who fall suffer moderate to severe injuries such as hip fractures, or head trauma (Bradley, 2013; WHO, 2014).

Hip fractures are the result of serious fall injuries, constitute a large proportion of hospitalised fall injuries in Australia, and are particularly burdensome amongst the elderly. Most hip fractures involve a fall sideways onto the hip. The most studied outcome in hip fracture patients is mortality (short-term and long-term). Mortality rates following hip fractures are high. It is estimated that between 25 and 40 percent of hip fracture patients die within a year of their injury (see Alzahrani et al. (2010). Although rates of death decrease over time, the increased risk of death persists, with suggestions that patients are at increased risk of premature death for many years after hip fracture (Abrahamsen et al., 2009; Panula et al., 2011).

Other hip fracture outcomes include short- and long-term complications, length of hospital stay, place of discharge (home vs. nursing home admission), post-treatment ambulatory ability, return to pre-fracture level of function and independence in activities of daily living. A variety of factors have been found to contribute to these outcomes.

These include, but are not limited to, age, gender, number and type of comorbidities, type of fracture, details of treatment, and pre-fracture functional status. About one-third of hip fracture cases in the older population do not reach their pre-fracture level of functioning within a year post-fracture, and those who do recover tend to take at least 6 months to return to their pre-fracture levels of functioning (Bertram et al., 2011) see also LeBlanc et al. 2011). Furthermore, one in three adults who lived independently prior to hip fracture require significant assistance afterward and remain in a nursing home for at least a year post-injury (Leibson et al., 2002).

Despite the prevalence of fall-related injuries, there has been relatively little research undertaken to address the issues surrounding falls that occur while walking in the street environment, with previous research on roadway pedestrian injuries generally focused on injuries caused by pedestrian-motor vehicle collisions (Naumann et al., 2011). Furthermore, to date most research or public attention on fall-related injuries has focused on indoor falls either at home or in aged care facilities, despite outdoor falls occurring at least as often amongst older adults (Li et al., 2006).

The Australian Institute of Health and Welfare recently conducted a review of trends in hospitalisation due to falls by older people in Australia. The study reviewed national hospital separations data from the National Hospital Morbidity Database (NHMD). From these analyses, it was determined that in 2010-11 there were 92,150 serious injuries due to falls in people aged 65 years and older (Bradley, 2013), with approximately 30 percent occurring outside of the home or aged care facilities. The study also found that one in every 10 days spent in hospital for persons over 65 years of age is directly attributable to injuries sustained from falls (Bradley, 2013). While this study provides a valuable insight into the prevalence of fall related injuries amongst older Australians, the study does not provide any details or insight into falls that specifically occurred while walking in public space.

One of the largest international studies conducted into serious injury falls affecting the elderly was undertaken in the US by Naumann et al. (2011). The study was performed using data from the National Electronic Injury Surveillance System-All Injury Programme (NEISS-AIP) for the years 2001 through 2006 for all older pedestrian (65+ years) injuries in the United States. Over this time period it was found that on average 52,482 older adults were treated in emergency departments (ED) each year for non-fatal pedestrian injuries. The study found that the most common mechanisms of injury for older pedestrians were falls, representing 77.5 percent of ED presentations, followed by being hit by a motor vehicle (15%). The study identified that as age increased, fall injuries comprised an increasing proportion of pedestrian injuries, however the study did note that the proportion of ED presentations from motor vehicle collisions decreased as a result of a higher fatality rate for older pedestrians (Naumann et al., 2011).

2.4 Risk factors

There are various risk factors associated with falls including socio-demographic, functional and behavioural, and environmental. The research evidence relating to each of these factors is briefly described below. Much of the research on the contributing factors to falls and fall-related injuries is focused on older adults who are living independently or in nursing homes, furthermore many of these falls occur inside the home. As such, relatively little is known about falls outside the home environment and in public places. Further, there is very little literature on the contributing factors to falls among younger adults. Notwithstanding, we can assess this overall evidence to draw some conclusions regarding the contributing factors to falling while walking in public places.

2.4.1 Socio-demographic risk factors

A range of socio-demographic characteristics and their association with falls risk have been examined, including age (and age-related changes), gender, ethnicity, and socio-economic status. Generally, we still know very little about these relationships, except for the strong evidence that the incidence and particularly the severity of falls increases with age.

2.4.1.1 Age and age-related changes

The major issue surrounding injury amongst older adults is fragility and much of the older road user injury profile has been attributed to their greater frailty, reduced tolerance to injury and reduced ability to recover from injury compared with younger adults (OECD, 2001). The energy required to cause injury reduces as a person ages (Augenstein, 2001): older adults' biomechanical tolerances to injury are lower than those of younger persons (Mackay, 1998; Viano, Culver, Evans, Frick, & Scott, 1990), primarily due to reductions in bone and neuromuscular strength and fracture tolerance (Dejeammes & Ramet, 1996; Padmanaban, 2001). For example, according to Evans (2004), in the same crash: a 79-year-old man is 3.2 times more likely to die compared to a 32-year-old man; a 79-year-old woman is 2.7 times more likely to die compared to a 32-year-old woman; and one-half of the deaths to those aged 70 years and older would not occur if they were as robust as those aged 69 years and younger. Li and colleagues (2003) used the US Fatality Analysis Reporting System (FARS) and a national probability sample of all crashes (both non-casualty and casualty) to examine the role of frailty in older driver crashes. The authors reported that older drivers' over representation in fatalities could be primarily explained by frailty, which accounted for 60−90 percent of the fatalities.

Gender-related factors also contribute to differences in gait, balance and risk of falls, particularly amongst older adults. This is primarily due to gender effects on physical attributes and greater frailty and susceptibility to injury following a fall. Women's muscle mass, lower extremity muscle strength and bone density decline faster than that of men, and women are more likely to suffer associated medical conditions such as osteoporosis (Sinaki, Brey, Hughes et al., 2004).

In addition to the frailty bias, much of the remainder of older adult injury research focuses on the identification of and reduction or mitigation of health-related risk factors such as medical conditions and impaired functional performance. Age-related sensory, cognitive and physical impairments are the most pronounced effects of normal ageing amongst all people, with even healthy adults experiencing some degree of impairment throughout the ageing process (Fildes et al., 1994). Fildes et al. (1994) identified common age-related impairments including:

- Declines in visual acuity;
- Declines in attention capacity;
- Declines in contrast sensitivity;
- Decision time deterioration;
- Visual field loss;
- Loss of memory capacity;
- Loss of auditory capacity;
- Neuromuscular and strength loss;
- Reduced perceptual performance;
- Postural control and gait changes;
- Reductions in motion perception;
- Slowed reaction time;
- Reduced dark adaptation and glare recovery; and
- Declines in cognitive processing ability.

Intuitively, physical skills can greatly affect the ability to walk safely. Physical changes occur throughout the life-span and skills deteriorate with age. There is no doubt that motor control and physical agility are of prime importance when crossing the road: older pedestrians with motor impairments have a reduced ability to initiate actions and respond to threats as quickly as other people.

Older adults suffer general physical weakening, are less agile and have reduced endurance (Brummel-Smith, 1990; Grob, 1989), they experience cardio-vascular degeneration, musculoskeletal wasting and neuro-muscular weakening (Grob, 1989; Bishu et al., 1991), and are often more dependent on other people for assistance. Loss of physical strength has also been associated with declines in muscle size, efficiency of the nervous and respiratory systems, joint flexibility and co-ordination, and sensory-motor integration - these changes result in more time required to initiate and complete a movement (Welford, 1977, 1985; Stelmach & Nahom, 1992), slower walking speeds and the need for frequent stops (Espenchade & Eckert, 1990), changes in gait patterns (Wyman, 1990), and increased risk of stumbling and poor entero-posterior and lateral balance (Lord, Clark & Webster, 1991).

Good balance is also essential for avoiding tripping or falling when crossing roads or walking on uneven footpaths, however, balance control mechanisms and postural reflexes are susceptible to age-related changes. Any disturbance in posture reduces a person's ability to walk freely and safely in the environment. Factors involved in control and maintenance of posture, including muscle strength, ankle and knee proprioception, all decline in the elderly (Overstall, Exton-Smith, Imms & Johnston, 1977). Reduced postural stability and reflexes have been associated with impaired mobility and risk of injury (Verillo & Verillo, 1985) because they can result in slower walking, restricted gait and difficulty maintaining balance. These declines result in increased sway (Overstall et al., 1977; Lord et al., 1991) and a reduced ability to quickly correct balance after a stumble (Brummel-Smith, 1990).

In addition to the effects of reduced physical attributes, there is a large body of literature providing strong evidence that cognitive and executive function declines are powerful predictors of walking ability and risk of falling. While walking is generally viewed as an automated, over-learned, rhythmic motor task, it seems that this is a simplistic view and that, for many older adults, walking is a more complex task requiring integration of a number of visual, cognitive, and psychomotor skills. The incidence of falling by cognitively impaired adults is approximately twice the rate of cognitively normal older people (Bergland & Wyller, 2004; Chen, March, Schwarz, et al., 2005; DiFabio Zampieri, Henke et al., 2005). Age-related declines in a range of cognitive/executive functions have been linked to:

- Reduced foot clearance while stepping over an obstacle (lag foot clearing obstacles at a much lower distance than lead foot (visual input, memory and planning): (DiFabio et al., 2005).
- Poor gait, step initiation, stepping errors, and reduced walking pace (reduced visual field and eye fixation, reduced executive function): (Hauer, Pfisterer, Weber, et al., 2003; DiFabio et al., 2005; Ble, Volpato, Zuliani, et al., 2005)
- Difficulties performing quick postural adjustments, maintaining postural control during quiet stance and walking and taking a quick step or to grasp for external support (reduced motor skills and availability of attention for balance control): (Hauer et al., 2003; Melzer & Oddsson, 2004; Verghese, Buschke, et al., 2002).
- Difficulties in making decisions and completing actions in complex environments (attentional and information processing limitations): (Melzer & Oddsson, 2004; Beauchet, Dubost, Stierlam, et al., 2002).

2.4.1.2 Socio-economic status

In addition to the association with ageing, there is some limited evidence of a link between risk of falls and social conditions and socio-economic status. These factors include income, education, inadequate housing, social exclusions and limited access to health, social services and community resources (WHO, 2008).

For example, studies of Mexican-Americans living in five US States have shown that there is a relationship between socioeconomic status and falls. Lower income is associated with increased risk of falling (Reyes-Ortiz et al., 2003).

Older people, especially those who are female, live alone or in rural areas with unreliable and insufficient incomes face an increased risk of falls. The environment in which they live, their poor diet and not being able to access health care services, even when they have acute or chronic illness exacerbates the risk of falling. The negative cycle of poverty and falls in older age is particularly evident in rural areas and in developing countries.

2.4.2 Behavioural risk factors

Behavioural risk factors concern human actions, emotions and daily choices. These risk factors include the use of alcohol or illegal drugs, the side effects of medications and also the associated risks of sedentary lifestyles (WHO, 2008).

Alcohol and illegal drugs have been associated with pedestrian injuries. Alcohol slows brain function, reduces judgement and increases risk raking behaviours. It can also affect sense of balance making pedestrians unsteady on their feet and less capable of performing tasks such as crossing the road. Previous research by MUARC found that almost 80 percent of alcohol-related pedestrian crashes with vehicles in Victoria occurred at night (Corben & Duarte, 2000) and demonstrated significant effects of alcohol on crossing decisions (Oxley et al., 2006). Alcohol-related pedestrian deaths have also been found to occur during peak social drinking times, between Thursday night and Sunday morning. Males are typically over-represented in alcohol-related pedestrian injuries.

Falls amongst older pedestrians can often occur as a side effect of prescribed medications. Incorrect medication usage can lead to a number of side effects including altered alertness, judgement, coordination, dizziness, altered balance mechanisms as well as feelings of increased stiffness or weakness (WHO, 2008).

Health seeking behaviours also differ by gender. Males have a tendency to not seek medical care until a condition becomes more severe which can result in substantial delays to the access to prevention and management of diseases, males are also more likely to engage in dangerous activities and riskier behaviours. They are also more likely to be affected by alcohol and recreational drugs.

There is recent evidence to suggest that the increased use of handheld technological devices has increased collision risk. Such devices can distract pedestrians and drivers, particularly when engaged in text-messaging, listening to portable music devices, talking on phones and engaging with various technologies (Hatfield & Murphy, 2007; Schwebel et al., 2012). It is of particular concern if portable technology devices are distracting pedestrians as they navigate potentially hazardous parts of the road environment which may lead to increased risk of collision or fall.

2.4.3 Environmental risk factors

Environmental risk factors are associated with the interaction of the individual with the surrounding environment. While the physical environment is considered to have an important role in falls, the specific characteristics and their association with falls incidence and injury severity are not well understood. While much of the literature regarding community-based falls (especially amongst older adults) addresses factors influencing the safe, independent mobility of people within their homes and surroundings and focuses on hazards in the home environment (e.g., Lord, Menz, Sherrington, 2006; Gulwadi & Calkins, 2008), the types of environmental features identified as being associated with home falls risk can be drawn upon to understand some of the potential risks outside the home.

Environmental hazards in the home generally fall under three categories, including i) spatial organisation, ii) interior characteristics and iii) sensory characteristics of the environment. The most common risk factors are: limited visual access and obstacles (including unstable furniture and obstructed walkways); poor home layout, proximity and location of rooms; inappropriate, slippery and uneven flooring (related to type of floor material (resilient vs. soft), the amount of contrast in the pattern, transitions with other floor materials, the coefficient of friction of the floor

surface and the floor finish (polished or high gloss); loose rugs; poor lighting levels; and, absence of handrails. (Lieberman, 2004; Dickinson, Shroyer, Elias, et al., 2004; Reiling, Knutzen, Wallen, et al., 2004).

As noted previously, there is little research addressing the environmental risk factors for falling while walking in public spaces, however, the extensive literature addressing environmental hazards in the home associated with falling can guide this discussion. Of note, most research addressing falls risk suggests that it is virtually impossible to determine the relative role of the built environment. For example, Lord et al. (2006) noted that the existence of home hazards alone is insufficient to cause falls, and the interaction between an older person's physical abilities and their exposure to environmental stressors appears to be more important. Taking risks or impulsivity may further elevate falls risk. Some studies have found that environmental hazards contribute to falls to a greater extent in older vigorous people than in older frail people. This appears to be due to increased exposure to falls hazards with an increase in the proportion of such falls occurring outside the home. There may also be a non-linear pattern between mobility and falls associated with hazards. Household environmental hazards may pose the greatest risk for older people with fair balance, whereas those with poor balance are less exposed to hazards and those with good mobility are more able to withstand them.

With regard to environmental risk factors for falls in public spaces, the literature generally suggests that the road and road infrastructure plays a role in safe mobility and that pedestrian-friendly road design in addition to aesthetic improvements such as wide footpaths, separation of road user groups, provision of street lighting, lowering vehicle speeds, etc. are necessary to ensure pedestrian safety. Figure 2 provides an overview of the key features of a safe pedestrian environment.

In general, pedestrian risk is increased when roadway design and land-use planning does not adequately plan for and provide facilities for pedestrian use. This includes roadway elements such as slippery, uneven damaged or missing footpaths, poorly designed approaches and access to crossings, kerbs, crossing facilities, intersections, and inadequate street lighting (WHO, 2008).

In their investigation of outdoor falls, Li et al. (2006) found that pedestrian falls were most often associated with sidewalks, kerbs, and streets. The study determined that among all groups, except middle-aged men, the highest percentage of outdoor falls occurred when participants were walking. Other activities that resulted in a fall included vigorous activity including jogging, running or dancing, using stairs or other activities which included reaching up or down, bending over, getting into a motor vehicle, gardening or climbing a ladder or stool.

Falls on sidewalks, kerbs, or streets were often attributed to uneven surfaces and tripping (Li et al., 2006). Their study also concluded that many outdoor falls appear to be preventable through better design and maintenance of walking infrastructure including, kerbs, walkways, streets, recreational places, parking lots and garages.

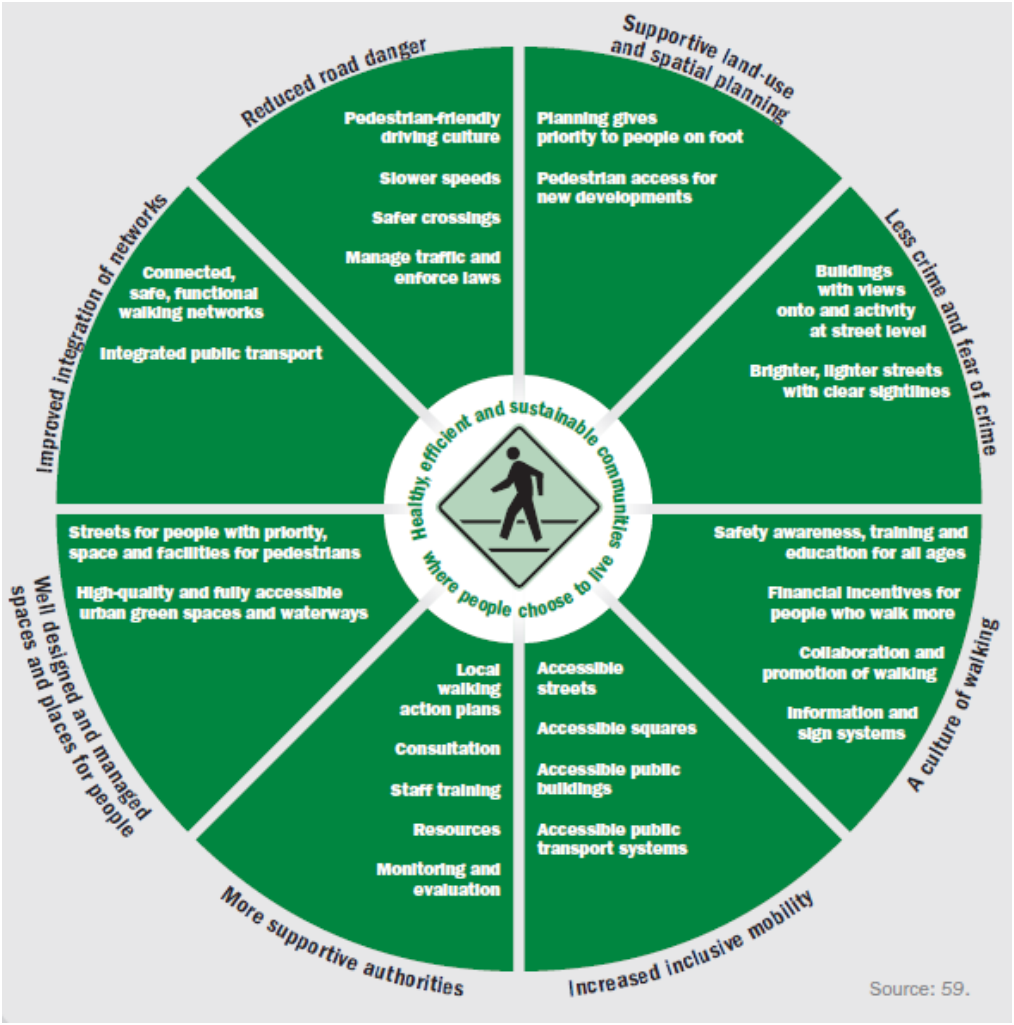

Figure 2: Components of healthy, efficient and sustainable communities (adapted from Egan et al. 2004)

Naumann et al. (2011) determined that the kerb was involved in nearly a quarter of pedestrian fall injuries. Their study also found that the percent of older adults who fell and reported that the kerb was involved increased with age. The study theorised that older pedestrians declining ability to negotiate kerbs is likely to be similar to previous research by Startzell et al. (2000) that has identified a reduced ability to negotiate stairs. The study recommended that modifications to the road environment such as installation of pram ramps at intersections, cleaning and maintaining sidewalks and streets and painting or marking kerbs may help to reduce the number of kerb-related fall injuries (Naumann et al., 2011).

Further, it has been demonstrated that older pedestrians experience difficulty in complex traffic environments and when performing complex traffic manoeuvres especially under conditions of uncertainty (Fildes, Corben, Kent, et al., 1994). Many of the problems stem from the fact that the system is generally designed for vehicles, and mainly for fit and healthy road users and is therefore often unforgiving of the needs and capabilities of older road users. The growing complexity of the road environment, particularly the dominance of vehicles, high speed and traffic volumes on many roads used by pedestrians place high demands on older person's adaptability to cope with many traffic situations. This can result in some older pedestrians being at increased risk of falling while walking, simply because of the complexity of the environment.

3 ANALYSIS OF HOSPITAL AND CRASH DATA

Analyses of two Victorian data sources were undertaken to enhance our understanding of fall-related injuries while walking:

- Victorian Injury Surveillance Unit (VISU) Data
- Victorian Police Report Crash Data (Crash Stats)

An additional data source (the National Coroner's Information System [NCIS]) is available that can complement the hospital injury data analysis with information on deaths as a result of a fall-related injury while walking. However, given that the number of deaths due to falls while walking are likely to be small, and therefore difficult to draw conclusions about potential contributing factors, analyses of these data were not undertaken.

This section outlines the methods of data extraction from the VISU and Crashstats databases and provides the findings of the analyses.

3.1 Victoria Injury Surveillance Unit (VISU) Data

The Victorian Injury Surveillance Unit (VISU) is situated within the Monash Injury Research Institute (MIRI), alongside the Monash University Accident Research Centre (MUARC). The VISU holds hospital-treated injury data at two levels of severity: hospital admissions and Emergency Department (ED) presentations. De-identified unit record files on Victorian injury hospital admissions and ED presentations are provided to VISU by the Department of Health.

3.1.1 Methods

Data from the Victorian Injury Surveillance unit was analysed for the most recent five year period available in the dataset, July 1st, 2009 to June 30th, 2014.

3.1.1.1 Emergency Department (ED) presentations

The Victorian Emergency Minimum Dataset (VEMD) is an ongoing surveillance dataset of injury presentations to 39 Victorian public hospital emergency departments. The VEMD data is collected in accordance with National Minimum Data Standards (NMDS) for injury surveillance. While data is *not* coded using the ICD-10-AM system, the code set in the VEMD is similar and comparable. Cases recorded in the VEMD were extracted using the following criteria:

- Injury cause codes: 9 (Fall -low [same level or less than 1 metre, or no information on height]) & 10 (Fall – high [greater than 1 metre])
- Place where injury occurred: (Road, street or highway)
- Human Intent: "Non-intentional harm"

All ED cases identified using this method of identification were examined for further details about the injuries. This dataset contains narratives for both admissions and non-admissions for fall injury. This narrative has the potential to provide some detail on the circumstances of the fall. An overview of the text narrative has been provided for the latest year of available data (2013/14), however further analysis of this information can be extensive and was beyond the scope of this initial examination. Further research would be required to extract this data.

3.1.1.2 Hospital Admissions

Hospital admissions recorded on the Victoria Admitted Episode Dataset (VAED) are coded using the ICD coding system, 10th Revision Australian Modifications (ICD-10-AM). Deaths in hospital and transfers within and between hospitals are not included in the dataset. Cases were extracted from the VAED and included the following variables:

- Place of occurrence indicated a road/street and highway: Y9240 - Y9249. These codes relate to sidewalks (designated walkway, footpath next to road and pavement), cycleway, other specified public highway, street or road and unspecified public highway, street or road (freeway, motorway & roadway).
- All ICD-10-AM external causes codes in the range of W00-W1999 (Falls), but excluded codes W020-W029, W061-W069, W072-W079, W130-W139, W05, W11 & W12 (which are related to falls associated with skateboards, scooters, wheel chairs, beds, chairs, buildings and similar structures, ladders and scaffoldings)
- Data on body region and injury type are based on primary diagnosis code.

All admitted cases identified using this method of identification were examined for further details about the injuries. The mechanisms (or causes) of the falls are not recorded in the VAED – this is a limitation of the dataset.

3.1.2 Emergency Department Presentations

Across Victorian Emergency Departments, there were at least 17,727 non-admitted presentations to emergency departments (EDs) in Victoria for fall-related injuries to pedestrians between July 2009 and June 2014. The number of emergency department presentations was found to increase over the five year period from 3,382 in 2009/10 to 3,665 in 2013/14, with an average of around 3,545 admissions per year (Figure 2). Females accounted for 55.5 percent of ED presentations, compared to 44.5 percent for men.

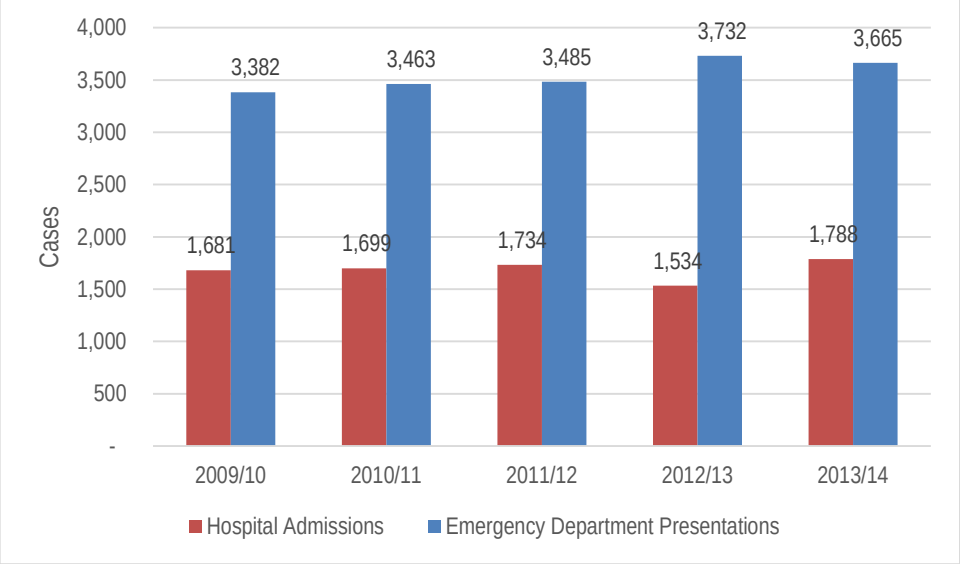

Figure 2: ED and Hospital Admission trends (2009/10 – 2013/14)

A notable finding is that falls affected all age groups, although children sustained a relatively low level of injury compared to adults (Table 1). For younger and middle-aged adults, the proportion of injuries is relatively consistent with their proportion of the population.

Table 1: Emergency Department Patients Demographics

Demographics		Frequency	Percent	ABS Population%
Gender	Male	7,883	44.5	49.2
	Female	9,844	55.5	50.8
Age Group	0-14yrs	1,863	10.5	18.7
	15-34yrs	5,282	29.8	27.7
	35-64yrs	6,428	36.3	39.5
	65-74yrs	1,845	10.4	7.5
	75-84yrs	1,641	9.3	4.8
	85+yrs	668	3.8	2.0
Total		17,727	100.0	100.0

While falls affect all age groups, age-adjusted rates of ED presentations highlight the increased rate of injuries for older pedestrians, with 129 ED presentations per 100,000 residents per annum for people over 75 years of age, compared to 60.9 for the 35-64 year age group (Figure 3).

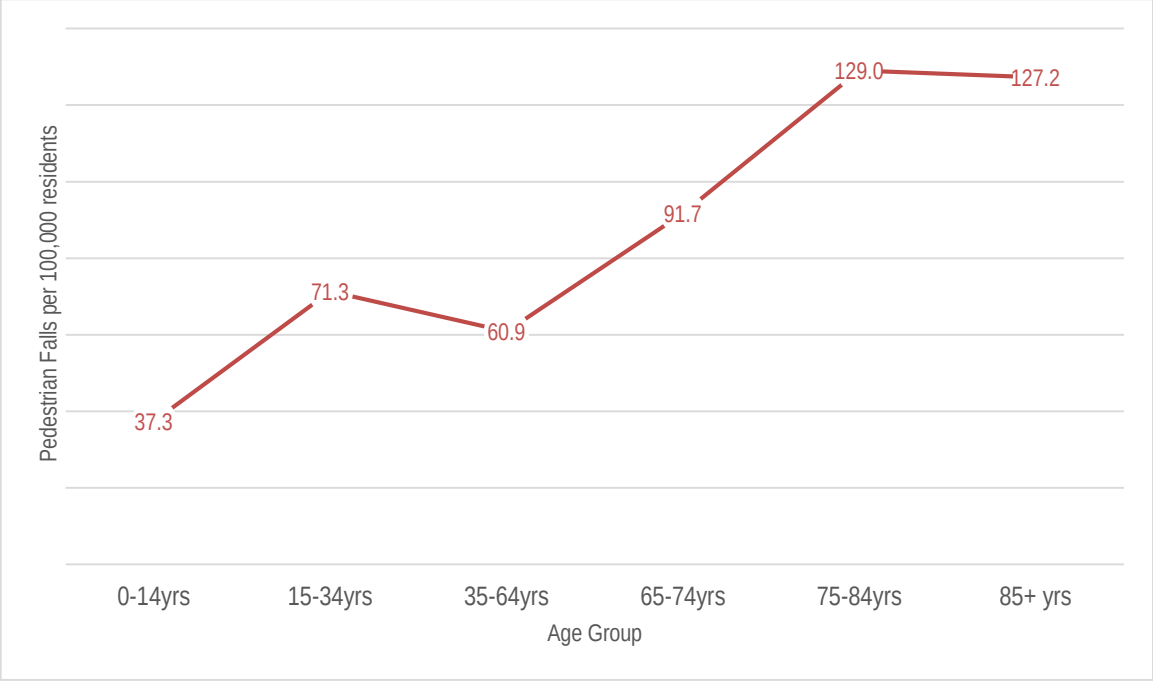

Figure 3: ED presentations per 100,000 residents per annum

The grouped body region most frequently affected were the upper extremity (arms/hands) and lower extremities (legs/feet/hip) followed by the head/face/neck (Table 2). The most commonly injured body sites being the ankle and foot (23%), the head (21%) and the wrist and hand (19%). Comparison of injury site by age group found that pedestrians over the age of 65 were increasing likely to suffer head, neck and facial injuries compared to younger cohorts. Analyses revealed that older adults had a significantly higher rate of ED presentations for injuries to their head compared with younger adults. Overall, adults aged 85+ years had a rate of 55.8 head injuries per 100,000 residents per annum, compared with 47.7 head injuries for the 75-84 year age group, and in contrast to only 10 head injuries per 100,000 persons per annum for those aged between 15 and 64 years. Injuries to the wrist and

hands were also found to occur twice as often for adults over the age of 65 years compared to younger cohorts, with approximately 20 injuries per 100,000 persons per annum, compared to 10 injuries per 100,000 persons per annum for those aged between 15 and 64 years. Younger cohorts between the age of 15 and 34 years were found to have the highest rate of ED presentations for injuries to the ankle and foot with 24 presentations per 100,000 persons, compared to only 2.6 presentations per 100,00 persons for people over 85 years of age.

Table 2: Emergency Department Grouped body site injured

Grouped body site injured	Frequency	Percent
Upper extremity	6,240	35.2
Lower extremity	6,024	34.0
Head/face/neck	3,891	21.9
Trunk	664	3.7
Multiple body regions	763	4.3
Unspecified body region	95	0.5
Body region not relevant	50	0.3
Total	17,727	100.0

The most frequent injury types were dislocations/sprains/strains (31%) and fractures (27%) followed by open wounds (14%) and superficial injuries (14%) (Table 3).

Table 3: Emergency Department Grouped nature of main injury

Grouped nature of main injury	Frequency	Percent
Dislocation, sprain & strain	5,433	30.6
Fracture	4,848	27.3
Open wound	2,549	14.4
Superficial injury	2,413	13.6
Injury to muscle & tendon	735	4.1
Intracranial injury	240	1.4
Crushing injury	45	0.3
Injury to internal organs	32	0.2
Injury to blood vessels	29	0.2
Eye injury- excluding foreign body	27	0.2
Injury to nerves & spinal cord	12	0.1
Foreign body	10	0.1
Traumatic amputation	2	0.0
Other & unspecified injury	1,352	7.6
Total	17,727	100.0

Emergency department presentation text narratives were extracted for the most recent year of ED data (2013/14). In total 3,665 cases were extracted. The quality of the text narratives varies between cases, some narratives include no information, others simply state “fall”. However for a large proportion of cases the narrative includes

useful information about the mechanism of the injury, the contributing factors and the injury outcomes. Some typical text narratives include:

- "walking stepped into gutter, landed funny"
- "stumble on way home after drinking twisted ankle"
- "sprain of left ankle when walking in high heels"

A summary of the commonly reported key words regarding contributing factors from the text narrative are included in Table 4. From the sample of cases, 50 percent of narratives included descriptions that the patient had fallen, with tripped (17.7%) and slipped (4.3%) the other most common mechanisms of the injury. The most common activities mentioned included walking (12.0%) and jogging or running (3.8%). Other key contributing factors included kerbs or gutters (4.3%), alcohol or drug use (3.0%), uneven surfaces (1.9%), tram or train tracks (1.1%), wet surfaces (0.9%) and wearing high heels (0.7%).

It is important to note that the frequency and percentages are not representative of all ED presentations, but instead represent the frequency of the term being recorded by ED doctors, as such these figures are likely to under-report the real proportions of these contributing factors.

Table 4: Summary of emergency department text narratives

Text narrative key word	Frequency	Percent
Mechanism		
Fell	1834	50.0
Tripped	648	17.7
Slipped	156	4.3
Activity		
Walking	441	12.0
Jogging/running	139	3.8
Crossing the road	22	0.6
Playing	17	0.5
Location		
Street/ road	302	8.2
Footpath	131	3.6
Time of Day		
Night	127	3.5
Day	27	0.7
Contributing factors		
Kerb or gutter	159	4.3
Alcohol/ Drugs	111	3.0
Uneven surface	69	1.9
Dog	64	1.8
Pothole	49	1.3
Tram or train tracks	39	1.1
Wet surface	33	0.9
High heels	24	0.7

3.1.3 Hospital Admissions

Within the Victorian Hospital Admissions dataset, there were 8,436 admissions for fall-related injuries that occurred within the road environment for the five year period between July 2009 and June 2014. The number of hospital

admissions was found to increase over the five year period from 1,681 in 2009/10 to 1,788 in 2013/14, with an average of around 1,680 admissions per year (Figure 2).

Overall, females accounted for 59 percent of hospital admissions, while 64 percent of injuries involved people over the age of 65 years (Table 5). Comparisons with the 2010 Australian census for Victorian residents highlights the over-representation of older pedestrians as a proportion of the population.

Table 5: Hospital Admissions Patient Demographics

Demographics		Frequency	Percent	ABS Population%
Gender	Male	3,466	41.1	49.2
	Female	4,970	58.9	50.8
Age Group	0-14yrs	129	1.5	18.7
	15-34yrs	690	8.2	27.7
	35-64yrs	2,214	26.2	39.5
	65-74yrs	1,488	17.6	7.5
	75-84yrs	2,396	28.4	4.8
	85+yrs	1,519	18.0	2.0
Total		8,436	100.0	100.0

Age-adjusted rates of Hospital Admissions highlight the increased rate of hospital admissions for older pedestrians (Figure 4). There were only 21 hospital admissions resulting from falls while walking per 100,000 residents per annum for the 35 to 64 year age group compared with 289.3 for the 85+ year age group.

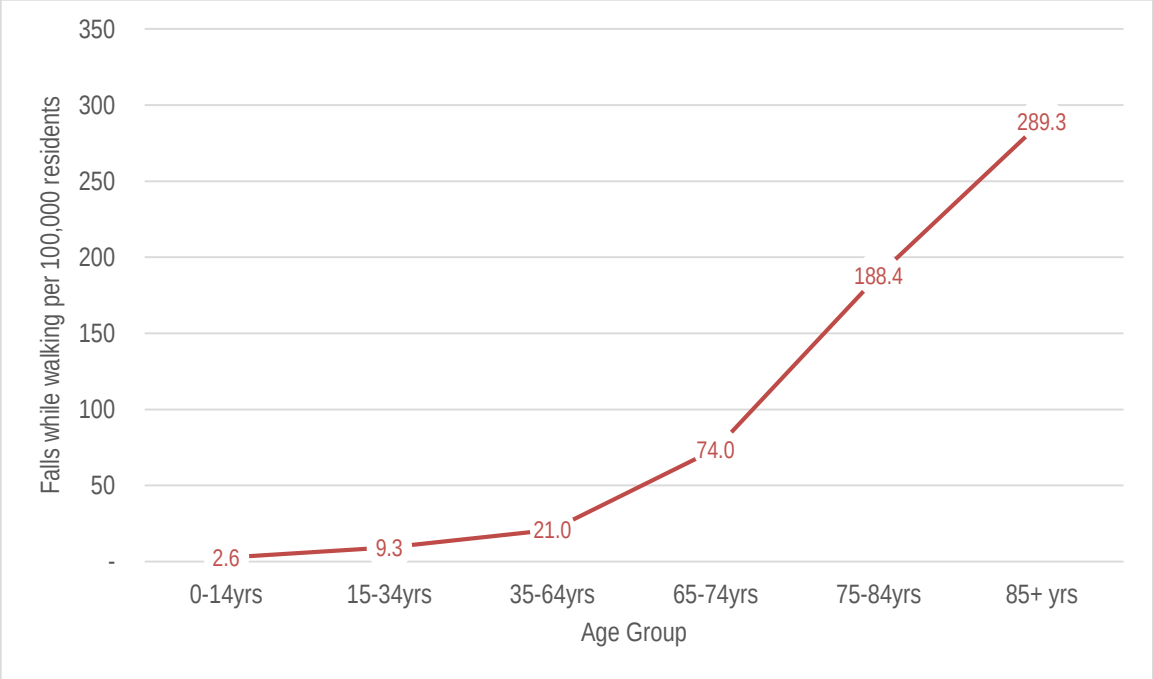

Figure 4: Hospital Admissions per 100,000 residents per annum

Analysis of the body site injured in the fall found that injuries to the head/face and neck accounted for 37 percent of hospital admissions. Injures to the upper extremity (arms, hands etc.) (29%) and lower extremity (hips, legs, feet etc.) (25%) were the next most common injury locations (Table 6). As with ED presentations, hospital admission data showed similar trends regarding head injuries. Adults over 85 years of age suffered much higher incidence rates of head injuries compared to younger cohorts. Adults aged 75+ years suffered approximately 109 head injuries per 100,000 residents compared to just 7 per 100,000 residents for those aged between 35 and 64 years of age.

For hospital admissions there were substantial age group differences in incidence rates for injuries to the hip and thigh region, with pedestrians over 85 years of age experiencing 48 injuries per 100,000 residents from falling injuries. This rate was over 45 times higher than the 35 to 64 year cohort. This is in contrast to ED presentations where presentations rates for hip injuries were substantially lower with only 2.8 adults over 85 presenting to the ED per 100,000 population. This is likely a reflection of the increased severity of these injuries for older adults, with the vast majority of injuries to this region requiring hospital admission.

Table 6: Hospital Admissions Grouped body site injured

Grouped body site injured	Frequency	Percent
Head/face/neck	3,139	37.2
Upper extremity (arms/hands etc.)	2,441	28.9
Lower extremity (legs/feet/hip etc.)	2,145	25.4
Trunk	602	7.1
Multiple body regions	6	0.1
Unspecified body region	26	0.3
Body region not relevant	16	0.2
Missing injury code	61	0.7
Total	8,436	100.0

When considering the nature of the injury, fractures were the most common injury type, accounting for 52 percent of cases. Open wounds (15%) and superficial injuries (10%) were the next most common injury type (Table 7). Comparison of injury types and injury sites by age groups found that the proportions of injuries were relatively consistent across the different age groups.

Table 7: Hospital Admissions Grouped nature of main injury

Grouped nature of main injury	Frequency	Percent
Fracture	4,349	51.6
Open wound	1,248	14.8
Superficial injury	840	10.0
Intracranial injury	609	7.2
Dislocation, sprain & strain	369	4.4
Injury to muscle & tendon	108	1.3
Eye injury- excluding foreign body	39	0.5
Injury to internal organs	21	0.2

Injury to blood vessels	17	0.2
Injury to nerves & spinal cord	16	0.2
Other & unspecified injury	759	9.0
Missing injury code	61	0.7
Total	8,436	100.0

Fifty-four percent of cases required a stay in hospital of less than two days and 32 percent required a stay of between two and seven days (Table 8). Comparison of hospital length of stay by age group revealed that older pedestrians were more likely to stay in hospital for longer compared with younger pedestrians (Figure 5). Twenty percent of those aged 75 or older were hospitalised for more than a week, compared to approximately nine percent for those aged 35-64 and less than one percent of under 35s.

Table 8: Hospital Admissions Grouped Length of Stay (days)

Grouped Length of Stay (days)	Frequency	Percent
< 2 days	4,542	53.8
2-7 days	2,677	31.7
8-30 days	1,161	13.8
31+ days	56	0.7
Total	8,436	100.0

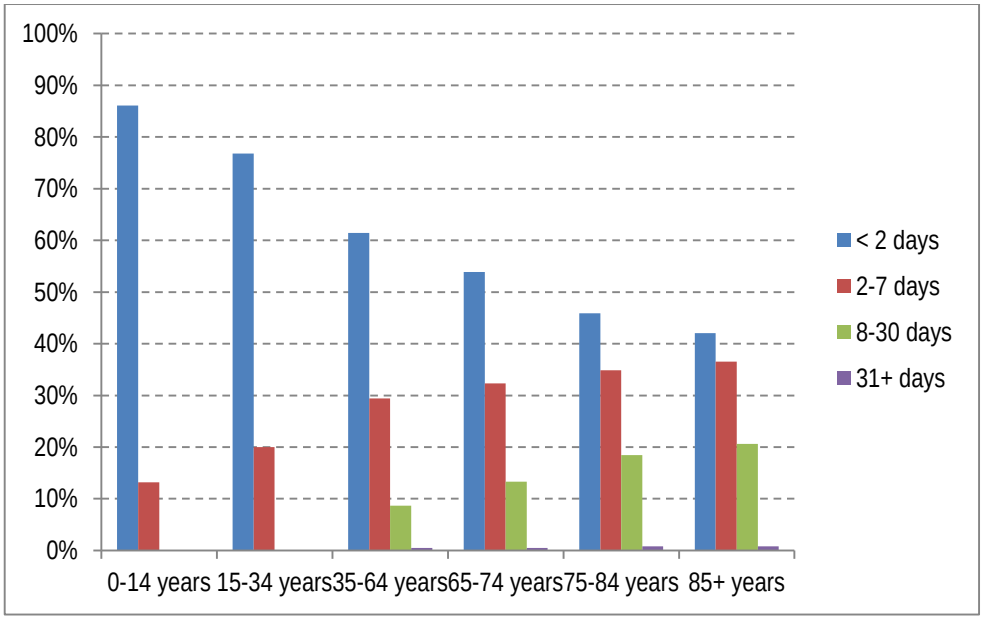

Figure 5: Hospital Admissions Grouped Length of Stay (days) by age group

Seventy-two percent of injured persons were discharged to private residence or accommodation and 22 percent were transferred to another acute hospital or extended care facility (Table 9). Comparisons by age group found that older patients were less likely to be released back to private accommodation and increasingly required transfer to acute hospital care, extended care or aged care facilities.

Table 9: Hospital Admissions Type of separation

Type of separation	Frequency	Percent
Separation to private residence/accommodation	6,048	71.7
Separation and transfer to acute hospital/extended care facility	1,845	21.9
Statistical Separation	260	3.1
Separation and transfer to aged care residential facility	154	1.8
Left against medical advice	87	1.0
Separation and transfer to Transition Care bed based program	*	*
Separation and transfer to mental health residential facility	*	*
Total	8,436	100.0

Note: Cells with values less than 5 have been replaced by an asterisk (*) as a privacy protection measure.

3.2 Victorian Police Report Crash Data

This component of the investigation sought to examine the extent to which pedestrian injuries due to a fall were collected within the Victorian Police-reported mass crash dataset. Analysis of the dataset covering the period of January 2008 to December 2013 was undertaken. The data set is administered by VicRoads, and includes a report of all police reported casualty crashes between 1987 and 2013 where at least one injury had occurred. The dataset provides a valuable tool for identifying trends in crashes, however, it is important to note that the dataset only records Police reported injuries and that many minor injury collisions or events are not reported to Police or do not require Police attendance.

Analysis of the database was undertaken for the period of 2009 to 2013 to assess if pedestrians falls were recorded within the dataset and to make some comparisons of falls-related injuries compared with other causes of pedestrian injury.

Overall, there were 7,735 reported pedestrian collisions/incidents during this period in Victoria, of which 226 (2.9%) had a fatal outcome, 3,210 (41.5%) a serious injury outcome, and 4,299 (55.6%) other (minor) injury outcome.

The investigation identified 85 collisions/events recorded over the time period that involved a pedestrian and no other road user. Further analysis of these events revealed that they generally were not related to pedestrian falls and typically involve road users being struck by their own vehicle for various reasons, such as when they had exited the vehicle but failed to put the hand brake on, or the vehicle had rolled forwards or backwards for some other reason. The other common injury mechanism amongst these events was vehicle owners injuring themselves when connecting or removing a trailer.

Of the 85 events, only two involved the pedestrian falling over, the first case was a result of a pedestrian tripping over the towbar of a vehicle causing a shoulder injury. The second injury involved an elderly pedestrian who caught their clothing in the door of a taxi which then drove away, causing the pedestrian to fall.

This brief analysis highlights that the database is not a useful data source for capturing pedestrian fall injuries. This is likely due to the fact that Police would rarely attend pedestrian falls and as such these injuries would not be captured in the Police-reported database. Further, there is no information available regarding the contribution of falls to pedestrian incidents, whether a fall occurs as a result of attempting to avoid a collision, whether a collision occurs due to a person falling, or other circumstances.

4 DISCUSSION AND RECOMMENDATIONS

In Victoria, pedestrians represent one of the most vulnerable road user groups. However, the majority of studies and publications addressing issues of pedestrian safety often do not consider crash and injury types other than those associated with collisions with vehicles. This study has highlighted that, while vehicle collisions result in approximately 1600 pedestrian casualty injuries per annum, pedestrian falls while walking in the road environment account for an average of 1,680 hospital admissions and 3,545 emergency department presentations each year and this number is rising.

A notable finding is that falls affected all age groups, although children sustained a relatively low level of injury compared to adults. For younger and middle-aged adults, the proportion of injuries is relatively consistent with their proportion of the population.

Older pedestrians are significantly over-represented amongst fall-related injuries that require hospital admission, while also having the highest rate of emergency department presentations when adjusting for age. This finding demonstrates the increased susceptibility to injury in the event of a fall or collision compared with younger adults, strongly suggesting that frailty plays a major role in sustaining an injury, more than showing an increased risk of falling.

Further, this finding is particularly important as Australia, much like many other developed nations, is experiencing an ageing population due to sustained lower fertility rates and increases in life expectancy (O'Hern & Oxley, 2015). This trend has seen the proportion of the population aged over 65 years increase from 11.1 percent to 13.6 percent between 1990 and 2010 and forecasts suggest that the proportion of older persons will to continue to increase (O'Hern & Oxley, 2015). This could result in increasing rates of pedestrian fall-related injuries (and those involving a collision with a vehicle) if appropriate countermeasures and interventions are not developed and implemented.

Generally studies on pedestrian collisions utilise Police-reported data which only capture the most severe pedestrian injuries and it is for this reason the key pedestrian safety priorities often relate to collisions with vehicles while crossing the road. The findings in this study show clearly that Police data (Crashstats) is of little use when trying to understand the full picture of safe travel for pedestrians. However, analysis of hospital admissions data provides an indication of the extent of pedestrian fall-related injuries. The majority of hospital admissions involved older persons, with pedestrians over the age of 85 years having a hospitalisation rate 14 times greater than pedestrians in the 35-64 year age group.

The study also highlighted that the most common injury sustained from a fall were fractures. These injuries are commonly associated with ageing, but are also a reflection on the hard surfaces associated with the pedestrian environment. Fracture injuries can be particularly burdensome for older persons, with many older persons not recovering to pre-fracture functionality and mobility following major falls (Bertram et al. 2011). As noted previously, outcomes from hip fractures can be devastating, with a high rate of death within a year of fracture, or serious consequences including poor recovery rates, loss of activity, mobility, independence, and ongoing low functional capacity and poor health (Lyles et al., 2007; LeBlanc et al., 2011).

The burden of injury for older pedestrians is made more apparent when considering the length of hospital stays, with an increasing trend of longer hospital stays for older pedestrians and with hospital separations showing that older patients are less likely to be released back to private accommodation following a fall while walking and instead are increasingly transferred to acute hospital car, extended care of aged care facilities. This highlights the significance of injuries sustained from falls, with many older persons unable to make a full recovery.

The analysis of keywords used in Emergency Department presentations appears to confirm the literature that suggests environmental elements, particularly kerbs, are causal factors for falls in the street environment.

Alcohol and drug impairment may be a significant behavioural factor for falls by younger adults, although it is falls by older people that result in the most serious injury impacts.

4.1 Study Limitations

It is noted that there are several limitations with the analyses conducted in this study, firstly the study has only considered hospital admitted and emergency department presentations and has not considered fatal injuries or minor injuries that did not require hospital treatment. Furthermore there are limitations with the use of the VISU dataset, in particular the de-identified aggregate dataset only allows high levelled analysis to be undertaken.

Further, while some contributing factors have been identified, these are only recorded in the VEMD dataset, therefore only related to less severe injuries. There may be additional or different contributing factors to more severe injury outcomes. Further research is therefore needed to better understand the issues of pedestrian falls and contributing factors to help identify solutions for the problem. This research may include in-depth pedestrian studies to reveal greater details regarding the nature of pedestrian falls and the environmental and behaviour factors that contribute to injuries. This research would be particularly insightful as it may highlight the relationships between pedestrian collisions and pedestrian falls, as well as identifying falls that occurred as a result of interaction with a motor vehicle.

Observational studies or surveys of the pedestrian population may also provide valuable insight into issues surrounding pedestrian and road user distraction and behaviours. Further understanding of the road environment is also needed to identify and detail deficiencies that may contribute to pedestrian falls. This may include reviewing existing Australian design guidelines for road infrastructure as well as road safety audits to identify safety issues within the road and roadside environment.

4.2 Implications of the findings and recommendations

The social cost of road crashes in Australia was an estimated $17.9 billion in 2006 (1.7 per cent of GDP) (Bureau of Infrastructure, Transport and Regional Economics [BITRE], 2006). This estimate comprises fatal crashes ($3.9 billion), injury crashes ($9.6 billion), and property damage only crashes ($4.6 billion). An understanding of the cost of road crashes is important to the safety debate in Australia and the unit values (particularly for a fatality, injury or cost of a fatal crash) are key inputs into policy development and cost-benefit analysis for safety programs and infrastructure programs. However, not all collisions or injuries on the road are considered by authorities to be road crashes, and not all crashes occur on public roads. Indeed, falls that occur in public spaces are highly unlikely to be captured/included in the overall cost estimates of road crashes.

Providing a safe system for pedestrians requires more than investigations of vehicle-pedestrian collisions and it is clear from this study that we need to look at other causes of injury (such as falls) to fully understand all issues of pedestrian safety and mobility. There is also a need to address issues associated with pedestrian safety to create a safer walking environment. At the same time it is important to propose changes that will not reduce access, mobility and amenity but will instead help to encourage increased participation in this important mode of transportation and exercise.

Australasia's Safe System road safety philosophy requires a profound shift in thinking and insight into society's efforts to curb road trauma. Translating the Safe Systems philosophy and principles into real-world practice has the potential to deliver major advances in road trauma reduction and improve the overall safety performance of Australia's road-transport system.

There are four 'cornerstones' within the Safe Systems framework, namely:

- Safe Roads and Roadsides
- Safe Speeds
- Safe Vehicles
- Safe Road Use

In addressing pedestrian falls while walking, the cornerstones of safe road users and safe roads and roadsides are likely to offer the most obvious improvements in achieving any reductions in the incidence and severity of these incidents.

Further, this first and exploratory study has revealed some gaps in our knowledge regarding falls while walking and some limitations of existing databases, warranting some areas for further research. The following recommendations are made.

4.2.1 Recommendations for safer road users

It is likely that similar strategies aimed at reducing falls in the home could also be used to address pedestrian falls while walking. Strategies that have previously been implemented for falls prevention in the home (Cassell & Lee, 2000) could inform programs such as:

- Community education programs, particularly for groups that may be concerned about falls, that highlight the risks for falls and also recommend preventative strategies, such as walking in familiar environments that are well lit, wearing appropriate footwear etc.;
- Exercise intervention, particularly for older pedestrians, with a particular focus on improving muscle strength and balance; and,
- Public fall hazard assessment and management that could be implemented through state or local council or the appropriate road authority

Agencies preparing public health and road safety campaigns around the risks of drug and alcohol impairment should consider incorporating the increased risk of fall injuries.

Behavioural programs targeted at driver behaviours may be beneficial in reducing the prevalence of pedestrian falls, in addition to collisions. It is recommended that strategies that encourage drivers to 'share the road' and meet their legal requirements to give way to pedestrians, particularly at key conflict points such as intersections, pedestrian crossings and driveways be considered. While this study only considered pedestrian falls and not collisions with motor vehicles or bicycles, it is likely that some pedestrian falls are the result of interaction with a vehicle without a collision occurring.

4.2.2 Recommendations for safe roads and roadsides

There are various ways that the environments that pedestrians engage in could be altered or enhanced to address the prevalence of pedestrian falls but also improve the injury outcomes when they do fall. The safety of pedestrians is often compromised by the design and operation of the road transport system (Oxley, 2010). Much of the literature on reducing pedestrian collisions with motor vehicles stresses the importance of separating pedestrians from motorised traffic. This can be done through construction of appropriate footpaths adjacent to the roadway and through separating pedestrians either spatially or temporally when they intersect with vehicle traffic.

A number of recommendations are suggested:

- Footpaths that are installed need to provide level surfaces that are free from tripping hazards, the materials used in construction should create a non-slip surface, particularly in wet conditions. Edges and potential hazards could be delineated through the use of tactile paving or colour markings so that they are conspicuous. Adequate widths must be provided to allow mobility for all users and benches or other types of rest areas should be provided in areas with high numbers of walkers, particularly older people. Good street lighting should be provided, particularly at crossing points.

- At crossing locations on minor roads, design should consider utilising raised crossings or raised thresholds, so that the footpath is at the same level as the street crossing. This may assist in reducing traffic speed and encouraging vehicles to give way to pedestrians. In suitable locations, shared space design can be used to eliminate the need for changes in grade between the roadway and the footpath. Otherwise, kerbs should be designed to minimise fall risk.

- When interacting with the roadway appropriately located, graded and aligned pram ramps should be installed that allow pedestrians to transition onto the roadway. These ramps help to minimise the need for pedestrians to negotiate kerbs and reduce the occurrence of having to step up and down from heights, which is commonly associated with pedestrian injuries (Startzell et al., 2000).

- Crossing facilities need to provide adequate time for pedestrians to cross the carriageway, including older pedestrians, who often have a slower walking speed than that which is assumed in traffic light phasing. Adaptive signal systems such as puffin crossings can provide increased walk times to accommodate older pedestrians' slower walking speeds. At un-signalised locations pedestrian refuges and kerb outstands can reduce the total crossing distance for pedestrians or allow them to stage their crossing. By making the interaction with traffic easier to negotiate, they can address both collisions and falls.

- As many pedestrian falls result in fracture injuries, consideration should be made regarding the installation of impact absorbing surface materials that reduce the transfer of kinetic energy. Similar principles have been adopted in children's playground to deal with falls from height and these concepts could be applied to areas that have high numbers of pedestrian fall related injuries.

4.2.3 Recommendations for further research

This Australian-first study has identified that injuries sustained from a fall while walking are generally not captured in official crash-based statistics, and may be under-represented in injury-based statistics, especially for less serious injury outcome incidents and among younger adults. Moreover, it highlights the need for more research to better understand the nature and extent of the problem and examine the contributing factors to fall-related injuries in more depth. It is therefore recommended that additional research is undertaken to:

- Extract detailed information from the narratives contained in the VEMD database to understand the contributing factors to fall-related injuries among Emergency Department presentations.

- Examine contributing factors to fall-related injuries among Hospital Admission patients – this could involve a survey or interview.

- Translate the recommendations into actions and programs, and evaluate the potential benefits.

- Explore the potential for more comprehensive collection of detailed information regarding the circumstances of falls in public spaces through emergency department, trauma registry, coronial data systems and crash data systems.

4.3 Conclusion

The issue of pedestrian falls while walking is significant and unless actions are taken there is a real possibility that the rates of pedestrian fall-related injuries will continue to grow. This research has identified the extent of the problem through investigation of injury-based data including hospital admission and emergency department presentations. It has also provided some preliminary analyses highlighting some contributing factors to injury.

Despite the limitations, this study has provided a valuable starting point that highlights the extent of the problem, and the limitations associated with traditional Police crash data sources that are typically used for investigating injuries that occur within the road environment. The findings provided a basis on which we can better address the risk of falls in public space management, ensure that the focus of road safety does not only consider vehicle-related incidents, and that these incidents are considered as an important part of the road safety debate.

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