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OLDER ROAD USER CRASHES

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Older Road User Crashes

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Abstract:

The aim of this study was to examine the accident involvement of elderly road users with a view to identifying incidence numbers and rates, target groups of accidents where older road users are over-represented, suitable countermeasures, and areas requiring further research. A review of the international literature was undertaken to highlight the extent of the older road user problem and directions and hypotheses for subsequent analyses. Analyses were conducted of recent casualty crashes in Victoria. Areas investigated included: driver and pedestrian accident trends over the last ten years, driver and pedestrian injuries and associated treatment and rehabilitation costs, and road and environment characteristics of driver and pedestrian casualty crashes. Results showed that the number and rates per head of population of casualty crashes amongst elderly road users have been generally decreasing since 1989 although this decline was more apparent for pedestrians than it was for drivers. Although they constitute only a relatively small proportion of crash casualties, older road users are far more likely to be severely injured in the event of a crash and more likely to sustain serious chest injuries than their younger counterparts. Older drivers represent about 5% of the total cost of trauma to drivers in the state of Victoria; older pedestrians, however, represent about 14% of the total cost of pedestrian trauma in this state. Older road users appear to be over-invlolved in crashes at intersections, particularly at cross intersections and those controlled by stop and give-way signs, and tend to have their crashes during daylight hours between 9a.m. and 3p.m. The results also suggested that older road users are over-involved in crash configurations with a relatively high level of complexity. The results are discussed in terms of their implications for interventions aimed at older drivers and pedestrians and for current issues such as older driver licence testing. Areas for further research identified in this study are also discussed.

Key Words:
(IRRD except when marked*)

Driver, Pedestrian, Elderly, Injury, Crash trends, Crash Characteristics, Road Trauma Costs, Countermeasures

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EXECUTIVE SUMMARY

INTRODUCTION

As the proportion of elderly people in Australia is increasing, so too is concern for the safety of the elderly in all types of environments. The accident risk of older road users is one area which is attracting increasing attention, especially given that the ageing process is associated with increases in functional disabilities which may impair driving safety and mobility. Overseas evidence suggests that older drivers and pedestrians do not represent a sizeable proportion of the road crash statistics; however, their risk of crash involvement per head of population or kilometre travelled is quite high. Moreover, once involved in a crash, older people have a higher risk of severe injury or death due to their increased frailty.

There have also been recent calls for mandatory licence retesting for older drivers in the State of Victoria. The consequences of such a scheme, with its potential to severely limit the mobility of older people, require careful consideration.

These current trends highlighted a need for more detailed research examining the nature and extent of the older road user problem in the State of Victoria.

PROJECT OBJECTIVES AND TASKS

The aim of this study was to conduct an extensive analysis of Victorian road accident data in order to highlight recent trends among older drivers and pedestrians, the types and severity of injuries sustained, associated road trauma cost, and the types of crashes in which the elderly seem to be over-involved. The study was divided into three main tasks:

1. A review of the international literature was conducted to demonstrate the extent of the older road user problem and to highlight directions and hypotheses for subsequent testing. The review contained a comprehensive account of the sensory, motor and cognitive effects of ageing and their implications for driver and pedestrian safety. Additionally, various characteristics of the road environment associated with crashes among older road users were identified, and existing countermeasures and interventions designed to improve the safety of the elderly in the road environment were reviewed.

2. Detailed analyses were carried out of two road crash databases containing information on casualty crashes in the State of Victoria over several years. Ten years of data from the VicRoads database of police-reported casualty crashes were analysed to demonstrate older road user accident trends. Two years of recent data from the Transport Accident Commission (TAC) database of no-fault injury compensation claims were analysed to examine injuries and associated treatment and rehabilitation costs.

Three recent years of police data were analysed in order to determine specific road and environmental characteristics causing problems for older road users.

3. The findings were then reviewed in terms of their implications for existing or future countermeasures to reduce the frequency and severity of road trauma to the elderly. Areas requiring further research were also identified.

FINDINGS FOR OLDER DRIVERS

Crash Trends

The numbers and rates of casualty crashes per head of population peaked in Victoria in 1989 and have been progressively decreasing since then. However, the decrease is more marked for younger than older drivers, possibly because older drivers have been less targeted and therefore less influenced by recent successful road safety initiatives such as speed cameras and Random Breath Testing. Economic recession factors may also have less effect on the amount of driving done by older drivers by comparison with their younger counterparts.

The average annual casualty rates per 100,000 population for drivers were highest for those aged 17 to 24 years and steadily declined until age 74, after which they started to rise slowly again. Casualty rates per million kilometres travelled, however, show that older drivers are especially at risk.

Injuries & Costs

Older drivers accounted for only 7% of all driver claims on the TAC during 1991. Moreover, while older driver crashes were estimated to cost the Victorian community more than $23 million annually, they represent only 5% of the total yearly cost of driver trauma in the State.

The average claim cost on the TAC for an older driver was roughly one-third less than for younger drivers. Although older drivers had higher claim costs for hospitalisation and rehabilitation, they had relatively low claim costs for death benefits, loss of earnings and earning capacity, compared with younger drivers.

Older and younger drivers sustained very similar injuries in casualty crashes, except for a slightly higher likelihood for older drivers to sustain a major or minor chest injury. This probably reflects their greater frailty and hence increased susceptibility to rib and sternum fractures from the seatbelt in crashes.

Crash Characteristics

Analysis of the last three years of data from police-reported casualty crashes highlighted a number of road, driver and environmental aspects of older driver crashes. However, it should be stressed that while these findings might suggest areas of risk for older road users, they also indicate times and locations where older road users are more likely to have their crashes, that is, where they are over-exposed. Without adequate exposure data, it is not possible to differentiate between increased risk of a crash or over-exposure.

Older drivers were over-involved in crashes at intersections, particularly cross and unsignalised intersections (stop and give way controls). They were also over-involved in crash configurations involving a relatively high degree of complexity (e.g., cross traffic, right-through, and U-turn collisions).

There was a high preponderance of older driver crashes on dry roads (80%), during the day (87%), and between the hours of 9am and 3pm (54%). These findings probably reflect the fact that older drivers tend to driver more during off-peak times during the day and in urban areas where there is less demand on their perceptual and cognitive abilities.

Older drivers involved in casualty crashes also tended to be male (69%) and to have had a blood alcohol level well below the legal limit (90% had either zero or very low BAC's).

FINDINGS FOR OLDER PEDESTRIANS

Crash Trends

The number and rate per 100,000 population also peaked for pedestrian crashes in 1988 and have been slowly falling since then for both young and old pedestrians alike.

Casualty rates for pedestrians injured on the road are high during early adulthood, progressively fall until age 44, and then subsequently rise again with increasing age (most markedly for serious injuries and fatalities). These findings probably confound both risk and exposure factors across the various age groups.

Injuries & Costs

Contrary to the findings for driver trauma, older people account for a much larger proportion of pedestrian accident claims on the TAC (27%) as well as a much larger share of all pedestrian trauma costs (14%). Older pedestrian crashes were estimated to cost the Victorian community more than $14 million annually. The average claim cost on the TAC for older pedestrians was again around one-third less than for younger pedestrians.

Pedestrians had more age-related differences in injuries sustained in casualty crashes in contrast to the driver findings reported above. Older pedestrians had more major head, chest and upper limb injuries, most likely reflecting their increased frailty and vulnerability to injury in casualty crashes. Of note, the likelihood of a serious or fatal injury, given a crash was 54% for older pedestrians, compared to only 19% for older drivers.

Crash Characteristics

There were a number of age-related characteristics of pedestrian crashes observed in these data, although again, some of these may simply reflect over-exposure rather than increased risk.

Older pedestrians were over-represented in crashes at cross and unsignalised intersections, compared to their younger counterparts. When crossing the road, older pedestrians were equally vulnerable in both near- and far-side collisions, suggesting that these crashes involve more than just reduced mobility among the elderly.

As for drivers, older pedestrians were over-represented among crashes occurring during the day (84%) and between the hours of 9am and 3pm (54%). Further, most of these crashes occurred during the week (83%) and in 60km/h zones (95%), again emphasising exposure patterns among older pedestrians.

Unlike drivers, however, the majority of older pedestrian casualty crashes were female which is also probably an over-exposure finding, given that 58% of the population aged 65 years and older are women.

OPPORTUNITIES FOR INTERVENTION

The results suggested a number of areas where intervention may be warranted to reduce the frequency and/or severity of injuries to older road users. In some instances, further work is still required to specify and develop suitable measures. Some of the suggested areas for intervention included:

- improved protection for older car occupants, especially measures aimed at reducing the number of chest injuries (eg: airbags, better belt systems, airbelts, etc.);
- greater consideration of the perceptual, physical and cognitive abilities of older road users in road design and traffic control, comprising measures such as:
  - (i) increased use of traffic signals and pedestrian crossings in areas where the proportion of older road users is known to be high;
  - (ii) improved intersection design to assist older people crossing the road (eg; longer walk cycles, clear road markings, lower kerb edges, more refuge areas);
  - (iii) greater use of roundabouts to enhance traffic control and increase safety for older road users at low volume intersections;
- informing older road users of situations where they are most vulnerable and ways in which they can minimise their risk of injury; and
- publicity to alert all road users to the special problems encountered by older people when using the road.

RECOMMENDATIONS FOR FURTHER RESEARCH

Given the lack of previous work in this area, the study was particularly interested in highlighting the needs for further research aimed at improving older road user safety. This included:

- the need for greater understanding of the role of the ageing process and the associated physical, perceptual and cognitive deficits in crashes involving older people;
- improved knowledge of older road user travel patterns for both drivers and pedestrians to separate risk from exposure features of their crashes;
- detailed investigations to highlight functional characteristics of older driver crashes and establish meaningful criteria for determining which older drivers are at risk on the roads; and
- the trade-off in crash or injury risk (and the subsequent cost to the community) when an older person stops driving and becomes a pedestrian.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Previous overseas research suggested that road accidents among the elderly are not a significant problem in terms of number of crashes compared with other age groups (e.g., young drivers and child pedestrians). Older road users appear to be no more at risk of being involved in a crash per head of population than younger road users.

However, it is often claimed that older drivers are over-involved in serious casualty and fatal accidents. This over-involvement therefore may be a function of their lack of driving exposure and their increased frailty; a USA study (cited in Evans, 1991a) suggested that elderly motorists were over-represented in crashes per kilometre of travel. Moreover, very little is known about the driving habits of older people and whether they adopt compensatory behaviours for their deficiencies.

Older people, too, are heavily involved in pedestrian casualties in Australia. In 1991, pedestrians accounted for 19% of all fatalities of which the majority were aged 60 years and over. Roughly 12% of all serious casualties in the same year were persons aged 60+ years.

Human factors research in the Monash University Department of Psychology established that reduced cognitive abilities among elderly people was likely to be at least partly involved in the above statistics (Triggs, Fildes & Koca, 1994). With predictions for an increasing aged society over the next 10 to 20 years and the relative gulf of detailed research in this area, there is clearly a pressing need for further research effort aimed at understanding the special problems of older road users.

Currently, there is considerable national and international interest in the accident risk of older road users. There has also been recent calls for mandatory licence retesting for older drivers in Victoria and the possibility of revoking the licences of those who fail these tests. Given the substantial consequences this would have on the lives of older people from reduced mobility, the likely effectiveness of such a scheme (including its cost effectiveness) needs to be fully assessed using up-to-date local statistics, and appropriate surveys.

1.2 PROJECT OBJECTIVES

The primary objective of this study was to examine the accident involvement of older road users with a view to identifying incidence numbers and rates, target groups of accidents, road users most at risk of involvement and injury and suitable countermeasures. The study also aimed to identify areas requiring further research in order to improve our knowledge and develop suitable intervention technology.

In the short term, this research aims to provide input to considerations of the need for licence re-testing of older road users and the need for educating these road users if they fail to adapt adequately to their reduced sensory and cognitive abilities.

1.3 RESEARCH TASKS

The project involved three main tasks, described below.

1.3.1 Literature Review

A review of the literature (predominantly overseas) was conducted to demonstrate the extent of the older road user problem internationally and to highlight directions and hypotheses for subsequent testing. The review examined crash statistics, sensory, motor and cognitive effects of ageing, the road environment, and countermeasures and interventions separately for older drivers and pedestrians.

1.3.2 Analysis of Relevant Databases

Analyses of existing VicRoads, TAC and allied databases in Victoria were conducted to highlight the extent of over-involvement of older road users (drivers and pedestrians) in crashes and to identify target groups of people and activities seemingly at risk. The variables used in the analyses related to the characteristics of the road user, the road and road setting, and other environmental influences. The costs of road trauma and aspects of treatment and rehabilitation costs where older road users are over-represented were also analysed to provide a focus for intervention and further research.

1.3.3 Interventions and Further Research Needs

The final task assessed the implications of the findings for behavioural and engineering interventions aimed at reducing the frequency and severity of road trauma to the elderly. The implications of the findings for existing education programs for older road users (e.g., "Walk With Care") and older driver licensing issues were also considered. As the study was a preliminary review of older road user safety in Victoria, a number of areas were identified for which further research was required.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Injury is one of the leading causes of death and morbidity in the elderly, ranking sixth in both the United States (Kallman & Kallman, 1989) and Australia (Australian Bureau of Statistics, 1989). Accidents represent the fifth leading cause of death for persons aged 65-74, and the sixth leading cause for those over 74. Motor vehicle fatalities represent the most common aetiology for the 65 to 74 age group and the second most common for those aged 75 or more (Copeland, 1989).

2.1.1 The Greying Population

Between 1981 and 1986 Victoria's aged population (those over 65 years of age) increased by 12.6% - more than twice as fast as the total population. This rate is expected to increase to between 19.1% and 21.8% by the year 2031, resulting in an aged population almost treble that in 1986 (Rudd, 1989). Similarly, in America, it is estimated that 17% of the total population will be 65 years or over by the year 2020, resulting in more than 50 million older persons eligible to drive, almost half of whom will be 75 years or over (Transportation Research Board, 1988). As the proportion of elderly people in western countries is increasing, there is a growing awareness of the implications this has for society and environmental planning (Sjogren & Bjornstig, 1991).

As interest in older people's injuries and concern about their safety in all types of environments is expanding, so too, the problem of the elderly in the traffic environment has received increasing attention in the last decade. It has been noted (Ernst & O'Connor, 1988; Evans, 1991a; Gebers & Peck, 1992; Kline, Kline, Fozard, Kosnik, Scheiber & Sekuler, 1992) that while elderly road users over the age of 65 years have a relatively low crash involvement rate per head of population when compared with the total number of traffic crashes, their involvement rate is markedly higher than that for their younger counterparts in terms of time spent on the road and kilometres driven.

The oldest drivers and pedestrians, along with the youngest, are known to have high crash risks when they are part of the roadway system. Studies have indicated that drivers 75 years and over are more at risk of crash involvement than the average driver, and that older occupants of vehicles are much more likely to be severely injured or killed than middle-aged occupants in crashes of equal severity (Transportation Research Board, 1988). Other studies have shown that elderly pedestrians, too, are more at risk of being involved in an accident and are more susceptible to severe injury or death than their younger counterparts (Alexander, Cave & Lyttle, 1990).

2.1.2 The Ageing Process

Traditionally age has been defined as a measure of chronological age (i.e., number of years since birth), and most studies have chosen to define 'the elderly' as the population of persons aged 65 years or more (OECD, 1985). However, chronological age may not be a good approximation to an individual's functional and subjective age. Variability in performance on various measures of cognition, vision, complex reaction time and other driving-related skills makes it difficult to select a chronological age at which drivers should be labelled as 'elderly' (Waller, 1991).

Ageing is a complex process involving biological, psychological, sociological and behavioural changes which inevitably result in reduced capacities in a variety of areas that are irreversible. However, changes occur gradually so that the individual is usually able to compensate for the losses and make adjustments (Verrillo & Verrillo, 1985). Biologically, the body gradually loses the ability to renew itself, various bodily functions slow down and vital organs become less acute. Psychologically, there are changes to sensory processes, perception, motor skills and problem-solving abilities. Sociologically, an individual ages in a society that imposes changing roles and definitions of self (Barakat & Mulinazzi, 1987).

Despite the vitality of many older persons, their ability to perform complex tasks such as driving becomes more difficult as age increases. Diminishing psychomotor and cognitive capabilities pose specific problems and limitations to the older driver (van Wolffelaar, Brouwer & Rothengatter, 1991). For example, older drivers experience difficulty in estimating distance and speed, particularly at dusk and in darkness. Complex situations can place demands on elderly drivers that may exceed their abilities and may cause problems in the selection of information and decision making; in such situations, older drivers are less likely to make decisions in a simultaneous parallel fashion, but rather in sequence (Wounters & Welleman, 1988).

The elderly therefore constitute a high risk group for traffic crashes because of the progressive slowing of reaction time, deterioration of vision and hearing, and degenerative changes in the musculoskeletal system causing balance and stability problems (Wong, 1987). Further, older people have lower injury thresholds and suffer poorer clinical outcomes once injured (Baker, O'Neill, Ginsberg & Li, 1992).

2.2 ELDERLY DRIVERS

2.2.1 Mobility of the Elderly Driver

Whilst ageing can restrict the margin of autonomy, independence and adaptability of the individual through the progressive reduction of the efficiency of biological and neurophysiological functions (OECD, 1985), mobility is an essential determinant of the 'quality of life' of older individuals. The ability to move about at will, to engage in social and recreational activities and to reach services when needed are crucial to the economic, psychological and social well-being of older persons. (Rosenbloom, 1988).

In addition to well being, mobility can affect the health of elderly people. According to a physician in Sweden (cited by Waller, 1991; p.499) elderly people who are mobile and drive have less osteoporosis, less obesity, less constipation, and fewer hip fractures, as well as less use of prescription drugs.

Traffic participation has become an essential part of living in society today. It has been suggested that the elderly of today are more affluent, healthier, and active (Martin, 1992). They live mainly in low-medium density dwellings in the suburbs, most own their own cars and make an overwhelming percentage of their trips in private vehicles, rather than by public transport or by walking (Godwin, 1989; Rosenbloom, 1988; Transportation Research Board, 1988).

Numerous studies have shown that elderly drivers are strongly interested in keeping their possibility of traffic participation as car drivers for many years after retirement and that traffic participation is a substantial part of elderly people's quality of life (Gelau, Metker & Trankle, 1992; Rosenbloom, 1988; Waller, 1991). Yet, despite the needs for independence, freedom and self-sufficiency that mobility fulfils, the safety needs of the elderly are also important. Often mobility and safety are thought of as trade-offs, that is, as one increases, the other decreases. Waller (1991) argues that the trade-offs are often more costly for the older segment of the population. Moreover, safety becomes a great issue for the elderly due to the fact that increased age is associated with a higher risk of being seriously injured or killed.

2.2.2 Types of Crashes

It has been well established that elderly drivers have quite distinct and different crash and traffic violation patterns than their younger counterparts. In heavy traffic at high speed, at night on poorly marked roads, at a complex intersection or in a potential accident situation, the demands placed on elderly drivers can exceed their abilities to avoid a crash.

While young drivers are often involved in crashes involving speed and risk taking, the elderly tend to be involved in crashes occurring at below-average speeds (Fildes, Rumbold & Leening, 1991), and they are most frequently involved in multi-vehicle crashes in complex traffic situations such as at intersections, when altering direction or entering a traffic flow (Ernst & O'Connor, 1988; Transport Research Board, 1988). Further, research indicates that not only are the elderly over-represented in multi-vehicle and intersection crashes, but that they are also more frequently responsible for these accidents (Cooper, 1990). Cooper suggests that this could be due to elderly drivers making more errors in perception, judgement, decision-making and reaction time.

McCoy (1991) looked at the problems of elderly drivers in terms of the accident situations and found that older drivers were over-involved in right-angle, left turn (equivalent to right turns in Australia), backing and parking collisions. They were more likely than young drivers to have right-angle and left-turn collisions involving failure to yield, they ran stop signs, disregarded traffic signals and made improper turns.

Accident data indicate that complex intersections are particularly troublesome for the older driver. It has been found that rear-end collisions and accidents at signalised intersections represent the most common form of accident involvement for the older driver (Transportation Research Board, 1991). A study focussing on problems experienced by elderly drivers at intersections (Stamatiadis, Taylor & McKelvey, 1991) concluded that elderly drivers experience problems in proper handling of left turns (an American study - equivalent to right turns in Australia). They frequently cause accidents that involve a turn and have a greater chance of being cited for a violation than the average driver. In addition, they found that elderly drivers are more susceptible to head-on-while-turning-left, angle and rear-end accidents than middle-aged drivers, supporting the fact that deficiencies related to visual deterioration contribute to these accidents.

2.2.3 Driving Behaviour of the Elderly

There is conflicting research on how older people's driving practices and crash experience change with age. On the one hand, the complexity of the environment places increasing demands on adaptability, whilst ageing, on the other hand, diminishes the capacities to cope with such situations. In addition, attitudes of the elderly to driving may be affected by the fear of an accident or violation that would lead to re-examination and possible loss of their licence and a resultant loss of independence.

Research has shown that the elderly often require more information on which to base driving decisions and may experience reduced performance (i.e. slowed reaction time) in recognition/response tasks compared with younger drivers. Subsequent compensatory behavioural strategies include attention to preventative measures, avoidance of driving and or denial of problems. Some of these coping behaviours lead to licence retention and safer driving, some may lead to premature surrender of a licence, and others may lead to revocation of a licence, unsafe driving and increased risk of accident involvement (Winter, 1988).

Data collected by the OECD (1985) suggest that the travel pattern of the elderly driver involves reasonably frequent, but short trips. The conditions under which driving is undertaken showed a decrease in driving under difficult or high risk conditions and a general lowering of speeds relative to younger individuals. A number of reports (Ernst & O'Connor, 1988; Wounters & Welleman, 1988) show that elderly drivers, in a bid to reduce their risk on the road, are likely to revert rather inflexibly to a kind of standard behaviour whereby they adopt various strategies and self-imposed limitations including travelling at lower speeds, a reduced rate of everyday driving, reduced peak-hour and night driving, and shorter trips.

A study on crash involvement trends in the older driver population (Stutts & Martell, 1992) showed that older drivers' night time and weekend crash rates per kilometre travelled were not elevated above their day time and weekday crash rates, supporting the notion that older drivers limit their driving to times and situations that they feel capable of handling. Stutts and Martell further suggested that older drivers are less likely at high risk times to combine their driving with alcohol use, speeding and other behaviours known to increase the likelihood of a crash.

Other studies (Cooper, 1990) have suggested that older drivers may be unaware of the difficulties they face and thereby fail to make adjustments to adequately accommodate their performance deficits. In a study to determine how the perceived risk in certain driving situations and the perceived competencies to handle such situations varies with age, Matthews (1986) found that both younger and older drivers tended to underestimate the risk and overestimate their ability to handle the risk when compared with middle-aged drivers. Further, they believed they had the necessary skills and abilities to avoid such accidents but did not believe such skills were possessed by their peers. Matthews concluded that among both younger and older drivers, there appears to be a dissociation between the objective risk and the perceived risk together with an over confidence in the ability to handle a driving situation with accident potential.

Ball and Owsley (1991), in a study on driving behaviour, found that older drivers continued to drive as long as possible and that, although they may cut down on their frequency of travel, they resisted any change to their preferred mode of travel. They concluded that self-regulation and self-imposed limitations are not a realistic strategy for reducing exposure to potential accidents among older people. Further, Cooper (1990) stated that such recognition or exposure modification may be insufficient to compensate completely for the additional risks involved, as evidenced by an increased number of accidents in certain situations and an increased level of fault in crashes.

For the most part, however, studies have examined strategies and limitations separately. Inadequate information exists on how older people drive, particularly those with functional limitations, and how older drivers adjust their driving practices to accommodate for limitations in functional capabilities.

2.2.4 Risk Characteristics

Evidence suggests that the increase in the accident rate among older drivers is attributable to age-related decrements in driving skill combined with an increased susceptibility to injury and death following trauma (Gebers & Peck, 1992). Accident risks which are specific for the elderly are thought to manifest in situations requiring fast and accurate reactions, in particular, complex, unexpected or time-critical situations.

As drivers age various capabilities relevant to driving decline: the sensory (visual acuity, hearing), the cognitive (memory, information processing), and the physical (ability to rotate neck, muscle control) (Evans, 1991b). Yanik and Monforton (1991) suggest that the changes in vision and cognition accumulate in the elderly driver to a point when they might overwhelm some of the normal attempts at compensation, such as retaining more empty space around the vehicle in traffic to allow for increased response time.

VISION: Perhaps the most recognised age-related decline associated with driving behaviour of the elderly is vision and it is the relationship between visual capability and driving performance which has attracted the most research attention. Age-related declines have been noted in dynamic and static visual acuity, peripheral vision, resistance to glare, contrast sensitivity, visual processing speed, visual search, low light sensitivity, perception of angular movement, movement in depth, colour vision and a variety of other functions (Klein, 1991; Kosnik, Sekuler & Kline, 1990). Moreover, it has been noted that there is a large increase in individual differences with increasing age. Briggs (1987) found that the difference in visual ability between the best and worst performing older adult was far greater than between the best and worst performing younger adults.

Models of driver information processing typically consider vision as the primary sensory channel, which is responsible for up to 95% of driving-related inputs (Shinar & Scheiber, 1991; Kline et al., 1992), however, it has been difficult to determine what specific visual skills are important for driving. Attempts to relate visual functions to driving in general have not been particularly successful. While laboratory studies have shown that ageing is accompanied by significant declines in visual functioning, the extent to which these declines alter the ability of older persons to perform such tasks as driving is not directly predictable from laboratory findings (Kline et al., 1992).

Kosnik and others (1990) pin-pointed three factors that might be masking the role of vision in accidents. First, crashes have many causes, of which a problem with vision is only one; second, older drivers use compensatory strategies to make up for deteriorating visual abilities; and third, current laboratory tests may not predict accurately the complex visual functions demanded by driving.

Elderly drivers have a great number of vision problems that affect visual acuity and/or peripheral visual fields. Most marked are changes in the lens (Olson, 1988). The lens continues to add layers of cells throughout life and as a result it becomes larger, more dense and less flexible. The reduced flexibility makes it more difficult for the lens to adjust (accommodate) to bring nearby objects into sharp focus. The lens yellows and hardens with age and becomes a less efficient transmitter of light resulting in less light reaching the retina and more light scattering when entering the eye (Olson, 1988). In addition, less light reaches the ageing eye because the pupil tends to become smaller and loses some of its ability to dilate in dim light.

A number of components of vision have been argued to be relevant to the visual needs for safe driving, namely, static visual acuity, dynamic visual acuity and visual field. One study (Kline et al., 1992) systematically explored adult age differences in the visual problems presented by a variety of driving tasks. The visual problems of drivers increased with age along five visual dimensions: unexpected vehicles, vehicle speed, dim displays, windshield problems and sign reading. Several of the age-related visual problems appeared to be related to the types of traffic accidents more common among older drivers. Despite arguments that older adults' impaired vision should be related to an increased risk of accident, research has failed to establish a strong link between specific vision decrements and accident risk in the elderly. It may be that sensory tests such as visual acuity and visual field sensitivity, though appropriate for the clinical assessment of vision loss, may not reflect the visual complexity of the driving task.

STATIC VISUAL ACUITY: Static visual acuity is the ability to discriminate fine, stationary, high-contrast details and this is thought to decline with age, particularly after the age of 50 (Bailey & Sheedy, 1988). The hardening of the lens of the eye and reduced ability to focus (beginning around age 45) also reduce near static acuity and this is especially notable at night. Shinar's (1977) study indicated small but significant correlations between either static or dynamic visual acuity and accident involvement.

DYNAMIC VISUAL ACUITY: Dynamic visual acuity is the ability to resolve details of a moving object; this declines with age (Shinar & Scheiber, 1991) and has been correlated with accident involvement (Burg, 1968; Shinar, 1977) because it combines multiple sensory and motor skills necessary for safe driving.

VISUAL FIELD: Older people tend to experience a contraction in their field of view, and theoretical arguments support the relevance of a large visual field for good driving performance. Several studies have reported an association between peripheral visual field loss and driving performance (Hedin, 1980; Keltner & Johnson, 1980, 1987). Other studies failed to find consistent relationships between declining visual field and accident rates amongst the elderly (Burg, 1968; Shinar, 1977) although these studies relied on simplistic field screening devices rather than diagnostic clinical tests.

Keltner and Johnson (1980), using automated visual field testing, found that the prevalence of visual field loss was 3-3½% for individuals between the ages of 16 and 60, about 7% for the 60 to 65 year age group, and 13% for those over 65 years. Drivers with visual field loss in both eyes had traffic accident and conviction rates that were more than twice as high as a control group with normal visual field. Further, the types of accidents most frequently associated with visual field loss were a failure to yield, inattention, stop signs, left turns, oncoming traffic and road signs. These findings demonstrated a strong association between peripheral visual field loss and driving performance, and they suggested that the elderly driving population may be at greater risk for traffic crashes that are related to peripheral visual field loss.

NIGHT TIME DRIVING: Changes in visual abilities as age increases are especially pertinent to night driving where the elderly driver needs greater brightness contrast and minimum glare. A greatly reduced level of illumination reaching the retina, combined with reduced retinal functioning place the older driver under a significant handicap when driving at night (Olson, 1988). Older persons have much less tolerance for glare and are disabled by glare for longer, which further reduces their visual abilities at night (Mortimer, 1989).

With the greater scattering of light as age increases, it would be expected that an older driver would find a given level of glare more disabling and uncomfortable than a younger driver would. Sensitivity to glare occurs when the light entering the eye is bright enough to interfere with the central image that is being focussed upon in the retina. The resulting reduction in the quality of the retinal image is often accompanied by significant loss of visual contrast, so that details are lost (Shinar & Scheiber, 1991). Many reasons have been advanced for the increasing sensitivity to glare that older adults experience: smaller pupil size, thickening and yellowing of the lens, and a tendency of the humor of the eye to become more opaque (Yanik, 1988).

Not only does visual function deteriorate in the presence of a glare source, but prolonged exposure can result in muscular fatigue and tenseness which has been associated with poor driving performance (Shinar & Scheiber, 1991). Olson and Sivak (1984) measured the effect of glare by directly presenting glare in rear-view mirrors. They found that older subjects had to adjust target disc luminance much higher than younger subjects and it took the older subjects longer to recover from exposure to glare and reach stable performance.

An analysis of the 1983 US Fatal Accident Reporting System (FARS) and the Nationwide Personal Transportation Study focussing on fatal night time crashes (Mortimer & Fell, 1988) showed that older drivers (65+) were particularly involved in multi-vehicle side or rear impact crashes. They concluded that because of the physiological changes that are known to occur with ageing, older drivers are at risk in the hours of darkness. Mortimer (1989) suggested that older drivers would be aided at night by increasing the reflectivity of objects, limiting the mounting height of headlights, appropriate reflectiveness of mirrors for control of glare, automatic headlight alignment, automatic headlight cleaning and beam patterns that emphasise glare control.

COGNITIVE PERFORMANCE: Driving requires a combination of perceptual skills in which cognitive performance plays a major role. A large body of research maintains that complex or higher-order functions are more relevant to the demands of driving and they manifest a faster rate of age-related deterioration. Cognitive performance is fundamental to attentiveness to the driving task, recognition of a stimulus, and choice of the appropriate way to respond (Transportation Research Board, 1988). Cognitive deficiencies that may affect driving ability include confusion and inattentiveness, slowed psychomotor reaction and decision time, difficulty in adjusting to traffic conditions, difficulty judging the speed and distance of other vehicles, and difficulty in reading and understanding traffic signs (Lerner, 1991; Staplin & Lyles, 1991; Stelmach & Nahom, 1992; van Wolffelaar, Brouwer & Rothengatter, 1991).

Kosnik and others (1990) discovered that there were cognitive components to the visual problems experienced by older drivers who had decided to give up driving. They found cognitive problems relating to difficulties in dynamic vision, visual processing speed, visual search, light sensitivity and near vision. They concluded that perceptual errors such as driver distraction, looking but failing to see, misjudgments of speed and distance, and incorrect interpretation of complex cues, rather than purely visual factors, could be identified as the cause of many traffic accidents.

The complexity of some traffic situations demanding quick and accurate judgements and decisions may place overwhelming demands on the cognitive processes of elderly drivers resulting in an over-involvement in crashes. The elderly often require more information than do younger drivers on which to base driving decisions and may also exhibit lower levels of performance in recognition and response tasks (Cooper, Tallman, Toukko & Beattie, 1993).

REACTION TIME: One of the most well established research findings regarding ageing is the slowing of reaction time (defined as the time interval between the presentation of stimulus and the initiation of a response). With advancing age, it takes longer to acquire information, process information, select and plan a response, and execute that response (Lerner, 1991). Reaction time is critically important in a number of driving situations. Many studies have compared reaction times for drivers of all ages, some using simple reaction tasks and others using actual driving situations with roadway hazards.

Studies show that slowing becomes more pronounced as task complexity increases, and this is particularly noticeable as age increases. Simulator studies have found statistically significant age effects in perception-reaction time [PRT] (defined as the time that lapses from the first visibility of an event to the initiation of an appropriate response) when responding to a visual event - a difference of around 2 seconds between reaction times of older and younger groups (Lerner, 1991). It takes longer for older drivers to complete the components of PRT (i.e. perception, analysis and reaction) especially for events which are not anticipated or are complex, and it may be that current sight distance criteria used for roadway design is inadequate for older drivers.

MOTION PERCEPTION: The ability to detect movement (motion perception) is a critical component of driving performance and it has been suggested that this ability declines with increasing age (Staplin & Lyles, 1991). Motion perception is controlled by neural and oculomotor mechanisms and is affected by the effort in smooth pursuit tracking, which increases with age (Shinar & Scheiber, 1991). Age-related declines in the efficiency of processing incoming information lead to difficulty in estimating distance and speed, particularly in dusk and in darkness (Wounters & Welleman, 1988).

Studies on the ability to judge the distance between objects have shown that older drivers are much more likely to underestimate the relative depth separating visual targets than are younger drivers (Hill & Mershon, 1985 - cited in Transportation Research Board, 1988; p.59). In addition, simulation studies have indicated that older persons overestimate the velocity of oncoming vehicles, but not enough to compensate for their underestimation of the distance between themselves and the vehicle (Kline, 1986 - cited in Transportation Research Board, 1988; p.59).

A review of age-related differences in motion perception abilities and accident involvement patterns was conducted by Staplin and Lyles (1991) using time-to-collision and gap-acceptance judgements. They reported a decline for older subjects in the ability to detect angular movement suggesting that older people require twice the rate of movement to perceive that an object's motion-in-depth is approaching, given a brief duration of exposure as in a traffic situation. They state that older drivers should have more difficulty than young drivers with specific traffic manoeuvres requiring angular movement detection, that is when turning left against oncoming traffic (again, equivalent to right turns in Australia), when simply crossing or turning into a traffic stream and where vehicle headways (i.e. the separation in space or time between two consecutive vehicles in a traffic stream) are important.

ATTENTION CAPACITY: The ability to focus on a task diminishes with age, older persons are more easily distracted by irrelevant stimuli and have more difficulty than younger adults in selectively attending to the most important stimuli (Transportation Research Board, 1988). A number of accident examination studies indicate that driver inattention contributes to between 25 and 50 percent of crashes (Transportation Research Board, 1988).

While driving, several sub-tasks may be in progress in parallel, so that drivers have to be able to divide attention and switch to other sub-tasks when necessary. A substantial collection of experimental studies have shown that older adults have difficulties in dual-task performance (Korteling, 1991,1992; McDowd & Craik, 1988; Transportation Research Board, 1988; van Wolffelaar, Brouwer & Rothengatter, 1991). A suggestion has been advanced by Korteling (1992) that the decreasing ability of the older driver to handle the relationship between parallel tasks may be caused by:

- limitations in the integrated uptake and processing of information from multiple sources; and/or
- limitations in combining related actions, associated with deteriorations in attention switching, prioritising sub-tasks combining related actions.

Using a simulated driving task van Wolffelaar, Brouwer and Rothengatter (1991) looked at age-related abilities to divide attention between different sources of information and performance in relation to different information and response modalities. They found a substantial deterioration in older basic people's performance on driving tasks, in particular, course-control as measured with the standard deviation of lateral position.

DECISION TIME: The type of accidents elderly drivers tend to be over-involved in (as discussed in section 2.2.2) suggest that time-critical traffic tasks are difficult for them. This may indicate functional impairments in decision making. Van Wolffelaar, Rothengatter and Brouwer (1991) assessed speed and quality of merging decisions for young and older drivers and found that older drivers responded much later when deciding to merge, yet accuracy was no worse than that of the younger drivers. They suggested that there may be a decrease in speed of mental operations in the decision making processes of the elderly.

INFORMATION PROCESSING: A review of the literature shows a general agreement among researchers that older persons process information more slowly than younger ones, and show performance deficits on complex, multi-factor tasks (akin to complex traffic situations) (Transportation Research Board, 1988; Wounters & Welleman, 1988). Further, it has been suggested that older drivers require more time than younger drivers to complete cognitive components of the driving task (including recognition, decision making, attention, and memory) (Transportation Research Board, 1988).

One study (Staplin, Lococo, Sim & Drapcho, 1989) sought to obtain relevant measures of age-related differences for three groups of functions, namely: sensory-perceptual, cognitive and psychomotor functions that underlie safe and effective usage of traffic control devices. The results indicated that deficits in cognitive tasks, rather than declines in sensory capacities, play a significant role in the driving difficulties experienced by the older driver. It was suggested that, in general, a fundamental difference in strategy exists where older drivers require greater certainty before responding.

Ranney and Pulling (1990) developed a battery of closed-course driving and laboratory tests to evaluate the skills required in routine suburban driving including responding to traffic signals, selecting routes, avoiding moving hazards and judging narrow gaps. They also measured perceptual style, selective attention, reaction time, visual acuity, perceptual speed and risk-taking propensity. Performance on these tests revealed large differences between young and older drivers, particularly in the laboratory tests. An overall decline of all information-processing abilities, rather than selective differences, was suggested as a possible explanation for the greater difficulty experienced by older subjects.

MOTOR-COGNITIVE ABILITIES: Motor control is of prime importance when faced with traffic emergencies where an action such as braking, steering, turning, lane changing, merging, recovering from a skid must be executed quickly.

Motor performance slows with increasing age (Stelmach & Nahom, 1992) and associated with this slowing, responses become more variable and rely more on feedback control processes than on programmed representations of movement. For the older driver, action sequences in an emergency situation become more complex and involve additional cognitive/motor processes.

Research suggests that age-related slowing in cognitive-motor processes include failure to use advance preparatory information, difficulty in processing stimuli and making responses that are spatially incompatible, initiation deficit in dealing with increased task complexity, and difficulty in precision (Stelmach & Nahom, 1992).

PHYSICAL PERFORMANCE: In addition to declining vision and decreased cognitive abilities, the elderly suffer physical weakening; they lose agility (Morris, 1992), and suffer physiological changes in their cardiovascular, musculoskeletal and sensory systems (Bishu, Foster & McCoy, 1991), all of which can cause impaired co-ordination and reaction abilities. It is claimed that physiological changes resulting from the normal ageing process are estimated to affect three out of five people aged over 75 (Bishu et al., 1991).

Older drivers may experience difficulty in looking behind and turning their head from side to side, causing specific problems in taking off at intersections and in merging traffic situations (Stelmach & Nahom, 1992). Further, age-related motor impairments have been linked to decreases in sensory receptivity, muscle mass and elasticity, bone mass, and central and peripheral nerve fibres (Stelmach & Nahom, 1992). These physical changes affect the ability of the older adult to control movement rapidly and accurately, resulting in less than adequate acceleration, braking, steering, general manoeuvring of the vehicle and operation of controls.

PHYSICAL VULNERABILITY: Tests have demonstrated that human tolerance to impact forces decreases with age over 40 years resulting in a higher incidence of crash injuries among older occupants (Viano et al., 1989). Further, Evans (1991) states that drivers over about 50 years have an increased risk of death when a crash occurs, that is, physiological factors associated with ageing play a role comparable to that due to declines in driving skill.

Traffic accidents involving older people have more severe consequences and are more often fatal. Additionally, older people are more vulnerable to injury and have a reduced capacity for recovery compared to younger people (McCoy, Johnstone & Duthie, 1989). Sjogren and Bjornstig (1991) analysed hospital records and found that one quarter of all traffic injuries and half of all fatalities were to people aged over 60 years.

An examination of hospital records of over 6,000 accident cases, of which 312 were over 65 years of age (McCoy et al., 1989), showed that older people were more likely to sustain serious injuries in a given accident, and that the risk to their life was significantly greater for a given injury severity. Elderly vehicle occupants sustained a similar distribution of injuries to those of other age groups, however, their injuries were generally more severe, and the fatality rate for all grades of injury rose from approximately 1% in those aged less than 20 years to almost 11% for those aged over 70 years. It was also found that given equivalent injury scores, those aged over 65 years tended to have higher hospital admission rates, spent longer in hospital and had a significantly higher mortality than younger patients.

A number of issues on changing injury patterns and under-reporting of injury events as a cause of death are particularly relevant to older persons. Mackay (1988) noted that while the Abbreviated Injury Score (AIS) is a scale of threat to life and is a useful tool in determining the severity of injury, it does not assess long-term consequences, it may not accurately reflect age differences and changing injury patterns and it is a less satisfactory measure for predicting mortality in older people. McCoy and others (1989) noted that AIS does not account for the fact that elderly people do not recover normal function as easily as younger people. Because of the relative frailness of older people, distributions of less severe injuries can lead to more significant impairment of function in older people, especially those to the head, limbs and back (Mackay, 1988).

Fife and Rappaport (1987) suggest that injury events may be under-reported as a cause of death for older people due to several factors. First, older people tend to die later after an injury than do younger people, and the long interval from injury to death may lead to under-reporting of the actual cause of death. Second, for many older people death is the culmination of a rather long chain of events, and it may be difficult to identify a specific cause of death resulting in the injury event being omitted from the list of diagnoses. Third, in the case of older people, physicians do not tend to perform autopsies, or to rigorously pursue signs, symptoms and diagnoses, resulting in a tendency to view the death as 'natural' in the sense that little further explanation is required.

DEMENTIA: Studies have revealed an association between dementia (particularly Alzheimer's disease) and increased crash risk even though patients with dementia may limit their driving (Friedland et al., 1988; Kaszniak et al., 1991; Williams & Carsten, 1989). However, little is known about the specific perceptual/cognitive deficits contributing to impaired driving.

Alzheimer's disease has been estimated to affect more than 10% of all persons aged 65 years and over and 47% of those aged 85 years and over (Evans et al., 1989). The syndrome of dementia involves impairment of memory in association with impairment in judgement or abstract thinking, perceptual deficits, and other disturbances of higher cortical functioning. The association between dementia and driving errors has long been recognised by clinicians as an area of great concern (Kaszniak et al., 1991).

Parasuraman and Nestor (1991) assessed whether the progressive cognitive deficits that occur in drivers with dementia of the Alzheimer's type increase their risk of accident. They found that attentional functions, particularly the switching of visual selective attention, are impaired in the early stages of dementia and contribute to increased accident risk.

Parasuraman and Nestor (1991) also found that patients with dementia have difficulties with those components of driving that rely heavily on recent memory - for example, following new routes and identifying unfamiliar road signs. Thus they argue, while the basic abilities needed to initiate driving are well preserved, however, those functions that allow driving to be goal directed and purposeful may be adversely affected early in the disease.

An associated concern regarding the appreciation of potential driving risk has been expressed by a number of researchers (Kaszniak et al., 1991; O'Neill, 1992;). This is of great concern given the steady, progressive nature of the disease, and raises the question of when elderly drivers with dementia should stop driving.

Patients with dementia may tend not to recognise age-related deficits in sensory, perceptual and cognitive abilities that are relevant to driving, may under-estimate driving dangers while overestimating their own driving skills, and as a result are reluctant to relinquish driving.

USE OF MEDICATIONS AND ALCOHOL: Several studies have examined the effects of prescription and over-the-counter medications such as benzodiazepines, cyclic antidepressants, antihistamines, narcotic analgesics and hypoglycemics on driving skills, and there are some data linking their use to crashes (Bauer, 1984; Ray, Gurwitz, Decker & Kennedy, 1992).

Although existing evidence is insufficient to establish that the use of medications by the older driver creates a road safety problem, there is reason for concern. Medication use increases with age and is very common among persons 65 years of age and older. While only 12% of the US population is over 65 years of age, this group receives 29% of all prescriptions. Additionally, more than 80% of those 65 years and over take one or more prescribed medications (Ray et al., 1992).

Older individuals are more susceptible to the central nervous system effects of many medications (Ray et al., 1992). With ageing, hepatic and renal function decreases, thus reducing the capacity of the body to inactivate and excrete many medications. Older people who take many types of drugs may have higher active blood levels of the drug for longer periods of time.

The literature on drinking behaviour among the elderly is contradictory and more research is needed. Some researchers have indicated that the prevalence of alcoholism may be rising in the elderly population, thus increasing the potential of alcohol-related traffic crashes caused by elderly drivers, while others have found no evidence of increased alcohol consumption with ageing (Ekerdt, De Labry, Glynn & Davis, 1989).

Brody (1982) found an increase in alcohol consumption or abuse after retirement. Two reasons why retirement may have an effect on drinking behaviours have been suggested. First, retirement can be an unsettling experience because of, or associated with, status loss, boredom, depression, loss of self esteem or role confusion. Second, retirement provides more leisure time and wider opportunities for alcohol consumption, relaxed role constraints and obligations.

2.2.5 The Road Environment

The road environment itself may be an important contributory factor to the level of risk elderly drivers face on the road. Ernst and O'Connor (1988) argued that the complexity of the road environment, in conjunction with diminished information processing capabilities of the elderly, results in a reduced driving performance. In addition, many other researchers have recommended improved road design in an effort to prevent crashes in the elderly (Gelau, Metker & Trankle, 1992; Khavanin & Schwab, 1991; OECD, 1985; Stamatiadis, Taylor & McKelvey, 1991; Staplin et al., 1990).

A Committee at the Transportation Research Board (1988) recognised that the roadway system can be better adjusted to the needs and abilities of older persons. They concluded that present sign visibility and maintenance standards, performance assumptions used in intersection design and traffic operation are inadequate and fail to account for the capabilities of elderly road users.

Although highways have improved dramatically during the past few decades, many design assumptions used today are based on the performance characteristics of a younger population (Godwin, 1989; Waller, 1991). Highway and traffic signs present critical guidance information to drivers and greatly influence their ability to safely control their vehicle (Khavanin & Schwab, 1991). However, signs and signals have the potential to present the elderly driver with a variety of problems, given the visual impairments and slowing of response to visual cues that occur with ageing.

The OECD (1985) recommended using road information systems (signs and signals, markings, guidance systems) that are clear, unambiguous, coherent, complete and easily visible both day and night. Given that ageing slows reaction times, reduces vision, and results in less efficient information processing, signs and signals need to provide relevant, conspicuous and timely information for the elderly regarding the selection and execution of necessary manoeuvres for an approaching traffic situation.

A number of studies have measured sign legibility and design criteria. Khavanin and Schwab (1991) examined the trade-off between traffic sign size and background material and their effect on legibility and conspicuity distances for drivers aged 60 and above in day time and night time conditions. Results indicated that both size and level of retroreflectivity affected sign visibility, and that size was particularly important for night time visibility.

Staplin and others (1990) addressed the magnitude of age-related differences in visual performance and their effect on recognition of delineation and sign word/message legibility. Significant age effects were observed in quantifying the required brightness of pavement striping to discriminate curves, and in the required character size to read single words and messages on signs. They concluded that deteriorating cognitive factors have wide implications for the design of traffic control elements and suggested countermeasures to accommodate the older driver population.

A review of sight distance design criteria (Lerner, 1991) raises concerns about the adequacy of current criteria for the older driver. Sight distance underlies a number of design criteria, such as stopping sight distance, decision sight distance, intersection sight distance, railway crossing sight distance, and passing sight distance, and is calculated on a) the time it takes the driver to perceive and react to the situation, and b) the time it takes to execute the desired manoeuvre. Design standards should be based on longer times to perceive, analyse and react to perceptual events to accommodate the older driver, especially when those events are complex or not anticipated.

The older driver is at even more disadvantage reading signs at night because of poorer acuity under low illumination (Mortimer & Fell, 1988) and suggestions for improvements in the overall night driving environment have been made. Sivak and others (1981) compared the distance necessary to manoeuvre in traffic after reading a sign for younger and older drivers. In this study, the older drivers (over 60 years of age) had a legibility distance only 65 to 77% of that of younger drivers (18 to 24 years). Given that the older drivers in this sample had excellent vision under high illumination, but a considerable disadvantage under low illumination, it is clear that current design does not provide enough time or distance for the average older driver to manoeuvre after reading a sign, especially at night.

A second recommendation proposed by the OECD (1985) to improve the safety of the elderly driver included elimination, where possible, of situations that become complex in dense or fast traffic. For example, application of one-way systems, prohibiting dangerous turns, avoiding or eliminating level junctions, separating flows, staggering the traffic decision process (use of roundabouts, offsetting crossroads, etc) were recommended. In a study of accidents involving elderly drivers and intersection traffic control devices, Stamiatadis and others (1990) found that elderly drivers face problems when the traffic condition becomes complex, for example, on multi-lane roads and with multi-phase signals, particularly when making left turns (right turns for Australians) indicating a reduced ability to handle and process information at a fast pace.

2.2.6 Vehicle Design

A number of aspects in the design of vehicles are important to older persons. These include crash protection and future design improvements that may simplify driving.

CRASH PROTECTION IMPROVEMENTS: As mentioned previously, the ageing process reduces tolerance to crash forces (Mackay, 1988; Viano et al., 1989). Older road users have reduced bone strength and fracture tolerance making them more vulnerable to injury when a crash occurs.

One of the major thrusts of traffic research is safety improvement to vehicles, particularly occupant protection in the event of a crash. Crash protection as a fundamental design criterion for vehicles has received increasing attention in the last decades. Manufacturers have an increased awareness of the changes that take place in the ageing process, however, the body of knowledge upon which effective crash-protective design is based is still relatively small, particularly regarding the needs of the elderly driving population (Mackay, 1988).

Current occupant crash protection standards set simple pass or fail thresholds for forces applied to the head, chest, and femur in simulated crashes, and a single value is used for measuring the forces applied to each body area (Transportation Research Board, 1988). Mackay (1988) points out, however, that the differing ability of different age groups to withstand these forces is not well known, and given their increased vulnerability to injury, older persons appear to be less well served by the existing standards than younger persons.

Older road users can benefit from improved safety belts, accessibility and ease of use of safety belts, improved head restraints, supplementary air bags, knee bars, cushioning of hard unyielding structural surfaces (including door surrounds, roof rails and pillars) and laminated windscreens. In response to the finding that elderly drivers are over-involved in intersection side-impact crashes Viano and others (1989) also suggest optimisation of side-interior padding to protect older occupants in low-severity crashes.

VEHICLE DESIGN IMPROVEMENTS: If manufacturers are to service the growing population of elderly drivers and vehicle occupants they must better understand the needs of older road users and provide them with a personal mobility that is comfortable, convenient and safe. A further understanding of ageing effects on interactions with vehicle systems such as controls and displays, mirrors, headlighting, seating, and entry and exit is needed to meet the needs of older drivers (Yanik, 1988).

Recommendations from the Older Driver Colloquium (1985) included improved "A" pillar design to improve forward and lateral visibility, optional safety features such as head restraints, headlight washing and wiping system, easily reachable driving controls and power steering and brakes. Additional research on the safety and comfort of the older driver was recommended, in particular, follow up on issues such as how well vehicle design accommodates vision and perception, best shape and colour for front and rear windscreens, the most suitable design and colour to increase readability of control panels and the best methods to accommodate the physical limitations of ageing (reduced strength, flexibility and comfort in relation to steering, braking, seeing to the side and rear, sitting, climbing in and out, adjusting the seat belt and so on).

DISPLAY PANELS: With age-related declines in vision, the reading of instrument panel displays becomes more difficult. Vehicle panel displays are located at an average distance of 50 to 70 cm from the eye, however, this distance is often inappropriate for older drivers and forces them to lean forward to help bring the display into a range that accommodates their vision. Yanik (1988) argues that an increase in the size of displays and provision of good luminance properties and high contrast ratios would be useful to older drivers.

Further, the time taken to adjust eye focus from distance objects outside the vehicle to the displays inside the vehicle increases as age increases (Yanik, 1988).

Colour perception is affected with ageing, and the role that colour can play in enhancing legibility, especially for older drivers, is often neglected in the design of instrument panels. With age, the lens absorbs almost twice as much blue energy as red or yellow, making it relatively insensitive to shorter wavelength colours such as cyan to deep blue, but enhancing sensitivity to colours of longer wavelengths like yellow and orange. Further, the lens yellows with age, augmenting the insensitivity to blues. Ageing also reduces the transmittance of fluids in the eye which makes all colours appear less vivid and bright. It appears that yellow, orange and white on contrasting backgrounds are the most legible display colours for older drivers (Yanik, 1988).

NIGHT VISION AND GLARE: One of the most difficult visual problems associated with the ageing process is a growing insensitivity to glare, and this is exacerbated with night time driving. At night, the older driver needs greater brightness contrast to see and minimum glare. Mortimer (1989) suggests inappropriate vehicle headlighting and related factors as contributing to these problems. An overload of light from a central source such as direct headlights prevents good vision by reducing the visual contrast in the subject upon which the driver is focussing so that its details are lost. Such glare can cause extreme discomfort and/or disability and forces the driver to look away from the subject completely. Further, with increasing age glare from lights produced by oncoming traffic or lights reflected in rear-view mirrors from following traffic become more irritating.

A number of vehicle design improvements have been suggested to increase visibility, comfort and safety and to reduce glare for the older driver at night. These include limiting a maximum mounting location for headlights, rear-view mirrors with low reflectivity, headlight cleaning systems to maximise light output and reduce associated glare, easy adjustment of outside mirrors to reduce glare (Mortimer, 1989; Olson, 1988), and tinting of the windscreen to absorb light before it reaches the eye (Allen, 1985).

2.2.7 Licence/Medical Testing/Re-testing

The extent to which older adults can monitor and assess their visual and cognitive capacity and then compensate for these deficits in their driving remains to be established. It has been argued that if older individuals cannot be assumed to restrict their driving as warranted, they must be monitored and/or controlled through the licensing system. Others, however, believe that current practices for identifying the critical characteristics of ageing that influence driving performance are of limited effectiveness (Ernst & O'Connor, 1988). In her review of current practices for licence renewal, Waller (1991) argues that driver licensing programs have been designed to qualify young beginning drivers, but relatively little attention has been given to the special needs and capabilities of the elderly.

Further, while evidence suggests that older drivers are over-involved in crashes per distance travelled (Williams & Carsten, 1989; Evans, 1991b; Waller, 1991) , the contribution of licence re-examination in reducing this over-involvement and the potential of driver licensing and control systems to improve safety has not been clearly established. Torpey (1986) reviewed the evidence showing crash rate by light conditions and by crash type of older drivers and argued that given their absolute and relative crash involvement and the costs of implementing a testing program for these people, any testing program is unlikely to be cost-effective. Despite dissatisfaction with re-testing requirements, however, many researchers still advocate retention of medical testing and improved measures of licence re-testing (Ernst & O'Connor, 1988) for older drivers.

Some issues have been raised in reviews of licensing systems, such as differences between functional age and chronological age, ambiguity in what is meant by 'older', the inherent conflict between avoiding any appearance of discrimination against older people and protecting other road users from potentially hazardous drivers, mobility needs afforded by keeping a driver’s licence and the consequences of restriction or denial of a driver's licence (loss of independence, economic, psychological and social losses).

There is a gradual deterioration in performance with age, associated with a gradual increase in crash risk. Despite documentation of a greater variation in group differences as age increases (Waller, 1991) many recommendations are based on group performances. While one driver may begin to show decline in the early 50's and be unable to drive safely by age 60, another driver may continue to drive safely well into their 80's and show little apparent difficulty. This presence of individual variation means that no specific chronological age can be singled out as an appropriate age at which a driver's licence should be automatically denied.

Victoria is the only Australian state that does not require licence/medical re-testing of older drivers from about the age of 70 years. In Victoria, re-testing requirements are only applied upon the receipt of voluntary information from family members or members of the public (neighbours, doctors and other professionals) suggesting to Police that a certain person is unfit to drive. All other states have some form of licence re-testing program for older drivers and these vary in the age at which they are implemented and in the extent of testing (Torpey, 1986).

The rationale underlying any form of assessment prior to driver licence renewal is to ensure that drivers remain competent and do not create a road safety risk for themselves or for other road users. Researchers have urged the adoption of a number of licensing system reforms. Suggestions include maintenance of the current Victorian practice of compulsory or encouraged reporting of functional impairment regardless of age by health professionals

(Hull, 1991), introduction of a system of review prior to licence renewal for the elderly (Hull, 1991), selective visual screening tests (Briggs, 1987), restricted licensing prohibiting driving under specific circumstances (eg., darkness, peak hour traffic or specified distances from home) (Alcee, Jernigan & Stoke, 1990), and gradually increasing the restrictions on the licences of older people, for example, re-examination of drivers' licences at least every 2 years over the age of 75 years (Stamatiadis et al., 1991; Waller, 1991).

2.2.8 Countermeasures

Driving combines a host of roadway, vehicle and human factors and many safety interventions for elderly drivers in these areas have been proposed. Driver education has been suggested for the older driver (Hogue, 1982). However, while it is commonly believed that educating people about problems and abilities can act as a countermeasure to improve safety, it has also been argued that injury control programs that automatically protect people without their having to take any action are most successful.

There is a growing body of evidence that engineering countermeasures (adapting the road environment and vehicle improvements) and heavy enforcement supported by publicity (e.g., speed cameras, random breath testing, mandatory wearing of seat belts and bicycle helmets) have a far greater success rate than those primarily aimed at changing behaviour through education. Unfortunately, very few engineering countermeasures have been systematically evaluated. There clearly exists a need for multi-disciplinary research to isolate problem areas related to the older driver and to develop suitable interventions.

DRIVER MODIFICATION (IMPROVED EDUCATION/DRIVER TRAINING): Training or re-training of older drivers is slowly being recognised as a possible approach to improving the performance of this age group. The Older Driver Colloquium (1985) recommended corrective courses for all drivers over the age of 55 years with sub-standard driving records. Courses should include information about the effects of normal ageing on driving ability, and a discussion of the ways to compensate for impairments. They also recommended that the importance of good health and the effects of medication and alcohol on driving skills should be emphasised. They further recommended that educational courses in traffic safety be made available regularly to all older drivers on a voluntary basis.

The Transportation Research Board (1992) suggested the development of an effective older driver training and informational program to improve driver awareness regarding personal limitations which may contribute to unsafe driving and/or limited mobility as well as to provide information regarding appropriate compensations for age-related limitations.

An evaluation of the driving knowledge of older drivers (McCoy, 1991) indicated that older drivers have deficiencies with right-of-way rules and procedures for crossing and turning left at intersection, safe following distances, correct lane positioning and selection and proper procedures for backing and parking. McCoy recommended driver education in these areas.

VEHICLE MODIFICATION (IMPROVED VEHICULAR DESIGN): As noted previously, installation of safety features in vehicles to accommodate the elderly driver has been recommended. Improved seat belt design, installation of air bags, supplementary restraint, head restraint, knee bars, cushioning of hard unyielding surfaces particularly side-interior padding and padding of pillars, improved windscreen safety, improved instrument panel design improved headlight performance (including availability of headlight washers and higher mounting) and power steering and braking systems have been suggested.

In addition to installing improved safety features in cars, better information about vehicle features that would enhance safety and convenience and facilitate easy operation is recommended (OECD, 1985). Improved consumer information can benefit older drivers by making them more aware of the specific ways in which their performance and susceptibility to injury are likely to change as they age and of the attributes that they should look for and consider when purchasing a new vehicle. Increased attention should be given to the need to develop good consumer-oriented printed materials on how older drivers should go about making vehicle purchase decisions that take their special needs into account

It has been noted (Transportation Research Board, 1988) that vehicle crashworthiness standards fail to account for the lower injury threshold of older persons and the types of crashes in which they tend to be involved, and that more research is needed to improve crash protection for older persons.

HIGHWAY MODIFICATION (IMPROVED ROAD DESIGN): It is important to recognise that the highway transportation system has generally not taken the older driver into consideration. Highways are built according to standards based primarily on measures of performance of young males (Waller, 1991). For example, many older drivers do not have sufficient time or distance to respond to visual cues, particularly under conditions of low illumination, because they cannot see as well as younger drivers. In addition, the speed required to decide and act in order to merge with high-speed traffic and negotiate complicated intersections can overtax the capability of some older drivers.

Adjusting the roadway system to promote the mobility and safety of older persons is not an easy task - the system is complex and the needs and abilities of older drivers vary widely; however, a number of interventions have been proposed.

The OECD (1985) proposed several road infrastructure interventions to improve the safety of the elderly driver. These included reducing speeds through road design or traffic control measures in areas where complex manoeuvres are required. This would allow elderly drivers adequate time for information-gathering and decision-making without stress, and enable them to perform the manoeuvres with minimum dynamic problems. They also recommended eliminating complex situations in dense or fast traffic by application of one-way systems, by prohibiting dangerous turns, by avoiding or eliminating level junctions, by separating flows and by staggering the traffic decision process.

McCoy (1991) found that older drivers were over-represented in crashes at higher volume intersections controlled by either traffic signals or stop signs. The older drivers were usually the driver at fault, especially in the case of right-angle and left-turn collisions. By arranging traffic situations clearly and making traffic rules and the regulation of traffic comprehensible, much can be gained for the safety of elderly drivers. In this context it is important that traffic signs should be visible and recognisable to people with poor visual acuity and that traffic rules, particularly new ones, should be known (Wounters & Welleman, 1988).

A number of improvements to highways have been suggested by a number of researchers (OECD, 1985; Stamatiadis et al., 1991; van Wolffelaar et al., 1991) including safer roads with wider lanes and shoulders, non-obstructed roadsides without nearby trees and other obstacles, increased levels of illumination of roads, bigger and brighter signs, easily understood and simple messages, multiple signage for advanced warning and improved sign placement and maintenance. Left-turn lanes and left-turn signals could also be used to simplify the complexity of urban intersections.

The longer perception-reaction times of older drivers require longer sight distances and larger gaps for them to turn safely at intersections. Widening the left-turn lane lines, the placement of additional signal heads at intersections and turning path-lines would help drivers follow the proper left-turn paths through intersections (McCoy, 1991).

TRANSPORTATION SYSTEM IMPROVEMENT: Given the inevitability that the elderly will lose their driving skills it is important to consider how well other modes of transport can be made to serve their travel needs when they can no longer drive. When older drivers are no longer able to drive with reasonable safety, it is essential that their transportation needs be addressed in a coordinated manner. Effective ways to co-ordinate licensing programs with alternative transportation for older citizens need to be explored so that older people can be directed toward other resources and services in the community to meet their transportation needs (Waller, 1991).

A study by Parolin (1991) reviewed travel mode preferences among the elderly and handicapped. Five preference sensitivities were highlighted including accessibility, level of service, cost, and travel burden concerns in the process of travel mode preference formation. These sensitivities were found to be related to varying levels of personal physical disabilities. This study provided criteria for establishing and improving travel services to the elderly.

The OECD (1985) proposed improvements in the availability of short distance public transport in urban and rural areas to enable the elderly to abandon the private car without suffering major losses in mobility and participation opportunities. They also suggested improvements to boarding facilities and interior safety of public buses in order to reduce the risk of injuries to elderly passengers. The Transportation Research Board (1988) has additionally recommended that communities develop locally based transportation services for the frail elderly and further experiment with subsidised taxis, paid and unpaid carpools and paratransit systems.

DRIVER ASSESSMENT (IMPROVED LICENCE SCREENING): Licensing programs are in need of better information on what older drivers can and cannot do and what skills and capabilities are related to safe driving. Current driver licensing programs have a limited capability to screen out drivers who are at a higher risk of accident involvement. Increased accident risk can result from many performance characteristics for which valid, cost-effective tests have not been developed. An efficient system must additionally ensure that persons professionally assessed as being functionally impaired to the level where their driving may be hindered are the only persons brought to the attention of a licence review process (Torpey, 1986; Hull, 1991). Further, countermeasures related to licence review or screening need to be inexpensive to implement if they are to be cost effective.

The Transportation Research Board (1992) recognise a need to develop and evaluate a model 'graded' licensing program aimed at monitoring and maintaining the mobility of reduced-ability drivers. They recommend the development of a clinical test to catalogue and assess the wide range of functional disabilities together with their impact upon driving-related performance. A graded licensing system based upon the functional abilities and the inability of certain aged driver groups to self-assess and take proper precautions in their driving is suggested.

The substantial research literature associating age-related declines in vision and vision-based cognitive functions with increased crash risk supports the suggestion for selective visual screening of older drivers. It has been argued (Briggs, 1987; Keltner & Johnson, 1987) that the requirement in most western countries of a visual acuity of 20/40 in both eyes is not sufficient for the ageing driver. They also argue that the most common visual tests are poor predictors of driving performance, since they are only weakly related to driving, have poorly controlled stimulus conditions, and test procedures which are vaguely defined. A visual test package developed by Briggs including tests of visual acuity, low contrast visual acuity, visual search, visual choice reaction time, contrast sensitivity, glare tolerance and a separate test of visual fields could be used to screen and evaluate elderly drivers and help to identify vision-related risk factors.

Good vision is one of the most important abilities needed for driving and opportunities exist to improve vision screening tests for drivers. In their report, Keltner and Johnson (1987) recommended that individuals over age 65 years should have their visual acuity and visual fields evaluated every 1-2 years. They also recommended development of a system where potentially unsafe drivers may be reported by physicians or concerned family members, and drivers of any age with multiple accidents and/or convictions should have compulsory evaluation of their visual acuity and peripheral visual fields.

RESEARCH IMPLICATIONS: There is a need for research to develop a greater understanding of the needs and capabilities of the elderly driving population and to develop system improvements that will enable as many older persons as possible to continue to meet their own transportation needs safely.

Inadequate information exists on how older people drive, particularly those with functional limitations. It is well known that older drivers tend to have poor visual accommodation, poor ability to see in darkness or under dim light, decreased accuracy at estimating distance and closing speed, decreased ability for selective attention and attention sharing, and poor short term memory. Issues for further research include gathering more details on how these limitations affect driving performance, how older people drive and its relationship to miles driven, time behind the wheel, quality of driving, and how performance compromises their safety or mobility. The Transportation Research Board (1992) suggests that new research data is needed on the performance capabilities and limitations of older drivers, particularly the older-old (those over 75-80 years) and those with specified functional limitations. They further suggest developing a predictive battery of driving performance measures to assess specific categories of driving capacity and limitation among older drivers.

In their study on driving performance in older drivers, Ball and Owsley (1991) addressed the quality of information at multiple levels in the visual/cognitive information processing system and recommended further research to refine the tests of useful field of view (i.e. the visual field area over which information can be acquired during a brief glance) and mental status (measures include orientation, visual memory, speech, comprehension, abstraction and block design) to improve their relation to crashes. Future research should strive to improve the sensitivity of measures currently found to be predictive of accident involvement and extend the range of possible measures to be examined in relation to driving.

Recommendations to improve the safety of older drivers at intersections are hampered by a lack of knowledge about the consequences of alternate designs and alternate levels of traffic control. Design criteria should be adopted that accommodate the capabilities and limitations of the older driver.

Ray and others (1992) claim there is an urgent need for research into issues concerning medication use in the elderly and the effects this may have on driving performance. Existing evidence shows that persons over 65 years take psychotropic drugs, narcotic analgesics and hypoglycemics and that the frequency and severity of adverse central nervous system drug effects increases with age.

Driving simulation provides an excellent method of conducting research on how performance can be related to the driving task for the elderly driver. The use of simulation for training, testing and evaluation of the older driver and for experimental research on the driving capabilities of older drivers is receiving increased attention. Measures of visual and cognitive capabilities such as dynamic visual acuity, peripheral visual acuity, attentiveness, information processing, decision-making, perceptual-reaction times and problem solving are able to be studied with simulation methods in the hope of gaining a better insight into safety and mobility issues of the elderly driver.

2.3 ELDERLY PEDESTRIANS

Pedestrian casualty crashes represent a substantial road safety problem in Australia. Many researchers have shown that older persons are over-represented in pedestrian casualties (Gilbert, 1990; Federal Office of Road Safety, 1986; Mackay, 1988; Safety for Seniors Working Group, 1989), and that this percentage is expected to increase more than in any other population group in the future. In addition, they suffer more severe injuries than do younger pedestrians and face the greatest risk of death (Gilbert, 1990; Sheppard & Pattinson, 1986). With young adults, one pedestrian in every nine who is seriously injured dies; in the case of pedestrians over the age of 60 years this rises to one in every four (Federal Office of Road Safety, 1986). These findings are consistent to findings in other developed countries in the world (OECD, 1985).

A study conducted by the Safety for Seniors Working Group (1989) found that each year around 550 pedestrians die on Australia's roads and a further 3,500 are hospitalised with injuries. Pedestrians over the age of 60 years are disproportionately represented, accounting for 40% of total pedestrian fatalities, even though they make up only 15 percent of the total population. Moreover, Alexander, Cave and Lyttle (1990) found that the relative risk of involvement in a pedestrian accident increased noticeably above 60 years of age and that the elderly pedestrian had more than twice the accident risk of younger adult pedestrians.

Despite the acknowledgment that pedestrian safety is a considerable problem on Australian roads, little research has been conducted as to why these crashes are occurring, nor has there been extensive research on risk factors or behaviour and exposure of elderly pedestrians. Moreover, few interventions have been suggested or implemented.

2.3.1 Characteristics of Accidents involving Elderly Pedestrians

Elderly pedestrians are more vulnerable to casualty crashes because they tend to have reduced road skills and reduced mobility. Allard (1982) attributed the high death rate for elderly pedestrians to poor understanding of older pedestrians' behaviour by car drivers, to the declining perceptual and motor abilities of the elderly and to an increase in severity of crashes with age.

There are a number of common patterns in elderly pedestrian accidents. Elderly pedestrians are often hit when crossing intersections, they are generally hit on the far side of the road, they are usually observing the law and not behaving dangerously, they often do not see the vehicle that hit them and when they do see a vehicle they usually believe that the driver has seen them and will take evasive action. Sheppard and Pattinson (1986) found that elderly pedestrians expect the driver to brake or alter their course to avoid them. They attributed this to elderly pedestrians’ lack of understanding of what a driver is likely to do, or could achieve even if he/she tried to do so. It seems that the elderly pedestrian generally does not accurately assess drivers' future actions. They also found that elderly people are more likely than other adults to become confused in busy, complex road situations and suggested that the elderly might benefit from advice on how best to compensate for physical handicaps, guidance as to what are safe routes on local common journeys and education on how to predict more accurately what drivers and riders are likely to do in particular circumstances.

Alexander and others (1990) found that these accidents were generally close to home (occurring within one kilometre of their home), they occurred on a regular trip (such as shopping) and occurred near shopping centres or recreational venues. They further found that most accidents occurred in inner city suburbs, on sealed arterial roads, straight road sections and most occurred in daylight hours.

The Federal Office of Road Safety (1986) further reported that an increase in older pedestrian fatalities occurs in winter compared with summer, with the most likely time of day being from 4pm to 8pm. They also showed that in almost half of the cases where an elderly pedestrian was killed crossing the road, the victim had already crossed one lane of traffic or was on the second half of the road and was not aware that a vehicle was about to hit them.

2.3.2 Risk Factors

Accident rates for elderly pedestrians resemble those of elderly drivers; when exposure is controlled for, the risk of severe injury or death is higher than for younger adult pedestrians. When involved in accidents, the elderly are more likely than younger persons to receive serious or fatal injuries. The increasing involvement of pedestrians over 60 years in severe crashes may reflect decreasing perceptual skills and agility, but also, perhaps, increased exposure as pedestrians because of less driving (Evans, 1991a).

As with elderly drivers, a number of risk factors for elderly pedestrians have been identified. Older people face major problems as pedestrians and accidents occur as a result of reduced road use skills associated with their age and, in particular, as a result of a substantial physical disability (Alexander et al., 1990). They walk more slowly, they take longer to react to danger and they are less able to get out of the way if they misjudge a situation. Failure to recognise dangerous situations, cognitive confusion, sensory changes including hearing and visual loss, reduced ability to judge distances and spot obstacles, decreased balance mechanisms, slower reaction time, and increased vulnerability to severe injury all may place the elderly pedestrian at a disadvantage when on the road.

VISION: As noted in earlier sections, the visual system declines with the ageing process and there is a gradual decline in the amount of light which reaches the retina. With increasing age, there is a decrease in the ability of the eye to respond to darkness, a decrease in glare tolerance, and a decline in depth perception, which is further magnified with reduced luminance. Elderly pedestrians require a larger amount of light compared to a young or middle aged person to cope with the visual environment (Safety for Seniors Working Group, 1989).

Considering the importance of vision in balance, ambulation and performance of daily activities, changes in visual acuity through ageing will have a profound effect on an elderly person's ability to walk in complex traffic situations. Night time may also pose a multitude of problems for elderly pedestrians whose visual system needs to accommodate for poorly lit roads, pavements and signs.

BALANCE INSTABILITY: A loss of righting reflexes and an increase in body sway after age 60 causes instability in the elderly. Consequently, an older person is more likely than a younger person to fall. Gait patterns also change with age, resulting in decreased steppage height and decreased stride length (Kallman & Kallman, 1989). Older women tend to walk with a waddling gait, have a narrow walk and standing base, have more erect posture and closer foot placement. For women, stepping down (such as from high kerbs) is especially difficult. Older men tend to walk with a small-stepped gait and have a wide walking and standing base, they have a decreased foot elevation, diminished arm swing, stooped posture, flexion of the hips and knees and stiffness on turning.

For the elderly person, the complex sensory organs that monitor balance or equilibrium do not function as efficiently or as fast as they do in younger adults (Overstall, Exton-Smith, Imms & Johnston, 1977). Therefore, older pedestrians are more at risk of a fall not only when they are moving but also at times when they are standing still. This risk is accentuated when confronted with fast moving traffic and the visual system has difficulties with scanning the visual field. Older pedestrians, then, in order to maintain balance, may move slowly and cautiously, look for some support when standing, and prolong the decision to cross a road.

SLOWED REACTION TIME: Many older pedestrians have an increased risk of a crash because they do not have sufficient neurological reaction to compensate for vision and balance deficits. The slowing of response selection is more marked with more complex situations such as traffic participation (Safety for Seniors Working Group, 1989).

Longer reaction times means that an older person has a shorter interval than younger adults in which to correct a faulty action and thus avoid a crash. This situation is further complicated by the increased chance of misjudgment due to a decline in visual function.

COGNITIVE ABILITIES: Research in the area of dual-task performance has generally demonstrated, across a range of experimental tasks, that older adults are more adversely affected by division attention conditions than younger adults. A study by Triggs, Fildes and Koca (1992) indicated that elderly pedestrians are over-represented in accidents at intersections where there are no traffic lights. They suggest that the requirement to divide attention and integrate information from several different sources is difficult for the elderly pedestrian and is a likely major contributing factor to pedestrian accidents. In a complex traffic situation, such as crossing at unsignalised intersections, the older pedestrian comes under stress when they need to divide their attention across several competing sources of information and they need to respond to short duration stimuli or are required to generate rapid responses.

In their survey of elderly pedestrians, Sheppard and Pattinson (1986) reported that some pedestrians had difficulties with understanding when to cross at traffic lights or found it hard to cope because a lot of roads met together at the intersection. They concluded that elderly people are more likely than other adults to get confused in such situations.

SEVERITY OF INJURY: The susceptibility of older persons to serious injury and death is clear from a number of studies. As in the case of elderly drivers and vehicle occupants, Vestrup and Reid (1989) have demonstrated that older pedestrians, too, are more vulnerable to severe injury or death once an accident has occurred. In fact, Cameron, Day, Mach, Neiger and Fildes (1992) suggest 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.

Vestrup and Reid (1989) reviewed records of 161 pedestrians admitted to two hospitals and found that 41% of all patients were over the age of 60 years. In addition, they noted that elderly patients surviving their injuries have longer hospital stays despite Injury Severity Scores similar to younger victims and are more likely to require long-term placement. Although only 37% of the surviving patients were over the age of 60 years, they consumed 51% of hospital days. Further, 12% of the patients over 60 years required placement in long-term care facilities.

THE ROLE OF ALCOHOL: Alcohol has found to be a factor in a large number of deaths among adult pedestrians of all ages. One study (Alexander et al., 1990) revealed that 40% of adult pedestrian victims aged between 20 and 79 years had been drinking and 24% had blood alcohol levels exceeding 0.15. The Federal Office of Road Safety (1986) reported that even though the measured blood alcohol concentrations tend to be lower in older pedestrian victims, the effects of alcohol at any level of BAC may be greater for older people. However, little evidence exists to support the notion that the use of alcohol is a noted risk factor for elderly pedestrians. Vestrup and Reid (1989) found that only 9% of elderly pedestrian victims in their study had been drinking. Moreover, Alexander et al. (1990) targeted males in younger age groups (20-39 years and 40-59 years) rather than those in older age groups as being at high risk for alcohol-related pedestrian accidents.

2.3.3 Road Crossing Behaviour

The elderly are often thought to precipitate their own accidents because they behave irresponsibly or incompetently when crossing roads. The way older people go about crossing the road is quite different from how younger people act. Observations show that they behave more cautiously than other adults (Arnold & Bennett, 1990), and that they are often unaware of the changes in their own ability to cope with the risks involved in being a pedestrian (Sabey, 1988).

The Safety for Seniors Report (1989) noted that elderly pedestrians delay longer at the kerb and make more head movements before crossing by comparison with younger adults, which may reflect the greater difficulty they experience in assessing a traffic situation and their cautiousness in crossing a busy road. It is suggested that the additional delay and attention paid to the task of crossing the road are not predictors of greater safety.

One major contributory factor noted in crashes involving elderly pedestrians is the short crossing time allowed at pedestrian crossings. Compliance by pedestrians with signals is often poor and this reflects their judgement of risk, their gap acceptance behaviour and their understanding of signal design. There is an over-riding concern by older citizens that traffic signal timings are inadequate and that the assumed walking speed adopted in signal design is based on walking speeds of younger road users.

The Transport Research Laboratory in Britain (cited in Safety for Seniors Working Group, 1989, p.13) studied crossing time from kerb to kerb and found times increased with age from 11.2 secs for pedestrians under 30 years old to 14.4 secs for those aged over 70 years. In addition, Grayson (cited in Safety for Seniors Working Group, 1989, p.13) found a kerb delay of 3-4 secs for those over 60 years old. The current Australian practice of giving pedestrians a ‘green walk’ time followed by a ‘flashing red’ clearance time may create anxiety and uncertainty for older pedestrians and cause them to not cross at signals but at a nearby location. Further, the formula for calculating walk and clearance times does not take account of the slower than average walking speeds of ederly pedestrians.

Sheppard and Pattinson's study (1986) revealed that elderly pedestrians often misjudged what a driver might do, especially when encountering reversing vehicles. Two-fifths of surveyed pedestrians involved in a crash complained of difficulties at the place of crossing, including such things as too many confusing roads, confusing traffic lights and busy and fast traffic. One-third also felt that their difficulty in walking or hearing, or deteriorating eyesight may have partially caused the crash.

2.3.4 Road Environment

The road environment can also impose risk factors for the elderly pedestrian. Urban planners and traffic engineers often do not consider the pedestrian when designing roadways, and elderly pedestrians, especially, are not treated as equal participants in the traffic environment.

Some of these inequities include: diverting pedestrians, either vertically or horizontally, from their intended routes (eg. through subways and over footbridges); pedestrian demand to cross at intersections is not taken into account by traffic control systems (Carsten, 1992); poor placement of pedestrian crossings (particularly around major shopping centres) encourages older people to be in places where they are not able to cope adequately; major roads and thoroughfares are devoid of facilities enabling older people to rest and use conveniences; many pedestrian crossings have inadequate time periods; many footpaths are badly surfaced and are frequently congested; and street and road lighting is often inadequate to illuminate pedestrian crossings at night (Calder, 1986).

2.3.5 Interventions

Studies of research and practice in Australia and overseas have identified environmental, human and vehicle design factors which influence pedestrian safety. It is not easy to change behaviour through education alone, and countermeasures which rely for their effectiveness on being able to do this may not be as effective as other countermeasures. The elderly are fiercely independent, value their mobility and often do not wish to seek help in crossing roads. These factors need to be taken into consideration when designing interventions. Interventions which focus on engineering and modification to the road environment with the aim of eliminating conflicts and preventing unsafe behaviour appear to be most effective in improving the safety of elderly pedestrians and are more likely to result in a reduction of pedestrian involvement in crashes in the long-term.

EDUCATION: A number of calls have been made for better informing elderly pedestrians (and motorists) about proper road use. Educational strategies have been suggested focussing on giving older pedestrians specific information on dangers and how to avoid them, encouraging awareness in drivers and other road users of the right of pedestrians to a share of the traffic environment and community-based education programs. Any strategies aimed at the elderly, however, need to be developed with care as previous studies have recognised that there are difficulties in getting older people to respond to educational campaigns to improve their safety (Federal Office of Road Safety, 1986).

DRIVER TRAINING: Drivers have been shown to be major contributors to pedestrian injury events. Factors such as driver incompetence and lack of attention to the rules of the road have been cited. Baker, Robertson and O'Neill (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. They also found that the driving records of those involved in pedestrian traffic crashes were significantly worse than for the total group of licensed drivers in the State of Baltimore.

Vestrup and Reid's study (1989) supports this finding. In their study, 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. From these results they suggested that driver education and traffic enforcement programs focussing on the road rules and pedestrian rights would be of value.

It has been argued that the elderly may be less capable than other pedestrians of taking the necessary avoiding actions in traffic situations, and that drivers seem not to be aware of the limitations of older people. Sheppard and Pattinson (1986) suggested that drivers might be informed that in an accident many elderly people fail to see the vehicle that hit them, so that one should 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 which commonly cause accidents to elderly pedestrians, so that particular care is needed. They further suggest that carers of elderly people might also be made aware of the dangers that elderly pedestrians face and could perhaps encourage them to use safe routes when they do go out.

COMMUNITY EDUCATION PROGRAMS: Information on strategies to offset the hazards faced by the elderly in today's traffic environment might be useful for alerting elderly people to the hazards confronting them as pedestrians. A heightened community awareness of behavioural and engineering services would be beneficial to the road safety of elderly pedestrians and community action is a positive means of raising awareness among local residents.

The avoidance by elderly pedestrians of certain behaviours and the adoption of others could make a significant contribution to their safety. The key messages to older pedestrians put forward in a report by the Federal Office of Road Safety (1986) were: cross at traffic lights, especially ones with a refuge in the middle of the road; don't assume that drivers have seen pedestrians; don't cross between parked vehicles; keep attention when on the roads; plan outings to avoid peak hour traffic; wear light coloured clothing, especially when walking at night.

The results from Alexander et al.'s study (1990) indicated that programs targeted at the local community would be most effective in reducing the number and severity of pedestrian accidents. On the basis of these findings a pedestrian strategy was documented which recommended the development of pedestrian safety programs at a local level. This allows individual local councils to assess their own problem areas and provide specific local initiatives required in order to improve pedestrian safety.

The "Walk With Care" project, an elderly pedestrian education and advocacy program was established in 1991 by VicRoads in conjunction with local government, local agencies and community groups. The main aim of the project is to reduce the rate of accidents involving older pedestrians by identifying the dangers affecting them and developing solutions to minimise their risk. This is achieved through the integration of education, advocacy and where appropriate, local area traffic engineering improvements, providing a link between older people in the community and those responsible for planning and development of traffic management facilities (Addicoat, 1991).

Where community groups with older pedestrian members are involved in identifying problems and formulating answers with councils, there are substantial and ongoing benefits for the community as a whole. Older residents can then gain a well developed sense of their own requirements and difficulties in dealing with the road system and have a real sense that their local government is interested and committed to improving road safety.

The first stage of implementation is an extensive local pedestrian awareness and education campaign aimed at raising the awareness in the community of the pedestrian accident problem, offering safer walking strategies to 'at risk' pedestrians, and encouraging advocacy on pedestrian issues. The “Walk With Care” education kit comprises educational pamphlets, a booklet of discussion issues, video, posters, statistical charts and accessories. Local pedestrian problems are discussed with elderly community members and an avenue is provided for the reporting of pedestrian hazards.

The second stage involves advocacy and public awareness campaigns through group discussions, brochures, information bulletins, magnets, pens and coasters. Group discussions are conducted to ascertain how elderly residents view the pedestrian issue, their reactions to the program, and to discuss any other concerns about the hazards facing elderly pedestrians. The information bulletin covers topics such as: being seen, using refuges and medians, roundabout use, taking care when using public transport and when at traffic lights (Addicoat, 1991).

VEHICLE DESIGN: A substantial amount of detailed crash investigation and experimental studies have reported on the shape and compliance of the vehicle exterior in relation to pedestrian crashes. The OECD (1985) recommended the development of more rounded car frontal structures so as to limit injuries to elderly pedestrian collision victims who have reduced body strength characteristics.

McLean (1991) notes that there is limited recognition of the importance of vehicle design in injury control in the case of a collision between a vehicle and pedestrian and that certain 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. It would be clearly advantageous for the pedestrian not to make contact with the windscreen, roof or road. Ideally the bonnet construction should be such as to provide some cushioning effect.

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 finally 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 for small cars is a hostile zone frequently struck by the heads of adults; the front edge of the bonnet of many cars can lead to serious pelvic and femur injuries particularly for older pedestrians; and the bonnet can be designed to provide a yielding contact for the head and protection against direct contact with the stiff lower edge of the windscreen frame (Mackay, 1988).

The reduction in severity of injury to pedestrians which changes to the frontal design of cars can produce is receiving increasing attention. McLean (1991) found that pedestrians struck by cars with a rectangular frontal shape and a pronounced leading edge are more likely to be seriously injured or killed than if they were struck by cars with a more sloping front, irrespective of the speed with which the car was travelling. There has been a marked change in the overall frontal shapes of passenger cars during the past two decades motivated mainly by attempts to reduce the aerodynamic drag factor and decrease fuel consumption; however, this change has had secondary benefits to the pedestrian. Today, the near elimination of a definable leading edge could be expected to be accompanied by a great difference in the pattern of injury to pedestrian crash victims and a significant reduction in the number and severity of pelvic injuries.

ENVIRONMENT MODIFICATIONS: There are specific aspects of the traffic environment which create particular problems for the older pedestrian and many reports call for road modifications to improve the roadway system in order to accommodate the elderly. Clearly, increased pedestrian safety would be achieved by reducing the conflict between people and vehicles without unnecessary restrictions on movement.

A persistent complaint by pedestrians, especially the elderly, is the design and placement of traffic signals. There is a great concern that the walk phases at traffic signals or pedestrian crossings is too short for elderly pedestrians to cross safely. Current signal design in Australia is concerned primarily with traffic flow. Having pressed the call button the pedestrian is assured of a minimum ‘walk’ time based on an average walking speed of 1.2 metres per second and a ‘flashing red’ time to complete the walk based on an average walking speed of 1.5 metres per second. However, the average walking speed time estimate does not take into account the fact that older pedestrians take longer to leave the kerb and walk slower, resulting in either agitation anxiousness or a general disregard for such signals.

Other improvements to pedestrian crossings include improved placement of crossings, design and maintenance of facilities, illumination and signage visibility. Poor placement of pedestrian crossings often mean that pedestrians need to go out of their way to cross the road at these points and only cross at points of convenience. Compliance with crossings is poor and often elderly pedestrians tend to cross the road close to, but not at traffic signals. Further, research into the visual scanning patterns of drivers indicates that pedestrians using crossings in the vicinity of moderate road curves may be at particular risk (Federal Office of Road Safety, 1986).

The provision of median strips to simplify complicated traffic patterns and to allow a refuge on which elderly pedestrians could pause while crossing has been suggested (Federal Office of Road Safety, 1986; Safety for Seniors Working Group, 1989) and evidence indicates that median refuges may be even more effective than the provision of pedestrian crossings in reducing the risk of accident to pedestrians. This would allow the elderly pedestrian to pause while crossing and give them time to assess the traffic situation in two stages, thus effectively halving the complexity of the crossing task.

Most pedestrian crashes occur in urban areas where the speed limit is usually 60km/h. It has been suggested that the general limit in urban areas should be reduced (Federal Office of Road Safety, 1986; OECD, 1985) and local speed limits can be supported by suitable road lay-out and/or traffic controls..

There is, in addition, a need for the provision of adequate street lighting near venues, public transport stops, pedestrian crossings and shops (OECD, 1985).

ENFORCEMENT OF TRAFFIC LAWS: The Federal Office of Road Safety (1986) proposed a number of law-enforcement strategies targeted at both pedestrians and drivers to reduce the number and severity of elderly pedestrian accidents. These included: penalties for jay-walking pedestrians, enforcement of parking restrictions near pedestrian crossings, and enforcement of speed limits in areas where there are large numbers of pedestrians.

2.3.6 Research Needs

The safety of the elderly pedestrian in the traffic environment is a pressing issue given the trend for continued growth of the elderly sector of the population. However, at present the level of knowledge about the crash involvement rate of older pedestrians is limited.

A large number of environmental, situational, pedestrian, crash and outcome factors associated with substantially higher injury severity for elderly pedestrians involved in crashes have been identified in this review. However, there is a lack of adequate and rigorous evaluation of the effects of many of the interventions suggested.

Intervention programs to assist vulnerable road users need to take into account why people behave as they do. Sensory and cognitive assessments have been suggested as an intervention against injuries to elderly pedestrians. There is a demand for research to assess the benefits of vision assessment for elderly road users. Further, the role of other sensory inputs such as hearing and balance mechanisms need closer scrutiny.

Arnold and Bennett (1990) argued that, given the physical and cognitive limitations of elderly pedestrians, the responsibility for pedestrian safety needs to be placed more with drivers. There is evidence suggesting that drivers place the responsibility for avoiding accidents almost entirely upon the pedestrian and are ill-prepared for unpredictable pedestrian behaviour, however, relatively little research has examined the part of drivers in pedestrian accidents.

There are a number of opportunities for research on age differences, attentional processes and elderly pedestrian safety. Triggs and others (1992) suggest that specialised training programs focussed on attentional performance in road-like environments may have the potential for reducing age-related pedestrian accidents. Research examining a wide range of trade-off situations between two tasks, and conducted with more realistic stimuli across a wide range of road-like situations would permit precise definition of the underlying shape of the attention operating characteristics and allow the generalizability of results to be evaluated.

2.4 CONCLUSION

As the proportion of elderly people increases in the general population, so too, the problem of the elderly in the traffic environment is expanding. Transport related crashes are the second main source of unintentional injury among the elderly of which pedestrian injuries feature predominantly. The literature has established that the oldest drivers and pedestrians have high crash risks when they are on the road and that they are much more likely to be severely injured or killed once involved in a crash than any other group of road users. Consequently, there is a growing need for investigations into elderly road user safety.

Inadequate information exists on how older people drive and walk within the road system, particularly those with functional limitations. Adult ageing is associated with increases in the incidence of functional disabilities which may impair driving safety and mobility. What is unknown is how these limitations affect driving and walking performance in terms of decision-making, vehicle control and road crossing behaviour. Many older individuals with reduced abilities continue to drive without demonstrating increased risk of becoming involved in an accident, still others tend to change their road use behaviour to compensate for a wide range of functional limitations. However, little has been done to catalogue the nature and extent of such compensatory behaviours nor to evaluate their role in maintaining mobility among older populations.

CHAPTER 3

DATA SOURCES AND ANALYSIS

3.1 DATABASES

The two major data bases which were sourced for this project were the VicRoads database for police-reported casualty crashes and the Transport Accident Commission (TAC) database for state-wide injury compensation claims. Entrance into the VicRoads casualty database requires a crash victim to have been reported by the attending police officer as injured. Entrance into the TAC database requires the claimant to have been injured sufficiently to have accumulated treatment costs in excess of $317 (July, 1989). It should be stressed therefore that all findings in this report are from an injured population and tell us nothing about those who crash and are uninjured (i.e., relative risk of injury). However, they do provide relative risk of involvement assessments for an injured population (i.e., whether a particular age group are more or less involved as injured victims). Population figures from the Australian Bureau of Statistics were also used to calculate over-involvement rates per 100,000 head of population and distance travelled by age group from National Surveys showed crash rates per 10^6 kilometres of travel thus providing comparison data for assessment of risk.

3.2 METHOD OF ANALYSIS

The databases were loaded onto a main frame computer for analysis using the SPSS package. Separate analyses were conducted for drivers and pedestrians. These analyses fell into three main parts:

3.2.1 Trend Analysis

Ten years of data from the VicRoads database (1984 - 1993) were analysed to demonstrate older road user accident trends.

3.2.2 Injuries and Costs Analysis

Data on claims made on the Transport Accident Commission (TAC) in 1987 and 1988 provided the basis for the analysis of injuries and associated treatment and rehabilitation costs. Community cost figures were estimated from published cost of injury studies in Australia and broken down by age group using US relative figures.

3.2.3 Crash Characteristics Analysis

Ratios of actual to expected casualty crash frequencies exceeding the value one may be evidence of over-representation of a given age range in the involvement of crashes of particular characteristics.

The three most recent years of the VicRoads database (1990-1992) were analysed in detail to pin-point specific road and environmental characteristics causing problems for the older road user. In order to identify tendencies towards over-representation of older drivers and pedestrians in casualty crashes, the ratio of actual to expected casualty crash frequencies was plotted against age groupings, for each of a large number of variables describing reported casualty crashes. While the description of road and crash characteristics may be subject to the individual interpretation of the attending police officer, it was assumed that this source of variation was randomly distributed throughout the sample of crashes in the database.

The actual numbers of a particular crash involvement category were compared with the expected number for that age group, given the distribution of individuals in the database. This process is akin to judging divergence from an expected value in a Chi-square test of significance. Ratios showing consistent trends for older road users above a value of 1 were assumed to be indicative of over-involvelment of that age group in crashes of that particular characteristic. The analysis also provided descriptive statistics of the extent of the problem caused by various crash characteristics for road users generally and for older road users (65+ years) in particular. While the trends highlighted in this analysis do not provide clear evidence of risk (over-involvement may still be a function of over-use or "exposure"), they do at least point to areas of sizable concern that need to be emphasised in subsequent research or intervention programs.

3.3 STATISTICAL INTERPRETATION

3.3.1 Exposure Data

As noted above, while the "actual/expected" ratio was useful in being able to highlight areas where the elderly are a sizable crash problem and "at risk of over-involvement", it begs the question of whether they are so because they are over-exposed. It may be that older people are more involved in intersection crashes (say) simply because they are more likely to cross the road at these locations. A number of potential sources of exposure data were identified, including:

- Australian Bureau of Statistics (ABS) population census data;
- The Victorian Integrated Travel and Land Use toolkit (VITAL) survey being implemented by The Transport Research Centre at Melbourne University;
- Federal Office of Road Safety exposure data from 1985 and 1986;
- VicRoads exposure studies 1984, 1985, 1986, 1988 (Rogerson & Keall, 1990); and
- VicRoads, Victorian driver licence holders by age and sex for the period 1984 to 1993.

While ABS population data were used as a broad adjustment for exposure in the trend analyses, unfortunately many of these other exposure data sources could not be used for the following reasons:

- they were not representative of the sample of drivers and pedestrians being investigated;
- they could not be obtained within the timeframe of the study; or
- data collection had commenced relatively recently and data were not available for a sufficiently representative period of a year.

This shortage of exposure data has been highlighted in earlier studies by Cameron et al (1994) and Cameron and Oxley (1994).

3.3.2 Higher Order Statistical Analyses

Cluster analysis is a technique that is used on occasions for highlighting natural groups or combinations of problems that warrant closer attention. Indeed, these ‘natural clusters’ can also point the way to specific behavioural or cognitive difficulties that might be experienced by the particular road user group under investigation as well as possible areas for intervention.

It had been hoped to undertake such an analysis on these data. Unfortunately, this was not possible within the time and budget constraints of this project. Thus, the analysis was confined to a pure descriptive summary of the variables of prime interest and any higher-order analysis of these data remains a task for future research.

CHAPTER 4

DRIVER CRASHES

4.1 TRENDS IN DRIVER CASUALTIES, VICTORIA, 1984-1993.

Figures 4.1 and 4.2 show the ten year trends for number and rate of driver casualties over the period 1984-1993. The number and rate of casualties for drivers under 65 years increased steadily until 1989 and have been declining since then. The number and rate of casualties for drivers over 65 years are noticeably lower than for drivers under 65 years and have shown less variation over the ten year period. Of some concern, though, while rates for drivers under 65 years have continued a steady decline since 1989, rates for drivers over 65 years have resumed a slight upward trend since 1991.

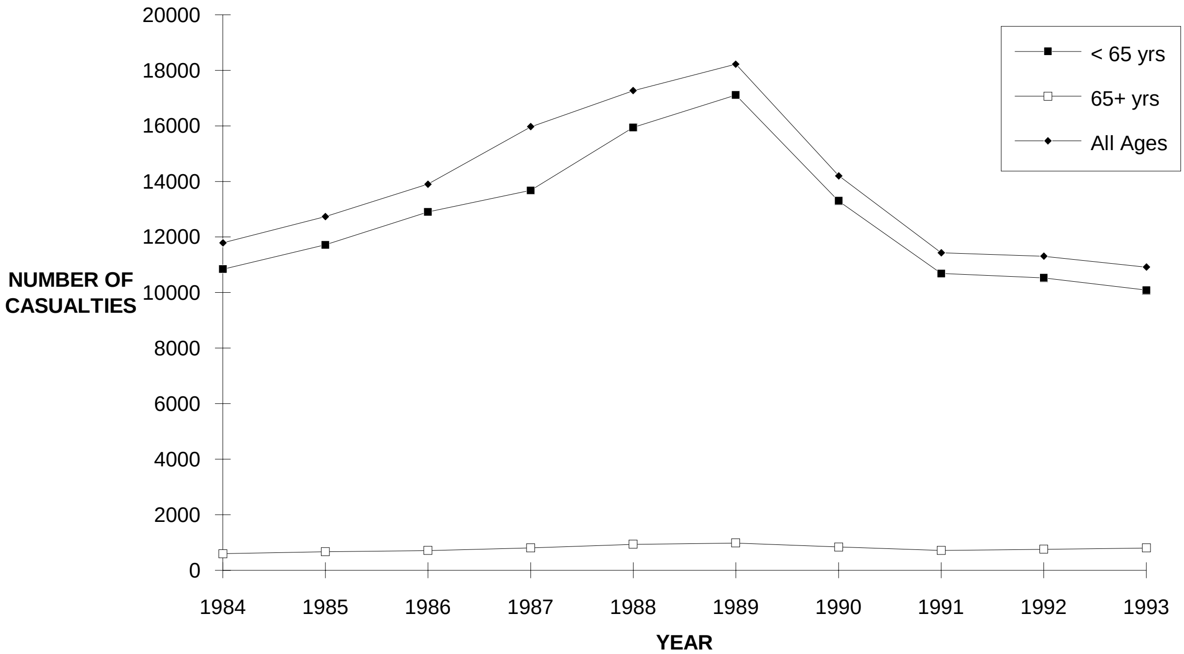

Figure 4.1 Number of driver casualties, VicRoads, 1984-1993

Annual average driver casualties and driver casualty rates are plotted in Figures 4.3 and 4.4 for various levels of injury severity. The average annual number of all driver casualties shows a sharp decline with increasing age, from about 4,500 per year for 17-24 year olds to 236 per year for 65+ year olds. Annual casualty rates (accounting for population distributions of a given age group) decline with age until age 65 years, after which they increase slightly for all injury levels other than fatals.

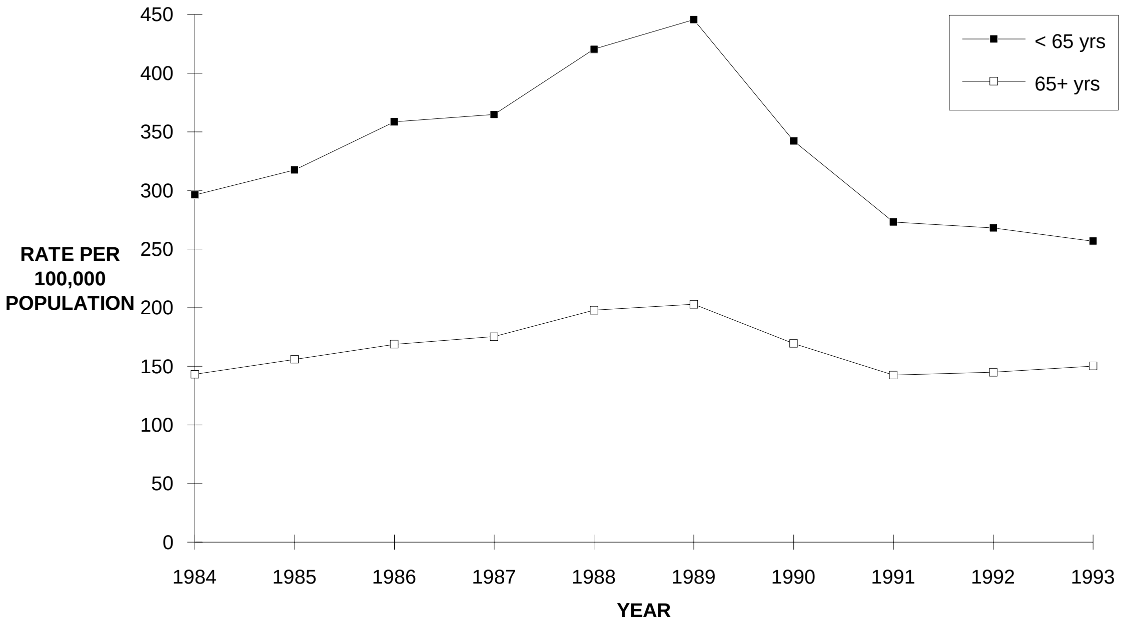

Figure 4.2 Driver casualty rate, VicRoads, 1984-1993.

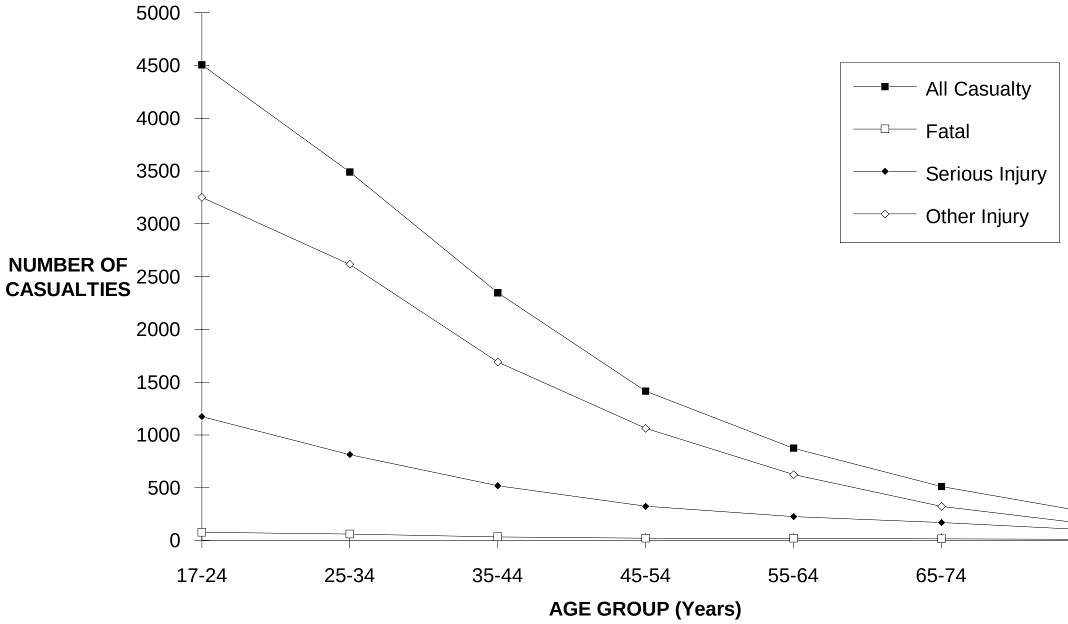

Figure 4.3 Annual average number of driver casualties, VicRoads, 1984-1993

Figure 4.4 Annual average driver casualty rate, VicRoads, 1984-1993.

Figures 4.5 and 4.6 show the annual rates of driver casualties (fatalaties and other injuries) per kilometre travelled. Figure 4.5 reveals that older drivers are over-involved in fatal crashes per distance travelled by comparison with all other age groups other than very young drivers (17-24 years). A similar, although less marked trend is apparent for crashes resulting in serious injury (Figure 4.6) with both older (65+) and younger (17-24) drivers being over-involved once again. These trends concur with American data published by Evans (1991a, pp.32 & 34) showing a marked upward trend in driver fatalaties and severe injuries per distance travelled from age 65 years on.

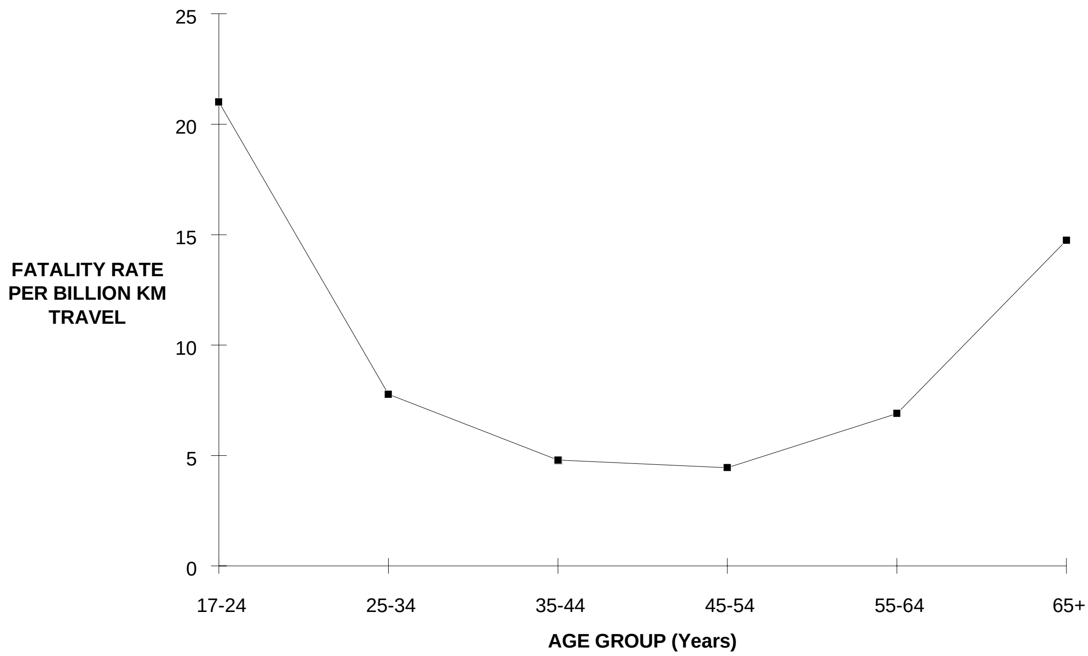

Figure 4.5 Annual driver fatality rate per distance travelled
(Sources: FORS,1988; VicRoads, 1992)

[These figures are based on exposure data from a survey of day-to-day travel in Australia (FORS, 1988) and data on the number of current licence holders in Victoria as at January 1992 (VicRoads, 1992). The numbers represented in the figures are the best estimates possible given the following limitations of the data: the exposure data covers the period 1985-86 and is now rather old; there are some anomalies in the licensing data but it was the best available at the time; a number of assumptions had to be made regarding the relationship between licence status and annual mileage.]

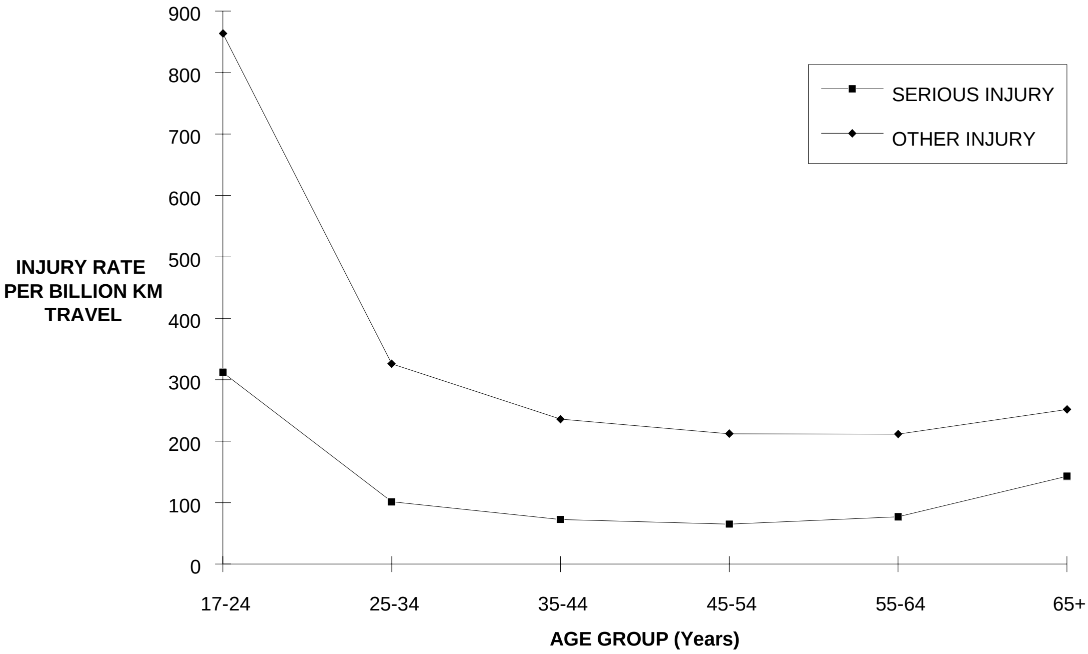

Figure 4.6 Annual driver injury rate per distance travelled
(Sources: FORS,1988; VicRoads, 1992)

4.2 INJURIES AND COSTS

4.2.1 Cost of Older Driver Crashes

To illustrate the size of the older (and younger) road user problem in this State, the numbers and cost of crashes in Victoria involving young (17 to 64 years) and old (65 years and over) road users was estimated. These figures are shown in Tables 4.1 and 4.2 below. It should be stressed that casualty costs by road user type and age group were not readily available in this country, so it was necessary to estimate these figures based on casualty class costs (1991 prices) published by Andreassen (1992) and factored for young and old adults using US relativities published by Rice and MacKenzie (1989). The amounts are in Australian dollar equivalents.

The cost of road trauma annually for older and younger drivers was determined using the annual average number of TAC claims for the years 1987 to 1992 and the derived casualty costs discussed above (see Table 4.2). Based on these figures, older driver casualties comprise 7% of all driver claims and cost Victoria around $23 million annually in 1991 prices. When compared with younger driver figures for the same period ($420 million), older drivers' costs represent only five percent of the total cost of road trauma for drivers in the State of Victoria.

TABLE 4.1
COSTS OF CASUALTY CRASHES BY CASUALTY CLASS AND AGE (A$1991 PRICES)

CASUALTY CLASS	ALL AGES (a)	YOUNGER ADULTS (b) (17 to 64 years)	OLDER ADULTS (b) (65 plus)
Killed	$625,065	$718,825	$50,005
Hospitalised	$107,267	$127,648	$65,433
Medically treated	$7,003	$9,174	$12,185

NOTES:

a. Australian casualty costs from D. Andreassen (1992). Costs for Accident-types and casualty classes, ARR227, Australian Road Research Board (in 1991A$ prices)

b. Young and old proportions from Rice and Mackenzie (1989) Cost of injury in the United States.

TABLE 4.2
AVERAGE ANNUAL NUMBERS AND COSTS OF CASUALTIES IN VICTORIA FOR DRIVERS (TAC, 1987-92)

CASUALTY NUMBERS

ROAD USER	KILLED	HOSPITALISED	TREATED	TOTAL
Younger road users (17-64 yrs)	433	3565	12249	16247
Older road users (65 plus)	122	597	995	1714
Total adult road users	***555***	***4162***	***13244***	***17961***
Younger drivers (17-64)	209	1590	7297	9096
Older drivers (65 plus)	40	243	441	724
Total adult drivers	***249***	***1833***	***7738***	***9820***

CASUALTY COSTS (A$000's)

ROAD USER	KILLED	HOSPITALISED	TREATED	TOTAL
Younger road users (17-64 yrs	$311,251	$455,065	$112,372	$878,689
Older road users (65 plus)	$6,101	$39,064	$12,124	$57,288
Total adult road users	***$317,352***	***$494,129***	***$124,496***	***$935,977***
Younger drivers (17-64)	$150,234	$202,960	$66,943	$420,137
Older drivers (65 plus)	$2,000	$15,900	$5,374	$23,274
Total adult drivers	***$152,235***	***$218,861***	***$72,316***	***$443,411***

It should be noted that these costs are only best estimates at this stage and that more detailed work is required to establish how accurate they are in terms of Australian age distributions. Nevertheless, they permit a preliminary assessment of the relative cost of trauma for these young and old road users which helps put in context the size of the older driver problem. As

TAC applies a minimum entry threshold, it is likely that these estimates of road trauma costs are conservative, although the relativities between old and young drivers probably hold.

4.2.2 TAC Claims, 1987-88

An analysis of TAC data for claims made by injured drivers during the years 1987-1988 is shown in Table 4.3. With increasing age there appears to be an increase in the probability of making a claim and the average claim cost for hospitalisation (Payhosp) and in-patient and out-patient rehabilitation (Rehabin$). That is, the older the claimant, the more likely it is for them to require these services after a car crash. While the probability of making a claim for ambulance services (Payambul) also increases with age, the average claim cost for this item remains about the same.

The probability of being assessed as impaired 18 months after making an initial claim (Payimp) and the average claim amount for impairment assessment increases with age up to 74 years but then decreases for those aged 75 years and above. This is probably a function of a reduction in the likelihood of survival for these people.

The probability of claiming a death payment allowance (Paydeath) decreases sharply with age, from 43% for drivers under 65 who are killed to only 4% for drivers aged 65 to 74, with no claims whatsoever for those aged 75 years or more.

It is worth noting that the average claim cost for older drivers is 33% to 41% less than it is for younger drivers. This is in spite of the fact that older drivers' average claim amounts are higher in several categories (hospital, rehabilitation, and 'other' costs). The main reason for this discrepancy is the almost total lack of a claim for loss of earnings and earning capacity among the older TAC claimants.

4.2.3 Injury Analysis, TAC Claims, 1987-88

The injuries sustained by drivers who made a claim on the TAC were compared for younger (18-64 years) and older (65+ years) drivers. The injuries were grouped into 17 categories reflecting the major body regions with two injury severity levels (major and minor) for most body regions (see Table 4.4). Overall, there were very few differences in the patterns of results for the two age groups. Older drivers were less likely to sustain (or claim for) neck injuries, namely whiplash, than younger drivers but more likely to sustain chest injuries (both major and minor). The latter result is most likely a function of older drivers' frailty and increased susceptibility to rib and sternum fractures, predominantly caused by the seat belt.

The injury analysis was further broken down by sex and speed zone (<75km/h and >75km/h). However, as there were no substantive differences in the patterns of results for these additional analyses, they have not been reported here.

TABLE 4.3
ANALYSIS OF CLAIMS FOR DRIVERS, TAC, 1987-88

Variable	Age Group	No. of Valid * Claimants	Prob of Claiming	Total Cost of Claims	Average Cost per Claim
Paydeath	18-64 years	185	0.43	$21,567,471	$116,581
	65-74 years	2	0.04	$89,448	$44,724
	75+ years	0	0.00	$0	$0
	Total	187	0.36	$21,656,919	$115,812
Payhosp	18-64 years	5839	0.75	$17,906,967	$3,067
	65-74 years	438	0.89	$1,761,553	$4,022
	75+ years	258	0.89	$1,136,727	$4,406
	Total	6535	0.77	$20,805,247	$3,184
Paymed	18-64 years	6434	0.83	$15,616,965	$2,427
	65-74 years	419	0.86	$799,937	$1,909
	75+ years	250	0.86	$409,529	$1,638
	Total	7103	0.83	$16,826,431	$2,369
Rehabin$	18-64 years	235	0.03	$3,597,111	$15,307
	65-74 years	18	0.04	$246,019	$13,668
	75+ years	10	0.03	$183,151	$18,315
	Total	263	0.03	$4,026,281	$15,309
Payambul	18-64 years	4873	0.63	$1,375,391	$282
	65-74 years	394	0.80	$123,005	$312
	75+ years	243	0.84	$59,416	$245
	Total	5510	0.65	$1,557,812	$283
Payother	18-64 years	2321	0.30	$3,295,961	$1,420
	65-74 years	136	0.28	$154,012	$1,132
	75+ years	75	0.26	$96,429	$1,286
	Total	2532	0.30	$3,546,402	$1,401
Payloe	18-64 years	3173	0.41	$15,821,281	$4,986
	65-74 years	12	0.02	$52,591	$4,383
	75+ years	0	0.00	$0	$0
	Total	3185	0.37	$15,873,872	$4,984
Payimp	18-64 years	493	0.06	$5,583,136	$11,325
	65-74 years	48	0.10	$623,052	$12,980
	75+ years	15	0.05	$133,181	$8,879
	Total	556	0.07	$6,339,369	$11,402
Payloec	18-64 years	506	0.07	$6,599,311	$13,042
	65-74 years	4	0.01	$9,973	$2,493
	75+ years	0	0.00	$0	$0
	Total	510	0.06	$6,609,284	$12,959
Total	18-64 years	7743		$91,363,594	$11,800
	65-74 years	490		$3,859,590	$7,877
	75+ years	290		$2,018,433	$6,960
	Total	8523		$97,241,617	$11,409

** A valid claim is one where the claim amount for all variables totals $317.00 or greater (July, 1989)*

Note. The probability of claiming a death benefit (paydeath) is the number of valid claimants/number who died in each age group.

TABLE 4.4
INJURY ANALYSIS BY AGE GROUP FOR DRIVERS, TAC 1987-88

INJURIES	DRIVERS			
	18-64 Years (15,943 claimants)		65+ Years (1561 claimants)	
	Number	Prob.	Number	Prob.
Head - major	806	0.05	82	0.05
Head - minor	2874	0.18	275	0.18
Face - major	634	0.04	40	0.03
Face - minor	5403	0.34	333	0.21
Neck - whiplash	2675	0.17	78	0.05
Spine - fracture	266	0.02	31	0.02
Shoulder - major	283	0.02	50	0.03
Shoulder - minor	372	0.02	19	0.01
Chest- major	1317	0.08	379	0.24
Chest - minor	2719	0.17	416	0.27
Abdomen - major	409	0.03	49	0.03
Abdomen - minor	2988	0.19	169	0.11
Upper limb - major	638	0.04	60	0.04
Upper limb - minor	4144	0.26	342	0.22
Lower limb - major	1045	0.07	109	0.07
Lower limb - minor	6099	0.38	579	0.37
Other/Unknown	2497	0.16	225	0.14
Total Injuries	**35,169**		**3,236**	
Avg. Injuries per claim	**2.2**		**2.1**	

Prob = probability of claimants in each age group sustaining that particular injury (i.e., number/number of claimants)

4.3 CRASH CHARACTERISTICS

This section describes the results of analyses of the crash involvement of older drivers, for a range of variables describing crashes. As mentioned in Section 3.2.3, the figures presented in this section note the actual from the expected value given crash involvement for a particular variable. They also describe the extent of the problem for drivers generally (% All Crashes = no. of crashes of a given characteristic/total no. of crashes) and for older drivers in particular (% Old Crashes = no. of crashes of a given characteristic involving persons aged 65 and over/total number of crashes involving persons aged 65 and over).

SEX OF DRIVER: Figure 4.7 reveals that male drivers aged 55 years and older were over-involved in road crashes compared to females. Males comprised 62% of the crash involved population for all ages and 69% of the older driver crash involved population.

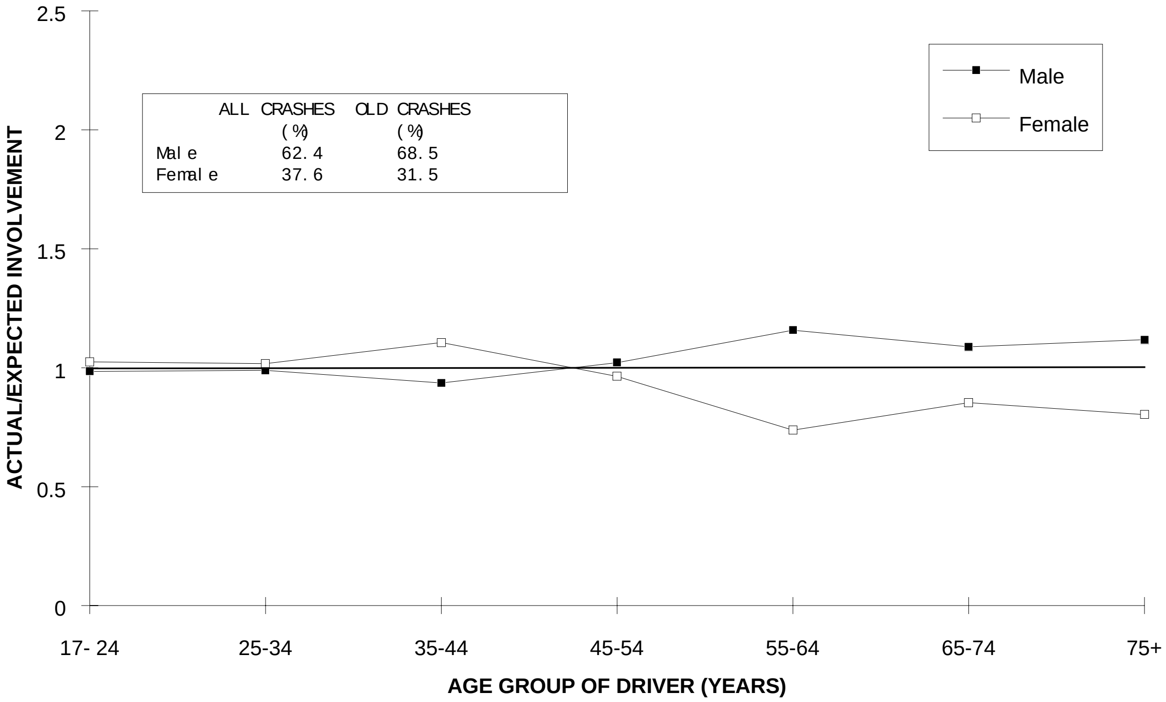

Figure 4.7 Involvement rate by sex of driver, VicRoads, 1990-92.

BAC LEVEL: Drivers aged 45 years and above seem to be under-involved in illegal BAC (0.05 or more) crashes and over-involved in nil BAC crashes as shown in Figure 4.8. Nil BAC crashes account for 61% of all casualty crashes, but 85% of older driver casualty crashes.

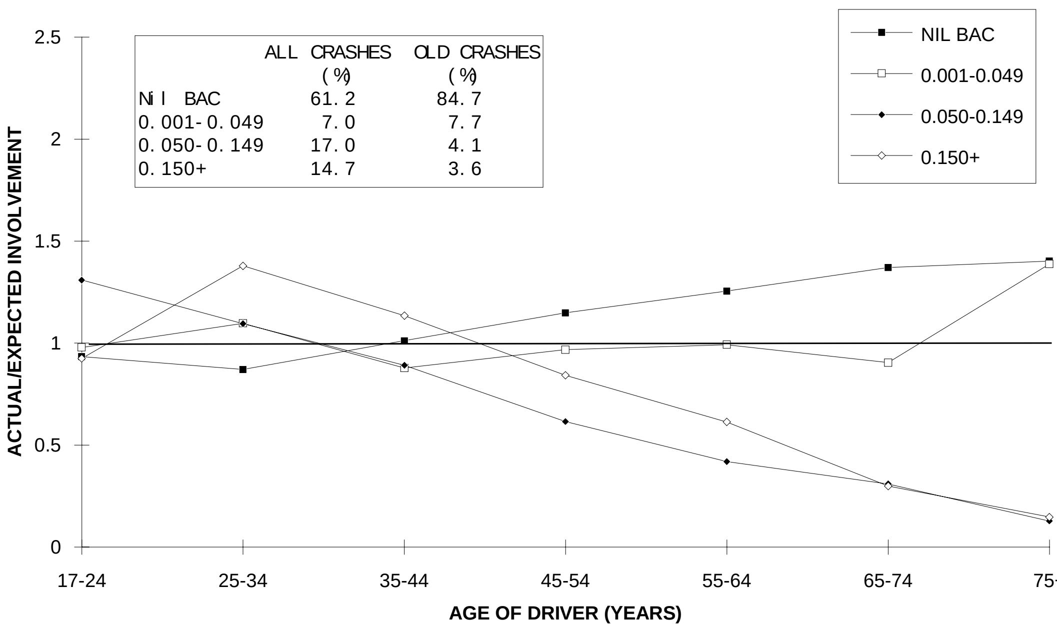

Figure 4.8 Involvement rate by BAC of driver, VicRoads, 1990-92.

CRASH SEVERITY: Figure 4.9 shows that older drivers are over-involved in collisions resulting in fatal or serious injuries. Fatal or serious injury crashes represent 11% of all crashes but 18% of crashes involving older drivers.

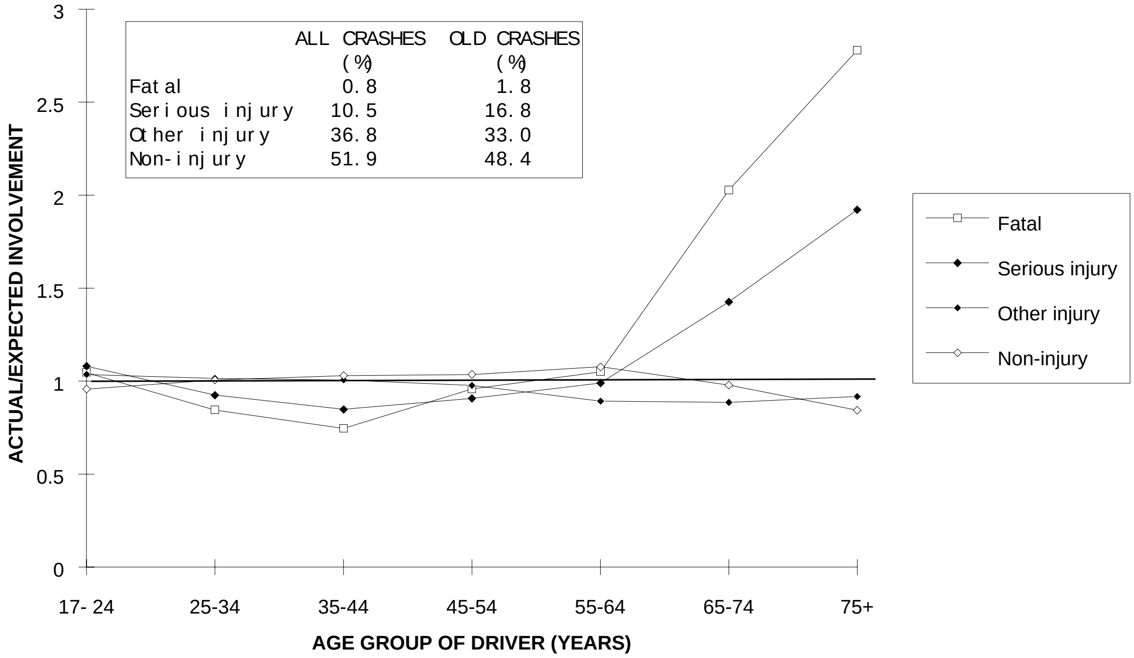

Figure 4.9 Involvement rate by crash severity, VicRoads, 1990-92

CRASH LOCATION: Figure 4.10 shows that drivers aged 55 years and older were slightly over-involved in intersection crashes. Intersection casualty crashes comprise about 59% of the total crash problem but 66% of the older driver crash problem.

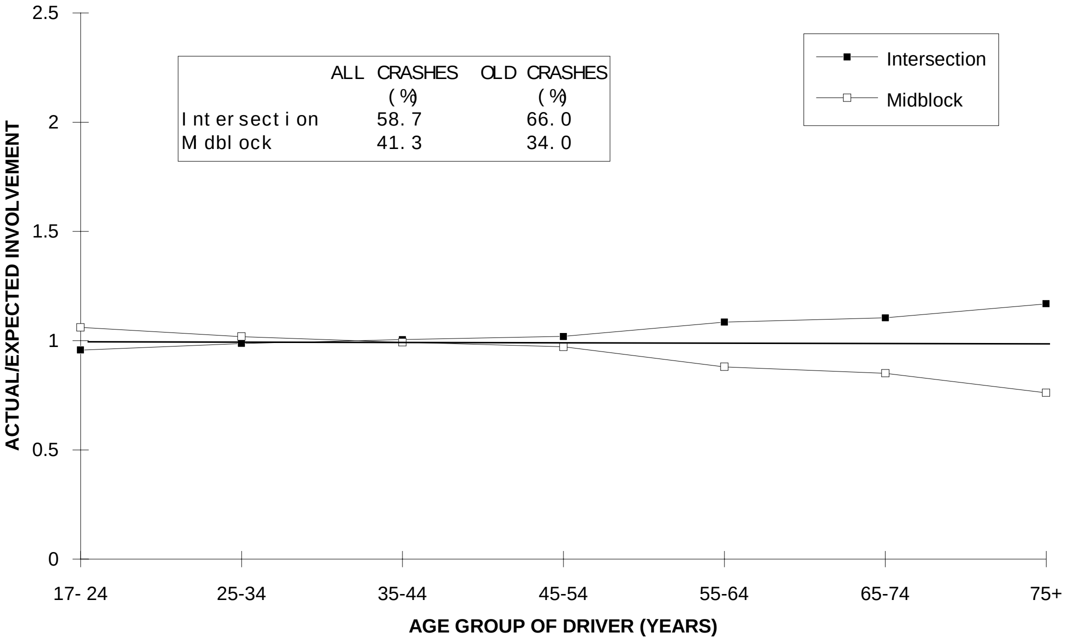

Figure 4.10 Driver involvement rate by crash location, VicRoads, 1990-92.

ROAD ALIGNMENT: Figure 4.11 shows that drivers aged 45 years and over were under-involved in crashes at curves compared to drivers under 45. However, crashes on curves represent only a small proportion of the casualty crash problem (7% of all crashes and 5% of older driver crashes).

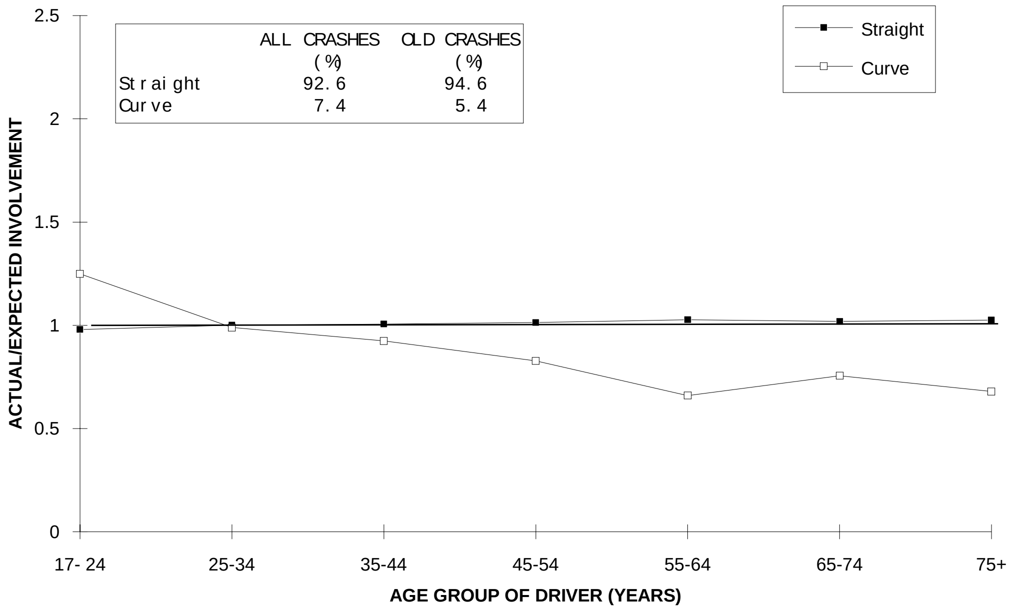

Figure 4.11 Driver involvement rate by road alignment, VicRoads, 1990-92.

INTERSECTION CONTROL: Figure 4.12 shows a marked trend for drivers aged 55 years and older to be over-involved in crashes at stop and give-way controlled intersections. Together, these crash types comprise about 15% of the total casualty crash problem, but 26% of the crash problem for older drivers.

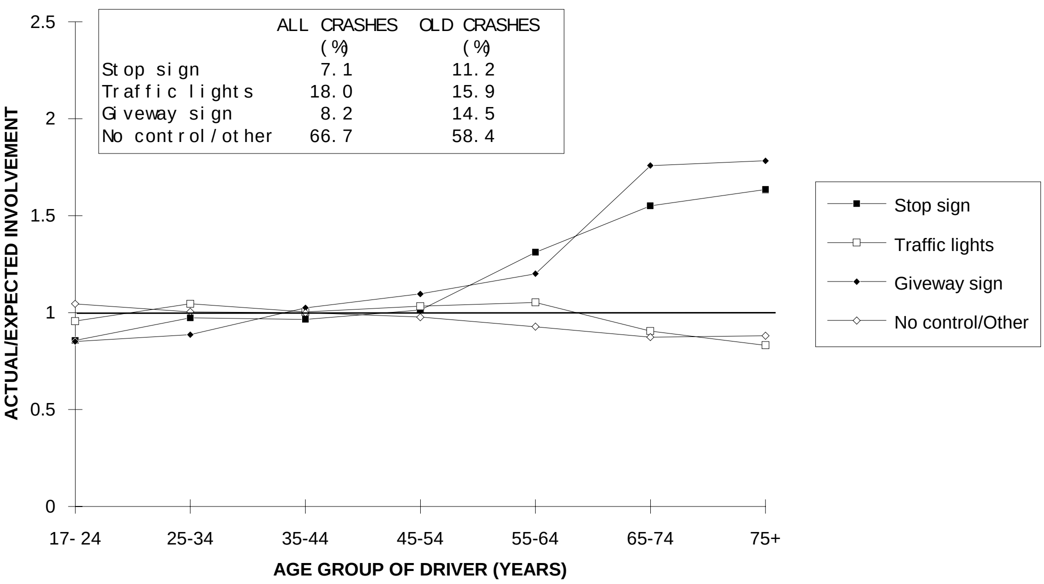

Figure 4.12 Driver involvement rate by intersection control type, VicRoads, 1990-92

INTERSECTION GEOMETRY: Figure 4.13 shows that drivers aged 55 years and more are consistently over-involved in crashes at cross intersections. Thirty-one percent of all crashes and 39% of older driver crashes occurring at this type of intersection.

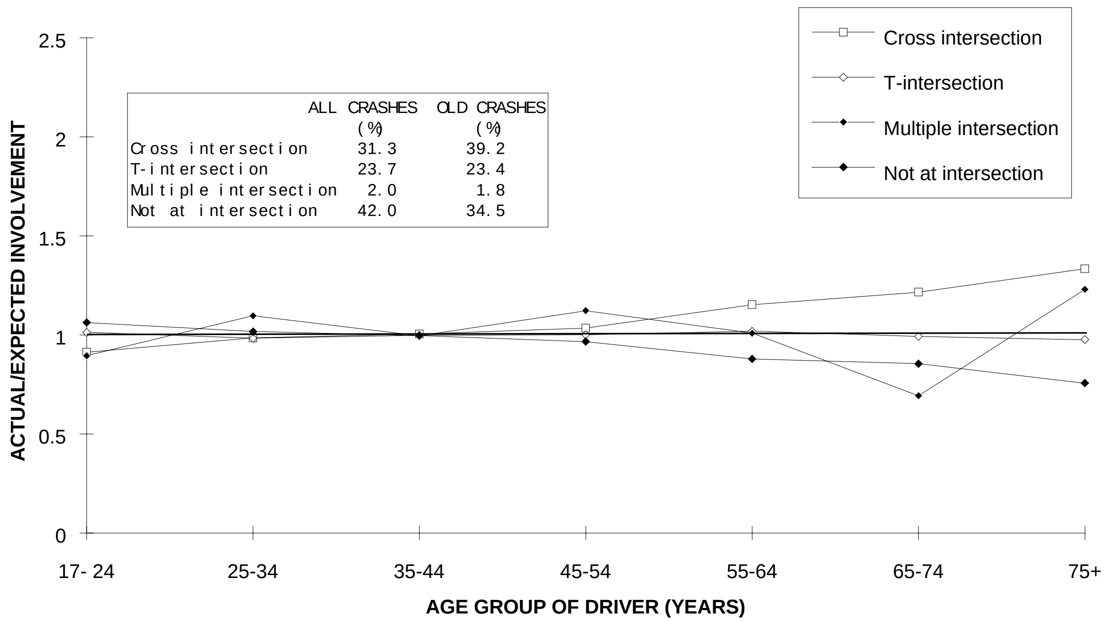

Figure 4.13 Driver involvement rate by intersection geometry, VicRoads, 1990-92

TYPE OF CRASH: Crash type was coded according to the VicRoads "Definitions for Classifying Accidents" (DCA). A diagrammatic description of the various DCA categories is shown in Appendix 1. Involvement rates by crash type are shown in Figures 4.14(a) and (b). Figure 4.14(a) shows that drivers aged 65 years and more are over-involved in collisions with other vehicles from adjacent and opposite directions as well as in collisions whilst manoeuvring. These crashes account for 44% of all driver crashes but 60% of older driver crashes. Additionally, drivers aged over 75 years appear to be over-involved in on-path collisions.

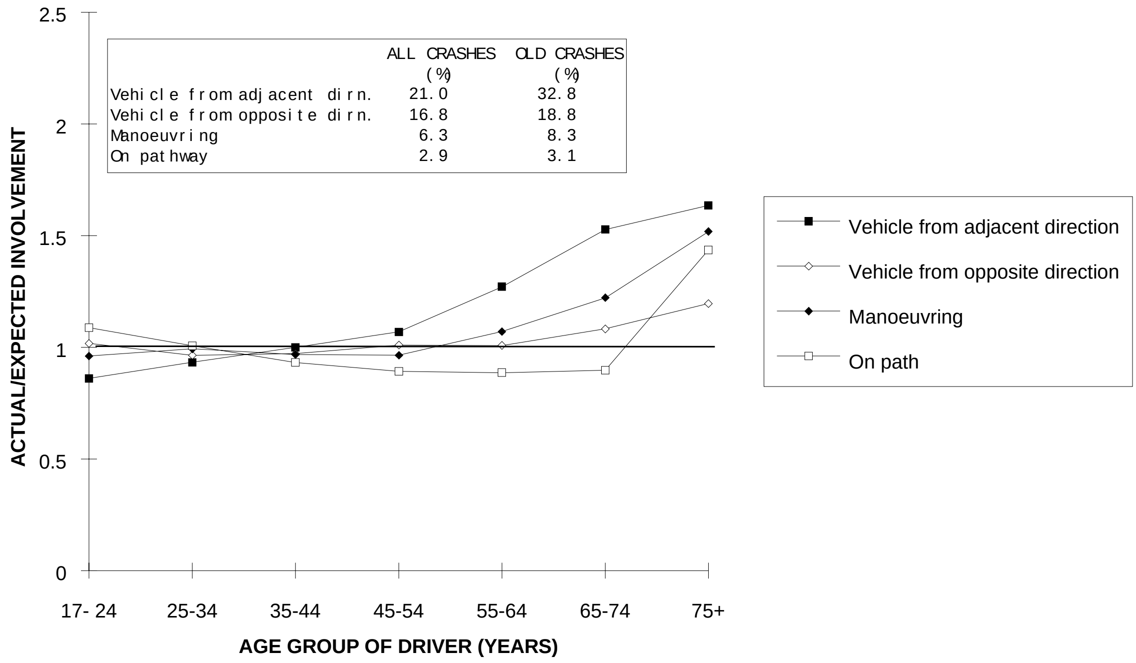

Figure 4.14 (a) Driver involvement rate by type of crash, VicRoads, 1990-92

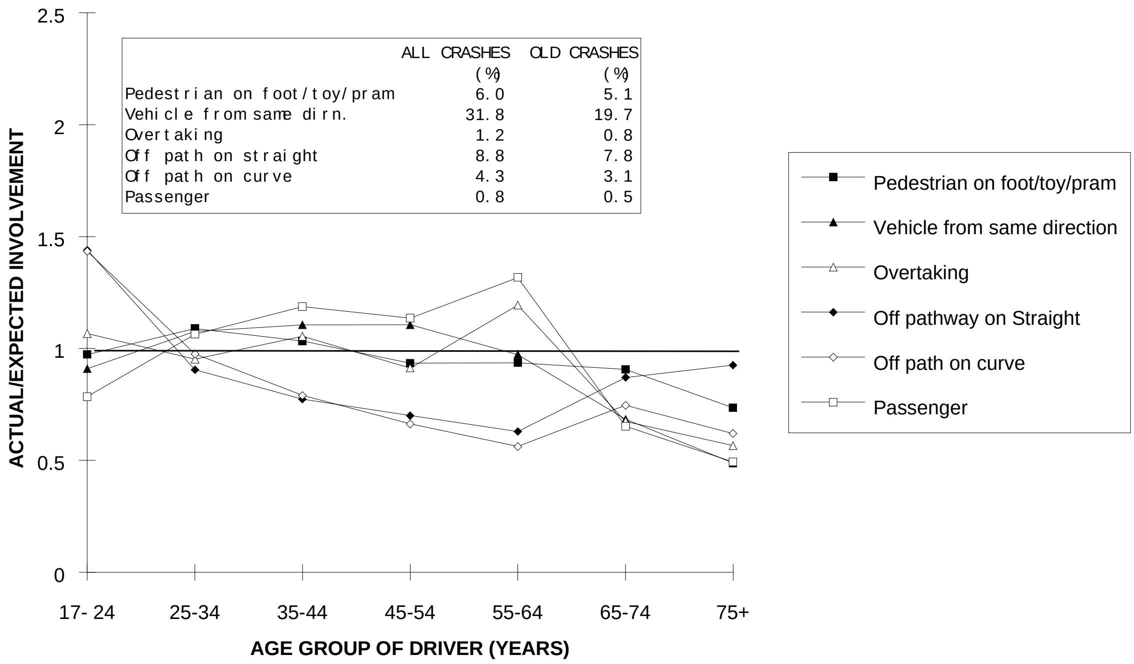

Figure 4.14 (b) Driver involvement rate by type of crash, VicRoads, 1990-92

CRASHES INVOLVING VEHICLES FROM ADJACENT DIRECTIONS: Involvement rates for crashes between vehicles from adjacent directions are shown in Figures 4.15(a) and (b). Figure 4.15(a) shows that only cross traffic crashes (DCA 110) show a small but consistent tendency for older drivers to be over-involved. Cross traffic crashes account for 43% of all adjacent direction crashes, and 45% of adjacent direction crashes among older drivers.

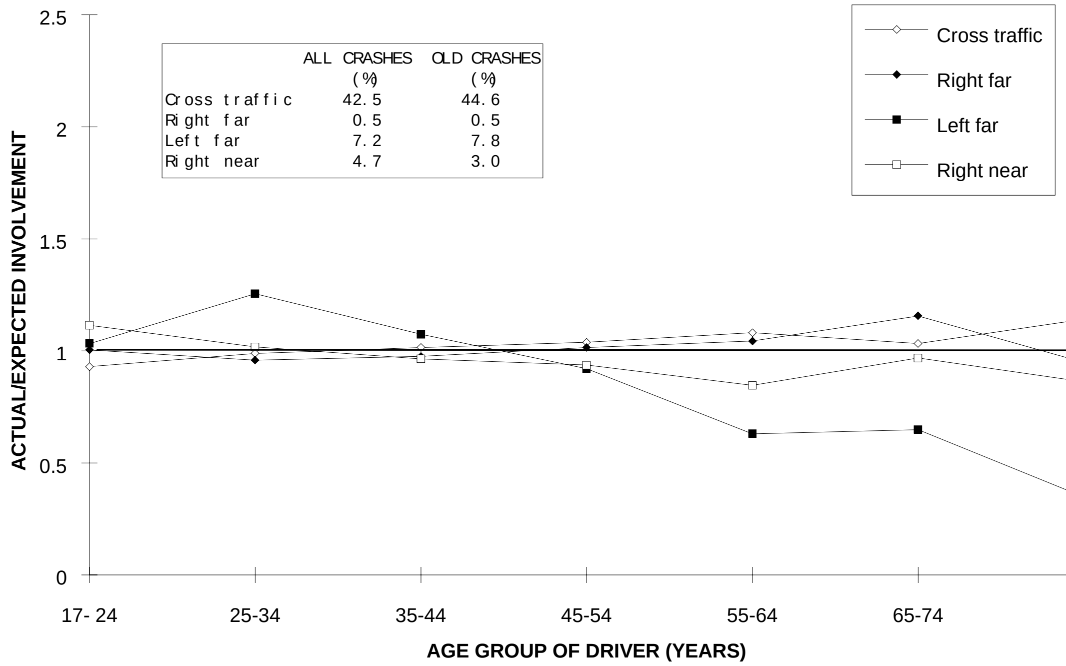

Figure 4.15 (a) Involvement rate for vehicles from adjacent directions, VicRoads, 1990-92

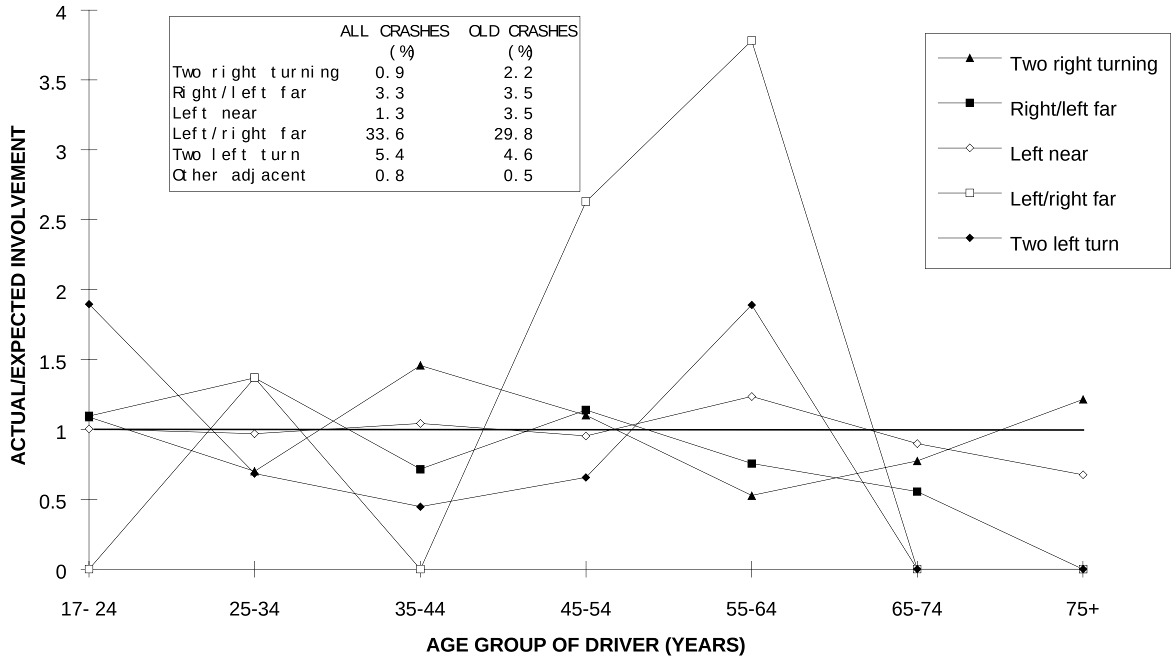

Figure 4.15 (b) Involvement rate for vehicles from adjacent directions, VicRoads, 1990-92

CRASHES INVOLVING VEHICLES FROM OPPOSING DIRECTIONS: Involvement rates for crashes between vehicles from opposing directions are shown in Figure 4.16. Only right-through crashes (DCA 121) show a trend for over -involvement of older drivers. Right-through crashes account for 66% of all opposing direction crashes and 76% of opposing direction crashes among older drivers.

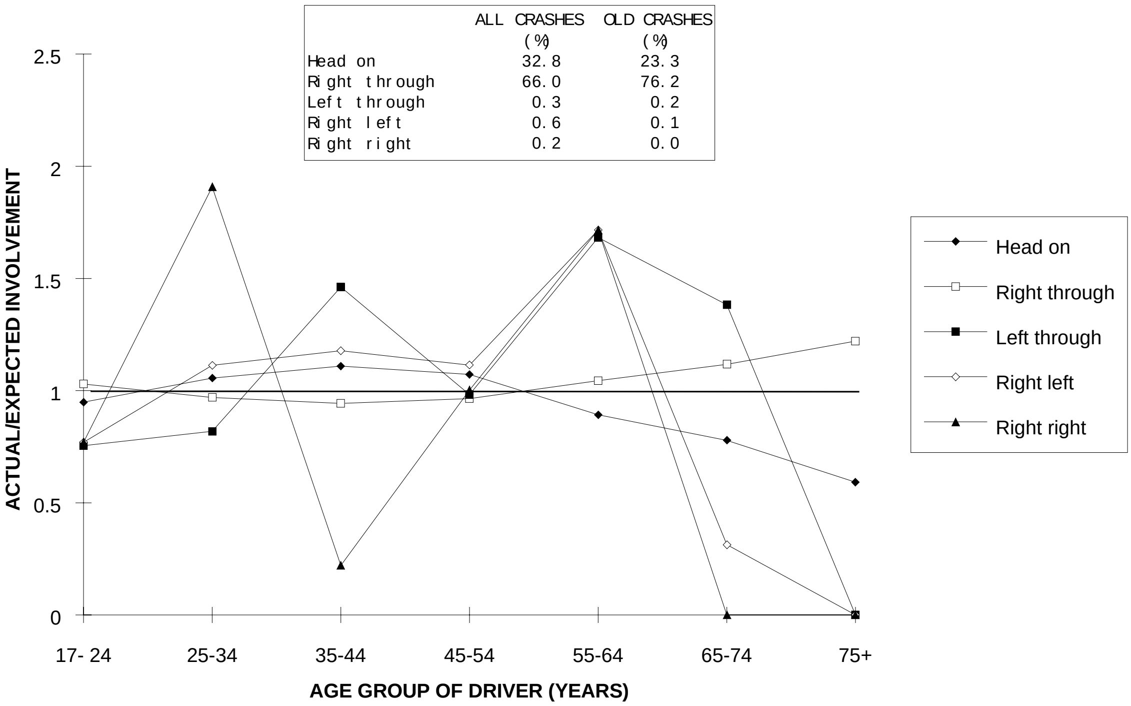

Figure 4.16 Involvement rate for vehicles from opposing directions, VicRoads, 1990-92

CRASHES INVOLVING VEHICLES MANOEUVRING: Involvement rates for crashes between vehicles manoeuvring are shown in Figures 4.17(a) and (b). Figure 4.17(a) indicates that drivers aged 65 years or more were slightly over-involved in crashes involving U-turn (DCA 140) and reversing (DCA 145) manoeuvres. Crashes occurring whilst executing U-turns account for 42% of all manoeuvring type crashes and 45% of older driver manoeuvring crashes. However reversing crashes account for a much smaller proportion of the manoeuvring crash problem (3% of all crashes and 4% of older driver crashes). Notably, crashes involving reversing or U-turns into a fixed object (DCA 146 & 141) and parallel parking (DCA 144) seem to represent a significant problem for drivers 75 years and over [see Figures 4.17(a) and (b)].

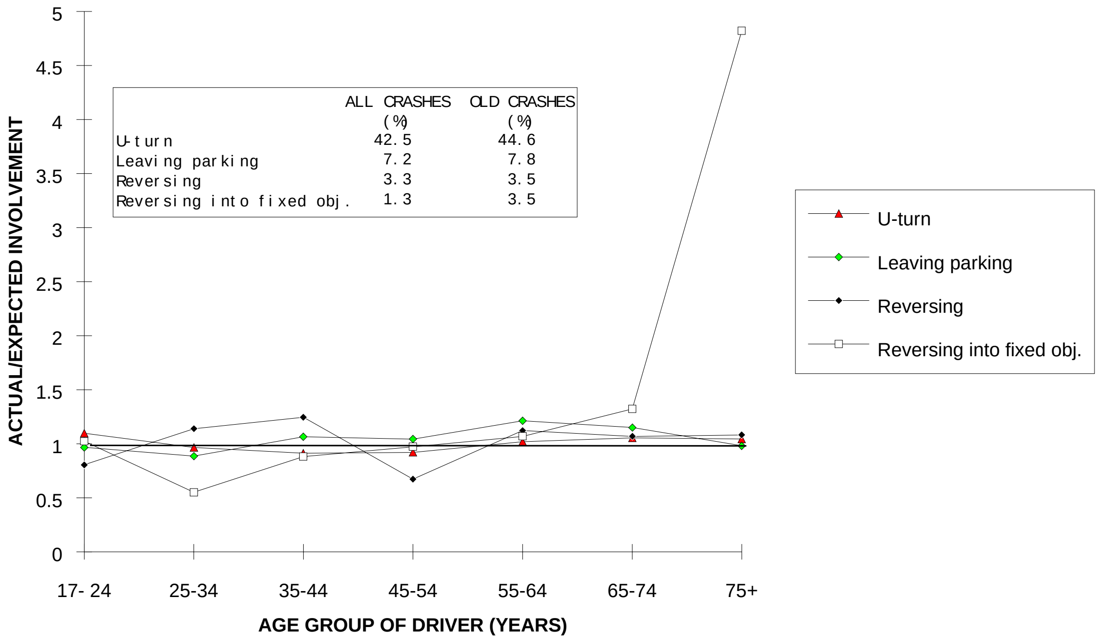

Figure 4.17 (a) Involvement rate for vehicles manoeuvring, VicRoads, 1990-92

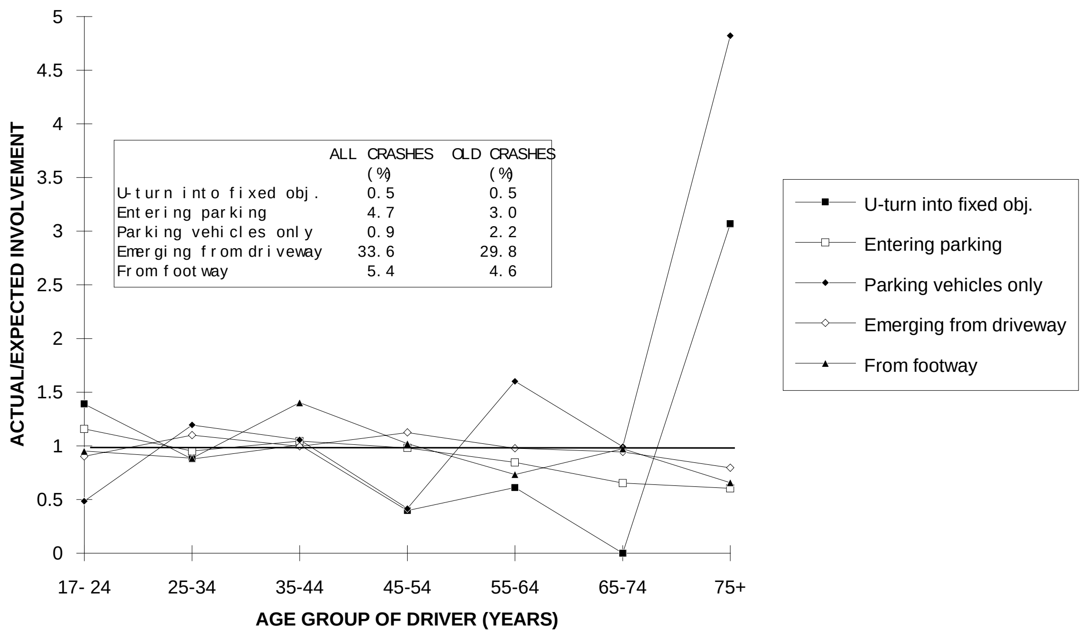

Figure 4.17 (b) Involvement rate for vehicles manoeuvring, VicRoads, 1990-92

ROAD CONDITION: Figure 4.18 indicates that older drivers tend to be over-involved in crashes on dry roads, which make up 75% of crashes for all age groups and 80% of crashes involving older drivers.

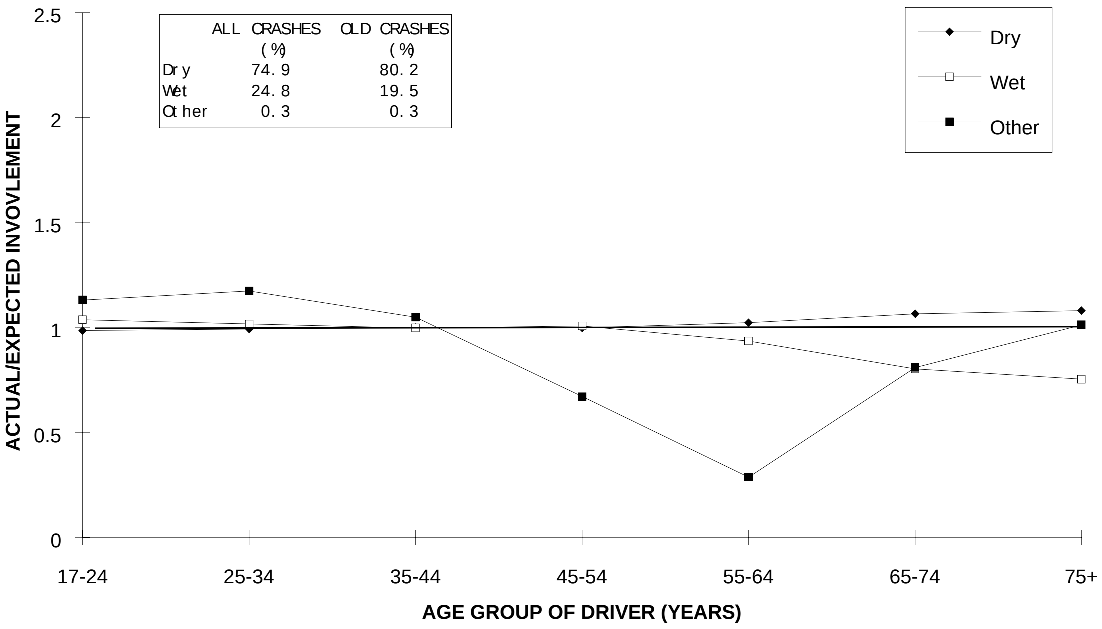

Figure 4.18 Driver involvement rate by road condition, VicRoads, 1990-92

SPEED ZONE: Figure 4.19 shows a trend for drivers aged 65 years or older to be slightly over-involved in crashes occurring in 60 km/h and 100 km/h speed zones. Crashes in 60 km/h speed zones account for 72% of all crashes and 73% of older driver crashes, while crashes in 100 km/h speed zones account for 16.6% of all crashes and 17.3% of older driver crashes.

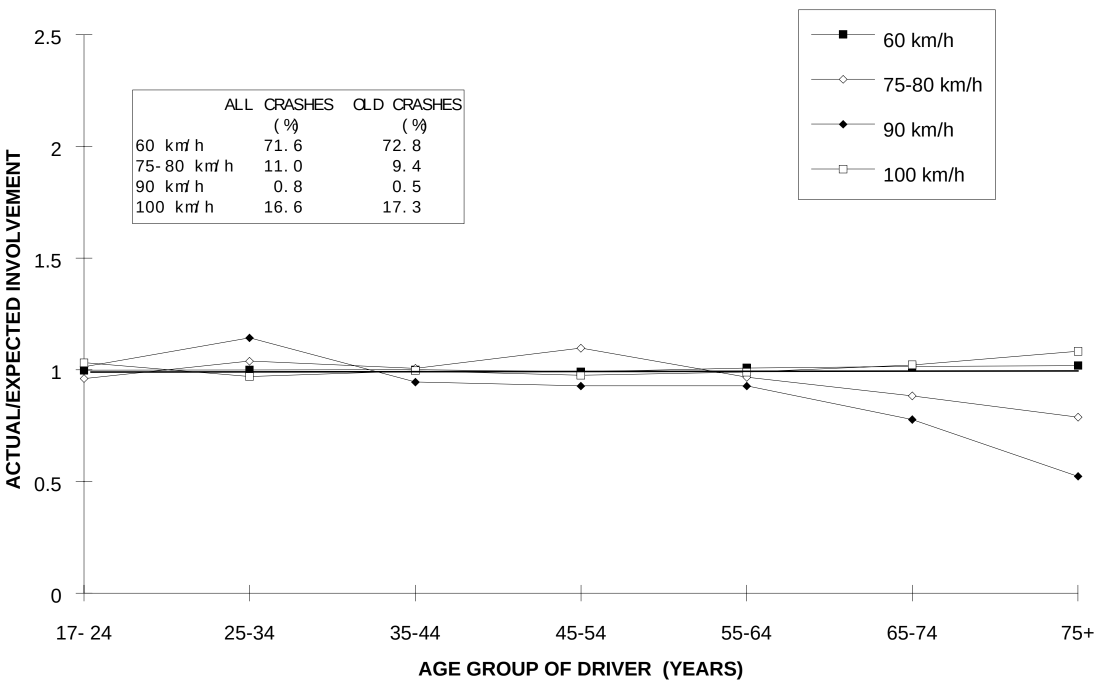

Figure 4.19 Driver involvement rate by speed zone, VicRoads, 1990-92

GEOGRAPHIC AREA: Older drivers tend to be over-involved in crashes in rural areas of Victoria as shown in Figure 4.20. Twenty four percent of all crashes occur in rural areas compared to 37% of older driver crashes.

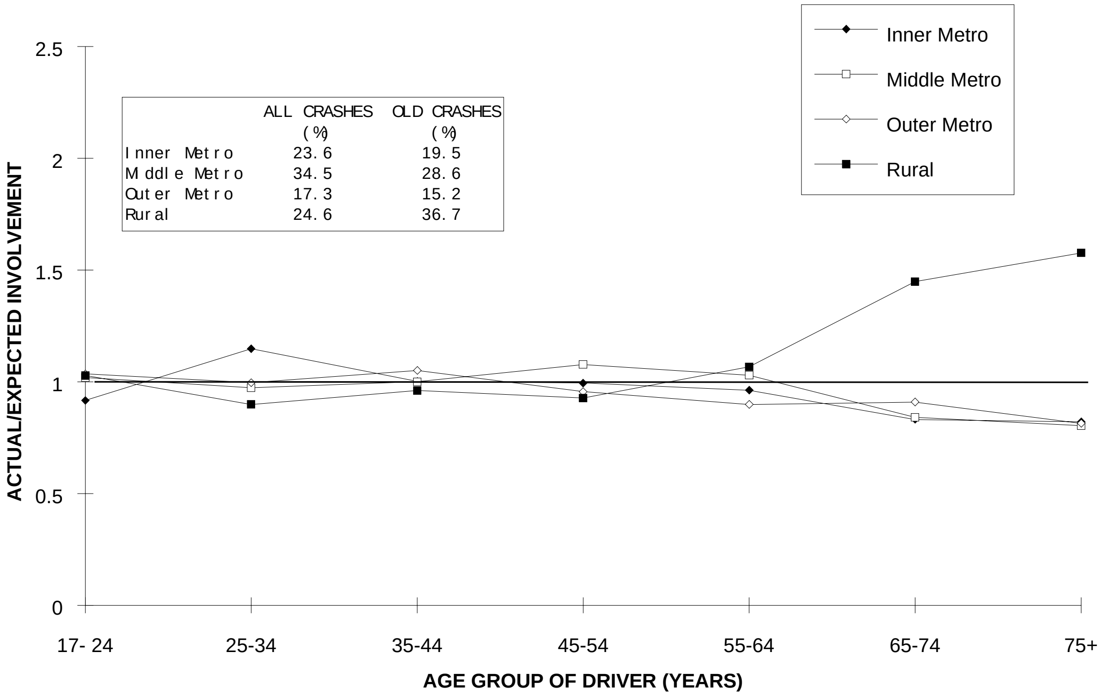

Figure 4.20 Driver involvement rate by geographic area, VicRoads, 1990-92

LIGHT CONDITION: Figure 4.21 shows that older drivers are over-represented in collisions occurring in daylight. These crashes account for 71% of all driver crashes but 87% of older driver collisions.

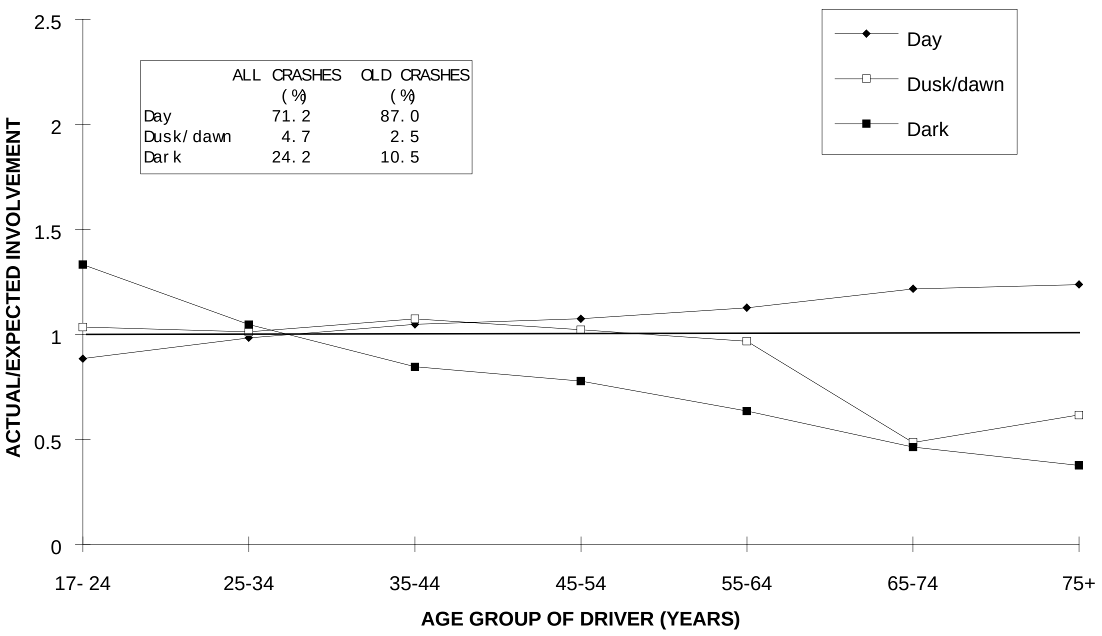

Figure 4.21 Driver involvement rate by light condition, VicRoads, 1990-92

PART OF WEEK: Figure 4.22 shows a very slight tendency for all age groups other than 17-24 year olds to be over-involved in crashes on weekdays. Interestingly though, 17-24 year olds appear to be over-involved in weekend crashes by comparison with all other drivers.

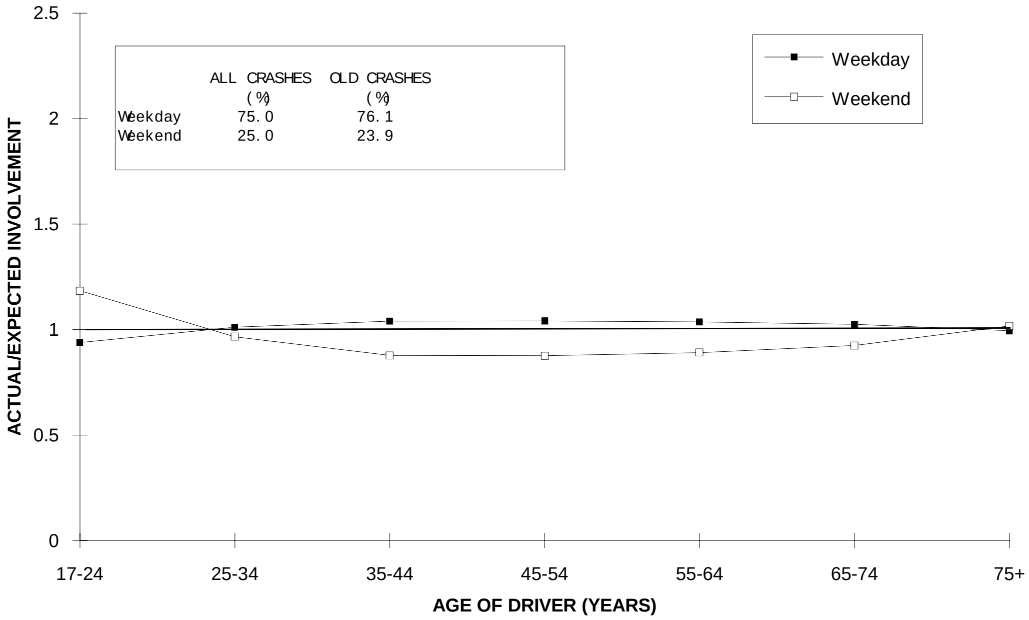

Figure 4.22 Driver involvement rate by part of week, VicRoads, 1990-92

TIME OF DAY: Figure 4.23 shows that drivers aged over 45 years tend to be consistently over-involved in crashes between the hours of 9am and 3pm. Interestingly though, there is also a hint of over-involvement from 3pm to 6pm, especially for those aged 55 to 64 years (presumably those still employed). Thirty percent of all crashes and 53% of older driver crashes occur between 9am and 3pm (the corresponding proportions are 57% and 80% for the time period 9am to 6pm).

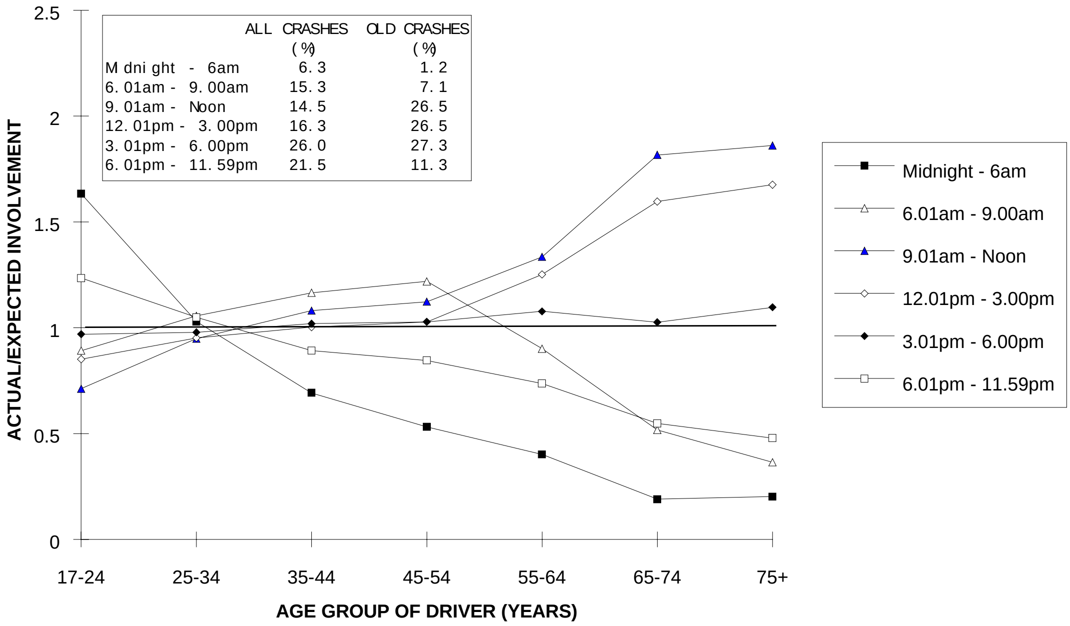

Figure 4.23 Driver involvement rate by time of day, VicRoads, 1990-92

CHAPTER 5

PEDESTRIAN CRASHES

5.1 TRENDS IN PEDESTRIAN CASUALTIES, VICTORIA, 1984-1993

Figures 5.1 and 5.2 show the trends for the last ten years in casualties and casualty rates per 100,000 population, for older and younger pedestrians. Both figures reveal a general decline in pedestrian casualties and pedestrian casualty rates since 1988. However, this trend is less marked for pedestrians aged 65 years and above than it is for pedestrians under 65 years.

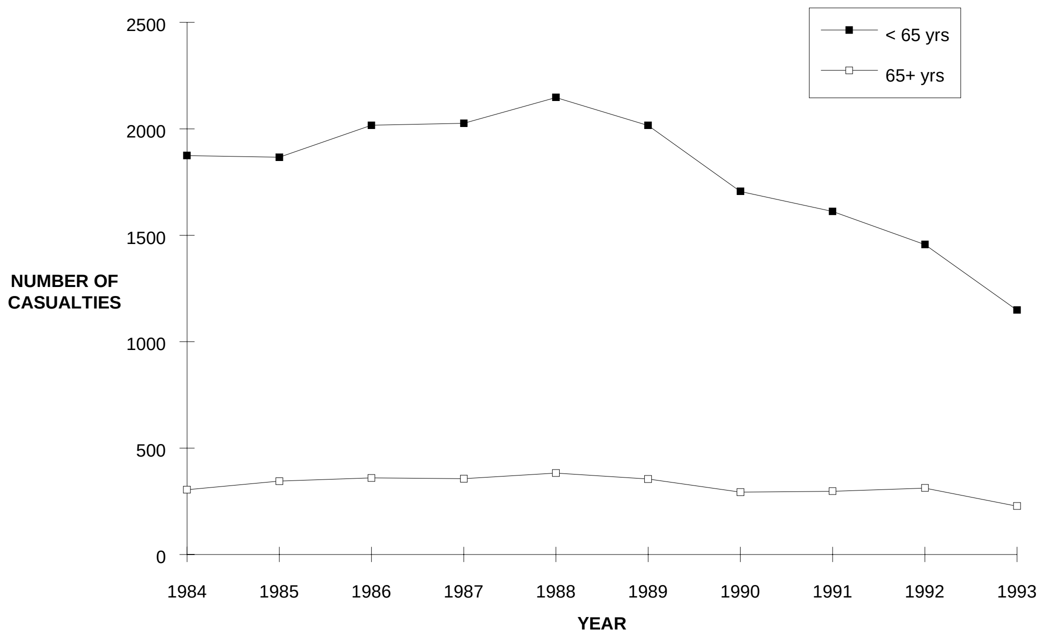

Figure 5.1 Number of pedestrian casualties, VicRoads, 1984-1993

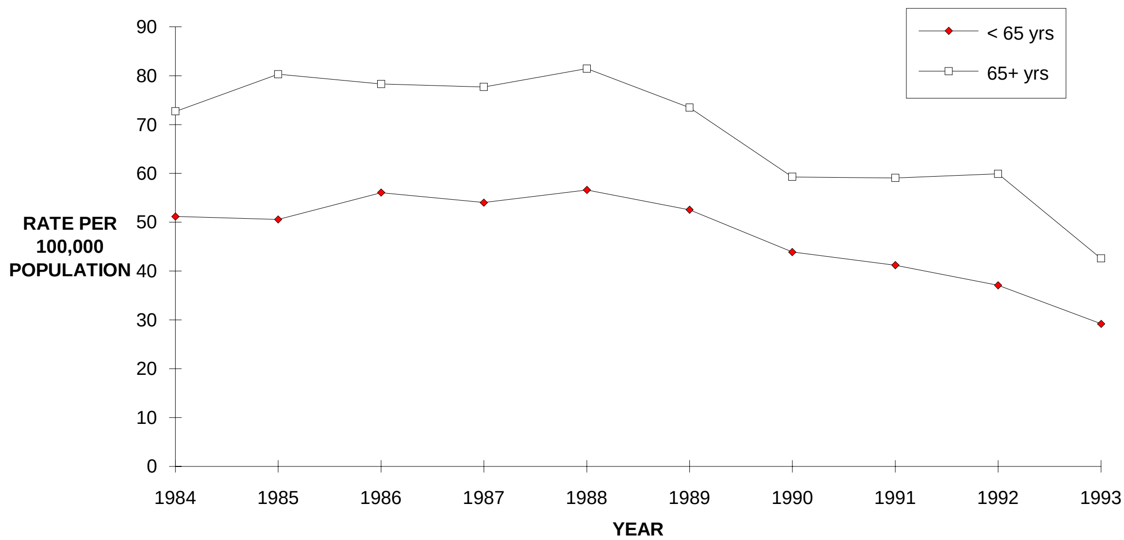

Figure 5.2 Pedestrian casualty rates, VicRoads, 1984-1993

Annual pedestrian casualties and casualty rates, averaged over the period 1984 to 1993, are plotted in Figures 5.3 and 5.4 against pedestrian age, for various levels of injury severity. The number of pedestrian casualties in Figure 5.3 for those aged 65 years and over average about 360 per annum, which is 16% of the total number for all age groups combined.

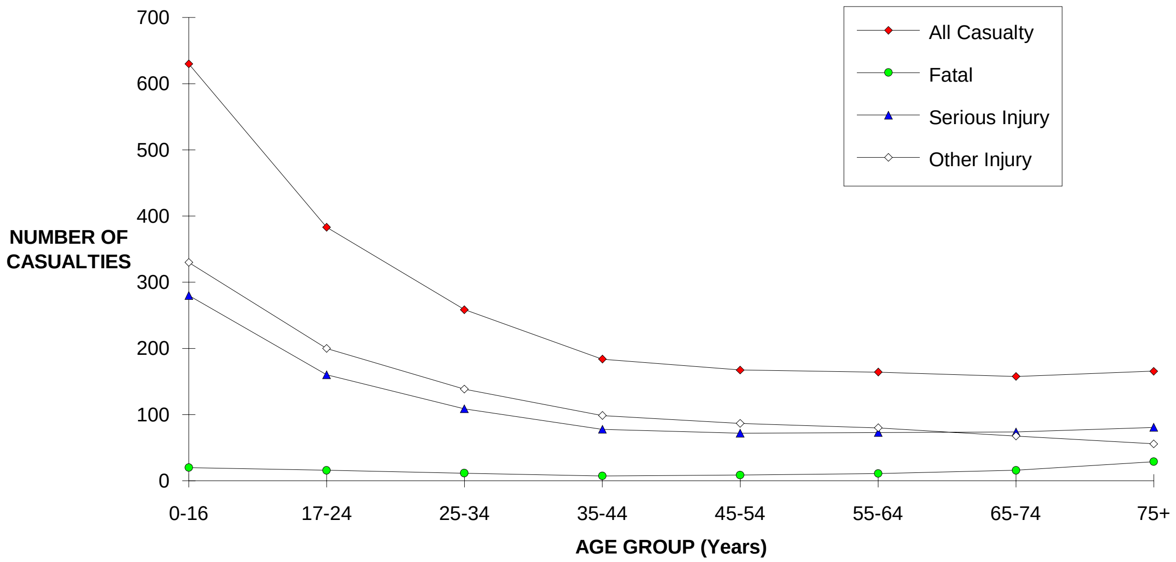

Figure 5.3 Annual average number of pedestrian casualties, VicRoads, 1984-1993

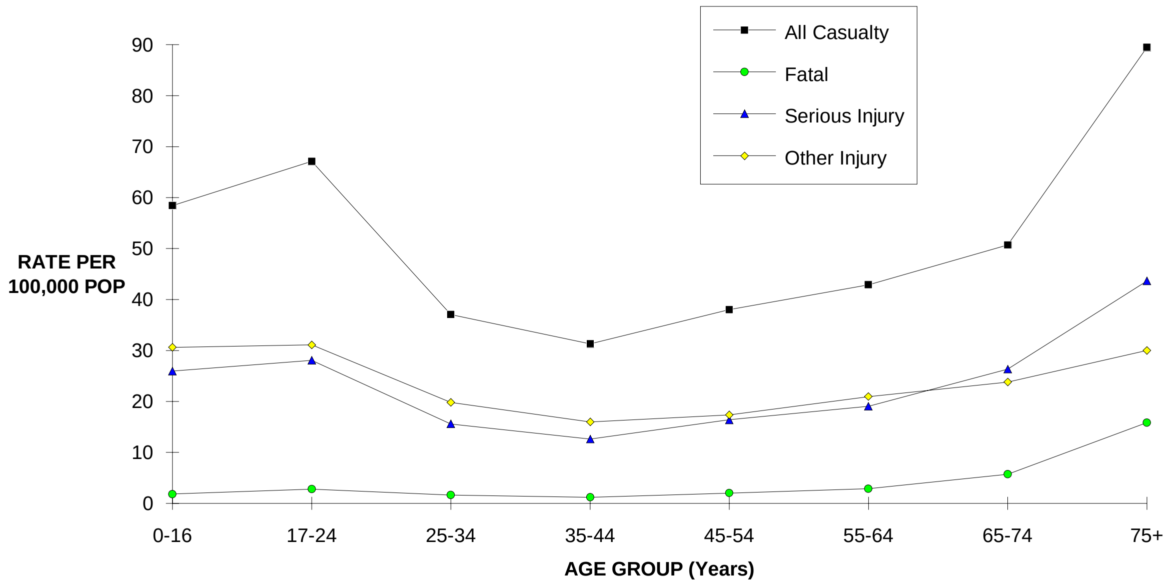

Figure 5.4 Annual average pedestrian casualty rate, VicRoads, 1984-1993

Figure 5.4 reveals that for all injury severity levels, there was a consistent and marked increase in the rate of casualties from 44 years onwards. Notably, the rate of serious injuries and deaths from pedestrian crashes increases sharply for pedestrians aged 75 years and above.

5.2 INJURIES AND COSTS

5.2.1 Cost of Older Pedestrian Crashes

The process used to make estimates of road trauma costs for drivers was described in Section 4.2.3. This process was again applied to the average number of younger (17-64 years) and older (65+ years) pedestrian crashes reported at the TAC during 1987 to 1992 to provide an estimate of the costs associated with adult pedestrian crashes in Victoria.

Table 5.1 shows the breakdown of annual average casualty numbers and estimated costs by casualty class and age group for adult pedestrians. Based on these calculations, it is estimated that road trauma costs for older pedestrians in Victoria are around $14 million each year and that this represents 14 percent of the total cost of adult pedestrian trauma annually in this State. Again, it is stressed that these figures are only preliminary estimates based on a number of overseas age-cost relativities and various assumptions, and that further work is required to confirm their accuracy.

Of particular interest, older pedestrians account for 27% of all pedestrian casualties, yet only 14% of pedestrian casualty costs. This is because of differences in the cost of trauma between the two age groups (eg; a younger death is priced at over $700,000 compared to only $50,000 for an older death based on US relativities, essentially because of differences in loss of productivity between the respective groups). Differences in treatment costs between older and younger pedestrians is considered in the following analyses.

TABLE 5.1
AVERAGE ANNUAL NUMBERS AND COSTS OF CASUALTIES IN VICTORIA FOR ADULT PEDESTRIANS (TAC, 1987-92)

CASUALTY NUMBERS

ROAD USER	KILLED	HOSPITALISED	TREATED	TOTAL
Younger road users (17-64 yr	433	3565	12249	16247
Older road user (65 plus)	122	597	995	1714
Total adult road users	***555***	***4162***	***13244***	***17961***
Younger ped (17-64 yrs)	60	327	476	863
Older ped (65 plus)	49	154	124	327
Total adult pedestrians	***109***	***481***	***600***	***1190***

CASUALTY COSTS (A$000's)

ROAD USER	KILLED	HOSPITALISED	TREATED	TOTAL
Younger road users (17-64 yr	$311,251	$455,065	$112,372	$878,689
Older road users (65 plus)	$6,101	$39,064	$12,124	$57,288
Total adult road users	***$317,352***	***$494,129***	***$124,496***	***$935,977***
Younger peds (17-64 yrs)	$43,130	$41,741	$4,367	$89,237
Older peds (65 plus)	$2,450	$10,077	$1,511	$14,038
Total adult pedestrians	***$45,580***	***$51,818***	***$5,878***	***$103,275***

TABLE 5.2
ANALYSIS OF CLAIMS FOR ADULT PEDESTRIANS (TAC, 1987-88)

Variable	Age Group	No. of Valid* Claimants	Prob. of Claiming	Total Cost of Claims	Average Cost per Claim
Paydeath	18-64 years	35	0.31	$3,677,918	$105,083
	65-74 years	1	0.02	$63,427	$63,427
	75+ years	0	0.00	$0	$0
	Total	36	0.15	$3,741,345	$103,926
Payhosp	18-64 years	956	0.85	$9,571,303	$10,012
	65-74 years	206	0.86	$2,341,729	$11,368
	75+ years	262	0.85	$2,653,133	$10,126
	Total	1424	0.85	$14,566,165	$10,229
Paymed	18-64 years	940	0.83	$4,369,484	$4,648
	65-74 years	209	0.87	$655,295	$3,135
	75+ years	254	0.82	$742,307	$2,922
	Total	1403	0.84	$5,767,086	$4,111
Rehabin$	18-64 years	154	0.14	$3,733,663	$24,245
	65-74 years	33	0.14	$504,089	$15,275
	75+ years	44	0.14	$827,857	$18,815
	Total	231	0.14	$5,065,609	$21,929
Payambul	18-64 years	832	0.74	$214,499	$258
	65-74 years	181	0.76	$55,600	$307
	75+ years	256	0.83	$63,585	$248
	Total	1269	0.76	$333,684	$263
Payother	18-64 years	569	0.50	$827,735	$1,455
	65-74 years	123	0.51	$143,531	$1,167
	75+ years	149	0.48	$232,079	$1,558
	Total	841	0.50	$1,203,345	$1,431
Payloe	18-64 years	495	0.44	$3,269,341	$6,605
	65-74 years	6	0.03	$30,727	$5,121
	75+ years	0	0.00	$0	$0
	Total	501	0.30	$3,300,068	$6,587
Payimp	18-64 years	173	0.15	$2,401,351	$13,881
	65-74 years	52	0.22	$694,747	$13,361
	75+ years	34	0.11	$420,520	$12,368
	Total	259	0.15	$3,516,618	$13,578
Payloec	18-64 years	123	0.11	$1,550,428	$12,605
	65-74 years	1	0.00	$3,588	$3,588
	75+ years	0	0.00	$0	$0
	Total	124	0.07	$1,554,016	$12,532
Total	18-64 years	1127		$29,615,722	$26,278
	65-74 years	239		$4,492,733	$18,798
	75+ years	309		$4,939,481	$15,985
	Total	1675		$39,047,936	$23,312

** A valid claim is one where the claim amount for all variables totals $317.00 or greater (July, 1989)*

Note. The probability of claiming a death benefit (paydeath) is the number of valid claimants/number who died in each age group.

5.2.2 TAC Claims, 1987-88

An analysis of TAC claims made by injured pedestrians during the years 1987 and 1988 is shown in Table 5.2 below. Unlike older drivers, older pedestrians do not have an increased probability of claiming for hospital, medical or rehabilitation expenses by comparison with their younger counterparts. Further, the average claim for medical and rehabilitation costs is lower for older pedestrians than for younger ones.

As for older drivers, the probabilityof claiming a death payment (Paydeath) decreases sharply with age. Roughly one third of pedestrians aged 18-64 years who are killed have a claim for death payment lodged, compared with only 2% of pedestrians aged 65-74, with no claims at all for those aged 75 years or more.

The average total claim cost for older pedestrians is roughly 30-40% less than for younger pedestrians (similar relativities as for drivers). This net effect is a reflection of lower average claim costs for older pedestrians on medical, rehabilitation, loss of earnings and earning capacity.

5.2.3 Injury Analysis, TAC Claims, 1987-88

The injuries sustained by TAC claimants who were pedestrians injured in a road crash were grouped into the same 17 categories as previously described for drivers and were compared for younger and older pedestrians (see Table 5.3). Overall, there were very few differences in the patterns of results. Older pedestrians had more major head injuries (and correspondingly fewer minor ones) than younger pedestrians and a higher proportion of chest and upper limb injuries. This, again, probably reflects the frailty of older age. The fact that older pedestrians sustained fewer lower limb injuries is somewhat surprising, given that pedestrians generally are vulnerable to these injuries because of the geometry of a person being hit by a car. This warrants further investigation.

5.3 CRASH CHARACTERISTICS

This section describes the results of analyses of the crash involvement of older pedestrians, for a range of crash, road and road user variables. As previously described in Section 4.3 on driver crash characteristics, the pedestrian figures also note the actual from expected value given crash involvement, and the percent of all crashes and older crashes for a particular variable.

TABLE 5.3
INJURY ANALYSIS BY AGE GROUP FOR ADULT PEDESTRIANS (TAC, 1987-88)

INJURIES	PEDESTRIANS			
	18-64 Years (1536 claimants)		65+ Years (732 claimants)	
	Number	Prob.	Number	Prob.
Head - major	239	0.16	151	0.21
Head - minor	323	0.21	132	0.18
Face - major	52	0.03	22	0.03
Face - minor	263	0.17	125	0.17
Neck - whiplash	62	0.04	7	0.01
Spine - fracture	58	0.04	38	0.05
Shoulder - major	52	0.03	28	0.04
Shoulder - minor	52	0.03	13	0.02
Chest- major	171	0.11	152	0.21
Chest - minor	87	0.06	43	0.06
Abdomen - major	56	0.04	34	0.05
Abdomen - minor	162	0.11	56	0.08
Upper limb - major	158	0.10	104	0.14
Upper limb - minor	349	0.23	174	0.24
Lower limb - major	471	0.31	223	0.30
Lower limb - minor	936	0.61	351	0.48
Other	377	0.25	187	0.26
Total Injuries	**3,868**		**1,840**	
Avg. Injuries per claim	**2.5**		**2.6**	

Prob = probability of claimants in each age group sustaining that particular injury (i.e., number/number of claimants)

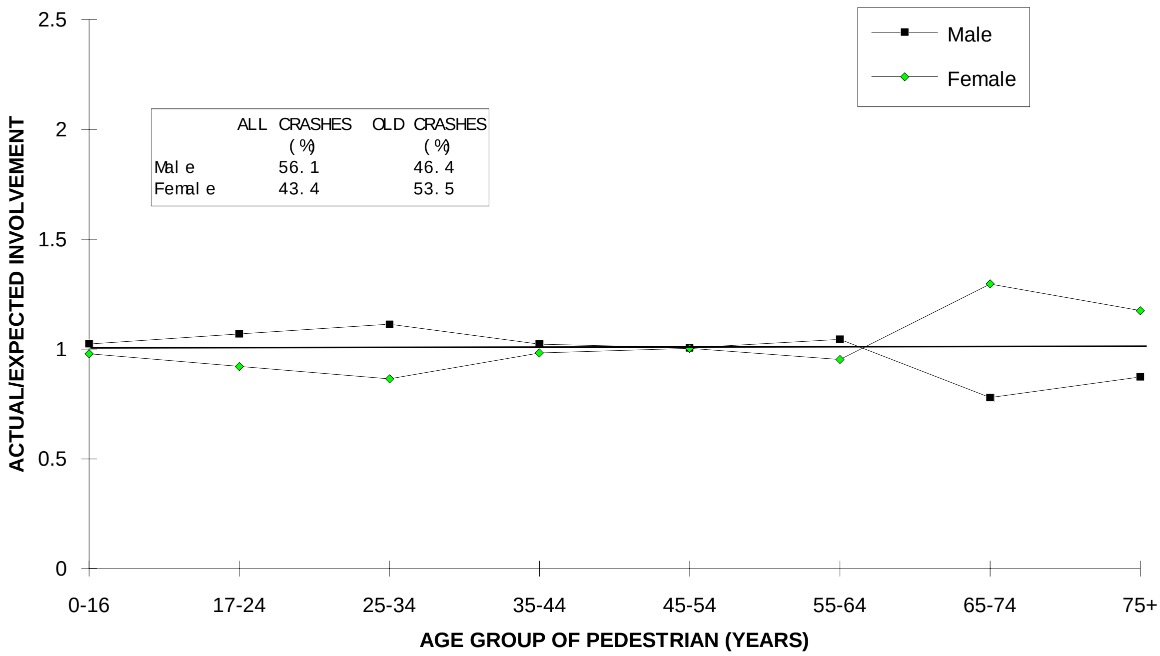

Figure 5.5 Involvement rate by sex of the pedestrian, VicRoads, 1990-92

SEX OF THE PEDESTRIAN: Figure 5.5 shows that older females aged 65 years and above were over-involved in pedestrian crashes compared to males. These collisions comprise 43% of all pedestrian crashes but 54% of older pedestrian crashes. It should be noted that women aged over 65 years made up 58 percent of the older population during this time period (ABS, 1991 census data) so this result probably reflects differences in exposure between the two sexes.

CRASH SEVERITY: Figure 5.6 shows that pedestrians aged 45 years and older (especially those beyond 75 years) were clearly over-involved in fatal crashes. There was also a slight over-involvement of older pedestrians in serious injury crashes, although this was more noticeable for those aged 75 and above. Most importantly, older pedestrians were well under-represented in pedestrian crashes where no one was injured.

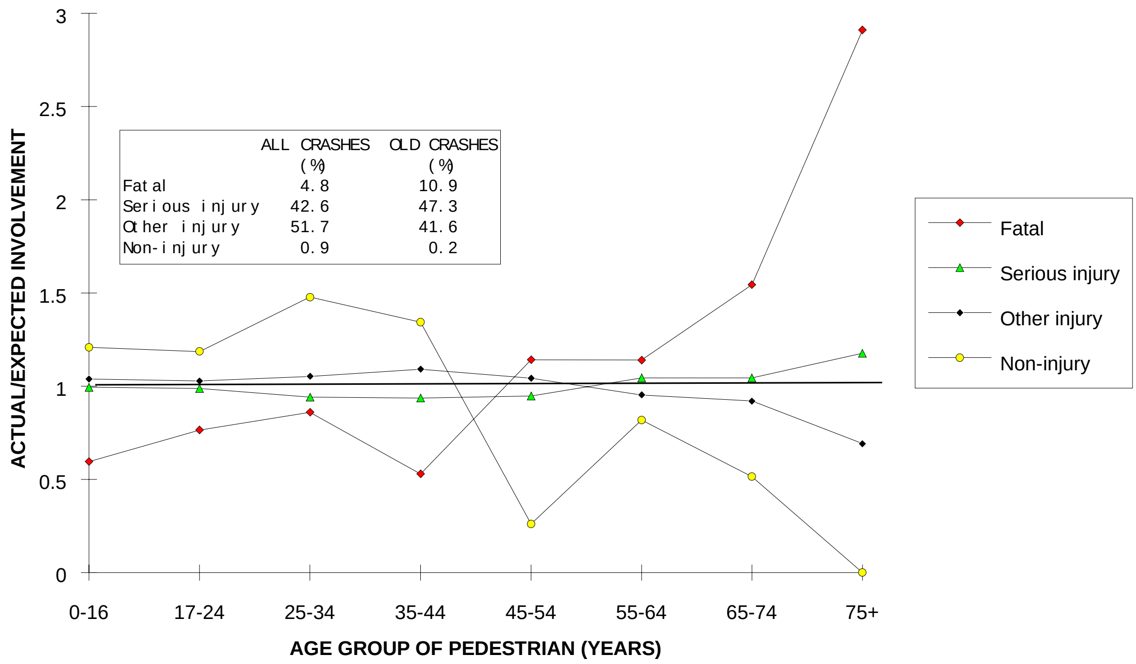

Figure 5.6 Pedestrian involvement rate by crash severity, VicRoads, 1990-92

CRASH LOCATION: Figure 5.7 reveals that pedestrians aged 45 years and above are slightly over-involved in crashes at intersections. While intersections comprise about 47% of the total pedestrian crash problem, they account for 50% of older pedestrian crashes.

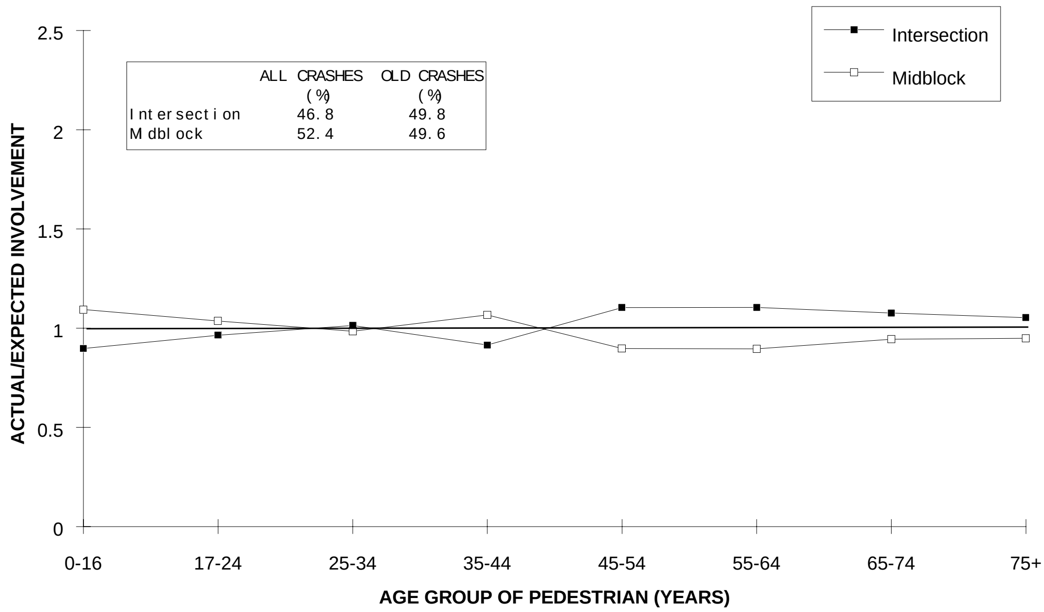

Figure 5.7 Pedestrian involvement rate by location, VicRoads, 1990-92

INTERSECTION CONTROL: Pedestrians aged over 45 years also appear to have been over-involved in crashes at stop and give way (unsignalised) intersections, as shown in Figure 5.8. It should be noted, however, that this crash type comprises only about 2% of the pedestrian casualty crash problem for all age groups and 3% of the problem for pedestrians aged 65 years and over.

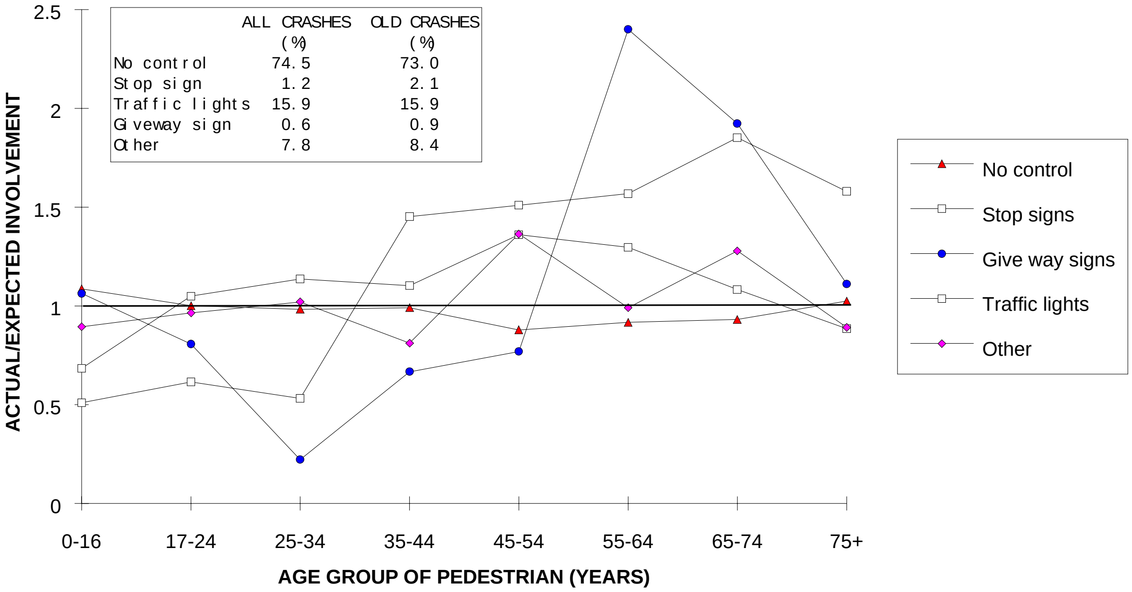

Figure 5.8 Pedestrian involvement rate by intersection control, VicRoads, 1990-92

INTERSECTION GEOMETRY: Pedestrians aged 45 years and above appear to have been over-involved in crashes at cross intersections (see Figure 5.9). This type of intersection crash represents about 23% of the pedestrian crash problem for all ages and about 27 % for older pedestrians.

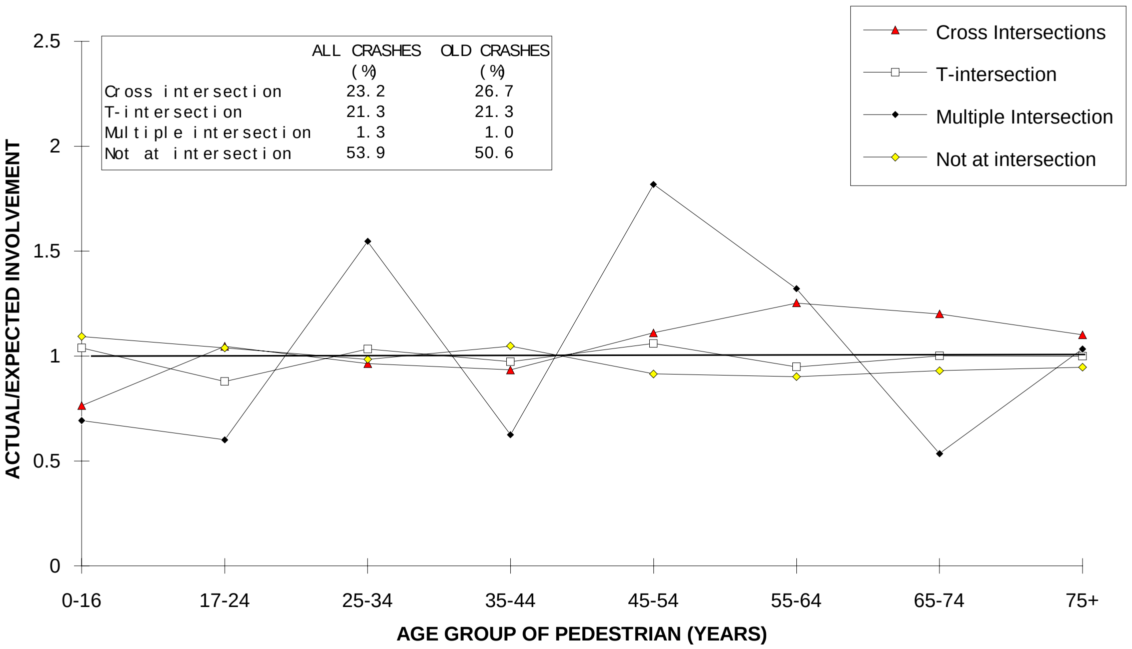

Figure 5.9 Pedestrian involvement rate by type of intersection, VicRoads, 1990-92

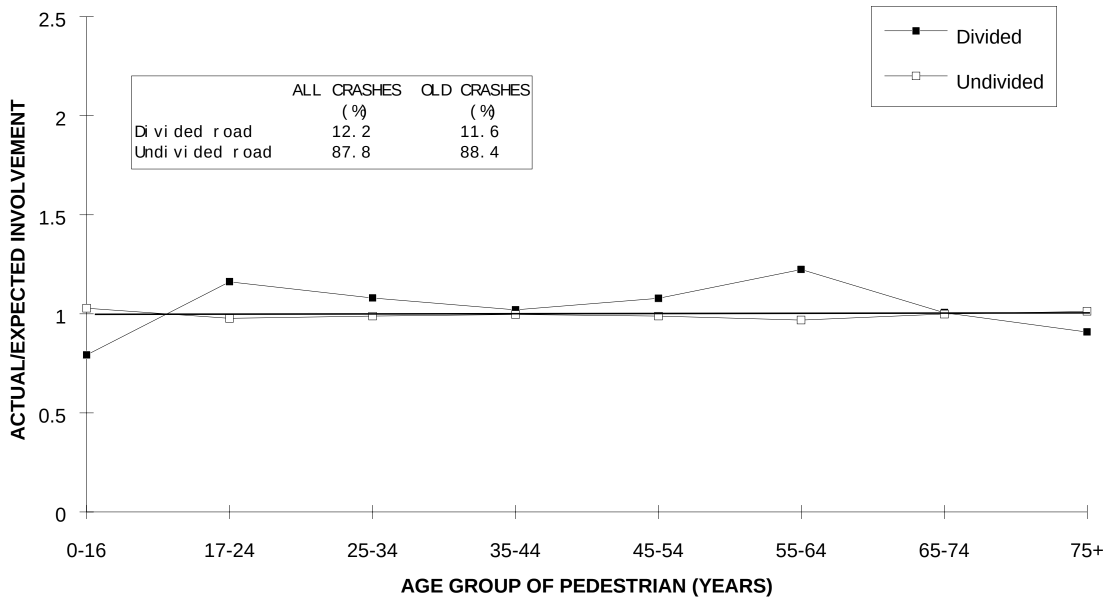

Figure 5.10 Pedestrian involvement rate by road character, VicRoads, 1990-92

ROAD CHARACTER: Figure 5.10 shows there are no age related differences in crash involvement on divided roads (i.e., with a median strip) versus undivided roads. The vast majority (88%) of both all and older pedestrian crashes occur on undivided roads.

CRASH TYPE: Analysis of the DCA coding of pedestrian crashes is illustrated in Figures 5.11(a) and (b). Figure 5.11(a) shows that older pedestrians are slightly over-involved in road crossing from both the near- and far-side of the road. Interestingly, near-side and far-side pedestrian crashes together accounted for some 63% of all-age pedestrian casualty crashes and 73% of crashes involving older pedestrians. There was also a large over-involvement rate for older pedestrians in driveway crossing crashes, although these collisions only make up 2% of all-age crashes and 5% of casualty crashes involving older pedestrians. None of the crash types shown in Figure 5.11(b) represented a sizable proportion nor indicated any over-involvement of older pedestrians.

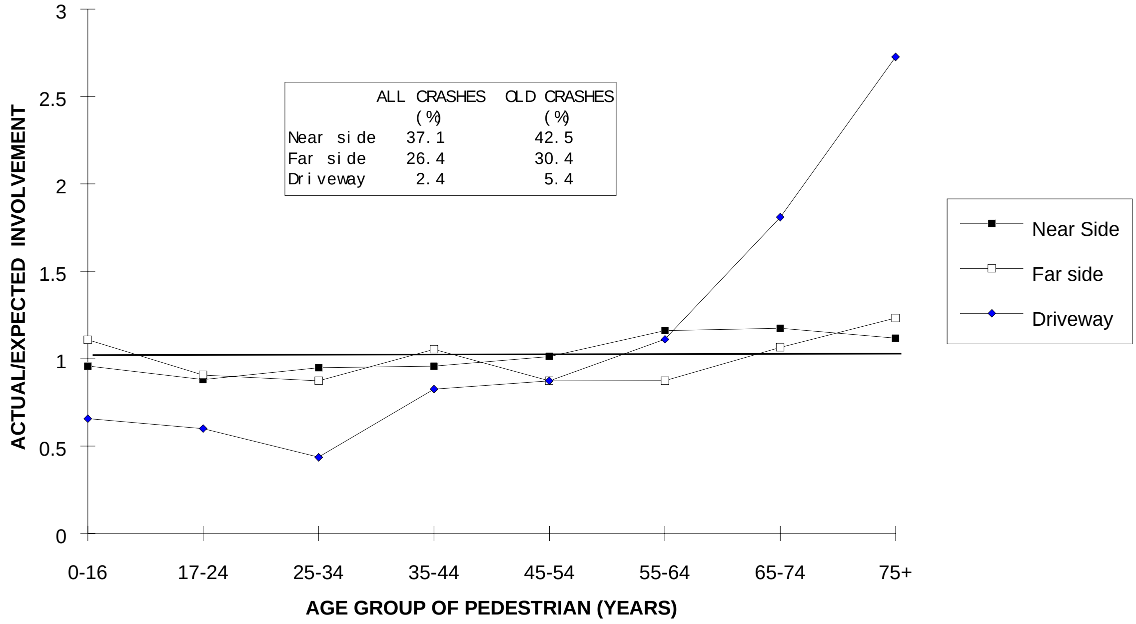

Figure 5.11 (a) Pedestrian involvement rate by travel lane when struck, VicRoads, 1990-92

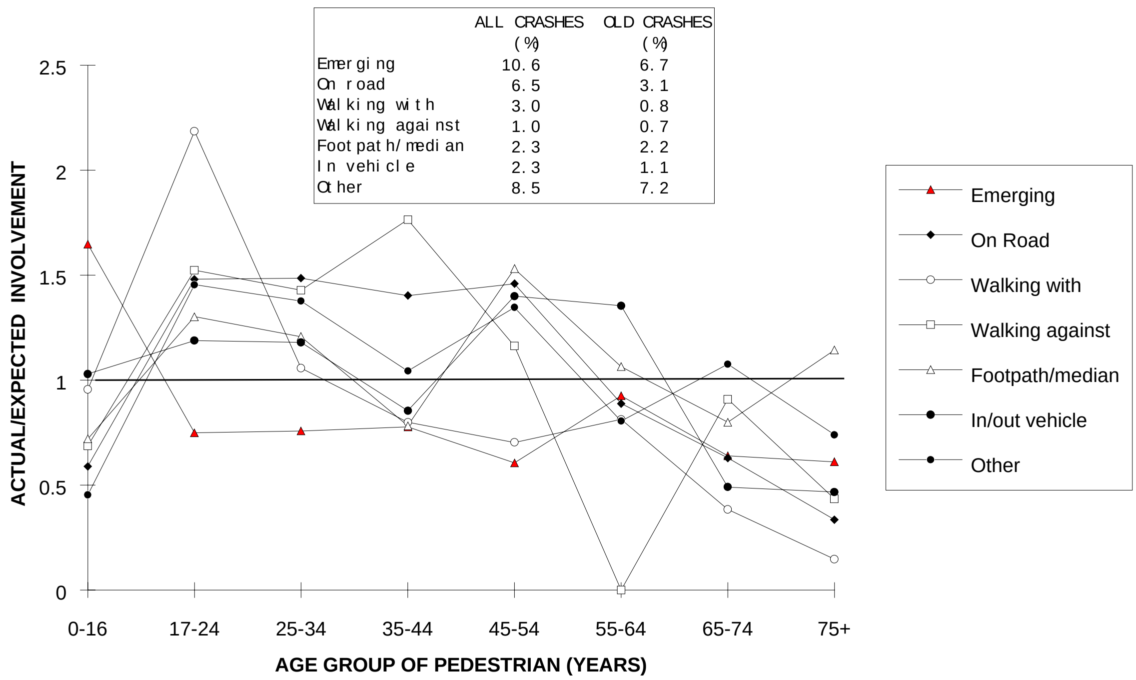

Figure 5.11 (b) Pedestrian involvement rate by other location when struck, VicRoads, 1990-92

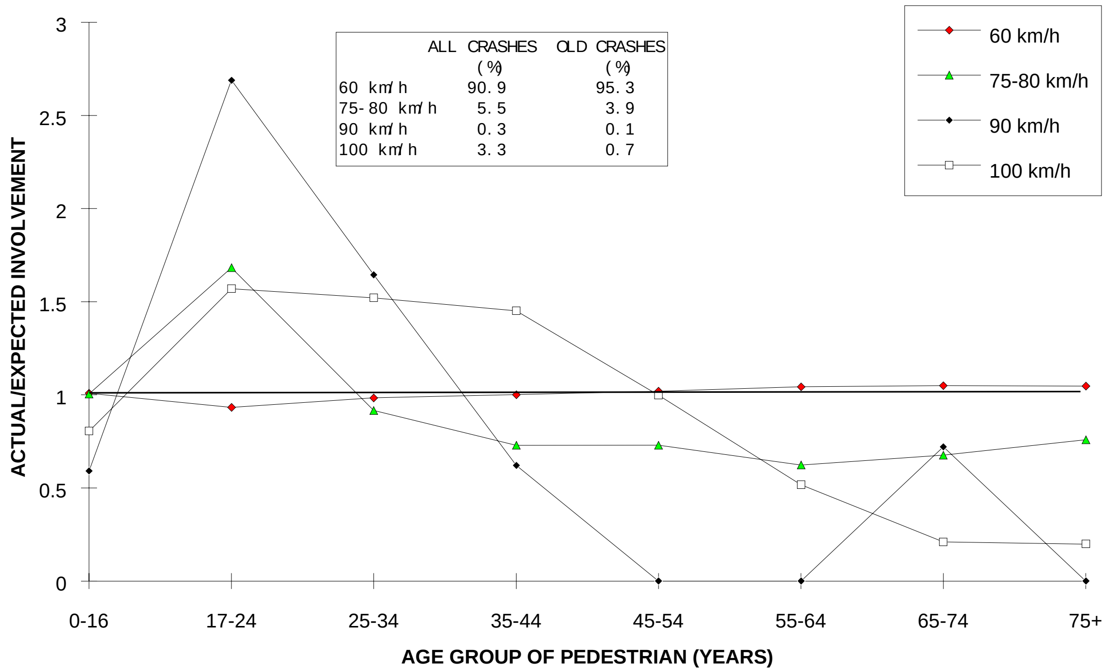

Figure 5.12 Pedestrian involvement rate by speed zone, VicRoads, 1990-92

SPEED ZONE: Pedestrian crash rates by speed zone are shown in Figure 5.12. Older pedestrians show a slightly higher tendency to have their crashes in 60 km/h speed zones accounting for 94% of all older pedestrian crashes.

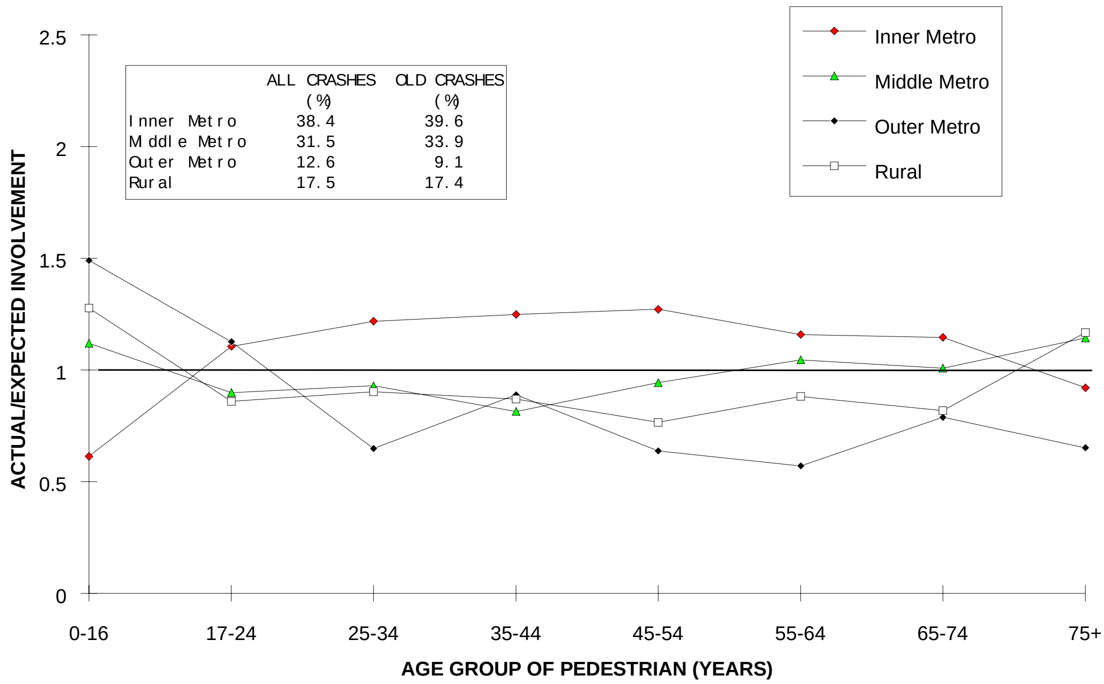

Figure 5.13 Pedestrian involvement rate by geographic area, VicRoads, 1990-92

GEOGRAPHIC AREA: Figure 5.13 suggests that pedestrians aged 55 years and over are very slightly over-involved in crashes occurring in middle-metropolitan areas of Melbourne. Thirty-two percent of all pedestrian crashes and 34% of older pedestrian crashes occur in middle-metropolitan areas.

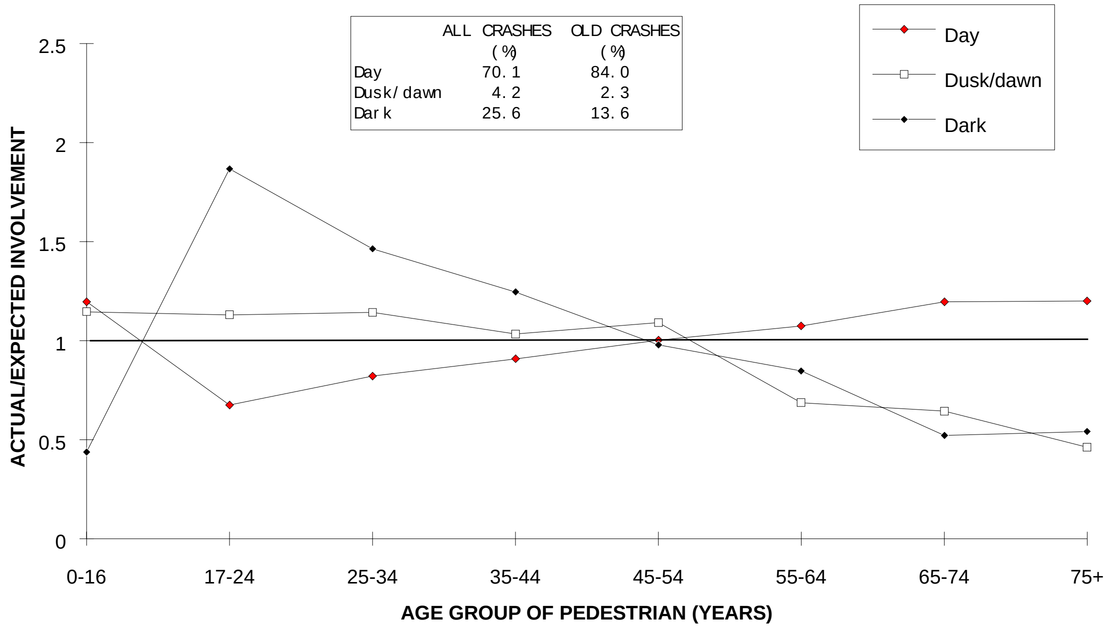

Figure 5.14 Pedestrian involvement rate by light condition, VicRoads, 1990-92

LIGHT CONDITION: Figure 5.14 reveals that older pedestrians are over-involved in casualty crashes occurring in daylight. Seventy percent of pedestrian crashes occur during daylight hours, but 84% of older pedestrian crashes occur during this time.

PART OF THE WEEK: Figure 5.15 reveals that pedestrians aged 45 years or more were under-involved in pedestrian crashes at weekends and slightly over-involved during the week. Seventy-eight percent of pedestrian crashes occur during the week compared with 83% for older pedestrians.

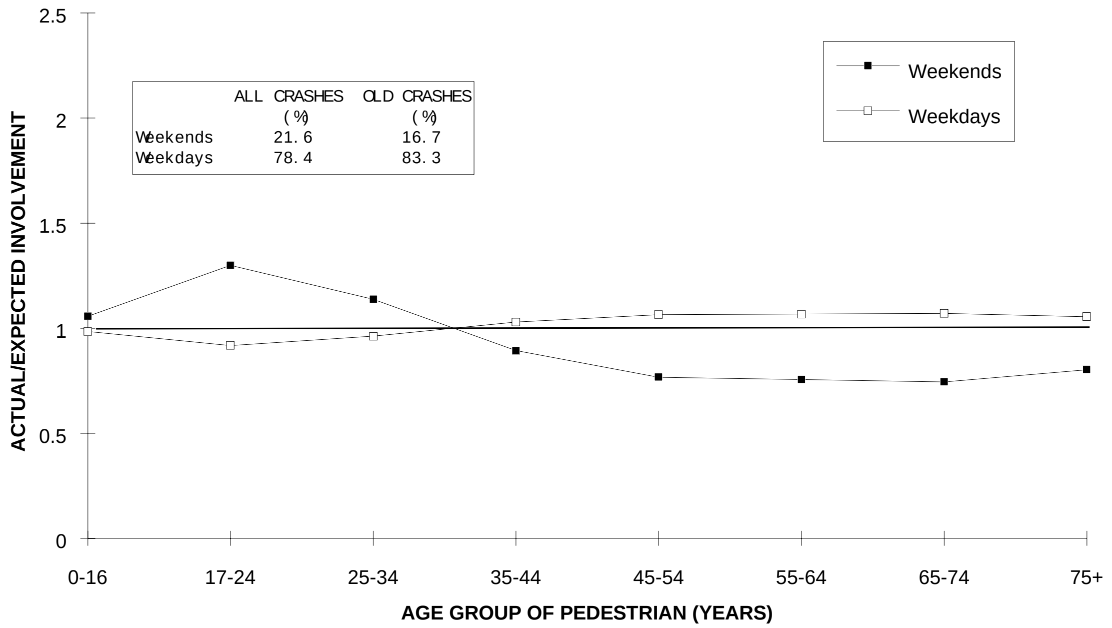

Figure 5.15 Pedestrian involvement rate by part of the week, VicRoads, 1990-92

TIME OF THE DAY: Figure 5.16 shows that pedestrians aged 45 years or more tend to be over-involved in crashes between 9 a.m. and 3 p.m. Forty-eight percent of pedestrian crashes occur during this six-hour period compared with 67% of older pedestrian crashes.

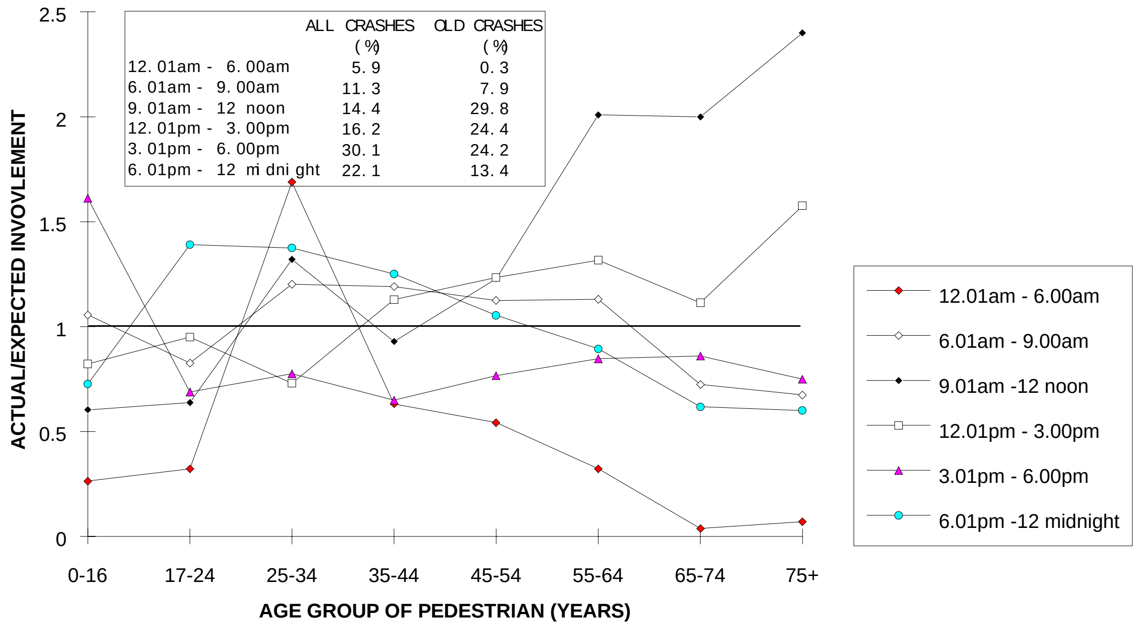

Figure 5.16 Pedestrian involvement rate by time of the day, VicRoads, 1990-92

CHAPTER 6

GENERAL DISCUSSION AND RECOMMENDATIONS

This final chapter of the Older Road User report attempts to bring together the findings from the literature review and data analyses to provide a broad overview of the extent of the problem and areas where older road users appear to be over-involved (at least in terms of injury if not the risk of having a crash). A number of recommendations are made in terms of opportunities for intervention to reduce the frequency and/or severity of injury as well as areas where further research is required.

6.1 OLDER DRIVER FINDINGS

It should be stated from the outset that the size of the older driver road safety problem, while still a significant source of pain and suffering for the individuals involved and cost to the community, is nowhere near the size of the problem for younger drivers. Drivers aged 65 years or more account for only 7% of driver crash claims on the TAC and 5% of the total injury costs sustained by drivers. It seems that the older driver problem is more one of increased likelihood of sustaining a severe outcome given a crash than it is of over-involvement in crashes, although this could not be firmly established for Victoria in this study because of the lack of driver exposure data.

6.1.1 Trends in Older Driver Crashes

The substantial reduction in road casualties from 1989 to 1991 was more apparent among young drivers than older ones, although there were reductions in the rates per head of population for both age groups. Of some concern, though, while the younger driver crash rates have continued to fall beyond 1991 (albeit at a lesser rate), the older driver crash rates show signs of marginally increasing from 1991 onwards. It could be argued that this might reflect the fact that the economic recession and high unemployment have had less influence on the elderly (the majority of whom are retired) and therefore less influence on their amount of driving than they have for younger adults. It might also reflect the fact that recent successful road safety initiatives in this State (speeding and drink driving) have had less influence on these people (and possibly correctly so given that they are less likely to offend).

The findings for the number of casualties experienced by all age groups in Victoria between 1984 and 1993 confirm the small size of the older driver problem discussed above. The rate of casualties per head of population further show that older drivers are far more likely to be injured (and severely injured) in the event of a crash compared to their younger counterparts. This shows the need for special attention to be paid to improved occupant protection measures for the old and frail in cars.

6.1.2 Injuries and Cost to the TAC

Injuries to older drivers were not too dissimilar to those sustained by younger ones. However, older drivers were much more likely to sustain a chest injury in a crash, which probably reflects their increased frailty and susceptibility to rib fractures from the seat belt. This finding has been reported in earlier vehicle occupant protection studies (Fildes, Lane, Lenard & Vulcan, 1991).

In terms of cost to the TAC, older drivers had an average total claim cost roughly two-thirds that of younger drivers. While they had a higher likelihood of claiming for hospitalisation, rehabilitation and ambulance, their average claim amounts were not consistently above those of younger claimants. Moreover, they rarely claimed for loss of earnings or earning capacity and death benefits were rarely claimed for those who died. In short, older drivers are not over-represented in terms of cost to the TAC compared to younger drivers.

6.1.3 Characteristics of Older Driver Crashes

A number of road and driver characteristics were shown to be over-represented among older driver casualties and these are listed in Table 6.1 below. It should be stressed again that these findings do not necessarily indicate risk factors but could also illustrate times and locations where older drivers predominantly do their driving. Nevertheless, they do suggest areas that ought to be focussed on for future injury prevention research and countermeasures.

TABLE 6.1
SUMMARY OF OLDER DRIVER CRASH CHARACTERISTICS

VARIABLE	OVER-INVOLVEMENT CHARACTERISTIC	SIZE OF EFFECT (Older Drivers)	DIFFERENCE * (Older v's All Drivers)
Sex of the driver	males	69%	+7%
BAC level	nil & <.02	91%	+25%
Crash severity	fatal & serious injury	19%	+8%
Road alignment	curves (under-involved)	5%	-2%
Crash location	intersections	66%	+7%
Intersection control	stop & give-way	26%	+11%
Type of intersection	cross-intersections	39%	+8%
Type of crash (DCA category)	adjacent/opposite/manoeuvres	59%	+15%
- adjacent	cross traffic	45%	+2%
- opposite	right-through crashes	76%	+10%
- manouevres	U-turns	45%	+2%
Road condition	dry roads	80%	+5%
Geographical area	rural	37%	+12%
Light condition	daylight	87%	+16%
Time of the day	9am to 3pm	53%	+22%

* *Difference between size of effect for older drivers and size of effect for all drivers.*

6.1.4 Opportunities for Older Driver Interventions

The lack of suitable exposure data to highlight areas where older drivers are more at risk of having a crash has been mentioned previously. Many of the areas where older drivers were shown to be over-involved in injury may simply be a function of their increased driving exposure in these situations. Nevertheless, there are a number of areas where intervention appears to be warranted even though the precise intervention mechanism (risk or exposure reduction) still requires further research. These are itemised below:

- improved occupant protection (e.g., airbags, improved seat belt geometry, air belts) to reduce the frequency and severity of chest injuries to older drivers;
- greater attention to older drivers in intersection design and control;
- greater use of roundabouts to increase safety at cross intersections;
- greater emphasis on simplifying the driving task for older drivers (e.g., improved legibility of traffic signs);
- publicity for older drivers stressing the times and circumstances when they are most vulnerable and methods they can use to reduce their likelihood of a crash.

6.1.5 Older Driver Licensing Issues

There have been several calls recently for more stringent licensing for older drivers in this State. Victoria is the only State in Australia which does not require older drivers to undergo some form of assessment when they apply for licence renewal. It has been consistently argued in Victoria that legislation requiring older drivers to submit to a licence re-assessment would not be cost-effective (Hull, 1994; Torpey, 1986). Moreover, the precise form of an efficient re-licensing test is far from clear.

Some States in Australia require older drivers to pass a medical examination proving their fitness to drive. Indeed, there is a handbook of what constitutes driving fitness, although it is subject to some criticism and is not applied equally in all States. While it seems intuitively so that certain medical disabilities would place an individual at higher risk of a crash, there is little research evidence demonstrating this. Hull (1994) in fact argued that there were no differences in a number of outcomes across States with different re-testing criteria, demonstrating the ineffectiveness of these test requirements. A National committee has recently been formed to re-examine this issue.

Furthermore, some road safety authorities maintain that driving assessment should be based on functional (observable) criteria that can be examined in a simple test. Again, there is little proof of what these test criteria are and further research is warranted before attempting to specify such a test.

Without a better understanding of these issues, therefore, it would seem premature (and indeed wasteful of resources) to expect older road users to have to submit to a re-licensing test in this State at this time. This is especially so, given the relatively small numbers of older drivers involved in road crashes. However, as the proportion of older people in the community gets larger, the so-called "greying society" phenomenon, obviously, this situation will change and it would be prudent to undertake further research aimed at identifying effective criteria that could be used to identify older drivers at high risk of crash involvement.

6.2 OLDER PEDESTRIAN FINDINGS

As with older drivers, the size of the road safety problem for older pedestrians is not as large as it is for younger adult pedestrians (27% cf. 73% of casualties; 14% cf. 86% of casualty costs). However, older pedestrians represent a much larger proportion of the road safety problem relative to older drivers (27% cf 7% of casualties; 14% cf 5% of casualty costs). Moreover, the likelihood of a serious or fatal injury given a crash rises dramatically for older pedestrians compared to older drivers (54% cf 19%). These findings are of some concern, given that pedestrian mobility is the only form open to older people who are no longer able to drive and that the figures are likely to increase in the years ahead as the numbers and proportion of older people increase in the community. (It should be noted that 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).

6.2.1 Trends in Older Pedestrians Crashes

The number and rate of pedestrian crashes (like all road trauma trends) has been systematically falling since the late 1980's and this is the case for older pedestrians too.

As noted earlier, the likelihood of a severe outcome (serious injury or death) rises sharply among older pedestrians. While the rates of serious or fatal outcomes begin to increase from age 35 onwards, the acceleration for those aged 75 and above is quite marked.

6.2.2 Injuries and Cost to the TAC

There were no substantive differences in injury patterns for old or young pedestrian casualties. There was a suggestion that older people experienced more severe head, chest and upper limb injuries, probably due to their increased frailty. The finding that older pedestrians suffered fewer lower limb injuries is a little puzzling and deserves closer scrutiny.

6.2.3 Characteristics of Older Pedestrian Crashes

A number of characteristics of older pedestrian crashes were revealed from an analysis of VicRoads data between 1990 and 1992. These findings are summarised in Table 6.2. Again, care should be taken not to assume these differences all reflect risk characteristics rather than simply exposure differences.

TABLE 6.2
SUMMARY OF OLDER PEDESTRIAN CRASH CHARACTERISTICS

VARIABLE	OVER-INVOLVEMENT CHARACTERISTIC	SIZE OF EFFECT (Older Drivers)	DIFFERENCE * (Older v's All Drivers)
Sex of the pedestrian	females	54%	+9%
Crash severity	fatal & serious injury	58%	+11%
Crash location	intersections	50%	+3%
Intersection control	stop & give-way	3%	+1%
Type of intersection	cross-intersections	27%	+4%
Type of crash (DCA)	near- & far-side lanes	73%	+9%
Speed zone	60 km/h	95%	+4%
Light condition	daylight	84%	+14%
Part of the week	weekdays	83%	+5%
Time of the day	9am to 3pm	54%	+23%

** Difference between size of effect for older drivers and size of effect for all drivers.*

6.2.4 Opportunities for Pedestrian Intervention

As with the older driver findings, there are a number of possibilities for intervention to reduce the frequency and/or severity of injury to older pedestrians. These are listed below:

- improved design of intersections to assist older pedestrians (longer walk cycles, clear road markings, lower kerb edges, etc);
- assessment of the benefits of traffic signals and pedestrian crossings in areas highly frequented by older pedestrians;
- publicity to alert drivers to situations where older pedestrians are over-represented in crashes and difficulties facing older pedestrians when using the road;
- publicity to alert older people to situations where they are most vulnerable and ways in which they can minimise their risk of injury;
- a rigorous evaluation of the "walk with care" program to demonstrate that the messages it includes are optimal and sufficient for older people.

Obviously, many of these countermeasures require further development and in some instances further research to clearly identify the mechanisms of injury. The cost-effectiveness of these measures, too, is an issue that also warrants greater attention in this process.

6.3 RECOMMENDATIONS FOR FURTHER RESEARCH

This study set out to identify the size of the older road user problem and areas where further research was required. It was envisaged as the first stage of a concerted effort to identify ways in which older road user trauma could be reduced in the years ahead. A number of areas for further research were identified during the course of this project and these are described below.

COGNITIVE EFFECTS OF AGEING: There was considerable evidence revealed in this study that older people experience deficits not only in their physical abilities but also in information processing and decision making. There was a strong suggestion that cognitive deficits associated with the ageing process may be involved in many of the crashes to older drivers and pedestrians. Little is known about these effects on the road and there does not seem to be much research underway to explain this phenomenon more fully and devise countermeasures. This is an area that warrants further research focussing on both drivers and pedestrians.

RISK FACTORS: The lack of exposure data was highlighted on several occasions throughout this study as a limitation on what can be said about the risks older road users face when using the road and what can be done to reduce their crashes. Indeed, while there is a need for greater information (publicity) aimed at older road users, it is not possible at this stage to clearly enunciate methods which could reduce their risk of crash involvement. As a first step, greater information on travel patterns among older road users is urgently required to provide the basis for risk assessments.

CRASH INVOLVEMENT: Allied to the previous discussion of risk factors is the need for more rigorous details on road situations where older people are over-involved in crashes. Case control studies of crash involved older drivers and pedestrians would be necessary to identify risky behaviours and dangerous road situations. This information would also be useful for designing functional assessment tests for older drivers, critical if future legislation is to mandate licence re-testing for older drivers in Victoria.

DRIVER & PEDESTRIAN TRADE-OFF: It is commonly thought that the way to reduce road trauma among older drivers is to simply reduce the amount of driving they do. In the extreme, this can mean withholding driving privilege, with the possible outcome of increasing their exposure as pedestrians. It was argued earlier that this would effectively trade one form of risk (as a driver) for another (as a pedestrian). The degree to which accident and injury reductions from the former are offset by increases in the latter needs to be assessed to demonstrate the advantages of such an intervention. This has implications for licensing policy as well as determining public and community transport priorities.

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