



MONASH University

Accident Research Centre

SAFETY OF OLDER PEDESTRIANS

Strategy for Future Research and Action Initiatives

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Abstract:

While older pedestrian crashes are relatively few in number, their rates are significant per head of population. Moreover, with expected increases in the proportion and mobility of older people in the years ahead, the problem will only get worse without active intervention. This review aimed to identify issues of relevance to the safety of older pedestrians and prioritise research and countermeasures for future initiatives. A literature review was conducted along with discussions with local and overseas specialists to highlight management and research issues likely to be of relevance. A total of 16 action and 14 research items were then distributed to a panel of Australian and international gerontology experts where these items were rated in terms of their likely importance for improved older pedestrian safety. Priority action initiatives emphasised more pedestrian friendly environments in high older pedestrian areas while research into exposure, travel patterns and older pedestrian road crossing behaviour were recommended.

Key Words:

(**IRRD except when marked***)

Pedestrians, Elderly, Health Conditions, Mobility, Road Crossing, Complexity, Testing, Research, Countermeasures.

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EXECUTIVE SUMMARY

Older pedestrian safety was nominated as a priority issue for future road safety programs in both the *National Road Safety Strategy* by the Federal Office of Road Safety and *Safety First* published by VicRoads.

This older pedestrian strategy project was subsequently undertaken to provide direction for future intervention and research effort aimed at improving the safety of this vulnerable road user group.

LITERATURE REVIEW

The study involved a comprehensive review of current knowledge and practice to identify issues where intervention and/or research were required. Areas reviewed included incidence and types of older pedestrian crashes, potential risk factors for older pedestrians, and other issues relevant for older pedestrians including mobility, current engineering awareness, and educational programs. These are summarised below.

Older Pedestrian Crashes

There were approximately 550 pedestrians killed on average each year on Australian roads during the early 1990s. While this figure was declining annually up until 1995, recent trends show that these road deaths are on the increase. A similar trend also existed for non-fatal casualties over the same time period.

Pedestrians aged 60 years and older accounted for 40% of all pedestrian fatalities in 1995 even though they made up only 15% of the population. These figures are likely to increase in the years ahead as the population ages.

Seventy-three percent of all pedestrian crashes involving those aged 65 years and above in Victoria occur while crossing the road and were equally likely whether they were stepping off the kerb or when in either the near-side or far-side traffic lane.

Crashes involving older pedestrians commonly occurred in 60km/h zones, at intersections (especially uncontrolled ones), during daylight and often in good weather. There is some evidence that complex road environments are particularly dangerous for older pedestrians. The evidence of who caused crashes involving older pedestrians is unclear.

Older pedestrian crashes during the late 1980s were estimated to have cost the Transport Accident Commission of Victoria around \$61 million annually. While the average claim cost was about two-thirds that of younger pedestrians, older pedestrians did experience larger hospital, medical and rehabilitation charges than their younger counterparts.

The Ageing Population

Most western societies are experiencing an ageing phenomenon as the proportion aged 65 years and older increases. It is estimated that the proportion of the Australian population aged 65 years or

more will double between 1991 and 2031 as the so-called “baby boomers” of the mid-1940s enter that age group.

Moreover, the increase in the proportion of the elderly is also associated with an increase in longevity and greater demand for individual mobility. Thus, the size of the older pedestrian safety problem is bound to increase in the years ahead without active intervention effort.

The Ageing Process

The ageing process is associated with reduced abilities in a number of anatomical and physiological processes. These include declines in visual acuity, sensitivity and visual field, substantial hearing losses, reductions in depth and motion perception and significant declines in physical and cognitive capacity.

Older people appear to be less able or willing to recognise these declines and to adjust their behaviour accordingly. In addition, older people are more susceptible to injury and death in the event of a crash than younger people.

Muscular atrophy during ageing has considerable behavioural consequences such as restricted walking speed, gait and the ability to twist and turn. While older people may be able to compensate for these restrictions by allowing greater time before crossing the road and increased gap acceptance, the degree to which they are able to compensate adequately is not well documented.

Health & Medical Issues

Health status also deteriorates with increased age where there is a greater tendency for these people to suffer on-going health or medical conditions than those of younger ages. Common ageing disorders include various eye disorders (cataracts, muscular degeneration, glaucoma and diabetes mellitus), dementia including Alzheimers and Parkinson's disease, arthritis, and various cardio- and cerebrovascular conditions such as angina, coronary and rheumatic heart disease hypertension, transient ischaemic attacks (mini-strokes) or cerebrovascular accidents (CVAs or full strokes). Many of these health conditions are likely to affect a person's ability to cross the road safely.

With declining health, there is also an increased likelihood that older people will also be taking one or more prescription medications on a regular basis, many of which are likely to affect their ability to use the road safely. Moreover, not all of these medications have clear and understandable messages of their likely influence on mobility, especially pedestrian performance.

Road & Traffic Complexity

As noted above, older people have considerable difficulty coping with multiple sources of information such as crossing busy and complicated road networks.

Despite the availability of traffic signals, marked walkways and stop signs, older pedestrian accidents often occur at intersections, especially those with minimum traffic control. In crossing the road, the pedestrian must not only look to the left and right in the near-side and far-side lane and often forwards and backwards for turning vehicles, they must also be continually assessing and modifying their walking behaviour as the situation changes. This can place undue demands on older pedestrians who may subsequently focus on simple inappropriate cues when crossing the road, thereby placing themselves at greater risk.

Furthermore, it is not always obvious or known who has right-of-way in certain situations on the road such as a vehicle entering or turning at an intersection or a roundabout. It is extremely unusual for there to be road markings or signs that help to clarify this at intersections.

Undivided roads also appear to cause considerable difficulty for older pedestrians crossing the road mid-block for many of the reasons already stated. Indeed, recent research seems to suggest that the use of median strips or pedestrian refuge areas in the centre of roads can lead to improved (safer) road behaviour by older pedestrians.

Traffic speed is also a problem for those attempting to cross over busy roads. While humans are generally poor at assessing the speed of an approaching vehicle, it is especially a problem for older people. Moreover, they are less likely to be able to avoid the sudden onset of a fast car. This is also the case with reversing vehicles where older pedestrians seem to be less able to spot the vehicle in the first place or getting out of its way as it approaches.

The Road Environment

The road environment, itself, may also contribute to the level of risk elderly pedestrians face when using the road system. Roads and pedestrian facilities are built according to standards often based on young adult performance. Highway designs will need to accommodate the needs of older adults more in the years ahead.

The use of signalised pedestrian crossings for older people is clearly desirable in areas often frequented by older people. However, with restricted walking abilities, it is ambitious to expect older people to go much out of their way to use these if it imposes much of a distant penalty. Moreover, traffic light cycles need to reflect older people's crossing speeds.

The desirability of subways and footbridges for older pedestrians is less clear as they commonly have fear for their safety and difficulty climbing stairs.

Footpaths alongside roads, poorly designed kerbs and overhanging foliage cause considerable problems for older people. Poorly positioned and illegible signs are also problematic. Indeed, most sign standards fail to take account of the visibility, colour and contrast levels necessary for ageing eyesight.

Vehicle Design

Most pedestrian crashes involve contact with a vehicle, commonly a passenger car. While external vehicle designs have changed considerably in recent times, these changes generally have not been introduced to protect pedestrians in the event of a collision. It is often the vehicle, not the ground that causes most serious injuries to pedestrians.

Many external aspects of modern cars are injurious to pedestrians such as bumper designs, bonnets (and what is close and relatively unprotected under them), windscreen panels and fittings, and various sharp and hard attachments. Current V-shaped front designs, too, may induce greater injuries by promoting contacts with the upper bonnet, windscreen and surrounding structures.

Educational Campaigns

Education, publicity and training to improve older pedestrian safety is scant. Given that behavioural factors play an increasing role in traffic safety, more emphasis needs to be placed on intervention programs aimed at changing unsafe behaviour.

Programs such as "Walk-With-Care" in Victoria and other Australian States need to be supported and adequately resourced in the years ahead. However, it is first imperative that their effectiveness be assessed to maximise their usefulness and allocation of resources.

REVIEW PROCESS

There were a total of 16 action items and 14 research items identified during the older pedestrian strategy review that had potential to improve the safety of older pedestrians or further our understanding of these problems. One of the aims of the strategy was to prioritise these in terms of their likely importance for future work in this area.

These findings were circulated to an expert panel of agency, researchers and community groups, both in Australia as well as overseas to assist in setting priorities.

Each expert was asked to make his or her judgement of the relative importance of each item using a 1-5 scale response and these judgements were then summed to provide an overall assessment of action or research priority. The top eight items in each group are shown in Tables 1 and 2 below.

Table 1 Older Pedestrian Strategy Action Item Priorities

Priority	Action Item
1	Greater effort to provide a safe traffic environment for older peds.
2	Reduced travel speed in high density pedestrian areas
3	Reduced traffic in high density pedestrian areas
4	Development of alternative mobility options for older peds.
5	Guidelines for adequate crossing times for older peds.
6	Better maintenance of footpaths, surrounds and street lighting.
7	Develop safer access for older people at bus and tram stops
8	Improved public transport access for older people

Of particular note, the first three priority action items all related to the provision of a safer and more pedestrian friendly environment in high-density traffic areas. There have been a number of innovative designs of malls and pedestrian and car precincts that have addressed the specific needs of the more vulnerable and more attention of these efforts would seem

warranted from these findings. Of particular interest is the need for greater attention to pedestrians rather than motorists in these environments.

Table 2 Older Pedestrian Strategy Research Item Priorities

Priority	Research Item
1	More detailed investigation of crash involvement patterns
2	Better appreciation of older ped. performance in complex settings
3	Examine the role of inappropriate behaviour in older ped. crashes
4	Evaluate effectiveness of speed reduction measures for older peds.
5	Evaluate the effectiveness of median strips for older peds.
6	Assess their mobility needs and patterns
7	Examine the suitability of road & hwy design for older peds.
8	Develop countermeasures at tram and bus stops

The research items judged to be most important by the panel of experts emphasised greater understanding of the exposure and travel patterns of older pedestrians to permit more accurate assessments of the crash involvement rates and mobility needs as well as a better appreciation of their performance and behaviour in complex road environments.

CONCLUSIONS

The strategic review identified a number of ageing, health, environment, road engineering and educational issues relevant for older pedestrian safety. These were prioritised in terms of their likely importance for improved safety for this vulnerable road user group. While the older pedestrian safety problem is currently not large in number, it is nevertheless significant in terms of their rate per head of population and represents a reasonably large cost to the community. As it is estimated that the number of older pedestrians will double in the next 30 years or so, it is imperative that additional resources be provided to improve their safety in the years ahead.

1.0 Introduction

Older road users as a group do not currently represent a major road safety problem in most Western societies, compared with other age groups such as the young. However, they are involved in significantly more serious injury and casualty crashes per head of population (Federal Office of Road Safety, 1986; Mackay, 1988; Safety for Seniors Working Group, 1989; Evans, 1991) predominantly due to their increased frailty. This is more fully addressed in a later section of this report.

Furthermore, as the proportion of older people in Australia is expected to double approximately over the next 40 years, older road users will become more of a road safety problem in the years ahead. Hence, it is appropriate to examine the nature of older road user safety now and to develop a strategic approach to improving older road user safety in the years ahead.

Given previous research in this area, the Monash University Accident Research Centre were asked to undertake this review of the nature and extent of the older road user safety problem and to develop a strategy for future research and road safety management initiatives. To date, a strategy for older driver safety has been published (see Fildes, 1997) and this document is intended to address the other major source of injury to older road users, namely pedestrian crash involvement.

1.1 THE NEED TO CONSIDER OLDER ROAD USERS

The National Road Safety Strategy document published by the Federal Office of Road Safety (1992) stipulates that there is a need to pay special attention to road users who are particularly vulnerable to road crashes. They identify this group as comprising the young and the elderly, with special emphasis on pedestrians, bicyclists and motor cyclists.

The Victorian Road Safety Strategy “*Safety First*” published by VicRoads, the Transport Accident Commission and the Victorian Police (VicRoads, 1991) emphasise the importance of programs aimed at reducing the extent and severity of injury to pedestrians and other vulnerable road users. They list various initiatives aimed at improving awareness and reducing trauma among these road users.

Safety First nominated pedestrians in the age groups 9-17 and over 71 years as high target “at-risk” groups and identified the need to make roads safer for pedestrians as a high priority issue. Older pedestrians do have their own particular needs and difficulties when using the road, which need to be focussed on for improving their safety. Four elements relevant to older pedestrian safety identified by *Safety First*, included:

- the identification of high-risk locations, involving local government in the process;
- the introduction of design features and engineering treatments to make roads safer for pedestrians;
- the development of programs to improve the visibility of pedestrians; and
- to help health professionals understand the issues relevant to older pedestrian safety.

What is still missing in this country, though, is a detailed plan for addressing this road safety problem for the elderly. A strategic approach is required involving a review of the literature and other sources of information to examine the various issues related to ageing and older pedestrian safety. In addition, the identification of outstanding research items and potential countermeasures to improve the safety of older pedestrians is also required. These items need to be prioritised in terms of their likely importance and ease of undertaking. This report attempts to develop such a strategy for improving older pedestrian safety in the years ahead.

1.2 PROJECT OBJECTIVES

Three major objectives were identified for this project, namely:

1. to undertake a comprehensive state-of-the-art synthesis of current knowledge and practice related to older pedestrian safety;
2. to develop an older pedestrian research and action strategy, highlighting priority issues and areas in need of further resolution and research; and
3. to prioritise these needs for further improvement in older pedestrian safety.

While the older road user strategy was developed as a Victorian initiative, many of the issues and directions may well apply across Australia and even internationally. Thus, areas where national or international coordination is warranted were to be highlighted.

1.3 PROJECT TASKS AND LIKELY BENEFITS

The approach used in developing this strategy was similar to that used in the development of the older driver strategy outlined in Fildes (1997) and included:

- a review of relevant Australian and international literature;
- meetings and discussions with a range of experts in the field;
- consultations through a Project Advisory Committee of key organisations and specialists in the road safety field in Victoria; and
- to develop and prioritise a list of relevant research and action initiatives.

The strategy document is intended to be of greatest benefit to road safety researchers and practitioners by helping to identify programs aimed at reducing older road user trauma. Moreover, it attempts to address questions relevant to “*Safety First*” as well as to identify new areas of relevance to older road users safety. It is intended that this document will assist in setting the stage for future research and countermeasure initiatives aimed at reducing injuries to these vulnerable road users in this state as well as elsewhere.

2.0 Older Pedestrian Crashes & Population Changes

Crash statistics internationally and in Australia clearly identify the elderly as an “*at-risk*” group among both driver and pedestrian casualty crashes. They have been reported as significantly over-represented in pedestrian crash statistics in a number of publications (see Federal Office of Road Safety, 1986; Mackay, 1988; Safety for Seniors Working Group, 1989; Fildes, Corben, Kent, Oxley, Le & Ryan, 1994). It is commonly assumed that this results from their increased frailty and because of increased exposure (they are more likely to be pedestrians per head of population). The degree to which older people are also more likely to be involved in a crash is less obvious from these reports. Moreover, pedestrian deaths and casualties involving older people is expected to increase in the years ahead as the population ages. These findings are discussed in more detail below.

2.1 OLDER PEDESTRIAN CRASHES

Older pedestrians are the other side of the older road user safety problem relative to older drivers. Victorian statistics show that pedestrians aged 65 years and above accounted for 16% of all pedestrian casualties and 20% of those severely injured, as shown in Figure 2.1.

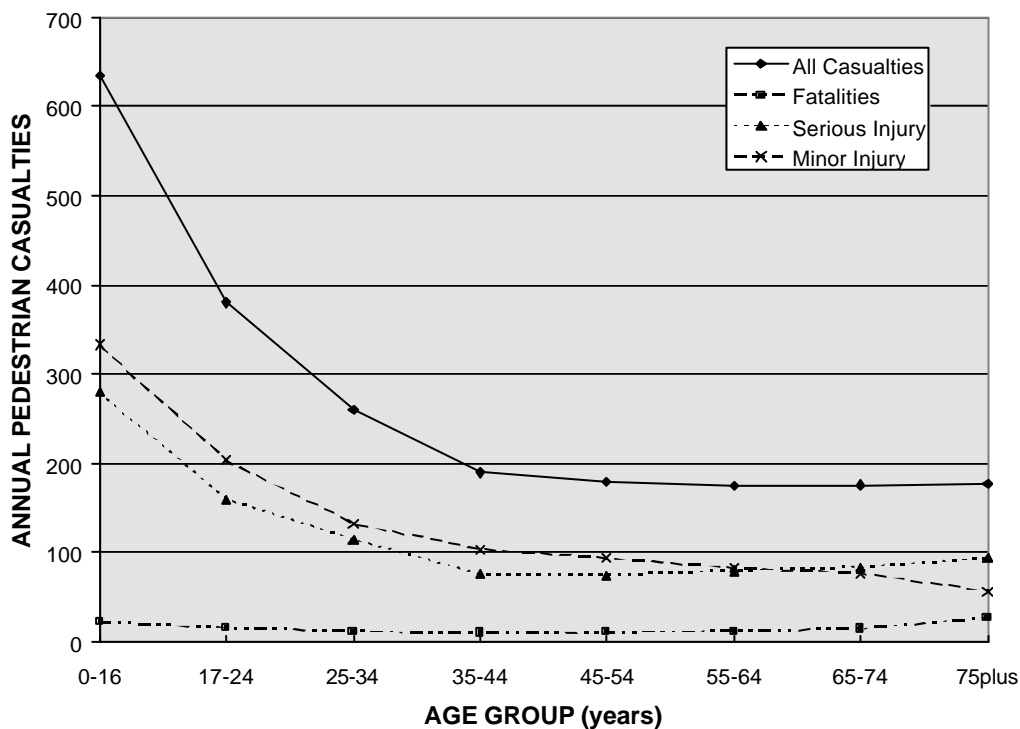


Figure 2.1 Annual average number of pedestrian casualties, Victoria, 1984-93

2.1.1 Crash Involvement

Each year around 550 pedestrians die on Australia's roads and a further 3,500 are hospitalised with serious injuries. Pedestrians aged over 60 years are disproportionately represented in these figures, accounting for 40% of total pedestrian fatalities, even though they make up only 15% of the population (Safety for Seniors Working Group, 1989). Relative fatality risks of pedestrians have been estimated to increase with increasing age (OECD, 1985), particularly for those aged over 75 years who are almost three times more likely to die in the event of a crash than their younger counterparts.

Pedestrian fatalities in Victoria alone averaged 144 per year during a seven year period between 1983 and 1989. While there was a considerable decline in the number of pedestrian fatalities, contributing to a 40% reduction, pedestrian fatalities in 1995, however, were 31% higher than in 1994. Further, an average of 992 serious injury crashes occurred between 1983 and 1989 in Victoria (Corben, & Diamantopoulou, 1996). Pedestrians aged 60 years or over accounted for 42% of total pedestrian fatalities and 19% of pedestrian crashes resulting in serious injury. By comparison, children 16 years or under, the other significant "at-risk" group comprised only 12% of fatalities but 27% of serious casualties (this difference is probably due to the frailty of the elderly predisposing them to fatal outcomes in the event of a crash).

The average annual number of pedestrian crashes in Victoria declines with increasing age, from about 380 for pedestrians aged 17 to 24 years to approximately 200 for pedestrians aged over 65 years (Fig. 2.1). Casualty rates per 100,000 population show a consistent increase in the rate of casualties from 44 years onwards (Fig. 2.2). Most noticeable is a sharp increase in the rate of serious injury and deaths for pedestrians aged 75 years and above (Fildes, Corben, Kent, Oxley, Le & Ryan, 1994).

While the trend in older pedestrian fatalities and serious casualties has shown a small decline over the last few years, the size of the problem is likely to increase in the following decades as the numbers and proportions of the elderly in the population increases.

2.1.2 Crash Risk

No data were available to adjust for travel differences of the various pedestrian age groups in Australia, which is an area requiring further research. However, if the numbers of pedestrian crashes are adjusted to take account of age differences in the population, then older people are significantly over-represented in serious injured and killed outcomes compared to their younger counterparts, as shown in Figure 2.2.

In the UK, Ward, Cave, Morrison, Allsop & Evans (1994) did attempt to adjust pedestrian casualty rates by amount of walking and number of road crossed for the Northampton district. They asked over 1000 residents of all ages to keep diaries of their walking patterns for a short period of time. They showed that pedestrians aged 65 and over were at higher risk per kilometre of travel for all walking as well as alongside traffic and per roads crossed than were adults generally but interestingly considerably less at risk than children and younger adults (see Figure 2.3). In addition, this seemed to be a particular problem for females. It would be useful in any future analysis to examine the rate of male casualties >65 years more closely as their rate is second lowest overall for men. Why this may be so is not clear.

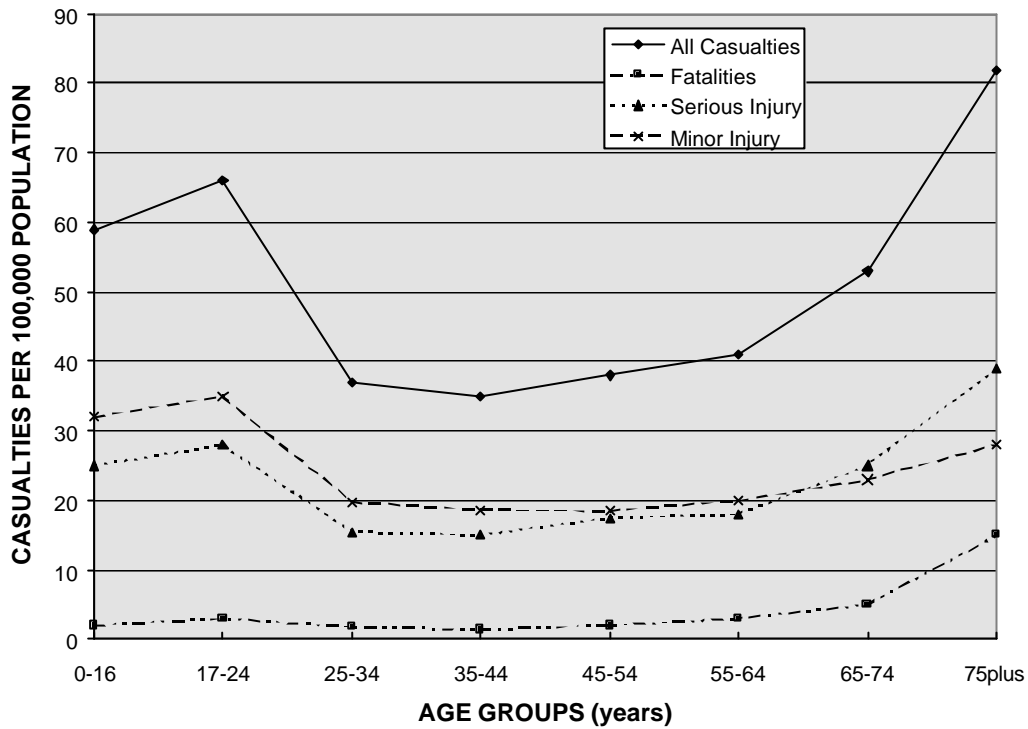


Figure 2.2 Annual average pedestrian casualty rate, Victoria, 1984-93

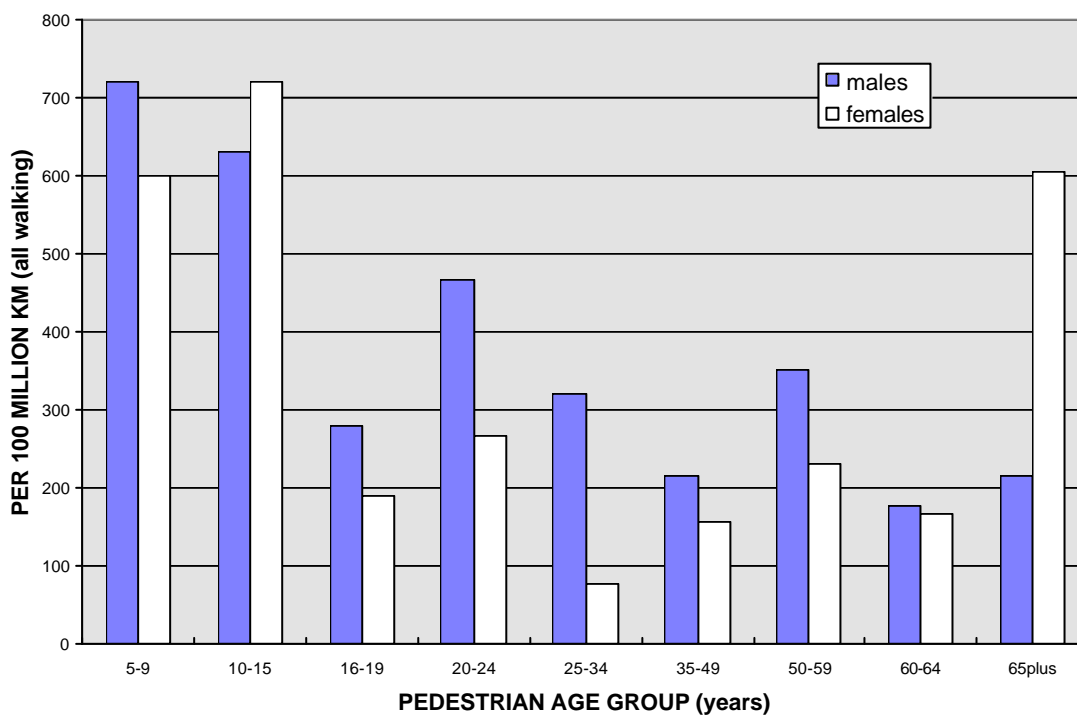


Figure 2.3 Casualty rates by age and sex per 100 million kms travelled (from Ward, Cave, Morrison, Allsop, Evans, Kuiper, Willumsen and Gleave, 1994).

2.1.3 Types of Older Pedestrian Crashes

The literature has identified a number of common patterns in crashes involving older adult pedestrians (Federal Office of Road Safety, 1986; Sheppard & Pattinson, 1986). In particular, older pedestrian crashes have been linked with reduced mobility (less able to quickly get out of the way of an oncoming vehicle). However, other evidence shows that pedestrian crashes involving the elderly often occur at intersections, and they often occur within one kilometre of their home (Federal Office of Road Safety, 1986; Safety for Seniors Working Group, 1989). Alexander, Cave & Lyttle (1990) further reported that most fatal and serious injury crashes involving older pedestrians occurred in inner city suburbs, on sealed arterial roads, on straight sections of roads and mostly in daylight hours.

Fildes et al (1994a) reported that 73 percent of older pedestrian crashes in Victoria occurred while attempting to cross the road, compared to other manoeuvres, such as crossing driveways, walking along the road with or against the traffic, stepping out from behind parked cars, on the footpath or alighting from a vehicle. Older people were over-represented in road crossing crashes compared to other age groups and were equally involved in crashes close to the kerb as they stepped off or on the far-side of the road. The Federal Office of Road Safety (1986) suggested that elderly pedestrians are usually observing the law and not behaving irrationally (as children or younger adults might). Fildes, Lee, Kenny & Foddy (1994) reported that elderly road users lack knowledge and understanding of current road rules, particularly in situations of right of way.

These findings are slightly different to those reported by Ward et al (1994) when adjusted for walking exposure (see Figure 2.4). They too found an increase in risk generally for those aged 65 years and over compared to other adults. However, there did not appear to be any marked difference in crash rate between crossing the road and other near-road pedestrian activities (there was a slight suggestion of an increase when crossing the road, but this is unlikely to have been a significant increase). Of particular interest, these findings show the marked increase in risk for children under 15 years when adjusted for walking exposure that has not been reported before. These are very interesting findings indeed and confirm the need for much more Australian research in this area as mentioned earlier.

Their crashes commonly occurred in 60km/h speed zones (urban areas) during daylight and in good weather conditions. Their collisions often occurred at intersections, especially those without traffic signals and suggested that they experienced difficulty with complex road manoeuvres. Further evidence of the role of complexity in older pedestrian crashes while crossing the road was recently reported by Oxley, Fildes, Ihsen, Day and Charlton (1995) from an investigation of road crossing behaviour of younger and older pedestrians.

2.1.4 Alcohol Involvement

A study of pedestrian crashes by the National Road Trauma Advisory Council (1995) reported that the most common factor in pedestrian crashes was a pedestrian error or misjudgment (65 percent) followed by the pedestrian being affected by alcohol and/or drugs (28 percent). This study further reported that pedestrians involved in fatal crashes were more likely to have been under the influence of alcohol and far more likely to have been severely affected than drivers. They reported that alcohol was a factor in a large number of deaths among adult pedestrians of all ages although the BAC levels were lower in older pedestrians.

The Federal Office of Road Safety (1986) also reported from their fatal file that alcohol was a factor in a large number of deaths among adult pedestrians of all ages. While the blood alcohol concentrations were again generally lower for older pedestrians, they argued that the effects of alcohol at any level of BAC may be greater for older people. Drivers affected by alcohol in the fatal file appeared to have caused relatively few older pedestrian deaths, although these data may have been clouded by the large number of cases where no BAC level was obtained.

Alexander et al (1990) found that 40% of adult pedestrian victims of all ages had been drinking and 24% had a BAC level exceeding 0.12. Pedestrians with BAC levels exceeding 0.10 have twice the crash risk of those below this figure. Males comprised 82% of victims exceeding the 0.15 BAC level of which two thirds were aged 20-39 years (the 40-59 year group, however, was also substantially represented). Fildes et al (1994a) failed to show any BAC over-involvement in casualty crashes for those aged 65 years and older. They argued that the Alexander et al (1990) finding was probably a consequence of the age groups selected in their analysis and any suggestion of an old age effect was likely to be confounded by time of day and location influences more than a general finding.

2.1.5 Nighttime Crashes

The National Road Trauma Advisory Council (1995) also found that adults aged between 26 and 59 years were more likely to be involved in pedestrian deaths at night and at weekends than their younger counterparts. However, those aged 60 years and over were more likely to be killed during the week and during daylight hours (84%). Nevertheless, 16% of older pedestrian deaths did occur during the night, generally before midnight. Alexander et al (1990) argued that most nighttime casualties for older pedestrians tend to be males and are heavily affected by their BAC level suggesting that these two effects are confounding.

The Federal Office of Road Safety (1986) reported that the most likely time of day for older pedestrian fatalities was between 4pm and 8pm and while many such deaths occur in the evening during winter, autumn and spring, a relatively large number also occur during summer mornings and evenings.

2.1.6 Ethnicity of Pedestrian Crashes

Very little is known about the role of ethnicity in older pedestrian crashes in this country as practically no data are collected on ethnicity of the victim in police and insurance road crash statistics. Hospital in-patient databases do collect data on the ethnicity of all patients admitted to public hospitals in this state and it would be possible to undertake an analysis based on the limited details collected by the hospital systems on road crashes.

In their summary of elderly pedestrian crashes, Alexander et al (1990) claimed that they appeared to be socially vulnerable, frequently living alone and/or dependent on others. They found that half of the group was, in fact, born outside Australia compared to only one-quarter of all pedestrians. The majority also lived in the inner suburbs of Melbourne. It is conceivable that different ethnic groups may have particular problems when using the road and this warrants further investigation.

2.1.7 Crash Causation

The cause of pedestrian crashes has not been examined thoroughly in the literature. Oxley et al (1995) suggested that many of these crashes seem to occur without the pedestrian being aware of

the approaching vehicle. This was also reported by Nagayama and Yasuda (1996) from a study of pedestrian collisions in Japan. They claimed that older pedestrians without a driving licence were 4 to 8 times more likely to have a pedestrian accident than those with a licence but its not clear whether both groups had similar levels of fitness. Whether the pedestrian or the car driver was in the “wrong” could not be ascertained from the crash data examined in either of these two studies. Indeed, very few studies were found in the literature that attempted to assess guilt or innocence of the pedestrian or the motorist in pedestrian crashes that would be worthwhile attempting in the future.

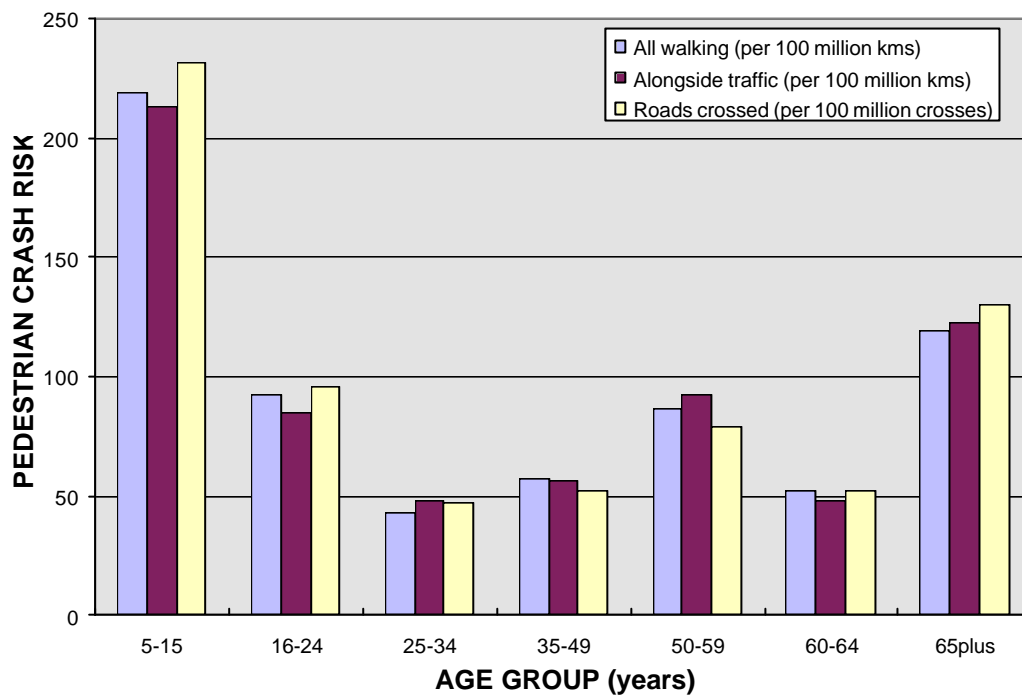


Figure 2.4 Casualty rates by age per 100 million kms travelled and roads crossed (from Ward, Cave, Morrison, Allsop, Evans, Kuiper & Gleave, 1994).

Oxley and her colleagues (1997) found a number of behavioural differences between younger and older adult pedestrians that may explain the over-involvement of the elderly in pedestrian crashes. These include performance decrements such as slowed walking speed, delay in leaving the kerb, a difficulty in judging appropriate gaps in the traffic in which to cross, and risky crossing strategies. These factors combined suggest that older adults may place themselves in great danger when crossing the road.

Further, the complexity of the traffic was raised in this study as a key issue in older pedestrian crashes. A combination of a complex traffic environment, fast speeds, and declining abilities to make appropriate judgements along with a failure to accommodate or modify behaviour quickly to avoid a potentially dangerous situation are several interacting sources of threat to the older pedestrian. This is supported by a number of other studies suggesting that older people are more likely than younger adults to become confused in busy, complex road situations (Sheppard & Pattinson, 1986; Carthy, Packham, Salter & Silcock, 1995).

2.1.8 Older Pedestrian Crash Costs

Crashes involving pedestrians aged 65 years and over were estimated to cost \$61million in Victoria (\$248 million for Australia) each year (Cameron, Day, Mach, Neiger & Fildes, 1994). The average claim cost for insurance compensation in Victoria for older pedestrians is about two-thirds that of younger pedestrian claims, essentially because of the lack of compensation for lost wages and earning capacity. There was little difference in hospital and rehabilitation charges for older and younger pedestrians, reflecting the general high level of severity of these collisions and the intensive treatment and rehabilitation often required for all age groups.

It is worthy to note that the long-term costs to society of the temporary or permanent functional disabilities suffered by elderly pedestrians are not known. Few studies have investigated ongoing costs of pedestrian trauma in Australia. One study includes an analysis of Transport Accident Commission (TAC) claims made by injured pedestrians during 1987 and 1988 and shows that the average total claim cost for older pedestrians is roughly 30-40% less than for younger pedestrians (Fildes et al., 1994a). This is a reflection of lower average claim costs on medical, rehabilitation, loss of earnings and earning capacity by older pedestrians. Further, the probability of claiming a death payment decreases sharply with age. Roughly one third of pedestrians aged 18-64 years who are killed have a death payment lodged, compared with only 2 percent of pedestrians aged 65-74 years, with no claims at all for those aged 75 years or more.

2.2 THE AGEING POPULATION

Much of the need for further research and management effort in this area relates to predictions of the number of older road users over the next 30 to 40 years as the present population ages. There are a number of relevant aspects that need to be considered.

2.2.1 A “Greying” Society

Most western societies predict substantial changes in the proportion of older persons in the foreseeable future as the current population ages. The so-called “baby-boomer” or post-war generation is ageing and the current younger generation is proportionally less, thus the society is said to be “greying”.

Predictions in Australia are for the proportion of older people to roughly double between 1990 and 2030 from 11% to around 22%, as shown in Figure 2.5. These figures are roughly equivalent to similar ones published for the USA (Stanfield 1996), in Western Europe (Schlag, Schwenkhagen & Trankle, 1996; Michalik, 1996; Hakamies-Blomqvist, 1996) and in Japan (Seo & Takamiya, 1996).

2.2.2 Chronological Vs Functional Age

Age is often described in the literature in terms of chronological or functional status. Chronological age is the easiest to define as it simply represents the number of years since birth. However, several papers have pointed out that years since birth can be a misnomer in terms of performance ability as humans of a similar mature age can differ substantially in terms of their performance abilities.

Functional age is more relevant as this equates human ability in terms of a common performance level. However, functional age can only be determined after a comprehensive examination of an

individual's abilities hence is not a useful concept for categorising population quickly. For this purpose, chronological age categories tend to be widely used for studies such as this one and this practice has been adopted here as well.

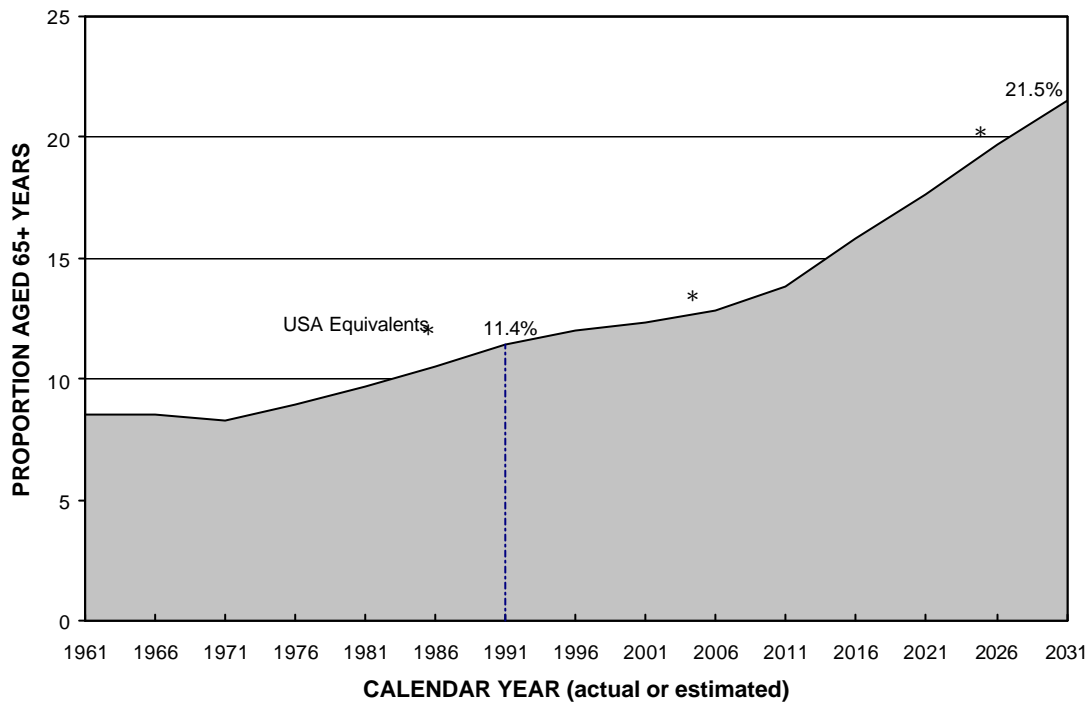


Figure 2.5 Proportion of Australian population aged 65 years or more (source: Young 1990)

What threshold level to set for old age is a second contentious issue in the literature. Some studies have chosen relatively early levels such as 55 years where there have been sound reasons to measure the onset of the ageing process. Others, such as those only interested in addressing the frailty issue have settled on a 70 to 75 year criterion. In general, 65 years (the traditional retiring age) has been most commonly accepted as the time when one enters the older age group and this seems to be a useful age threshold for this strategy review, too. However, it should be stressed that many of the problems of ageing can commence much earlier than 65 while others might not be evident much before one enters his or her seventies.

2.2.3 Mobility Issues

Mobility is essential to the quality of life of older people. While the majority of older people are relatively healthy, there is a need to preserve the mobility of the oldest people. Considerable research has focussed on the importance of keeping individuals independent in their own homes as long as possible. However, little systematic analysis has been conducted to determine how older people manage trips necessary to shops, to receive medical attention, to maintain social outings, and to associate with friends and family.

One way of preventing crashes involving elderly road users is to use legislation and/or group pressure to restrict their participation in traffic. Indeed, moves for licence renewal and restrictions are suggested for older drivers. However, while restrictions of this nature may have immediate

benefits by reducing crashes, these people will become pedestrians which is likely to result in other crashes, or to inactivity and withdrawal with detrimental consequences for their general health and social well-being. Similarly, while no legislation can restrict pedestrian participation, encouragement to restrict walking may well prevent crashes, but may also increase mental and somatic morbidity (OECD, 1985).

The issues of older driver licensing, graduated licences and stopping driving and availability and maintenance of alternative transport systems may have a great impact on a potential increase in the number of older pedestrians on our roads. One of the consequences of removing driving privileges for older people is an increase in the numbers of pedestrians and thus a road safety trade-off exists between these two modes of mobility for the elderly. At present, fitness to drive is usually assessed when concern for a particular individual's safety is raised with the licensing authority. The individual is then required to attend the licensing agency to discuss his or her driving and may be required to submit to a written or driving test. In most cases, the individual surrenders his/her licence voluntarily, however, in some cases it may be necessary to cancel the licence.

2.3 MANAGEMENT & RESEARCH NEEDS

There are a number of relevant management and research issues that warrant closer investigation from the examination of crashes involving older pedestrians as detailed below.

- A detailed assessment of the mobility needs of the elderly population is needed. Little is known about the importance of outings and how older people manage necessary trips.
- As the number of older pedestrians is likely to increase in the years ahead, there is a need to continue to monitor these crashes to ensure that appropriate countermeasures are in place to reduce the frequency and severity of injuries to older pedestrians.
- More details are also required on the particular types of crashes that are prevalent in older pedestrian crashes. This is relevant for the development of future crash interventions for older pedestrians.
- The role of ethnicity in older pedestrian crashes and whether particular ethnic groups are particularly at risk requires investigation.
- More information is required on the long-term consequences of older pedestrian trauma, including medical, economic, psychological and social consequences.

3.0 Ageing & Health Issues

Many of the health issues discussed relating to the older driver are also potential risk factors for elderly people crossing the road. It is clear that older people face major problems as pedestrians (Alexander et al., 1990; Transportation Research Board, 1989). However, the lack of pedestrian exposure data makes it difficult to determine whether older people are more likely to be killed as a result of injuries received in a pedestrian crash or whether they are more likely to be involved in a pedestrian crash than other age groups.

Older people do rely on walking for mobility more than any other age group thereby putting themselves at greater exposure to a crash. However, it has also been suggested that older people are less likely to be pedestrians than those in other age groups (Tobey et al., 1983, cited in Transportation Research Board, 1989). The ageing literature predicts that the ability to cross the road safely decreases with age. Older pedestrians' behaviour on the road may render them more vulnerable to being involved in a crash (Mathey, 1983; Harrell, 1990), where diminished skills, medical conditions, or a combination of both may place the elderly at a disadvantage when crossing the road.

It would be useful, therefore, to review the potential age-related factors that might put an older person at risk in pedestrian crashes. These include a range of declining skills including visual and hearing losses, perceptual, cognitive and motor declines, performance in complex environments, and medical conditions including ocular disease, dementia, arthritis, and medication use, as well as their susceptibility to injury per se.

3.1 THE AGEING PROCESS

Ageing is a complex process resulting in reduced performance in a variety of areas and there are many ways of defining what constitutes old age. In general, older people have been shown to perform more poorly than younger adults on a variety of measures of perception (Kausler, 1991; Staplin & Lyles, 1991), cognition (Salthouse, 1991; McDowd & Craik, 1988; Rabbitt, 1982), psychomotor response (Lerner, 1991, Stelmach & Nahom, 1992), and physical functioning (Brummel-Smith, 1990; Welford, 1985). While onset of these deficits is slow and many older people are able to adapt to these changes, some older people remain unaware of their reduced capabilities or may not compensate adequately. Moreover, increasing age is often accompanied by an increasing incidence of medical conditions.

3.1.1 *Susceptibility to Injury*

In addition to the increased risk of crash involvement for older pedestrians the outcomes of crashes are more severe. As in the case of older drivers and vehicle occupants, Vestrup and Reid (1989) have demonstrated that older pedestrians, too, are more vulnerable to severe injury or death once a crash has occurred. Indeed, Cameron et al (1994) suggested that pedestrians as a whole are the road user group with the highest injury severity, and that among pedestrians, the elderly sustain a substantially higher severity of injury than do younger pedestrians.

The aged body is less able to withstand trauma. A number of age-related physical and functional changes contribute to the vulnerability and increased susceptibility to injury of older people. Ageing is associated with a progressive loss of adaptability. Frailty due to decreased bone mass, osteoporosis, decreased muscular strength and cardiovascular degeneration increases with age. All these changes result in a lower tolerance to injury following road trauma.

3.1.2 Perceptions of Ageing

It is well documented that many elderly people deny that they are old and tend to identify themselves as younger than their years (Linn & Hunter, 1979). While reduced skills can affect safety as a pedestrian, older people are generally also unaware of the impact of ageing on their ability to perform tasks (Sabey, 1988), thereby accentuating their risk of injury. Sabey reported that knowledge and judgement of age-related declines was poor among older people and that they were less able to react to these changes in their behaviour than their reduced abilities would dictate. These factors combined constitute an increased potential for older people to be injured while crossing the road.

Matthews (1986) investigated the relationship between perceived skill and/or confidence in one's driving abilities and perceived risk as a function of age. He found that older drivers (along with younger drivers) see risks of crash as being a problem for their peers and not themselves. Similarly, they believed that they possessed the necessary skills and abilities to avoid crashes, but not their peers.

3.2 DIMINISHING SKILLS

A number of age-related physiological and functional changes may contribute to a decrease in safety for older people when on the roads. Many of the documented changes that affect driving ability can also be considered risk factors when elderly people consider crossing roads (Fildes, 1997). However, these associations are not as well recognised for elderly pedestrians as they are for elderly drivers. A safe road-cross requires the pedestrian to:

- both see and hear the traffic,
- recognise all potential hazards,
- decide how to respond appropriately, and
- execute a safe physical movement.

The perceptual, cognitive and motor declines that accompany age raise questions about how well older pedestrians can perform in all phases of the road-crossing task. A review of the literature shows that impairments affecting driving such as visual decline, hearing loss, perceptual, cognitive and motor declines can also be related to pedestrian performance. These impairments will be discussed separately.

3.2.1 Visual Declines

As with elderly drivers, declining vision presents a problem for the older pedestrian. While researchers typically consider vision to be responsible for the greatest proportion of sensory inputs for drivers (Shinar & Scheiber, 1991; Kline, Kline, Fozard, Kosnik, Scheiber & Sekuler, 1992), it is difficult to determine what specific visual skills are essential for safe road crossing. Considering,

however, the importance of vision in performance of daily activities, in appropriate detection of potential hazards, in balance and ambulation, changes in the visual system are likely to have profound effects on an elderly person's ability to walk safely in complex traffic situations.

Ageing generally leads to a number of deficits in the visual system. These include losses in dynamic and static visual acuity, peripheral field loss, resistance to glare (tolerance and recovery time), a reduction in contrast sensitivity, and low sensitivity to the light source. Moreover, older people experience a decline in visual processing speed, visual search capabilities, perception of angular movement and alignment and movement in depth, and colour vision (Kosnik, Sekuler & Kline, 1990; Klein, 1991). However, few studies have demonstrated whether these visual impairments affect older pedestrian safety.

Retting (1988) reported that visual impairment among the elderly attempting to cross a wide road resulted in an inability to distinguish between the "walk" and "don't walk" signs from across the street. He also noted an inability to determine the boundary between the kerb and the street, resulting in some pedestrians stepping off the kerb and into the path of oncoming vehicles. In support of this, Fildes et al (1994b) noted that older pedestrians experienced difficulty with edges that are hard to see and high gutters, suggesting that greater use of edge delineation is required where there is a lack of contrast between uneven surfaces and steps. Further, Sheppard and Pattinson (1986) found that 63% of the respondents did not see the striking vehicle until it hit them. Other interview studies have also indicated some relationship between visual difficulties and crash risk. For instance, Carthy et al (1995) showed deterioration in the ability to see distant objects clearly among older pedestrians, particularly in the oldest group (85+ years).

Visual acuity - this refers to the ability to discriminate fine detail. Two forms of visual acuity, static and dynamic, are recognised, both of which show age-related declines. Dynamic visual acuity in particular has been related to high crash risk for drivers in a number of studies (Burg, 1964; Shinar & Scheiber, 1991), yet few studies have tested for or subsequently reported a relationship between dynamic visual acuity declines and pedestrian performance. Many of the visual requirements for road crossing require the assessment of changing information on the retina and hence it would seem inconceivable that dynamic visual acuity was unimportant here too. Loss of dynamic acuity may therefore result in difficulties in perceiving vehicles from the rest of the optic array, and can affect depth and motion perception leading to inaccurate estimations of vehicular distances. Clearly, more research is urgently needed here.

Contrast sensitivity - is the ability to perceive visual detail under differing levels of contrast between a target and its background and is shown to diminish with age (Bouwhuis, 1992). Reduced contrast sensitivity in a complex environment may put the older pedestrian at higher risk of a crash. The older person is more likely to have difficulty discriminating details of objects (such as the kerb) and moving objects (oncoming vehicles) and this difficulty could explain Fildes et al., (1994b) finding that older pedestrians reported problems seeing edges and high gutters on the road.

Visual field - it is well noted that a contraction in field of view and "blind spots" are associated with age through degenerative process such as glaucoma (Corso, 1981; Scheiber, 1992; Ball & Owsley, 1991). Again, few studies have focussed on the relationship between field of view and performance of elderly pedestrians, although studies conducted with elderly drivers have reported an association. Older adult drivers with 61-90% shrinkage in their useful field of view were found to be six times more likely to have incurred one or more crashes in the previous five years (Ball, Owsley, Sloane, Roeneker & Bruni, 1994).

Lovie-Kitchin, Mainstone, Robinson & Brown (1990) showed that visual field extent influenced mobility performance in low vision patients. The impact of small field size on mobility suggests that a relationship may exist between field of view and older pedestrian crash risk, although this needs to be scientifically confirmed. Considering the importance of field of view in balance and ambulation, a reduction in visual field of view may affect an elderly person's ability to perform efficiently in complex traffic situations.

Visual information processing and search capacities - it has been shown that older adults require longer processing times than younger adults to complete peripheral and central visual information processing tasks. Walsh (1982) for instance, showed that older people experienced greater delays between presentation of a stimulus and response. Further, older people take longer to identify stimuli in a visual search task (Rabbitt, 1982), suggesting that they are less able to use efficient scanning strategies. It seems that with increasing age, the flexibility in visual scanning, particularly when a rapid decision is required, is diminished. For the older pedestrian, quick interpretation and efficient scanning of important stimuli would seem paramount for safe road crossing. No studies, however, have investigated this aspect of visual performance and its impact on pedestrian safety.

Effect of glare - night time may also pose a particular problem for elderly pedestrians whose visual system needs more time to accommodate to changes in illumination levels. With great difficulties experienced in reduced levels of illumination, greater scattering of light, and reduced retinal functioning, the older pedestrian may be at more risk in darkness because they need greater brightness contrast and minimum glare. Poorly lit roads, pavements, and signs, as well as intense luminance from car headlights and street lighting will create visual problems for these people. Prolonged exposure to glare is also likely to impact on pedestrian performance through muscular fatigue (Shinar & Scheiber, 1991) resulting in longer times required to recover and reach stable visual performance (Olson & Sivak, 1984). The effects of glare have been associated with a high involvement of fatal crashes at night for older drivers (Mortimer & Fell, 1988), however, this has not been demonstrated for pedestrian risk.

3.2.2 Hearing Decline

Little research has been conducted examining the relationship between age-related hearing loss and safe traffic participation. Grattan and Jeffcoate (cited in Carthy et al., 1995), suggested that hearing deficits may cause problems in localising sounds and consequently in ascertaining from which direction a vehicle is approaching. Indeed, interview respondents considered they had some noticeable hearing loss, particularly the oldest group of females and that this influenced their mobility (Carthy et al., 1995). Further, Carthy et al suggested that if visual and auditory information is incongruent, confusion may result and lead older pedestrians to panic. This is another area for which further research is warranted.

3.2.3 Perceptual Declines

Part of the increased risk of crashes for the older road user may also be attributable to visuoperceptual declines which impair the ability to detect integrate, organise and interpret changes in the traffic correctly. Specifically, age differences in the ability to perceive depth and motion can increase the likelihood of erroneous crossing decisions for older pedestrians.

Depth perception - diminished proficiency in depth perception can lead to difficulty in orientation and misjudgments of the nearness of obstacles in the environment, such as the distance of an oncoming vehicle or the distance of a step from the ground. Kausler (1991) suggests that such misperceptions are major contributing factors to the frequency of accidents found for the elderly.

Motion perception - accurate perception of the distance and speed of moving vehicles is pertinent to the road-crossing task. The evidence regarding age-related deficits in motion detection suggest that older adults are less accurate in estimation of time-of-arrival than younger adults (Schiff, Oldak & Shah, 1992). For the older pedestrian, accurate gap selection is vital; information about moving traffic must be combined with information about their own walking speed, and this must be re-assessed as age increases and walking speed slows (Lee, Young & McLaughlin, 1984). In their observations of road crossing behaviour, Oxley et al (1997) found that some older pedestrians (particularly the slowest and oldest ones) left very little time between reaching the centre of the road and the first oncoming vehicle reaching the crossing point. They attribute this finding to a reduced capacity of the oldest pedestrians to judge safe gaps and to appropriately compensate for their slower walking speed.

Whether this difficulty results from an inability to judge distance or estimate speed of approaching vehicles is not clear. Scialfa, Kline, Lyman & Kosnik (1987) found that the elderly judged vehicles to be travelling more quickly than was judged by the young. More recently, Scialfa, Guzy, Leibowitz, Garvey & Tyrell (1991) found that relative to younger adults, older adults tended to overestimate at lower speeds and underestimate at higher speeds. Oxley and her colleagues are currently examining this issue further.

3.2.4 Cognitive Declines

Accurate cognitive performance is fundamental in the road crossing task, incorporating recognition of a stimulus, selection of relevant inputs for processing, integration of information, choice of the appropriate way to respond, and coordination of resultant behaviour. Inattention and deficiencies in information processing have been attributed to many older driver crashes (Planek & Fowler, 1971; Transportation Research Board, 1988; Ranney & Pulling, 1990). Reduced information processing capacity may render older pedestrians less efficient at simultaneously processing incoming information in order to decide on a safe course of action. Further, slowed reaction time, decision time and memory capacity have been identified as potential problems for the older pedestrian (Carthy et al., 1995; Safety for Seniors Working Group, 1989).

McDowd, Vercreyssen and Birren (1991) and Salthouse (1991) reported that processing resources are more limited for older than younger adults and diminishes with increasing age. Older people experience more difficulty than younger adults selectively attending to the most important stimuli (Transportation Research Board, 1988; Maule & Sanford, 1980). Corso (1981) and Kausler (1991) also reported that older adults experience difficulty in detecting and identifying relevant visual cues, ignoring irrelevant stimuli or distracting information. Rabbitt (1965), Madden, Connolly and Pierce (1994) further argued that they have difficulty in dividing attention while Triggs, Fildes and Koca (1994) claimed they were less able to integrate information from several different sources of information simultaneously.

For the older pedestrian in complex and fast moving traffic, the simultaneous processing of many sources of information is difficult. Reductions in reaction and decision time may also put the older pedestrian at greater risk than their younger counterparts. With advancing age there is a tendency to

take longer to acquire information, process that information, select and plan a response and execute that response (Lerner, 1991). It has been demonstrated that older drivers require more time and information prior to responding especially under conditions of uncertainty (Planek, Barrett, Sterns & Alexander, 1977) and some studies point to a similar need for pedestrians (Safety for Senior Working Group, 1989; Oxley et al., 1995). Increased reaction and decision times means that older pedestrians have shorter intervals than younger pedestrians in which to respond to potential hazards, and to correct misguided actions.

3.2.5 Age-Complexity Effect

Many studies have shown that older people have much greater difficulty dealing with complex situations than younger adults (Salthouse, 1991; McDowd & Craik, 1988; Oxley et al., 1995), particularly where some time or speed stress is involved. Older pedestrians often find multiple-choice traffic environments confusing and difficult to manage. The complexity of many traffic situations demanding quick and accurate judgements may place overwhelming demands on cognitive processes of elderly pedestrians resulting in higher risk of crashes than for younger pedestrians. A number of studies have found that elderly pedestrians were over-involved in accidents in complex traffic environments including busy intersections, and in high-density traffic (Alexander et al., 1990; Safety for Seniors Working Group, 1989; Oxley et al., 1995).

Sheppard and Pattinson (1986) showed that many pedestrian crashes occurred at difficult places to cross and in many instances, the pedestrian was confused. From interviews with older people, they reported that the majority claimed that road crossing was difficult because of the volume and speed of traffic, confusing (many roads joining) and oncoming traffic hard to see because of parked cars. Oxley and her colleagues (1997) found that in two-way traffic many older pedestrians made more unsafe crossing decisions than younger pedestrians, leaving very little time between reaching the centre of the road and the first oncoming near-side vehicle reaching that point. Further, many crossed with close moving traffic in both directions, thus putting themselves in great danger of being caught out in the traffic. In one-way traffic, however, their behaviour was more safe and similar to their younger counterparts.

Oxley attributed these differences to the traffic environment, arguing that road crossing in two-way traffic is a more cognitively complex task for the older pedestrian than crossing in one-way traffic. Difficulties arise in two-way traffic where the older pedestrian is confronted with multiple source of information and must make quick and accurate decisions based on the most important stimuli. Changes in the traffic must be monitored and efficient cognitive processing and a regularly updating memory system is essential to cross busy roads safely. Compared to younger adults, the older pedestrian may be impaired in complex traffic because they have a reduced ability to retain information in memory while simultaneously processing other information sources. Thus, they have less of the relevant information available when it must be integrated or evaluated to reach a decision.

The crash involvement of older drivers in complex traffic situations has been well documented (Stelmach & Nahom, 1992; Stamatiadis, Taylor & McKelvey, 1991; Ranney & Pulling, 1990). Road accidents for older drivers are often characterised by slowness in identifying and reacting to rapidly developing traffic situations. For the older driver, the risk of a multiple-vehicle intersection accident increases, particularly when making right turns. Further, manoeuvres such as changing lanes, merging, leaving from a parked position, and reversing are more evident in the crashes of older drivers than younger drivers. These driving situations involve complex speed and distance

judgements under time constraints. For the older pedestrian, however, more research is needed to demonstrate an association between over-involvement of crashes and complexity of the traffic environment.

3.2.6 Physical Declines

Fast and efficient motor performance is important when faced with fast moving traffic, particularly in emergencies where actions must be executed quickly. Motor performance, however, declines with increasing age as a result of neuromuscular and strength changes and postural and gait changes. For elderly pedestrians, mobility problems increase the risk of being involved in a crash because of slower walking speed, the need for frequent stops, difficulties in starting, with stumbling, and poor entero-posterior or lateral balance. It is possible for older pedestrians to compensate for these difficulties by increased gap acceptance and seeking out safer places to cross the road, although the degree to which they are able to do so is not well researched. Older people do take longer to leave the kerb, delaying twice as long as their younger counterparts, and spend more time crossing the road (Safety for Seniors Working Group, 1989; Oxley et al., 1995) than younger adults, potentially leaving them exposed for longer times to dangerous situations. Further, motor control is of prime importance when faced with traffic emergencies where actions must be executed quickly.

Muscular and strength declines - the elderly suffer general physical weakening; they lose agility and endurance, and experience cardiovascular degeneration, musculoskeletal wasting, and neuromuscular weakening. These physical changes may result in associated pain, stiffness, abnormal movements, and impaired coordination and reaction abilities (all essential for safe road crossing performance).

Instability - poor balance control mechanisms and declines in postural reflexes in the elderly has consistently been related to impaired mobility and injury risk (Overstall, Exton-Smith, Imms & Johnstone, 1977; Verillo & Verillo, 1985). For the elderly pedestrian, balance control is an important aspect of safe and efficient road crossing. Elderly people tend to sway more than younger adults (Overstall et al., 1977; Lord, Clark & Webster, 1991) and are less able to correct balance after a stumble (Brummel-Smith, 1990). Further, a loss of righting reflexes, an increase in body sway, and inefficient functioning of sensory organs that monitor balance cause instability and this can be accentuated when confronted with fast moving traffic (Overstall et al., 1977). In order to maintain balance older pedestrians often move slowly and cautiously, look down at the ground, look for support when standing, and may prolong the decision to cross a road. Carthy et al (1995) noted that difficulty or discomfort in walking was clearly an important feature in pedestrian safety, along with sense of balance.

3.3 MEDICAL CONDITIONS

A further consideration of possible risk factors for older pedestrians includes a discussion of general health issues. While it is sometimes difficult to distinguish between “normal” and “pathological” ageing, a discussion of medical conditions that may intensify the difficulties experienced by the elderly and affect performance on the road is worthwhile.

Physical well being affects physical performance. A number of comprehensive reviews have examined the role of medical conditions on the driving competency of older persons (Janke, 1994; Marottoli, 1996) and, as with normal age-related skills, most of these conditions can be applied to

the older pedestrian. Dementia, arthritis, osteoporosis, various eye conditions, cardio- and cerebrovascular conditions and medication use would seem most relevant to older pedestrians. These conditions are discussed briefly below.

An important issue to note is the role of multiple medical conditions in crashes. Co-morbidity of medical conditions and diminished skills is prevalent among the elderly (Waller, Naughton, Gibson & Eberhard, 1981, cited in Janke, 1994). Waller (1992) noted that while an elderly driver or pedestrian may be able to compensate adequately for a single impairment (for example, arthritic pain), it becomes more difficult to compensate for added effects of other conditions or diminished skills such as impaired vision or confusion in complex traffic.

3.3.1 Eye Conditions

Ageing is associated with physiological changes in the visual system that have been well documented (Kline, Kline, Fozard, Kosnik, Scheiber & Sekuler, 1992; Klein, 1991) and a decline in functional vision occurs progressively from around 60 years in normal ageing. This is due not only to the effects of normal ageing, but also on eye diseases prevalent in the elderly. The most important causes of significant decline in visual acuity, visual field and contrast sensitivity are age-related ocular diseases including macular disease, cataract, glaucoma, and diabetic retinopathy. Macular degeneration, cataracts, glaucoma and diabetic retinopathy are common in the elderly population and account for 11% of new patients with legal blindness (Fozard, Wolf, Bell, McFarland & Podolsky, 1977).

Cataracts - are one of the most common eye conditions in the elderly population, occurring in between 5 and 7% of those above 65 years (Scheiber, 1992) and are characterised by an opacity and clouding of the lens that impairs vision. Early cataracts may cause little decrease in visual acuity but can affect light scattering, glare sensitivity, colour perception and night vision. Advanced cataracts can impair high-contrast acuity. While being the most common ocular condition, it is also one of the most easily and successfully remedied.

Macular degeneration - is characterised by the development of deposits behind the retina, followed by degeneration of the retinal pigment epithelium, bleeding or scarring and atrophy in the macular area of the retina. When this occurs there is a significant decrease in vision, and a scotoma (blind area) in the central field of view (Klein, 1991). While not losing all sight, loss of central vision frequently renders people with macular degeneration unable to read road signs or to see vehicles (Klein, 1991). Macular diseases may have a large impact on vision for detail and is estimated to account for around 45% of the vision problems in elderly persons (Fozard et al., 1977).

Glaucoma - is often characterised by high intraocular pressure associated with damage to the optic nerve and visual field abnormalities. There is often a gradual constriction in the peripheral visual field, which can result in loss of all vision. Further, abnormalities in contrast sensitivity may be present. An elderly pedestrian with glaucoma may experience difficulty seeing cars approaching from the side (Klein, 1991).

Diabetes mellitus - the incidence of this condition increases with older age, affecting between 10 and 20% of the elderly population (Klein, 1991). It is characterised by accelerated ageing of the arteries, and one of the long-term complications of this disease is blindness. People with diabetes are also at higher risk of developing cataract and glaucoma. As diabetics achieve greater longevity, the retinopathy associated with the disease has become more of a problem in the elderly population.

While there is a large literature concerning the relationship between ocular conditions and driving in the elderly, and little doubt that vision is important to pedestrian safety, no empirical evidence exists relating these conditions and pedestrian performance.

3.3.2 Dementia

Dementia involves impairment of memory in association with impairment in judgement or abstract thinking, other disturbance of higher cortical function, or personality change and is estimated to occur in as many as 15% of persons over 65 years of age (Kaszniak, 1987, cited in Kaszniak, Keyl & Albert, 1991).

Alzheimers disease - is thought to be the most prevalent form of dementia, estimated to be around 12% for those aged 65 years or older and as high as 48% for those aged over 85 years (Janke, 1994). This condition commonly results in slower performance on timed tasks than unimpaired counterparts, and there is little doubt that this would impact on pedestrian safety. Janke (1994) provides a comprehensive discussion of dementia as a risk factor in driving ability. In their assessment of cognitive deficits in demented drivers and accident risk, Parasuraman and Nestor (1991) found that attentional functions, particularly that of switching visual selective attention from one source of information to another, are impaired even in the early stages of dementia and contribute to increased accident risk. While no evidence is cited relating this to pedestrian performance, it may be assumed that older pedestrians with dementia would face similar diminished abilities as older drivers to function appropriately in traffic.

Parkinson's disease - is an impairment that includes mental slowness, lack of initiative, forgetfulness, impairment of cognition, and mood disturbance. This disease may be particularly debilitating for older drivers and pedestrians because of its effects on neuromuscular performance. Parkinsonism results in slowness of movement, rigidity, tremor, and extraocular motor abnormalities. While few studies relate Parkinsonism with driving performance, Ritter & Steinberg (1979, cited in Janke, 1996) found that 43% of patients with Parkinson's disease still had drivers licenses, although a number had voluntarily given up driving. The prevalence of active elderly pedestrians with Parkinson's disease is unknown.

An association between dementia, particularly of the Alzheimer type, and driving errors and crash performance is recognised even though patients with dementia may limit their driving (Friedland, Koss, Kumar, Gaine, Metzler, Haxby, Moore & Rapoport, 1988; Kaszniak et al., 1991; Eberhard, 1996). While it is reasonable to assume that the effects of dementia would be similar for older drivers and pedestrians, this has not been firmly established. Further, little is known about the specific perceptual/cognitive deficits contributing to impaired road use.

3.3.3 Arthritis

Mobility is a key component of the quality of life. Rosenbloom (1989) suggests that the elderly have both personal and environmental problems that prevent them from walking more. Reductions in mobility and range of movements, strength, and reduced physical endurance are often the result of arthritis. This is a common condition among older people, estimated to affect more than 50% of those over 65 years and severely in 12% of this age group. Roberts and Roberts (1993, cited in Janke, 1994) argued that osteoarthritis with accompanying pain is probably the most common cause of musculoskeletal disability among the elderly.

Range of motion is restricted with arthritis where older pedestrians may experience decreased head and neck mobility, along with difficulty in walking and involuntary hesitancy. These skills are necessary for detection of hazards, and executing fast, accurate actions. Janke (1994) cited a study by John States which suggested that arthritic joints and tight musculature result in a loss of range of motion and increased reaction times. He also noted that general discomfort and pain leads to fatigue and distraction while on the road, thereby possibly contributing to crashes. However, this hypothesis has not been proven to date.

Furthermore, there are no studies that have clearly established driver or pedestrian crash risk for arthritis sufferers. Given the high prevalence rate of arthritis in the older population and the possible safety consequences, this would be worthy of further research.

3.3.4 Cardio- and Cerebrovascular Conditions

Cardiovascular conditions including angina, coronary and rheumatic heart disease, myocardial infarction, arrhythmia pulmonary disease and hypertension, along with cerebrovascular conditions or transient ischaemic attacks (as a result of stroke), may affect road crossing skill. Janke (1994) cites studies suggesting that these conditions can affect safe driving as a result of shortness of breath, a decreased capacity to undergo exertion, weakness, pain of angina pectoris, symptoms such as dizziness of blurred vision, mental disturbance and loss of consciousness. Further, while some of these conditions can be controlled through medications, several of these drugs have side effects which can impair driving (Janke, 1994). The effects of these conditions and driving ability have been researched but there is little conclusive evidence and no direction for addressing this problem. No studies have been conducted associating performance decrements while crossing roads with any of these disorders. Clearly, this is an area requiring further research.

3.3.5 Medication Use and Polypharmacy

Use of prescription medications may constitute a real risk for elderly pedestrians because of harmful interactions and various psychotropic effects. Use of prescribed drugs is prevalent among the elderly, with this group receiving a larger proportion of all prescriptions than any other age group. Further, it is suggested that the elderly are more sensitive to the effects of medications than younger adults (Ray, Gurwitz, Decker & Kennedy, 1992). A number of studies have attempted to correlate medication use with increased injury risk in the elderly, particularly the risk of falling.

Medications are thought to contribute to injury risk in the elderly in a number of ways, including, (i) sedation slowing reaction time and diminishing awareness of hazards, (ii) impairment of postural stability, and (iii) impairment of balance through use of aminoglycoside antibiotics, aspirin, quinine, furosemide or alcohol. There are good reasons to conclude that some drugs might contribute to injury risk for older pedestrians, however, there is little evidence directly implicating specific medications, or combinations of these medications and risk on the road. Many medications are considered, from knowledge of their systemic effects, to have the potential to adversely affect road skills. Janke (1994) cites inconclusive evidence relating drug use with driving skill. No studies were found that examined the effect of medication use on pedestrian performance. Clearly, research that examines the effects of medication on pedestrian safety is warranted. It should, however, be pointed out that quantifying the risk is difficult and many older people require continuing medication (including polypharmacy) for their on-going health and quality of life needs.

3.3.6 The Role of Health Professionals

Not only can medical practitioners assist in advising the elderly about pedestrian safety and the dangers arising from diminished health and loss of skills, but other health care professionals, too, are in a good position to provide similar advice. Such health care professionals can include district nursing services, occupational therapists, optometrists, ophthalmologists and low vision clinics, cardiovascular centres, the arthritis foundation, cancer organisations, community health care associations, etc. There are a number of other community groups and clubs, too, who can monitor the health and safety of their clients and advise and promote safety pedestrian habits when necessary. Programs such as Victoria's "Walk-With-Care" can be arranged for group demonstration through VicRoads to help provide this information.

3.4 HEALTH MANAGEMENT & RESEARCH ISSUES

Before effective preventive strategies can be developed and implemented to reduce mortality and yet maintain the mobility and independence of older road users, some major challenges need to be addressed. Foremost among these is the identification of "high-risk" older pedestrians. Age-related declines in sensory, perceptual, cognitive and motor functions along with disabling health conditions may put some older pedestrians at higher risk of crash.

It has been argued that many crashes are caused by human error and that the elderly precipitate their own accidents because they behave incompetently or irresponsibly when crossing the road. Efficient pedestrian participation requires a combination of well-developed skills that allow an individual to assess changing traffic, and to choose and execute appropriate responses. Despite the vitality of many older people, the effects of diminished age-related skills and health conditions predict that the ability to perform complex tasks becomes more difficult.

This brief review considered the effects of older people's diminishing skills and health issues on pedestrian performance. The effects of the majority of these issues for older pedestrian safety have not been investigated thoroughly. A number of conclusions therefore can be drawn about the current state of knowledge and areas where further research and/or management initiatives are required. These are discussed below.

3.4.1 Diminished Skills Potentially Important

The ageing conditions discussed in this review are similar to those noted for older drivers (Fildes, 1997). Visual losses through normal ageing include diminished visual acuity (both static and dynamic), contrast sensitivity, field of view and visual information processing and visual search. Hearing loss may also influence the safety of older pedestrians. The relationship between pedestrian safety and either vision or hearing declines has not been established and a number of research and management needs have been identified to provide a better understanding of the relationship between these factors.

Perceptual and cognitive processing seems to influence pedestrian performance. Normal ageing of these systems appears to influence appropriate traffic judgements, including detection of moving vehicles, judgement of safe gaps in which to cross, reaction and decision times, and executing timely actions. While some evidence exists to suggest a relationship between pedestrian risk and skills in these areas, further research is warranted to highlight these risks and their potential influence on pedestrian safety.

Mobility is of major importance to pedestrians. Age-related physical declines along with associated slower walking speeds, instability, and inability to execute actions quickly, however, heighten the risk of crash for older pedestrians. An association between slowness and high risk for pedestrian safety has been documented.

The age-complexity effect was discussed as another major determinant of risk for older pedestrians. It seems that the risk of being involved in a crash is increased in difficult or complex traffic for older pedestrians. Again, while there is some evidence of a relationship between complexity and increased risk this requires further substantiation. Further, it is not clear how and if pedestrians are aware of the effect of diminished skills and particular difficulties in complex situations and compensate for their disabilities. This would be worth further investigation.

3.4.2 Health Conditions Potentially Important

Ocular diseases common in the elderly include the conditions of cataract, glaucoma, macular degeneration, and diabetic retinopathy. Each condition is prevalent in the older population and would seem to influence pedestrian safety. With poor vision as a consequence of ocular diseases, the task of accurately detecting objects, particularly moving vehicles, during road crossing would necessarily be a difficult task for the older pedestrian.

Cognitive degeneration (in the form of dementia) has been raised as a risk factor for older pedestrians. While some research has been conducted reporting on rates of demented drivers and the need to cease driving, any consideration of the effect of the removal of these people from the driving population has not been attempted. One of the consequences of this may be an increase in the number of demented pedestrians on the roads. No data on the rates of demented pedestrians is available, nor is there any evidence of the effect of dementia on road crossing ability.

Further, the disabling condition of arthritis would result in great difficulty of mobility, particularly in some situations where fast movement is required. Any evidence of their road safety risks for the older pedestrian, however, is either not conclusive or not available and requires further substantiation.

Cardio- and cerebrovascular conditions may effect performance on the road. Inconclusive evidence relating these conditions and driving performance is available, however, no evidence exists either on the prevalence of these conditions among elderly pedestrians nor what effect they have on road crossing performance. This requires investigation.

3.4.3 Relevant Research Issues

The safety of older pedestrians in traffic is a pressing issue, given the trend for continued growth of the elderly sector of the population, along with discussed changes to licensing requirements for older drivers. It is clear then that there is a great need for more research into the factors affecting older pedestrian safety. Much research has focussed on the relationship between various age-related declines and medical conditions and the older driver, however, few relationships have been established for older pedestrians. It is probable that all risk factors identified for older drivers are applicable to older pedestrians, however, this needs to be substantiated. The areas most in need of further research include the establishment of:

- an association between visual and hearing impairment and crash risk
- an association between the complexity of the traffic and crash risk

- an association between medical conditions (ocular disease, dementia, arthritis and cardio- and cerebrovascular conditions) and medication use and crash risk

3.4.4 Relevant Management Issues

Once an association between reduced skills and medical conditions and pedestrian performance has been established further initiatives may be able to be put into place. This is a sensitive issue requiring knowledge of specific factors affecting older pedestrians. Unlike the management of older drivers, there is no facility (in the form of licences) to restrict or prevent high-risk groups from walking and crossing roads. However, initiatives to encourage health professionals to identify and advise older adults on the risks associated with pedestrian travel may help to reduce pedestrian risk. Indeed, this is one factor identified in the “*Safety First*” road safety strategy (VicRoads et al., 1995).

It is first necessary to assist health professionals understand the issues relevant to older pedestrians. Identification of “high-risk” people is of primary concern for health professionals. Recognition of which skills and medical conditions that may affect efficient performance on the road is vital. Medical practitioners and other health care professionals then may be in a good position to advise the elderly about pedestrian safety. They can make them more aware of the dangers arising from diminished sensory, physical and cognitive skills and the effects of particular conditions, and can warn them about potentially unsafe road crossing behaviours and conditions.

Alternative methods to reduce pedestrian risk include behavioural countermeasures such as awareness and education packages. It may be possible for medical practitioners to identify people at risk and refer them to road safety programs (such as the VicRoads “*Walk-With-Care*” education and advocacy program). Initiation of future road safety initiatives must take into account key risk factors for older pedestrian safety and incorporate them in such a way to convey the most appropriate messages to older people.

4.0 Environment, Engineering & Education Issues

Researchers and practitioners alike have raised a number of other issues regarding older pedestrian safety and these are discussed further in this section. The road environment has received much interest as a means to improve older pedestrian safety. However, many design features are lacking in consideration of the mobility needs of the elderly. These include the lack of convenient crossing facilities, fast walk cycles on pedestrian crossings, poor legibility of road signs, difficult entries/exits on public transport and high speed levels. These findings question whether roads are equipped to match the needs and abilities of the older person whose functional abilities have declined with age. In addition, the road crossing behaviour of older pedestrians, vehicle design, attitudes of drivers to pedestrians, knowledge of current road laws and the topic of exposure will be discussed in this section.

4.1 ROAD ENVIRONMENT

The road system itself may contribute to the level of risk elderly pedestrian face and may be better adjusted through improved roadway design to suit the needs and abilities of older persons resulting in prevention of some pedestrian crashes in the elderly (Transportation Research Board, 1989). In their literature review of the factors contributing to pedestrian crashes, Struik, Alexander, Cave, Fleming, Lyttle & Stone (1988) identified a number of aspects of the road environment relevant to pedestrian casualty crashes. These include:

- the characteristics of the road and surroundings,
- the road section (whether it's a mid-block or intersection),
- type of traffic control and its compliance level,
- traffic and pedestrian volumes,
- any engineering innovations which alter usual functions, or
- other visibility and/or conspicuity issues.

The adoption of a number of improvements to the road environment has been suggested by a number of researchers, however, adjusting the roadway system to promote the mobility and safety of older pedestrians is not an easy task. Urban planners and traffic engineers often do not consider the pedestrian when designing roadways, particularly older pedestrians. Roads and pedestrian facilities are built according to standards based primarily on measures of performance of young adults (Waller, 1991), the system is complex, and the needs and abilities of older pedestrians vary widely. Pedestrians are often forced to divert from their intended routes through subways and over footbridges, creating mobility problems, and promoting crossings in unsafe places if climbing stairs is difficult. Traffic control systems often do not take pedestrian demand into account (Carsten, 1992) and older people are often encouraged by poor placement of pedestrian crossings (particularly around shopping centres) to cross in places where they may not be able to cope adequately.

In addition, Calder (1986) noted that major roads and thoroughfares have few facilities that enable older people to rest and use conveniences and many pedestrian crossings have inadequate time periods. Fildes et al (1994b) also argued that many footpaths are badly surfaced and are frequently congested and that road lighting is often inadequate to illuminate pedestrian crossings at night.

Traffic engineering countermeasures have been very popular and often successful in the last few decades and many roadway design countermeasures aimed at pedestrian safety have been implemented. A continued emphasis on providing a safer traffic environment in areas where there is a high population of elderly pedestrians should be stressed.

Clearly, increased pedestrian safety would be achieved by reducing traffic volumes in high pedestrian areas by encouraging alternative routes. A redefinition of the traffic function of a road would reduce the conflict between people and vehicles without unnecessary restrictions on movement on the pedestrian's behalf. A reduction in traffic volumes would result in decreased exposure to risk for pedestrians. Further, for the older pedestrian, a reduction in traffic means a less complex traffic environment with associated lower demands on crossing decisions.

4.1.1 Complex Roads

The literature on ageing documents clearly the effect of task complexity on performance. Older adults seem more affected than younger adults as the conditions of a task become more complex and demanding (Salthouse, 1991). It has been argued that a complex road layout may contribute to the increased risk of an accident for older road users. Complex traffic situations may act to provide further interference to an information processing facility which may already be affected by the ageing process (Ernst & O'Connor, 1988; Triggs et al., 1994). A complex road environment would necessarily lead to difficulty in making appropriate decisions for older adults because they must integrate and process many sources of information. The majority of pedestrians in Sheppard and Pattinson's (1986) study complained of difficulty in the crossing place as a result of busy and fast traffic, difficulty in seeing traffic, and confusion because many roads joined or traffic lights confused them when trying to decide when it was safe to cross.

A number of road situations have been identified as potential hazards for older pedestrians due to the difficulty they present to older adults. These include intersections, reversing vehicles, two-way traffic and tram stops.

Intersections - despite the availability of signal lights, walk lights, marked walkways at intersections and stop signs, a substantial number of injuries to older pedestrians occur at intersections, particularly unsignalised intersections in urban areas. Turning vehicles pose particular problems for older pedestrians (Retting, Van Houten, Malenfant, Van Houten and Farmer, 1996; National Highway Traffic Safety Administration, 1981). The complexity of many intersections requires extra effort for pedestrians to ensure a safe crossing. They must not only look left and right on the road being crossed, but also must look both forward and backward for turning vehicles from the intersecting road.

Research conducted at the National Highway Traffic Safety Administration (1981) reveals three major pedestrian hazards at intersections:

- left-turning vehicles (equivalent right-turn in Australia) where the vehicle has to cross at least one lane of oncoming traffic before making the turn;

- risk when first stepping off the kerb (the pedestrian is most at risk when first stepping off the kerb because the driver may not notice the pedestrian until they are on the roadway);
- cars exiting the intersection where drivers may not see pedestrians in the “far” crossing section as easily as they do those in the “near” crossing section; and
- drivers who typically increase speed as they exit the intersection.

Few countermeasure design initiatives have been suggested to decrease the complexity of intersection crossings for older pedestrians. Measures including larger and high contrast road signs and improved lighting requirements and pavement surface to accommodate the needs and restrictions of older pedestrians with failing eyesight and reduced mobility are likely to be important.

Perhaps measures to assist drivers to detect crossing pedestrians would be more beneficial. Under Victoria’s road safety regulations, the driver of a turning vehicle at an intersection is required to give way to pedestrians crossing the road into which the vehicle is turning. However, conditions sometimes result in a proportion of drivers failing to see the pedestrian crosswalk and failing to see a pedestrian as they are crossing. Catchpole and Morrissy (1997) investigated the conspicuity and legibility of “give way to pedestrians” signals and found that clear, well understood signs are effective reminders to drivers of the obligation to give way to pedestrians. Good placement, visibility and maintenance of signs would be expected to be effective in reducing vehicle-pedestrian conflicts.

Reversing vehicles - older pedestrians are over-represented in crashes with reversing vehicles (Fildes et al., 1994), particularly reversing from car parks and driveways. This type of crash often occurs as a result of inattention on both the driver and pedestrians behalf, and problems in anticipating unexpected events by older pedestrians. Drivers often do not look carefully enough and rearward visibility from a vehicle is poor, and cues such as the sound of the car engine often go unnoticed by the pedestrian. In a road situation, usually a pedestrian is concentrating on moving vehicles and safety in relation to them, rather than parked cars that might start to move. In a parking area risk may be underestimated because speeds are generally slower and it is not perceived as a roadway. Further, the pedestrian may consider the footpath to be non-threatening and fail to recognise that a driveway intersecting the footpath can be as dangerous as the intersection of two roads.

No countermeasure initiatives to reduce collisions of this type were cited. Installation of barrier fencing where parking bays are present would encourage pedestrians not to cross in locations that may be hazardous. Further initiatives targeting driver awareness may serve to reduce these types of crashes.

Undivided roads - as noted previously, older pedestrians are over-involved in potentially unsafe crossings by comparison with their younger counterparts on two-way roads (Oxley et al., 1995; Carthy et al., 1995). A number of older pedestrians accept gaps in the traffic which are too short to compensate for their slower walking speed, thereby risking collision with oncoming traffic on undivided roads. They further make judgements on the near-side traffic and commence to cross without consideration of the far-side traffic, often needing to interact with the traffic in the middle of the road.

Provision of median refuges through hazardous sections of arterial roads, particularly in areas with a high number of older pedestrians has been identified as a potentially effective countermeasure for pedestrian safety (Safety for Seniors Working Group, 1989; Corben & Diamantopoulou, 1996). Refuges not only provide a safe section in which to rest in the middle of the road but also simplify the

crossing task in busy complex traffic environments, enabling a two-stage crossing with attention focussed in only one direction at a time. Given the fact that older people experience further difficulty in interrupting a particular action to reassess the traffic situation mid-course, it is of great benefit that a road crossing is broken down into more manageable stages. The provision of medians may also act to reduce vehicle travel speeds, further enhancing safety for pedestrians.

Through an initiative of the West Australian Department of Transport, it has become common practice to install median islands on main roads. An evaluation study of one section of road showed that after installation of median strips the pedestrian crash rate was halved even though the traffic volume increased by 50 per cent (Safety for Seniors Working Group, 1989). There is still, however, a need to evaluate the importance of median strips as a countermeasure to older pedestrian safety in high density pedestrian areas in Victoria.

Tram stops - a higher proportion of older pedestrians are involved in crashes when boarding and alighting trams than their younger counterparts. Corben and Diamanopoulou (1996) found that tram involvement was high amongst crashes with up to 30% of pedestrians struck by trams either while on pedestrian crossings or immediately after alighting from trams. In other cases, trams were indirectly involved in that other vehicle types struck pedestrians boarding or alighting trams. They argue that provision of safe access to and from trams is a high priority issue.

Measures such as skid resistant pavement road surfacing, installation of safety zones, perceptual countermeasures to influence driver speed perception, and awareness of drivers of the heightened pedestrian crash risk around the vicinity of tram stops may reduce the risk to pedestrians alighting and boarding trams. An evaluation of the effectiveness and importance of these measures is needed.

4.1.2 Pedestrian Signals

While Alexander et al (1990) reported that elderly pedestrians have a high level of traffic light compliance at pedestrian crossing facilities compared to other age groups, over 40% of older pedestrian crashes still occur at signalised crossing facilities. They suggested that three factors may contribute to these crashes; first, a failure to complete the crossing procedure within allotted pedestrian signal phase, second, a failure to perceive or anticipate unexpected vehicle movements, and third, an inability to take appropriate avoidance action.

It is well documented that older people experience difficulty at signalised crossings (Fildes et al., 1994; Safety for Seniors, 1989); walk phases are too short for them to complete the road cross, and phase signals are often confusing. Traffic engineers assume a walking speed of 1.2metres per second to allow adequate time for pedestrians to cross a road, yet many older persons walk more slowly than that. Measurements of the walking speed of elderly pedestrians aged 70 years or more in Sweden revealed that most of them failed to reach a speed of 1.4m/sec. necessary to cross safely at signalised intersections (OECD, 1985). This is a sensitive issue for traffic planning, where maintenance of traffic flow, particularly on busy arterial roads, is deemed to be paramount. While a longer cycle time would accommodate their slower walking speeds, this would impose large delays on motorists. Further, there are many differences in vehicular and pedestrian traffic volume, lane width, and geometric design on road sections, particularly at intersections where a single standard for pedestrian signals is impossible. Nevertheless, it will become more important for traffic light cycles to reflect older pedestrian crossing times as the population ages in the years ahead.

It has been suggested that traffic engineers should be more attentive to potential problems at the local level and should make site-specific adjustments when appropriate. For instance, at

intersections adjacent to or in areas used regularly by older people, priority may be given to either phasing traffic lights to give adequate time for older pedestrians to cross or provide pedestrian-activated signals, or refuge islands at the median. Further, signs could be made bigger and brighter which would benefit pedestrians as well as drivers. It has further been suggested that audible as well as visual signals, and more appropriate visual aides should be included at signal controlled intersections frequently used by older pedestrians (City of Port Melbourne and South Melbourne, 1990).

The difficulty of “walk” and “don’t walk” phases has also been raised as a potential hazard for older pedestrians. The walk time (green “walk” display) is intended to ensure that the pedestrian, once started, will keep going forward rather than return to the starting point, assuming a walking speed of 1.2m per second. The clearance interval (flashing red display) is intended to be sufficient to allow a pedestrian that commences crossing at the end of the walk time to reach the far kerb or median strip; this assumes a walking speed at 1.5m per second. These signals have not been applied consistently and many pedestrians, not just older ones, may be confused about when they have the right of way. Signs should be clear (an elderly pedestrian may have greater difficulty in understanding what is expected of him/her) and well displayed, especially in a complex environment such as a shopping street. The design and placing of signs and signals should also accommodate the elderly (a sign placed too high, for instance, will not be seen by an older person who finds it difficult to raise his/her head).

A continuing effort aimed at improving placement, maintenance, walk times, and cycle times of pedestrian signals would encourage greater use, compliance and safer crossing movements with traffic signals by older pedestrians.

4.1.3 Conspicuity of Pedestrians

While this is referred to as an important feature of pedestrian safety in the “*Safety First*” Road Safety Strategy (VicRoads et al., 1995), little evidence of research or countermeasure initiatives in this area was cited. While wearing of reflective stickers or light coloured clothing is encouraged as part of the “*Walk-With-Care*” program, little evidence exists describing whether this is an effective measure to reduce pedestrian crashes or not. Furthermore, compliance in wearing light clothes and/or reflective stickers has also not been studied.

Kerb extensions are an engineering measure introduced in a number of shopping centres. These have a two-fold benefit. Not only do they reduce the width of the road to be crossed, but they aid visibility of pedestrian crossing from in between parked cars. In addition, improved street lighting, particularly at intersections and pedestrians operated signals, would offer drivers a better awareness of pedestrians. Pedestrians would be able to be seen more readily and sooner so that drivers can take evasive action if needed.

4.2 SPEED LIMITS

Recommendations for reduction of speed limits are widely accepted and practiced in all areas of road safety. Lowering of speed limits in residential streets and areas where there are large numbers of older pedestrians (shopping centres, around clubs and social venues) would dramatically enhance the safety of pedestrians in these areas. If older pedestrians are inattentive and often cross roads

without being able to assess the situation appropriately, then other measures such as speed reduction is a worthwhile measure so that emergency stops are possible over shorter distances.

It has been suggested that the chances of a pedestrian being killed when hit by a vehicle rise dramatically as the speed of the car increases (Proctor, 1991; McLean, Anderson, Farmer, Lee & Brooks, 1994). Higher vehicle speeds reduce the time available to drivers to avoid conflict with pedestrians and, if a pedestrian is struck, the higher energy transfer will result in more severe injuries. McLean and his colleagues (1994) demonstrated that a reduction of only 5km/h in vehicle travelling speeds could result in a reduction of 30% of the incidence of fatal pedestrian collisions and in 10% of cases a collision with a pedestrian could be avoided altogether. This strongly suggests that an innovative approach is required to reduce vehicles speeds to uniformly lower levels in pedestrian environments.

Modification of the road and the roadside to induce drivers to travel at speeds more appropriate in areas of high pedestrian density can reduce the potential conflict with pedestrians. In particular, measures such as narrowing road pavements/widening footpaths, constructing medians, and “streetscaping” in areas such as strip shopping centres tend to influence driver behaviour. They bring about lower speeds, by conveying to drivers that they are passing through an environment where road use by vehicles should be equitably shared with pedestrians. Perceptual countermeasures that influence driver sensory perception have been shown to be effective in speed reduction in different types of conditions (Fildes & Jarvis, 1994). Measures such as visual patterns and road surface treatments providing a tactile or audible stimulus serving to reduce the perception of riskiness have the potential to be developed into cost-effective pedestrian crash countermeasures in high density pedestrian areas. In addition, provision and maintenance of skid resistant road surfaces would improve the braking capabilities of vehicles on both wet and dry surfaces, thereby reducing the risk of severe impacts with pedestrians.

4.3 VEHICLE DESIGN

Characteristics of vehicle design can have a marked effect on the nature and severity of the injuries sustained by a pedestrian struck by that vehicle. McLean (1991) argues that while exterior vehicle design has changed, these changes have not been introduced primarily to protect the pedestrian even though the severity of injury is strongly influenced by the crashworthiness of the vehicle. This, he argues, is a result of two misperceptions. The first is that the severity of the impact forces are such that there is little opportunity to reduce them by changing the design of the vehicle, and secondly, that the pedestrian is run over by the striking vehicle.

It is the vehicle, not the ground, that causes most of the serious injuries to pedestrians, and in a typical collision the victim strikes the bonnet, hits the windscreen with the head, then rotates on the roof and then falls to the road. A long bumper lead is hostile for the legs and may increase the head impact velocity. The base of the windscreen in small cars is also a hostile zone frequently struck by heads of adults and the front edge of the bonnet of many cars can lead to serious pelvic and femur injuries particularly for older pedestrians (Mackay, 1988). It would be clearly advantageous for the pedestrian not to make contact with the windscreen, roof or road. Ideally, a bonnet construction should be such as to provide some cushioning effect.

There has been a marked change in the overall frontal shapes of passenger cars during the past two decades which will benefit pedestrians, however, the recent increasing trend of four-wheel drive

vehicles in the vehicle fleet may impact on pedestrian safety. The OECD (1985) recommended the development of vehicle frontal structures so as to limit injuries to elderly pedestrian collision victims who have reduced body strength characteristics. While vehicle test procedures to optimise the level of protection afforded a pedestrian in the event of a collision have been developed overseas little assessment of the influence of frontal design on the risk of significant injuries has been conducted in Australia.

4.4 PUBLIC TRANSPORT SYSTEM

Public transport is normally provided in most cities. Most Victorian cities are provided with train and bus transport, with the addition of tram facilities in inner Melbourne areas. While a number of problems with public transport for older users have been raised, little research has been conducted of the extent of difficulties for older users of the public transport system. In their interviews with pedestrians, Fildes et al (1994b) found that, apart from regularity of the service and cost, older pedestrians expressed some concern about step height, getting on and off public transport vehicles and getting to and from the service. Further, many older people fear surrounding traffic and as a result curtail their excursions. Nighttime travel on public transport is out of the question for most older people in other than high density and very secure services.

Taxi services are also available as an alternative form of private transport. However, many older people do not like using taxis as they have limited resources, are unaccustomed to the regular use of taxis and often feel quite vulnerable and unsafe in a car driven by a stranger. Further, while discount rides are available for older people, the cost of taxi travel is often too costly for pensioners.

Some local communities have attempted to overcome these problems by providing special community bus services for the elderly and disabled. These can operate either on a regular pre-booked schedule or occasionally on an "on-call" basis. With recent restrictions in health and local government funding, many of these existing services are no longer available. No documented evidence is available on the use and user reaction to these services and this would seem to be one area where further research would be warranted.

Straight (1996) argued that there is a general lack of policies in the US and other countries on providing alternative transport for older people. She reported on a pilot study where fit older volunteers provided rides for less able senior citizens. This pilot program has met with considerable success and the use of older people as chauffeurs seems to have overcome the natural uneasiness with taxi drivers. It may be worthwhile to introduce policies to initiate a similar form of alternative transport for the older population in Victoria.

4.5 OTHER CONFLICTS IN THE ROAD ENVIRONMENT

Several environmental factors have been raised as potential hazards for older pedestrians. These include uneven paths, surfaces and high gutters, poor edge delineation, presence of overhanging trees and shrubs on walkways, and poor street lighting. These factors make the task of walking on the footpaths difficult for older pedestrians as a result of declining eyesight and mobility difficulties.

In addition, a new problem has emerged for the elderly. This is an increased rate of cycling, skateboard riding and rollerblading on footpaths resulting in an increase of danger for pedestrians (Safety for Seniors Working Group, 1989). Unlike crashes on the road, collisions involving the

elderly and these other footpath users are often unreported, but are claimed to be an increasing problem. For the older pedestrian, the ability to get out of the way of these fast moving footpath users is difficult and may result in serious and sometimes fatal injury. Further, older people are encouraged to cross roads in potentially hazardous places as a means of avoiding congested footpaths made dangerous by cyclists, skateboard rider and rollerbladers in areas such as local shopping centres (Calder, 1986).

An effort by local government to maintain footpaths, particularly uneven surfaces and overhanging trees would reduce the risk of a stumble or a fall while walking. Further, legislation prohibiting footpath use by cyclists, skaters and those using rollerblades in high pedestrian areas may also reduce collisions with older pedestrians.

4.5.1 Speed Humps

An increasing problem for pedestrians generally but older pedestrians in particular is confusion about right-of-way on speed humps in this country. These devices were designed initially as a speed reduction measure with considerable success in traffic calming especially on residential streets and at shopping centres. Markings typically involve two solid lines running across the top of the hump at approximately 2-3 metres spacing with a series of comb-like bars running off the transverse lines towards the road surface leading up to and away from the hump. These marking give the impression of a pedestrian crossing to many older people and not unusually they can result in conflict between the pedestrian and the driver of an approaching vehicle. What makes matters worse is that there are instances where speed humps also incorporate pedestrian crossings, although these are normally hatched in the usual manner associated with a pedestrian crossing. Nevertheless, there is considerable potential for these traffic management devices to cause confusion and possibly pedestrian crashes and it would be useful to carry out some research to see if a more appropriate method of marking speed humps is not possible to eliminate this confusion.

4.6 CRASH EXPOSURE

While crash data show a decrease in the number or rate of pedestrian crashes, the majority of studies do not include information about pedestrians average exposure in terms of roads crossed, of distance travelled or of time spent on the roads. Therefore, it is difficult to determine whether this downward trend is due to safer pedestrian travel, or, alternatively, because it has become more dangerous but with a disproportionate reduction in the amount of pedestrian travel.

There are no readily available data on trends in exposure rates for pedestrians in Australia. It is commonly believed that older pedestrians compensate for their degraded skills by reducing their exposure through walking less, not walking at peak traffic times, and not walking at night. However, the degree to which older pedestrians compensate by exposure reduction is not clear and little is known about the amount of walking and its relationship to the number of pedestrian crashes. This makes the task of providing an accurate estimation of the older pedestrian problem a difficult one because it is not possible to be very definitive about the relative “riskiness” of pedestrian travel.

The lack of exposure data makes it difficult to determine whether older people are more likely to be killed as a result of higher involvement in pedestrian accidents, their increased frailty or because they are exposed to traffic for longer periods of time while actually on the road. Some have argued that the high fatality rate for older pedestrians is simply due to their greater reliance on walking for

mobility, they spend more time crossing the road and therefore are exposed for longer periods to a dangerous situation and more likely to have a collision. Tobey et al (1983, cited in Transportation Research Board, 1989) suggests, however, that older persons are actually less likely to be pedestrians than those in other age groups.

Data used to investigate pedestrian crashes in Australia has often been extracted from police road crash reports pertaining to persons killed or seriously injured and adjusted for head of population using ABS population data. In this way, child and older pedestrians are highlighted as high-risk groups. Ideally, however, high-risk groups should be identified from crash involvement rate per exposure (i.e., time spent on the road, number of roads crossed, or kilometres walked). Currently, however, this is not possible because exposure data are not available (Cameron et al., 1994).

A comprehensive study investigating pedestrian activity conducted in Britain by Todd and Walker (1975, cited in Clayton, 1993) showed that evaluating casualty rates against different measures of pedestrian activity showed different patterns of risk for different ages and sexes of pedestrians. In the case of older pedestrians these measures of exposure indicated even greater increases in risk over younger adult pedestrians than were apparent from rates per head of population.

A more recent study in Britain (Ward et al., 1994) sought to establish a methodology to gain a measurement of pedestrian exposure to risk and to define appropriate units for measurement in different road environments. They found that people aged over 65 years walked the least amount and crossed the least amount of roads overall compared with other age groups. Given that the distance travelled and roads crossed by the elderly is much smaller than that walked by younger adults, the risk of being involved in a crash is greatly increased for this group.

Firth (1982) argues that exposure measures are vital for identifying factors contributing to crashes and that studies which do not account for exposure can only give clues about the extent of certain types of accidents. Measures of exposure can make an important contribution to increasing the understanding of the patterns of walking of pedestrians of different ages and in different parts of the road environment. Any findings will necessarily contribute to direction of future research into pedestrian safety and provide more information available to inform policy decisions about the safety of the pedestrian environment.

4.7 AWARENESS, EDUCATION AND TRAINING CAMPAIGNS

Changes in the environment or in vehicle design are indirect ways for reducing pedestrian collisions. Education, publicity and training can also be used to affect behaviour more directly. While behavioural interventions have been thought to be less effective than other countermeasures, particular for the elderly, Evans (1990) argues that behavioural factors are playing an increasingly larger role in traffic safety and that more emphasis should be put on intervention programs aimed at altering human behaviour and attitudes.

4.7.1 Crossing Behaviour

Crossing the road is the largest single cause of trauma between vehicles and pedestrians. While it has been noted that a higher proportion of older pedestrians have a tendency to cross at signalised crossings than their younger counterparts, a sizeable proportion of older people also cross the road mid-block and therefore increase their risk of being struck by a vehicle. Corben and Diamatopoulou (1996) observed a tendency for all age pedestrians to use the shortest and/or

quickest route to cross, and showed a definite reluctance to walk substantial distances to use pedestrian signals or other facilities.

The over-involvement of the elderly in pedestrian crashes has often been attributed to incompetence and ineptitude in traffic. Physical, perceptual and cognitive impairments could be associated with a general decline in road user skills. Older pedestrians may fail to detect oncoming vehicles, and fail to cross roads quickly enough to evade oncoming traffic. They are often unaware of the changes in their own ability to cope with the risks involved in being a pedestrian (Sabey, 1988), making them more vulnerable road users.

Research suggests that the elderly tend to behave more carefully than other adults do when crossing roads. They are more likely to stop at the kerb and spend more time at the kerb (Safety for Seniors Working Group, 1989), more likely to make use of controlled crossings and other aids, and more likely to cross directly rather than diagonally (Arnold, Bennett & Hartley, 1990). Wilson and Grayson (1980) observed road crossings by adult pedestrians in shopping streets without crossing facilities. While they found some age differences they were small in magnitude. They concluded that in behavioural terms, the elderly do not appear to form a distinct sub-group within the adult pedestrian population. Similarly, Wilson and Rennie (1981) observed the behaviour of pedestrians using crossing facilities. They, too, found only small differences including larger kerb delays and crossing speeds for the elderly. They concluded that the elderly tend to be more cautious and observe the rules and that their crossing strategies cannot be said to increase their risk. They suggested that higher crash involvement is likely to be a consequence of the inherent characteristics of the group and the limitations these impose upon the capacity for swift and evasive action in a threatening situation.

Others, however, report demonstrations of more unsafe behaviour while crossing (Carthy et al., 1995; Oxley et al., 1997), and a tendency to cross in places that minimise walking distance and delay (not necessarily the safest places to cross) (Daff, Cramphorn, Wilson & Neylan, 1992). Oxley and her colleagues (1997) found that while older pedestrians displayed cautious behaviour while waiting on the kerb, they took longer to leave the kerb, spent more time crossing the road, and adopted more unsafe crossing strategies than younger pedestrians in complex two-way traffic. The older group (particularly those aged over 75 years) crossed with closer moving traffic both in the near and far side more often than younger pedestrians, often finding themselves caught out in the traffic and less able to cope. This, however, was not the case in one-way traffic. In simpler traffic, the older adults made more safe traffic judgements. Carthy et al (1995) found similar differences between young and older adult pedestrians on two-way streets in the UK and drew similar conclusions about potentially unsafe road crossing behaviours adopted by older pedestrians. It may be that in simpler traffic situations, older people are more able to compensate for their declining abilities and can cope as well as their younger counterparts, but when the demands of the task are high and complex decisions need to be made, collisions are more likely to occur.

In addition, Fildes et al (1994b) found a lack of understanding of who has right of way at give way (unsignalised) intersections. This was particularly the case for older pedestrians. They argued that, as many of the pedestrians interviewed had never held a licence to drive, they would not have been required to formally learn these rules. This confirms the need for on-going education of rules of rights of way between vehicles and pedestrians with a particular focus on pedestrians.

Older pedestrians often expect the driver to brake or to alter their course to avoid them and frequently do not accurately assess drivers' future actions. Many pedestrians either become anxious

or uncertain of their rights at crossways or choose not to cross at the signals at all but at a nearby location. Compliance by elderly pedestrians with signals is often poor due to problems coping with fast and heavy traffic, confusing traffic lights and confusing roads.

Awareness and education strategies - behavioural factors have been shown to play a large role in traffic safety (for instance, changes in seat-belt wearing rates, drink driving, bicycle helmet wearing rates, and speed reduction through attitude change). Educational strategies for older pedestrians have been suggested that focus on providing specific information on the dangers and risks when walking. They should also encourage awareness among drivers of the right of pedestrians when in traffic, and avoidance of certain behaviours and adoption of others to make a significant contribution to their safety (Federal Office of Road Safety, 1986). Intervention programs aimed at altering human behaviour have been criticised and thought to be less effective in this age group. In general, the elderly are considered to be fiercely independent, unwilling to admit they have difficulties, they are self-assertive, suspicious of offers of help, do not see themselves as the ones who should change their behaviour, and value their mobility. However, others have argued that appropriately designed interventions should work just as effectively for older adults as younger adults (Kent & Fildes, 1997).

Very little intervention programs for older pedestrians have been attempted. The ‘*Walk-With-Care*’ initiative established by VicRoads in 1991 which targets the elderly through the local community, has been effective in reaching a large amount of older pedestrians in Melbourne and country Victoria. This program incorporates education (awareness, discussions, information on safety and hazards facing older pedestrians), advocacy and, where appropriate, local traffic engineering improvements thus providing a link between older people in the community and those responsible for planning and development of traffic management facilities (Addicoat, 1991). To date, though, there has not been an evaluation of the program since its inception in 1991. A recent review of the structure, format and administration of the program identified new messages and more effective ways to convey existing ones so that the program is implemented with maximum efficiency, accountability and quality control (Kent & Fildes, 1997).

Media programs have the advantage of reaching a large population to raise awareness of road safety issues. The Transport Accident Commission (TAC) has made a large impact on road safety through mass media advertising on television in Victoria since 1989 and clear links between TAC publicity supporting road safety programs and reductions in casualty crashes have been established (Cameron, Haworth, Oxley, Newstead & Le, 1993). Recently a pedestrian safety advertisement has raised the awareness of pedestrian crashes, however, depicts a collision between a young male pedestrian and a vehicle. Perhaps more effort needs to be put into developing advertisements aimed at older pedestrian safety to target this age group more effectively.

Training strategies - in general, the literature indicates that there are a number of interrelated reasons for a majority of older pedestrian crashes, including sensory deficiencies, slow information processing, lack of driving experience, failure to anticipate outcomes, and an inability to take evasive action. Although they are more cautious than younger adults in their behaviour, their compensatory behaviours are not always safe.

It may be possible to train older pedestrians on how to cross roads more safely and improve their road crossing skills. Roadside training with children in the UK has proven to be effective (Lee et al., 1984). New medical tools and technologies have made a contribution to the training and physical rehabilitation of the elderly and may play a role in compensating for age-related physical changes

and impairments relevant to road safety. Improvements are reported in such areas as muscular strength and bone density (Wolfson, Whipple, Judge, Amerman, Derby & King, 1993) and memory and intellectual capacities (Birren & Schaie, 1977). No research appears to have been undertaken to assess the effectiveness of training for older adults, particularly for skill improvement in a road setting.

4.7.2 Driver Attitudes and Awareness

Some studies point to drivers paying little attention and/or possessing certain attitudes to older pedestrians as an explanation for high rates of older pedestrian crashes (Baker, Robertson & O'Neill, 1974; Job, Prabhakar, Lee, Haynes & Quach, 1994). Baker et al (1974) found that 23% of drivers involved in pedestrian fatalities failed to yield the right of way and a further 11% were driving without due care and attention. Further, Vestrup and Reid (1989) found that 25% of all drivers involved in pedestrian crashes were charged by the police, 88% had been involved in previous crashes, 79% had at least one moving violation, and 37% had five or more previous citations for moving violations. Arnold, Bennett and Hartley (1990) suggested that drivers place responsibility for avoiding collisions almost entirely upon the pedestrian and are ill prepared for unpredictable behaviour.

In their interviews with drivers, Job et al (1994) found that the majority of drivers felt that the elderly often cross dangerously, relying on vehicles stopping for them more than younger pedestrians. They claimed that the elderly are potentially a traffic hazard and should avoid crossing busy roads in peak hour traffic, and should do more to avoid holding up traffic. Almost half of the respondents also agreed that drivers are inconsiderate to elderly pedestrians. McLean, Brewer and Sandow (1979) found that in more than half of the pedestrian crashes they investigated, there was an obvious error committed by the driver. Further, Arnold et al (1990) concluded that drivers do not engage adequate strategies which prepare them to react to unpredictable behaviour of children and elderly pedestrians. Drivers, therefore, may contribute to pedestrian crashes as much as pedestrians themselves, however, little research has examined driver behaviour that precedes pedestrian accidents.

Awareness and education strategies - it has been suggested that drivers need to be made more aware of the limitations and reduced capacities of older pedestrians and their impact on pedestrian safety. If some groups of pedestrians are incapable of being consistently cautious on the roads, then drivers should be more cognisant of their difficulties and accordingly behave more cautiously themselves.

Training strategies - driver-training packages have been suggested to reduce the number of older pedestrian crashes. Sheppard and Pattinson (1986) suggested that drivers should be informed of the limitations of older people, and not assume that an elderly pedestrian will make the appropriate checks or see the vehicle even if they do check. Drivers could also be made aware that reversing or moving away from parking are two situations that commonly cause crashes with elderly pedestrians, so that particular care is needed.

4.8 MANAGEMENT AND RESEARCH NEEDS

The safety of elderly pedestrians in the traffic environment is a pressing issue, however, the level of knowledge about the crash involvement, and contributing factors to older pedestrian safety is

minimal. A number of environmental, behavioural, vehicle, crash and outcome factors associated with higher crash involvement and injury risk for elderly pedestrians along with associated interventions have been discussed in this chapter. Many interventions have been implemented, however, concern for their effectiveness is often not addressed. Further, there is often a lack of adequate and rigorous evaluations of these and other behavioural initiatives.

4.8.1 Research Needs

This review has illustrated the need for a number of new and continuing management and research initiatives and these are summarised below.

1. There is an urgent need for research aimed to clearly identify behavioural factors that may contribute to pedestrian crashes. While some research has been conducted on the behaviour of older pedestrians on our roads, a more detailed investigation of these factors is essential. The behaviour of drivers, too, in environments of high pedestrian activity should be examined. In addition, comprehensive exposure data on pedestrian travel by the elderly remains a critical research needs. These include:
 - comprehensive exposure data on pedestrian travel by the elderly;
 - the identification of specific behavioural risks to older pedestrians in complex environments;
 - the examination of the effectiveness of training to improve road skills for older pedestrians; and
 - the evaluation of the effectiveness and compliance of wearing light or reflective clothing for increased pedestrian visibility.
2. There is a continuing need to evaluate the effectiveness of all road safety initiatives in terms of what they are attempting to achieve, whether they are effective and whether there is a need to up-date them. In particular, an extensive program to evaluate all existing and new road design countermeasures should be introduced. These include:
 - undertaking a feasibility study of redefining traffic functions of roads with high pedestrian activity;
 - evaluating the importance of median strips;
 - assessing the effectiveness of measures to reduce crashes at tram stops;
 - demonstrating the effectiveness of measures to reduce traffic speeds in high pedestrian areas;
 - assessing the impact of vehicle design on pedestrian trauma; and
 - investigating the need for improved public transport systems to cater for an expected increase in the elderly population.
3. There is also a need to assess the benefits of road and vehicular improvements and examine the role that inappropriate highway design might play in pedestrian crashes.

4.8.2 Management Needs

A number of management initiatives were also identified in this chapter that can reduce pedestrian/vehicle conflicts. These include:

1. Continuing programs to implement effective engineering countermeasures, such as;

- good placement and visibility of road signs (to alert drivers of presence of pedestrians, and to guide pedestrians to safe road crossings),
 - maintenance and installation of good street lighting,
 - installation of barrier fencing near parking bays and intersections, and
 - installation of kerb extensions and medians in appropriate places.
2. Initiatives to reduce traffic-volumes in high pedestrian areas, such as redirecting traffic onto other roads and streets.
 3. Continued initiatives for speed reduction including consideration of lowering speed limits in high pedestrian areas, and/or introduction of perceptual countermeasures in these areas.
 4. Improved guidelines for placement, walk-times maintenance, signage and cycles of pedestrian operated signals.
 5. Initiatives to provide safe access to and from tram stops.
 6. The management of public transport systems that will accommodate the elderly. This may include policies to initiate an alternative form of transport for older road users.
 7. Increased effort by local government to maintain even and clear footpaths.
 8. Measures such as legislation and enforcement to prohibit non-walkers use of footpaths in high pedestrian areas and times.
 9. Initiation of vehicle-pedestrian regulations and test procedures.
 10. A continuing emphasis on the provision of programs aimed at modifying behaviour on the road, such as:
 - ongoing effort to expand administration of the “*Walk-With-Care*” road safety initiative in local communities to reach a larger number of older road users;
 - initiation of mass media awareness campaign such as a Transport Accident Commission television advertisement targeting older pedestrian safety; and the
 - initiation of a driver awareness campaign to inform drivers of the limitations of older people and driver responsibilities in impending collisions.

5.0 Research & Management Priorities

The final phase of this project involved bringing together the various research and management or action items identified into a comprehensive list and ranking these in terms of their importance for the community in improving road safety for older pedestrians. Appendix A lists the various research and action items identified during this strategic review.

5.1 THE RANKING PROCESS

It was considered important that a wide selection of views on priority was necessary to ensure that the final rankings reflected a consensus viewpoint, rather than that of any one single person or agency. A team of people with expertise on older drivers was sought to assist with this procedure and these are listed below in Table 5.1. In addition, a number of international specialists also agreed to participate in this ranking process and they are listed in Table 5.2.

Table 5.1: Panel of Australian specialists who participated in the priority ranking task

REPRESENTATIVE	AGENCY	ORGANISATION
Robert Klein	government	VicRoads, Victoria
Samantha Cockfield	government	Transport Accident Commission of Victoria
Greg Deimos	government	Victorian Police
Ben Witham	government	Dept. Human Services, Victoria
Margaret Smythe	government	Federal Office of Road Safety
Jim Langford	government	Dept. Transport, Tasmania
Michael White/Trevor Bailey	government	Office of Road Safety, South Australia
Peter Eynaud	government	Dept. of Justice, Victoria
Anne Harris	Community	RACV Limited, Victoria
Judy Elsworth	Community	Hawthorn Community Education Services
Denys Correll	Community	National Council of the Ageing
Peter Cecil	Research	Private Consultant
Peter Vulcan	Research	Monash University Accident Research Centre
Bruce Corben	Research	Monash University Accident Research Centre
Brian Fildes	research	Monash University Accident Research Centre
Jennie Oxley	research	Monash University Accident Research Centre
Sam Berkovic	research	Neurologic Medicine, Austin & Repat Hospital
Elfriede Ihlen	research	Swinburne University, Lilydale
Ross Day	research	La Trobe University, Bundoora

It was important, however, to contrast the Australian views with those from overseas to gauge what were local and international issues. These people represented a range of different interests from researchers, government agencies, and community groups and involved representatives from Victoria, interstate and overseas organisations. The author is especially grateful to all those who willingly agreed to help out with this important task.

Table 5.2: Panel of International specialists who participated in the priority ranking task

REPRESENTATIVE	AGENCY	ORGANISATION
John Eberhard	government	NHTSA, Washington DC
Barbara Sabey	community	AA Foundation, UK
Derek Packham	research	University of Newcastle upon Tyne, UK
Bill Frith	government	LTSA, New Zealand

5.2 PROCEDURE

Two lists were prepared of all items that had been identified during the review as issues requiring either further research or management action. The lists contained a brief description of each item, a range of possible techniques available to address each item, and what the likely benefits would be if they were implemented. The final lists contained 14 research and 16 action or management items, listed on separate spreadsheets. The spreadsheets developed for this ranking exercise are contained in Appendix A to this report.

The two lists were distributed independently to each of the experts with instructions about how to rate each item on a scale from 1 to 5 depending on their judgement of that item. Participants were asked to make their judgements based on how important they or the organisation they represented believed each item was for greater knowledge or improved safety management. They were asked to respond **1** if they felt that the item was *very important* and **5** if they thought it *less important* and were encouraged to spread their judgements wherever possible between these two extremes.

Respondents were given approximately two weeks to make their judgements and were also provided with draft copies of the review to help explain the background behind each of the research and action items if required. They were encouraged to make their judgements independently of any other person undertaking the ranking. Responses were returned to the Centre and assembled into a group response matrix for both categories of items.

5.3 RESULTS

The respondents comprised four possible organisation categories or interest groups, namely government authorities, researchers, community groups, and overseas representatives. The responses were analysed both overall and within the four interest groups. While the numbers in each of the groups was rather small, nevertheless, it was felt to be of additional interest in that it reflected differences in the priority each organisation or interest group might place on particular issues relating to older pedestrian safety.

Table 5.3 Summary of the Research Priority Rankings from the Older Pedestrian Strategy Review

PRIORITY	RESEARCH ITEM	AVERAGE SCORE	SCORE DISTRIBUTION					REPRESENTATIVE GROUP PRIORITY SCORES			
			1's	2's	3's	4's	5's	Gov. (n=8)	Community (n=3)	Research (n=9)	Overseas (n=4)
1	Crash involvement and patterns	1.9	9	9	5	1	0	(1.8)	(1.7)	2.3	(1.5)
2	Performance and limitations	1.9	9	9	4	2	0	2.4	1.8	(1.6)	(2.0)
3	Effectiveness of median strips	1.9	12	7	2	2	1	(1.9)	2.3	(1.3)	2.8
4	Mobility needs and patterns	2.0	11	6	3	4	0	(1.9)	(1.3)	2.1	2.5
5	Role of inappropriate behaviour	2.1	8	7	7	2	0	2.6	2.3	(1.9)	(1.5)
6	Effectiveness of speed reduction	2.1	7	10	4	3	0	2.6	2.0	(2.0)	(1.5)
7	Road & hwy design for pedestrians	2.3	6	8	6	4	0	2.8	(1.3)	2.2	2.5
8	Countermeasures at tram & bus stops	2.5	6	4	11	0	2	(2.0)	2.5	2.3	3.0
9	Use & difficulties of public transport	2.6	5	4	9	5	0	2.4	(1.5)	2.9	2.5
10	Evaluate "Walk-With-Care" program	2.8	4	7	5	6	2	2.6	2.2	2.8	3.5
11	Driver & pedestrian safety trade-off	3.0	2	7	7	3	4	2.8	2.2	3.1	3.0
12	Long term consequences of trauma	3.3	1	6	4	11	2	3.1	2.8	3.6	3.3
13	Need for additional training programs	3.2	1	7	8	2	6	2.9	2.8	3.8	2.8
14	Reflective clothing	3.7	3	0	5	9	7	3.5	4.3	3.9	3.3

Note: Research items listed from top to bottom in order of overall priority. Respondents scored 1 for items judged to be very important and 5 for those not very important, and were encouraged to use all 5 points on the scale. An item with a low average score, therefore, was judged to be more important than one with a higher score. The score distribution shows the number of respondents who marked a particular item either 1, 2, 3, 4 or 5. The priorities for each group (eg; government agencies, community groups, researchers and overseas agencies) are shown on the right-hand side of the table (the top 4 priority items are highlighted and shown in parenthesis for each group).

5.3.1 Research Priorities

Table 5.3 shows the summary of responses for the research priorities, listed in terms of their perceived importance, averaged across all respondents. The top 8 research priorities were:

1. More detailed investigation of crash involvement patterns;
2. Better appreciation of older pedestrian performance and limitations in complex settings;
3. Evaluate the effectiveness of median strips for older pedestrians;
4. Assess their mobility needs and patterns of older pedestrians;
5. Examine the role of inappropriate behaviour in older pedestrian crashes;
6. Evaluate effectiveness of speed reduction measures for older pedestrians;
7. Examine the suitability of road & highway design for older pedestrians; and
8. Develop countermeasures at tram and bus stops for older pedestrians.

The research items judged to be most important by the panel of experts included a greater understanding of the exposure and travel patterns of older pedestrians. This would permit a more accurate assessment of crash involvement rates and mobility needs as well as a better appreciation of their performance and behaviour in complex road environments.

In addition, the perceived importance of each item for each of the groups represented is also listed on the right-hand side of the table. Government responses tended to emphasise practical research topics of particular interest to road traffic authorities such as crash analysis, effectiveness of median strips and countermeasures at bus and tram stops. Community groups were more focussed on mobility needs, road and highway design issues and use and difficulties for older people using public transport. Researchers' ratings were spread across both practical and fundamental research topics ranging from effectiveness of median strips and speed reduction measures, to understanding older pedestrian performance and limitations and the role of inappropriate behaviour. Overseas representatives gauged crash analyses, the role of inappropriate behaviour and effectiveness of speed reduction measures equally important.

While interesting, care should be taken not to place too much emphasis on these group ratings as many contained very small numbers of responses and may not be representative.

The distribution of scores across the 5 response categories is shown to the left of the average scores where the distributions for the top 6 or 7 items were tightly clustered around the top end of the scale. Mobility needs and patterns were an exception here where there appears to be more of a bimodal distribution, suggesting two distinct patterns of response to this item across the raters. This was confirmed in the group responses. The lower ranking items tended to have wider distributions, reflecting more general (and therefore less clear) assessments of these items.

5.3.2 Intervention (Action) Priorities

Table 5.4 shows the summary of responses for the action or countermeasure priorities, listed in terms of their perceived importance averaged across all respondents. The distribution of scores across the 5 response categories is shown to the left of the average scores and the perceived importance of each item for each of the groups represented is again shown on the right-hand side of the table.

Table 5.4 Summary of the Action Priority Rankings from the Older Pedestrian Strategy Review

PRIORITY	ACTION ITEM	AVERAGE SCORE	SCORE DISTRIBUTION					REPRESENTATIVE GROUP PRIORITIES			
			1's	2's	3's	4's	5's	Gov. (n=8)	Community (n=3)	Research (n=9)	Overseas (n=4)
1	Reduction of traffic speeds	1.6	13	9	1	1	0	(2.0)	(1.7)	(1.4)	(1.0)
2	Provision of safe traffic environment	1.7	16	4	0	4	0	2.6	(1.7)	(1.0)	(1.3)
3	Reduce traffic in high density areas	1.8	11	8	4	1	0	(2.1)	2.0	(1.6)	(1.5)
4	Traffic light cross-phase guidelines	2.1	6	10	7	1	0	(2.3)	2.2	(1.9)	2.3
5	Better public transport access	2.4	5	8	7	2	1	(2.0)	(1.5)	2.3	3.3
6	Maintenance of footpaths & lights	2.5	8	2	10	2	2	3.0	(1.7)	2.6	2.0
7	Safe access at tram & bus stops	2.6	5	6	8	4	1	2.6	1.8	2.6	3.0
8	Handbook for health professionals	2.6	4	6	11	1	2	2.8	2.5	2.9	(1.8)
9	Better advice from health professionals	2.7	3	7	10	3	1	2.8	2.3	3.0	2.0
10	Alternative mobility options	2.8	6	6	3	4	3	2.8	2.8	2.1	2.8
11	Alternative lamp design trial	2.8	4	7	6	3	4	2.9	2.2	2.9	3.0
12	Redevelopment of "Walk-With-Care"	2.8	4	7	7	3	3	2.5	2.7	2.8	3.3
13	Mass media awareness	2.8	4	4	11	2	3	2.4	2.5	3.1	3.3
14	Resources for "Walk-With-Care"	2.9	3	8	5	5	3	2.6	2.5	3.0	3.3
15	Pedestrian-vehicle design standards	3.1	2	3	10	5	2	2.4	2.7	2.9	3.8
16	System for referral into programs	3.3	0	7	7	5	5	2.9	2.7	3.8	3.8

Note: Action items listed from top to bottom in order of overall priority. Respondents scored 1 for items judged to be very important and 5 for those not very important, and were encouraged to use all 5 points on the scale. An item with a low average score, therefore, was judged to be more important than one with a higher score. The score distribution shows the number of respondents who marked a particular item either 1, 2, 3, 4 or 5. The priorities for each group (eg; government agencies, community groups, researchers and overseas agencies) are shown on the right-hand side of the table (the top 4 priority items are highlighted and shown in parenthesis for each group).

The top **eight** priority action items averaged across all respondents were:

1. Initiatives to reduce travel speed in high density pedestrian areas;
2. Greater effort to provide a safe traffic environment for older pedestrians;
3. Initiatives to reduce traffic volume in high density older pedestrian areas;
4. Guidelines for providing adequate crossing phases for older pedestrians;
5. Better public transport access for older people;
6. Improved maintenance of footpaths, surrounds and street lighting for older pedestrians;
7. Develop safe access provisions for older pedestrians at tram and bus stops; and
8. An informational handbook of older pedestrian problems and difficulties for health professionals.

Many of the priority action items related to the provision of a safer and more pedestrian friendly environment in high density traffic areas. Reducing traffic speed and volume would lead to fewer pedestrian-motorist conflicts while providing more time to cross at traffic lights, better access to public transport and improved maintenance of the road and the surrounding environment would also be expected to improve the safety and mobility of these older road users. Interestingly, while respondents saw the need for a handbook on older pedestrian safety and difficulties, the role of health professionals and the media in providing information to these people was not seen as a priority item.

The importance of each item as judged by each of the groups represented is again shown on the right-hand side of the table. Contrary to the research findings in the previous section, there was much more agreement among the four groups here. Reduced traffic speed, traffic density and the provision of a safe environment for older pedestrians were ranked highly by all groups. Governments and community groups also rated better access to public transport as priority issues. Overseas representatives saw much greater value in the provision of a handbook of information on older pedestrian problems and difficulties than did the Australians.

The distribution of scores across the 5 response categories is shown to the left of the average scores. Once more, the high priority items had less response variation than the lower priority items did with less evidence of bimodal distributions here. This again reinforces the fact that there was high consistency in the action item priorities nominated across these respondents.

5.4 DISCUSSION

5.4.1 Research Priority Issues

The main findings for priority research issues for older pedestrians related to a better understanding of their crashes and the role that their age-related performance limitations might play in their enhanced crash risk. Very few studies have addressed these issues and there is clearly a lack of detailed knowledge about how older people cross the road and what they judge important in making these decisions. It is hoped that the work of Oxley and her colleagues (Oxley et al, 1997) will go some way to addressing this shortage but there is clearly scope for further research in this area.

A more detailed examination of older pedestrian crashes and the role of driver and pedestrian causation is clearly warranted, especially as the proportion of older pedestrians and drivers will increase dramatically in the years ahead. It would be interesting to examine the rate of older pedestrian with older driver crashes in this context.

The research priorities revealed in this analysis showed a degree of diversity across the various interest groups represented. Government and community representatives saw the need for further research to understand the mobility needs and patterns of older people. This would presumably provide fresh information on whether these needs are currently being met and what needs to be addressed in any future initiatives in this area. In this context, the need for a more comprehensive account of exposure patterns would seem to be paramount in identifying new countermeasures to address older pedestrian crashes.

The importance placed on evaluating the effectiveness of median strips for older pedestrians crossing the road by many of the respondents was also interesting. It is widely assumed that these traffic control devices are very effective in simplifying the crossing task for older people. This new finding seems to suggest that the respondents felt that this still needs to be firmly established and perhaps in doing so, alternative designs and improvements might become obvious.

The community representatives highlighted road design as a priority issue but not others. It is not clear what aspects of road design they felt needed to be addressed; that is, whether it is design standards per se or rather aspects of the road that might cause older people difficulty when crossing the road. In this respect, older people themselves have remarked on the difficulty they face in stepping on and off the road and in who has priority at many locations (see Fildes, Lee, Kenny, & Foddy, 1995, for one such account).

The lack of interest in existing and future training programs to improve the safety of older pedestrians was a curious finding. The need for education to improve child pedestrian safety has been well supported in the past. Perhaps this might suggest that these respondents did not believe that it would be possible to modify older pedestrian behaviour through educational programs (“you can’t teach an old dog new tricks”). This is rather strange as it would appear that the Victorian “Walk-With-Care” package for older people has had some success. The fact that these same respondents failed to acknowledge the need to evaluate this package is therefore somewhat difficult to comprehend.

5.4.2 Intervention or Action Priorities

As noted earlier, there was a high degree of consensus among the four interest groups involved in this rating exercise. Of special note, the first three priority action items all related to the provision of a safer and more pedestrian friendly environment in high density traffic areas. There have been a number of innovative designs of malls and pedestrian and car precincts that have addressed the specific needs for those who are more vulnerable (see Figure 5.1) and more attention of these efforts would seem warranted from these findings.

The advantage of greater separation between cars and pedestrians in high pedestrian areas has been long recognised in many European countries such as the Netherlands, Denmark and Sweden. The development of exclusive pedestrian precincts was first promoted in these regions and have since been adopted by many others, including Australia. The need to give greater attention to pedestrians rather than motorists in these environments is well founded. Obviously, the respondents feel that there is more that can be done in this area still to improve the safety of older pedestrians in the years ahead.

The walk-time allocated for pedestrians at traffic lights has been a contentious issue at many locations throughout cities and towns in Victoria and the rest of Australia. Older people in

particular, feel that these times are too brief for them to cross the road safely and have asked for an increase in these times to accommodate their slower walking pace (Fildes et al., 1994b).



Figure 5.1 Example of a pedestrian friendly mall design in Hobart, Australia

While there have been recent useful trials of alternative (responsive) pedestrian crossings (Catchpole, 1998), this does not negate the need to examine current guidelines for their suitability for older people and make changes where required. Increased traffic flow should not be allowed to dictate safe crossing times for all pedestrians at traffic light locations, especially with an ageing population.

As noted earlier, there was a high degree of agreement among the respondents for more attention to improved (safe) access and travel for older pedestrians (eg; better public transport access, safe access at tram and bus stops, improved maintenance of footpaths, surrounds and street lighting). These items need to be given greater attention by the respective government departments.

Most local respondents again downplayed the role of health professionals in providing information as a priority for older pedestrian intervention. Interestingly, the overseas raters placed greater importance on the need to provide a handbook of information on older pedestrian problems and difficulties for health professionals. This is one issue that warrants further investigation to understand the basis for this discrepancy.

5.5 CONCLUSION

The strategic review identified a number of ageing, health, environment, road engineering and educational issues relevant for older pedestrian safety. These were prioritised in terms of their likely importance for improved safety for this vulnerable road user group. While the older pedestrian

safety problem is currently not large in number, it is nevertheless significant in terms of their rate per head of population and represents a reasonably large cost to the community. As it is estimated that the number of older pedestrians will double in the next 30 years or so, it is imperative that additional resources be provided to improve their safety in the years ahead.

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PRIORITY ITEMS FOR OLDER PEDESTRIAN SAFETY RESEARCH

- 1 Assess the mobility needs and patterns of older pedestrians
- 2 Investigate further crash involvement and crash patterns of older pedestrians
- 3 Examine the trade-off between older driver and pedestrian crash risk
- 4 Investigate the long-term consequences of trauma to older pedestrians
- 5 Better understanding of older pedestrian performance and limitations in complex traffic situations
- 6 Evaluate the effectiveness of median strips for older pedestrians
- 7 Evaluate the effectiveness of speed reduction measures for older pedestrians
- 8 Develop a range of counter-measures at tram and bus stops for older pedestrians
- 9 Examine the suitability of road and highway design for older pedestrians
- 10 Assess the use and difficulties of public transport for older people
- 11 Examine the role that inappropriate behaviour plays in older pedestrian crashes
- 12 Evaluate the "Walk-With-Care" program for improved safety of older pedestrians
- 13 Examine the role and need of extra training packages for older pedestrians
- 14 Examine opportunities and likely compliance of reflective clothing for older pedestrians

PRIORITY ITEMS FOR OLDER PEDESTRIAN SAFETY INTERVENTION

- 1 Handbook of information on older pedestrian problems and difficulties for health professionals
- 2 Assist health professionals to provide advice to older pedestrians
- 3 Develop a system for referral of older pedestrians into road safety programs
- 4 Continued effort to provide a safe traffic environment for older pedestrians
- 5 Initiatives to reduce traffic in high density pedestrian areas
- 6 Initiatives to reduce travel speeds in high density pedestrian areas
- 7 Trial of alternative lamp designs for pedestrian traffic signals
- 8 Guidelines for providing adequate crossing phases for older pedestrians
- 9 Develop safe access provisions at bus and tram stops
- 10 Better public transport access for older people
- 11 Improved maintenance of footpaths, surrounds and street lighting for older pedestrians
- 12 Review suitability of pedestrian-vehicle design standards for older people
- 13 Continued re-development of the "Walk-With-Care" training package for older pedestrians
- 14 Greater emphasis and resources for implementing the "Walk-With-Care" program for older pedestrians
- 15 Development of alternative mobility options for older pedestrians
- 16 Initiation of a mass media awareness campaign for older pedestrian safety