



MONASH University

Accident Research Centre

THE ELDERLY AND MOBILITY: A REVIEW OF THE LITERATURE

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Abstract:

The ability to travel is associated with freedom, activity and choice and driving offers an important mobility option for most elderly. Driving cessation is linked to an increase in depressive symptoms and a decline in out-of-home activity levels and community mobility. Further, for at least some people, the same health conditions and functional impairments that cause a change in driving patterns will also limit access to other transport options (walking, cycling, public transport), thereby further contributing to restricted community mobility and its consequences. Driving status thus plays a critical role in the complex interactions between ageing, physical and psychological health, community mobility and use of health services. A good understanding of these relationships is required in order to enable older people to maintain economic and social participation and quality of life.

This report provides a comprehensive review of international literature to assess the current state of knowledge with regard to the complex relationships between changing driving and travel patterns, ageing, health status, and reduced mobility and the impact of poor mobility on quality of life. The findings from the literature review were used to compile a set of 'best-practice' recommendations to effectively manage the safe mobility of elderly road users.

It is recommended that a co-ordinated approach that encompasses innovative strategies and initiatives to manage the mobility of older road users be adopted. Such an approach should include measures that focus on safer road users (appropriate management of 'at-risk' older drivers through appropriate licensing procedures and development of targeted educational and training programs), safer vehicles (improved crashworthiness of vehicles, raising of awareness amongst older drivers of the benefits of occupant protection, and development of ITS technologies), safer roads (creating a safer and more forgiving road environment to match the characteristics and needs of older road users), and improvements to alternative transport options (provision of accessible, affordable, safe and co-ordinated transport options that are tailored to the needs of older adults and promotion and awareness of alternative transport options amongst older drivers and their families/caregivers). Options for further research are also highlighted.

Poor mobility places a substantial burden on the individual, families, community and society and there is a real need for policy makers, local governments and communities to consider the transportation needs of the elderly to support ongoing mobility.

Key Words:

Older Road Users; Mobility; Travel Needs; Driving; Quality of Life; Crash Risk; Safety; Education; Road Design; Vehicle Design; Public Transport.

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EXECUTIVE SUMMARY

The ability to travel is associated with freedom, activity and choice and driving offers an important mobility option, especially for the elderly. Most people drive to fulfil basic needs as well as to fulfil social and psychological needs.

While there is a strong emphasis around the world for older people to maintain their mobility for as long as possible, there is limited understanding and recognition of the significance of mobility for the elderly, their transportation needs, mobility changes in later life, and the impact on quality of life of reduced mobility. Moreover, there is little information about the measures that can be taken to increase, or at least, maintain mobility in older age.

This report presents the results of a literature review on the issues of older people's mobility needs, how reduced mobility impacts on quality of life, health and well-being, and provides a set of recommendations based on world 'best-practice' for managing the transportation and mobility requirements of this growing road user group.

The next few decades are likely to see a steady growth in the number of older road users as the population ages. This highlights an urgent need to put into place appropriate interventions to ensure that the safety and mobility of older road users is not compromised.

The evidence is clear that, for older adults who cease driving, quality of life is reduced, and that poor mobility places a substantial impact on the individual, their family, the community and the society in which they live. Furthermore, the evidence suggests that there are subgroups of the elderly who are more likely to suffer more pronounced mobility consequences including women and financially disadvantaged groups.

The review discusses a number of facts and myths about the 'older driver problem' in an attempt to dispel some of the misconceptions regarding the risks that older drivers pose on the road and how their safe mobility should be managed. Over the last few decades, many measures have been proposed to address the issues surrounding the safe mobility of older drivers. For example, there has been much focus on re-licensing procedures for older drivers, with many countries and jurisdictions imposing age-based license renewal procedures, with a range of screening tests to determine fitness to drive. However, there is much debate regarding the identification of those older drivers who are most at risk. Moreover, many of the procedures currently in place have been called into question regarding their efficacy in reducing crash risk and implications of reduced mobility.

It is argued that, in general, the great majority of older drivers are at least as safe as drivers of other age groups, and that only a small proportion of older drivers are unfit to drive. This has major implications for the management of 'at-risk' older drivers. The evidence strongly suggests that age-based mandatory assessment programs are ineffective in identifying and managing these drivers. Most importantly, while it is difficult to find any safety benefits of such programs, they can compromise the mobility of some older drivers (through the tendency of premature cessation) and possibly result in a safety disbenefit (those who cease driving are likely to undertake more trips as pedestrians – a much more riskier form of transport).

Driving is the safest and easiest form of transport and many older adults experience difficulty using other forms of transport, particularly walking. Continued mobility means access to a private vehicle for as long as possible as it is safe to drive, or as a passenger.

Managing the safe mobility of older adults requires policies and initiatives that achieve an acceptable balance between safety and access to critical services and amenities.

The evidence suggests that provision of safe travel options that allow easy access to services and amenities is a vital factor in maintaining mobility amongst older road users, and it is argued that, unless there is a fundamental reconsideration of the traffic and transport systems to ensure that the mobility and safety needs of these road user groups are met, the problems and risks associated with ageing will worsen in the coming decades.

It is recommended that a co-ordinated approach is required that encompasses co-operation between government policy, local government initiatives and community programs to manage the mobility of older road users. ‘Best-practice’ measures were identified in four broad categories. These were: safer road users; safer vehicles; safer roads and infrastructure; and, provision of new and innovative alternative transport options that are specifically tailored to older adults. The recommendations are as follows:

Strategies addressing safer road users should focus around improved licence re-assessment procedures, medical and other rehabilitation and educational and training programs. To improve road user behaviour, it is recommended that:

- It be recognised that most older drivers manage adequately their own safety as drivers;
- These older drivers be treated no differently than other age groups by licensing authorities;
- For the small proportion of older drivers who represent an unacceptable crash risk and who cannot manage their own safety as drivers, rehabilitation and/or training strategies should, where possible, aim to restore functional performance;
- In the management of these at-risk sub-groups, consideration is given to the introduction of more valid and acceptable licence re-assessment systems that are not age-based but based on functional ability, involve only those suspected of being ‘at risk’, and use valid assessment instruments to determine fitness to drive.
- Educational and training programs be developed to raise awareness of changing abilities and to promote safe driving, walking and cycling practices. Such programs should acknowledge that the elderly are a heterogeneous group and need to be designed accordingly.

Strategies addressing safe vehicles should focus on improved crashworthiness and occupant protection, development of Intelligent Transport System (ITS) technologies that are designed to avoid crashes and simplify the driving task, and improved frontal structure design to improve the safety of pedestrians. To improve vehicle design, it is recommended that:

- Strategies addressing the purchase and use of vehicles with high crashworthiness and occupant protection standards be developed.
- Improvements to vehicle crashworthiness be further encouraged, particularly with regard to testing programs that include a component specifically addressing older driver safety.
- Continued development of ITS technologies that may improve the safe mobility of older drivers, be undertaken. Such technologies should ensure that they are optimal for targeted users and may include (but are not limited to) force-limiting seat belts, supplementary airbags, vehicle adaptations to make driving more comfortable and

easier, and crash avoidance technologies such as speed alerting and limiting devices, cruise control devices, navigation systems, vision enhancement and rear collision warning devices.

- Continued development of frontal structure design of passenger vehicles to provide ‘optimum’ crash conditions for pedestrians and development of ITS technologies to assist drivers detect and avoid pedestrians.

Strategies addressing safer roads include creating a safer and more forgiving road environment that match the characteristics and travel needs of the road users that use it. It is recommended that:

- Road design and operation standards be adopted that reflect the needs and capabilities of older road users.
- Consideration be given to improved environments that older drivers experience difficulty negotiating. This includes improved intersections, freeway interchanges, horizontal curves, passing zones and construction zones.
- Consideration be given to improved environments for pedestrians and cyclists. This includes consideration of measures to moderate vehicle speeds, separation of vulnerable road users and motorised traffic where appropriate, provision of facilities suited to older pedestrians’ and cyclists’ needs, introduction of measures to reduce the complexity of travel environments, and provision of facilities and public transport stops.
- Consideration be given to improved infrastructure and land-use to facilitate accessibility and availability of transport options, to ensure the safety and security of the public environment, and to deliver a range of public and private services appropriately.

Strategies to improve alternative transport options focus on the provision of viable, affordable, accessible, safe and co-ordinated transport options. It is recommended that:

- Consideration be given to providing improved public transport options that are viable, affordable, accessible, safe and co-ordinated.
- A range of new and different kinds of mobility services that are tailored to the needs of older adults be considered. These may include subsidised taxi services, independent transport networks, door-to-door community transport services, carpooling schemes, volunteer driving programs and new forms of demand services.
- Resources be developed to promote the use of and raise awareness of alternative transport options amongst older drivers and their families/caregivers.
- Consideration be given to the continued development of programs that support walking and cycling including resources to promote these activities and provision of a safe and comfortable environment in which to walk and cycle.

- Consideration be given to the emerging issues surrounding the use of motor scooters including improved design standards, improved road design to cater for widespread use of scooters.

In addition, two research priorities are recommended as key avenues to assist older drivers maintain safe mobility. It is recommended that the prime new research priorities should focus on the following issues:

1. Assessment of safe road users, road and vehicles as they affect older driver safe mobility, as an integrated framework
2. Changes in driving behaviour amongst older adults (i.e., self-regulation) appears to be a key factor in determining mobility, safety and licensing needs. This gives rise to a series of research questions:
 - Can older drivers be relied upon to manage their crash risk through self-regulation?
 - If not, which older drivers do not, or cannot?
 - What are the most productive strategies for developing the most appropriate self-regulation behaviours amongst older drivers?
 - How feasible is it to use self-regulation as a principle mechanism for maintaining older driver mobility, as an alternative to total driving cessation?

CONCLUSIONS

Older people continue to have travel needs after retirement and the private vehicle is likely to remain the dominant and safest mode of transport for the elderly. Moreover, to most older people, driving represents a symbol of freedom, independence and self-reliance, and having some control of their life.

Poor mobility places a substantial burden on the individual, family, community and society and there is a real need for consideration of the transportation needs of older adults at all levels to support ongoing mobility for older road users. This review has highlighted the poor understanding of the mobility needs of older adults, and the lack of appropriate systems to manage their safe mobility. A range of measures are proposed to achieve a positive influence on traffic participation, safety, mobility and associated quality of life.

THE ELDERLY AND MOBILITY: A REVIEW OF THE LITERATURE

1 INTRODUCTION

Mobility is essential for general independence as well as ensuring good health and quality of life (QoL), and one of the most relevant and important activities of daily living for maintaining independence is the ability to drive. Most people drive to fulfil basic needs such as acquiring food and obtaining health care as well as to fulfil social needs such as visiting friends and relatives, and reaching various activities. Moreover, the extent of this need to drive depends on the distance to be travelled from home to these activities and available transportation options.

To most older people, driving represents not only a means of transportation, but a symbol of freedom, independence and self-reliance, and having some control of their life. In contrast, forfeiture of driving privileges is considered a major loss by many older adults in terms of social identification, control and independence. For many, particularly those with a decline in health status, driving cessation is likely to lead to an increase in depressive symptoms and a decline in out-of-home activity levels and community mobility. Further, for at least some people, the same health conditions and functional impairments that cause a change in driving patterns will also limit access to other transport options (walking, cycling, public transport), thereby further contributing to restricted community mobility and its consequences.

Driving status thus plays a critical role in the complex interactions between ageing, physical and psychological health, community mobility and use of health services. A good understanding of these relationships is required in order to enable older people to maintain economic and social participation and QoL. Unfortunately, while continued mobility is of utmost importance to the elderly, much of the literature on older road users focuses on their safety. Less is known about transportation needs, the meaning of mobility and the measures that can be taken to increase or, at least, maintain mobility.

The Swedish Road Administration (SRA) recognises the importance of understanding mobility changes in later life and the impact on QoL, and commissioned the Monash University Accident Research Centre (MUARC) to conduct a literature review to assess the current state of knowledge in regard to the key issues in older people's mobility needs, how reduced mobility impacts on QoL, health and well-being, to identify measures that can be taken to ensure that the transportation and mobility needs of this group are met, and to highlight a set of 'best-practice' recommendations for managing the transportation and mobility needs of this road user group.

In the proposal, MUARC stipulated that the review would assess the current state of knowledge in regard to the following issues:

- Understanding the facts and myths of the elderly and traffic safety;
- Understanding the need for mobility; and

- Identifying methods to increase mobility for the elderly.

The findings from the literature review will be used to compile a set of recommendations to effectively manage the safe mobility of elderly road users.

1.1 METHOD

This review takes, as its starting point, the recent report by the OECD Working Group on older road user safety and mobility issues (OECD, 2001). For each of the topics addressed in this report, the appropriate material from the OECD document has been summarised and used as a basis on which more recent literature complements the initial report.

The literature search was undertaken on the Australian Transport Index, which contains over 135,000 records of publications from throughout the world, on roads, transport and related fields. Records cover books, reports, journals articles and conference papers. The database is produced by the ARRB Transport Research Library and is Australia's major transport database. As well as the holdings of the ARRB Transport Research Library collection, it also includes the holdings of a number of other Australia libraries with transport-related collections. The TRIS database, produced by the US National Transport Library, the ITRD database, produced by the Organisation for Economic Co-operation and Development (OECD), and PsychInfo/Lit database were also searched for relevant references. In addition, the SWOV library database was searched for relevant European publications.

All abstracts were read and selected for relevance and research strength. As a general rule, only publications from 2000 onwards were selected from the literature lists. This criterion was waived, however, where articles appeared to have exceptional worth, were not included in the OECD report or justified fuller treatment.

1.2 STRUCTURE OF THE REVIEW

This review addresses the many issues associated with the transportation and mobility needs of older road users. While much of the literature focuses on driving (as driving is regarded as one of the most important indicators of mobility), other transportation modes are also discussed, including walking and cycling, and public transport use.

The remainder of this introductory Chapter provides a review of older people's mobility needs and addresses particularly the association between reduced mobility and QoL. As with following Chapters, it starts with the conclusions relating to older people's mobility reached by the OECD Working Group in its recent report and then discusses other research findings.

Chapter 2 provides a structured overview the safety literature, particularly focussing on the facts and myths on older road user safety. It discusses seven issues surrounding the safety of older road users including: older road users' extent of crash risk; contributing factors to crash risk including vulnerability and the impact of functional changes and medical conditions on crash risk; effectiveness of assessment of fitness to

drive; impact of loss of licence on safety; impact of loss of licence on mobility; and impact of the ‘greying of society’ on safety.

For each set of ‘facts and myths’ conclusions are drawn based on both the literature reported in the OECD document and findings from more recent literature.

Chapter 3 presents the literature on measures that may meet the transportation and mobility needs of older road users. Measures that have been suggested and/or implemented that aim to improve the mobility of older drivers, pedestrians and cyclists are identified and discussed. Methods include: medical and other rehabilitation measures; driver training measures; vehicle adaptations and Intelligent Transport System (ITS) technologies; road infrastructure, design and operation; public transport and other transport options; options for walking and cycling; and, other measures. Very few countermeasures or programs aimed to improve the mobility of older road users are ever evaluated. However, where evaluations have been performed, the effectiveness is reported. The major and most effective measures to increase or maintain mobility for the elderly are highlighted.

Chapter 4 provides a summary of the review. It pulls together the main findings from the preceding Chapters and presents a set of best-practice recommendations for managing the transportation and mobility needs of older road users, whilst ensuring their safe travel.

1.3 OLDER PEOPLE’S NEED FOR MOBILITY

1.3.1 Findings from the OECD Working Group

The Working Group discussed mobility issues for older road users, basing many of its conclusions upon a series of travel surveys conducted in: Australia (Rosenbloom & Morris, 1998); Britain (Oxley, 1998; Department of the Environment, Transport and the Regions, 1999); Germany (Brög, Erl & Glorius, 1998); the Netherlands (Steenart & Methorst, 1998; Tacken, 1998); New Zealand (LTSA, 2000); Norway and Sweden (Hjorthol, 1999; Hjorthol & Sagberg, 1998; Kranz, 1999); and the US (Rosenbloom, 2000).

While the Working Group discussed a number of issues relevant to older people’s travel patterns, they also warned that future cohorts of older people could well differ from today’s cohort: longer working lives, different health status and higher driver licensing rates are all factors which could impact upon future travel needs and patterns.

The Group’s main conclusions included:

- Older people continue to have travel needs after retirement, although the nature of these needs may change. Overall, as people age they make fewer journeys, mainly due to reductions in the number of work journeys and the average length of all journeys consistently decreases. The number of journeys made for non-work activities remains almost constant to the age of 75 and decreases thereafter, with the length of these journeys also reducing with

increasing age. However relative to earlier cohorts, older people are increasingly driving greater distances, partly due to their greater access to cars;

- The private car is likely to remain the dominant form of transport for the elderly in most OECD countries, due especially to the expected increase in the number of licensed older drivers, particularly women. In most countries, increased car use is replacing walking, and to a lesser extent, public transport use among older people. There are however, considerable differences between Europe and North America. Currently in Europe, walking is still an important transport mode for between 30 and 50 percent of journeys made by people aged 65 and over. In contrast, over the past 20 years in the US, there has been a sustained decline in walking by those aged over 65;
- The available evidence suggests that, as older people develop age-related health problems, they are likely to experience difficulties walking and using public transport before experiencing difficulties with driving. Older people who cease driving as a consequence of functional limitations are likely to experience substantial mobility difficulties, given their inability to use most other transport forms. More feasible alternative transport modes need to be available and accessible if adequate levels of mobility are to be maintained;
- Mobility is critical to well-being and QoL by virtue of enabling continued access to services, activities and to other people. It was also recognized that more research is needed into the relation between QoL, welfare and health costs, and mobility among older people in different countries.

1.3.2 Findings from the research

1.3.2.1 Mobility is more than travel

In its narrowest sense, mobility may be defined as the ability to travel (Giuliano, Hu, & Lee, 2003). Suen & Sen (2004) have used a more comprehensive definition: mobility is being able to travel where and when a person wants, being informed about travel options, knowing how to use them, being able to use them, and having the means to pay for them – with the private vehicle coming closest to providing full mobility. Metz (2000) has extended the notion of mobility even further to encompass the following elements:

1. Travel to achieve access to desired people/places;
2. Psychological benefits of movement, ‘getting out and about’ – benefits that are closely associated with feelings of independence and self-esteem;
3. Exercise benefits – direct benefits of exercise for muscle and bone strength, cardio-vascular improvements and overall health;
4. Involvement in the local community – social activities that involve mobility reduce mortality in older adults (Glass, Mendes de Leon, Marotolli, & Berkman, 1999, cited in Metz, 2000); and

5. Potential travel – knowing that a trip could be made even if not actually made, for example in the case of an arising emergency.

Increasingly attention is being given to the association between mobility and QoL. As noted by Metz (2000), QoL remains a broad concept, often inadequately defined but generally considered to include dimensions such as physical health, psychological well-being, social networks and support and life satisfaction and morale. This association is pursued more fully in a later section of this chapter.

1.3.2.2 Travel needs

It is critical to understand the travel needs of older adults in order to develop and plan for a more mobile society in the future. This section includes the general travel patterns of the elderly, and then describes the travel patterns of those older adults who have never driven, followed by a discussion of differences in travel patterns of males compared to females.

General travel patterns and needs

The travel patterns of older drivers appear to differ from those of younger drivers. It seems that lifestyle transitions that correspond with age influence driving activity, destinations and kilometres driven. With retirement, the need to regularly commute to a work-place is eliminated and retirement affords older individuals more flexibility in their choices of when and where to drive. Furthermore, the types and frequency of recreation and social trips change with increasing age (Eberhard, 1996).

Even though most older people (like all other age groups) rely heavily on private vehicles for their transportation needs, mileage driven decreases as age increases (Rosenbloom, 2004). Trips tend to be shorter, closer to home, and for different purposes than those of other drivers (the most common trip being for shopping for older women and social, recreational and medical visits for older men, as opposed to work-related trips for younger drivers) (Benekohal Michaels, Shim & Resende, 1994; Rosenbloom, 2004; LTSA, 2000).

Gender differences

Rosenbloom (2006) and Rosenbloom and Winsten-Bartlett (2002) estimated that in 2050, 80 million people in the US will be over 80 and the majority of these will be women. Moreover, older female drivers are the fastest growing segment of the driver population due to a proportional increase of women in the population, increased licensing rates and increased driving and it is predicted that crash and injury rates amongst older females drivers will exceed that of older male drivers in the coming decades (Oxley, Charlton, Fildes, Koppel, Scully, Congui, Moore, 2006). Older females also have a higher prevalence of illness, disability and long-term medical conditions and use health services more than older men. Given these factors, the safety and mobility of older females has become an important community and road safety concern.

Surveys on the travel behaviour of older men and women in Europe (Sirén, Heikkinen, & Hakamies-Blomqvist, 2001), the US (Collia, Sharp & Giesbrecht, 2003; Rosenbloom & Winsten-Bartlett, 2002) have found the following trends:

- Women travel less than men;
- Women drive less than men;
- Women are more likely than men to travel short distances;
- Women are more likely than men to report medical conditions that hinder their mobility;
- Women are more likely to give up driving earlier than men;
- Womens' reasons for giving up driving are generally due to social factors such as lack of driving experience and finances, whereas men are more likely to give up driving due to health factors;
- Whilst both men and women report the private vehicle as the preferred driving mode, women are more likely than men to use other options, including walking, public transport and taxis; and,
- Older men and women drivers have substantially different driving patterns and therefore cannot be treated as a homogenous group.

Hakamies-Blomqvist and Sirén (2003) suggested that, given changes in licensure, travel patterns, independence, health, activity level and car ownership amongst future cohorts of older women drivers, many gender differences will gradually disappear. It remains, however, that women do have different travel patterns and mobility needs compared with men, despite policy discussions often treating men and women as a homogeneous group. For instance, Rosenbloom and Winsten-Bartlett (2002) point out that women non-drivers travel less than men non-drivers, indicating that they may be foregoing important trips to maintain QoL.

1.3.2.3 The impact of driving reduction and cessation on QoL

Cessation of driving can occur either after a gradual reduction process, or suddenly. A person's decision to stop driving may be voluntary (recognition of the situation or influence by others) or involuntary (forfeiture of driving privileges). There is no doubt that, for many older people, reduction and more particularly, cessation of driving is a stressful experience, which seems to have a negative effect on their psychological outlook and QoL. Most importantly, losing a licence can be associated with an increase in depression, loss of self-confidence and status, and in extreme cases, even early death (Harper & Schatz, 1998; Yassuda, Wilson & von Mering, 1997; Kostyniuk & Shope, 1998; Harris, 2000; Rabbitt, Carmichael, Shilling, and Sutcliffe, 2002; Persson, 1993).

As an example, Harrison and Ragland (2003) undertook a comprehensive literature search to identify the consequences of driving cessation or reduction for people aged 65 years and older, and found nineteen studies meeting specified criteria which were

published between 1971 and 2001. They concluded from their review that ‘driving reduction or cessation is apparently associated with a number of adverse consequences, including reduced out-of-home activity, increased dependence on caregivers or others for transportation, loss of independence, loss of personal identity, increased depressive symptoms, and decreased life satisfaction’ (p. 1843).

They also warned that these associations could not automatically be interpreted as causal. For example, reduced out-of-home activities may be due to lack of transport options arising from cessation of driving but equally, could be due to an increased preference for in-home activities. As another example, it might be that a given adverse ‘consequence’ might be better attributed to poor health, which could also have led to driving cessation. (At the same time however, it appeared from several studies that health is a poor predictor of driving cessation, with there being evidence that former drivers had fewer medical conditions than those continuing to drive.) The need for further research on this issue was urged.

A subsequent longitudinal study of 1,953 drivers aged 55+ years on driving status, depressive symptoms, health status and cognitive function revealed that rates of depressed status at baseline and at a 3-year follow-up were higher for former drivers (20.7%) and ‘never drivers’ (15.2%) compared with current drivers (8.3%) (Ragland, Satariano, & MacLeod, 2005).

Interestingly, the results also showed that depressed status was linked to certain socio-demographic characteristics. In comparison with current drivers, former drivers tended to be older, have fewer years of education, female, have poorer health, and to be widowed. This profile was similarly found amongst those that had never driven. After controlling for the socio-demographic factors related to driving status, driving status remained strongly associated with depression. Former drivers at the 3-year follow-up showed a statistically significant increase in depression compared to current drivers. Former drivers tended to be older than current drivers, and more likely to have had a change toward poorer health status and be widowed.

Ragland et al. (2005) discussed the notion that the association between driving cessation and depression could operate through various mechanisms. Firstly, driving cessation could contribute to depressive symptoms via a loss in mobility. Conversely, depressive symptoms may accelerate the process of driving cessation. Finally, a change in some third variable (e.g. presence of a particular health condition) could affect depression, then driving experience. They pointed out that studies showing a relationship between driving cessation and other variables need to distinguish between the effects of changes in driving itself and the effects of other factors that are related to changes in driving. They argued that their results showed evidence that the association between driving cessation and depression is due to the effect of driving cessation on depression because they first conducted preliminary analyses to ascertain whether baseline depression was associated with driving cessation. As there was no association between baseline depression and driving cessation they argued that it was inconsistent with the explanation that depression has an important effect on driving cessation. Secondly, their longitudinal analyses controlled for several factors that may affect driving cessation and depression (especially health and cognitive status). Neither health nor cognitive status decreased the association between driving cessation and depression which, they argued, contradicts the explanation that a third variable affects both depression and driving cessation.

Fonda, Wallace and Herzog (2001) used samples of 3,543 drivers aged 70 years or older to assess the impact of changes in driving (driving cessation or driving reduction) on depressive symptoms. Respondents who had ceased driving reported worsening depressive symptoms after cessation and were also more strongly associated with other sentinel life events, including death. The speculative explanation: 'driving cessation signifies- in ways that are especially tangible – the attainment of old age and its stigma of dependency and/or the constriction of access to necessary and recreational activities' (p. S349). These effects were found to be not modified by the presence of a spouse who continues to drive.

The findings in regard to drivers who had restricted their driving were mixed. Those who had restricted the driving relatively recently (that is, over the course of the study) were not at increased risk of depressive symptoms, whereas those who had restricted before the study began, showed worsening depressive symptoms – although not to the extent of those who had stopped driving totally. A possible explanation offered, was that longer-term restricting drivers view total cessation as a looming outcome, whereas shorter-term restricters see the decision as a means to maintain adequate levels of transportation and well-being.

More recently, Banister and Bowling (2004) conducted interviews with 1,000 people aged 65 years and older, first to better understand the notion of QoL and second, to identify the role of transport in achieving this concept. Based on survey responses, six 'building blocks' of QoL were constructed:

1. People's standards of social comparison and expectations of life.
2. Optimism and belief that 'all will be well in the end'.
3. Good health and physical functioning.
4. Engaging in social activities and feeling supported.
5. In a neighbourhood with good facilities (including transport).
6. Feeling safe in one's neighbourhood.

The authors considered that Blocks 4 and 5, and to a lesser extent Block 6, were heavily influenced by transport – which for a growing number of people, meant use of the private car. Where there were negative perceptions of the transport circumstances (for example, speed and volume of traffic), QoL was duly threatened. By implication, inability to use a private car for transport would for many people directly threaten most if not all the six building blocks.

Reasons for driving reduction and cessation

As skills decline with age, it is inevitable that at some point, it becomes necessary for most individuals to consider retiring from driving. There are often subtle signs that indicate when a person is approaching the time to stop driving, particularly health and medical changes.

Raitanen, Törmäkangas, Mollenkopf and Marcellini (2003) sought both to quantify older drivers' extent of reduction in driving and the reasons for any reduction, by surveying a sample of active drivers aged 55 years and older in Finland, Germany and Italy. Reduction of driving was common to all three countries (62% of the samples in Germany and Finland and 44% in Italy), reflected in driving fewer kilometres, driving less frequently and avoiding particular traffic situations. When drivers who had reduced their driving were asked for reasons, the results were as follows (considering all three samples combined):

Reason for reduced driving	No of responses*	% of responses
Health reasons	68	14.4
Due to an accident	3	0.6
Economic reasons	17	3.6
Traffic too hectic	58	12.3
Difficult to find parking	49	10.4
Difficulties in handling a car	9	1.9
Parallel parking too difficult	12	2.5
Can reach and do everything without a car	82	17.4
Have someone to drive me	20	4.2
Other	154	32.6
Total	472	100.0

* More than one response per respondent allowed.

Respondents from all three countries consistently identified no need for a car, health reasons, hectic traffic and parking shortages as the key factors in reducing driving. 'Other' reasons were also prominent for all three countries and on inquiry, largely related to a decline in the need for driving, often related to retirement from work. Involvement in a crash was a very minor factor.

As noted by the authors, health reasons had only a modest direct role played in reducing driving – and after logistic regression analyses, had an association only for the Italian sample. This was unexpected, given previous general findings from the research (and may perhaps be explained by poor health possibly underlying a number of the other reasons). In all three countries, retirement had the strongest association with reduced driving.

As a further example, Ragland, Satariano and MacLeod (2004) surveyed a sample of 1,889 US respondents aged 55 years and older who had either recently stopped or restricted their driving. Problems with eyesight was the leading cause for both men and women to avoid or cease driving, with the association increasing with age. For respondents aged 75 years and older, 40 percent of women and 29 percent of males

mentioned this factor. However other specific medical conditions were reported by only very small proportions of respondents. The next most frequently mentioned factor was 'no reason to drive', followed by 'concern about being in an accident' and 'concern about crime'.

In another study, Stutts, Wilkins, Reinfurt, Rodgman and Van Heusen-Causey (2001) noted the following:

- Close to 72 percent of drivers said they had stopped driving abruptly, while the rest stopped gradually.
- For those who stopped abruptly, crash involvement, health problems and licence cancellation were reported as reasons for stopping.
- For those who stopped gradually, reasons such as dislike of the driving environment and poor reflexes were reported.
- Most drivers believed that they had made their decision at the right time, however, nearly a third said they stopped earlier than they should have and a sizeable proportion (9%) admitted that they stopped too late.

Two recent MUARC surveys have focussed on understanding the prevalence and type of self-regulation in driving, attitudes towards driving cessation and the use of alternate forms of transport amongst current and former drivers (Charlton, Oxley, Fildes, Oxley, Newstead, O'Hare & Koppel, 2003; Charlton, Oxley, Fildes, Scully, Koppel, Congui, & Muir, 2006).

These studies reported that around 40 percent of drivers said that they were driving less and slower now than they were five years ago, particularly females. Reasons for reductions in the amount of driving included general lifestyle changes, such as moving house and employment changes, while fewer than 20 percent of drivers who reduced their amount of driving attributed this to health or general ageing issues. Reasons for driving slower predominantly focussed on safety issues and adherence to road rules.

Approximately three-quarters of current drivers said that they had thought about giving up driving one day, however less than 20 percent said that they had actually made plans for this. The majority of participants indicated that health related issues would be the primary factors that would make them think about stopping driving. Those who had made plans were more likely to be female, aged 75 years and older and living in either an urban area or a country town. The single most important issue that would concern drivers about not being able to drive one day was a loss of independence. Others described a general loss of mobility, restricted activities, reliance on alternative (usually public) transport and the general inconvenience of not having a car.

Planning for driving reduction and cessation

According to Oxley and Fildes (2004) older adults often do not plan for the day when they stop driving, and because many are reluctant to stop driving, major social and psychological implications can arise when drivers do eventually stop driving.

However, it may be that with proper planning, the transition to not driving can be much easier and less stressful and should not compromise mobility and safety significantly.

Oxley and Fildes (2004) argued that planning for future mobility should occur as part of the retirement from work process. Individuals should plan for their mobility in retirement and ensure that they have adequate transport options if they are unable to drive. This, for some people, may mean re-locating. Moving to a location or into a setting where driving is less essential for meeting basic necessities is a way of addressing mobility problems. Areas that either have good public transport services, or are close to family and friends who are able to provide transportation, and are close to essential services such as shops, medical service and social facilities are ideal for those considering retiring from driving.

Another planning process is to become familiar with public transport. While patronage of transport services among people who can still drive is low, it would be beneficial to those planning for retiring from driving to become familiar with and use public transport in the local area, including buses and taxis, community transport and volunteer services. Substituting some car trips with public transport will mean that, if people need to stop driving, the transition will be easier (Oxley & Fildes, 2004).

They also argued that it is essential that partners begin to share the driving. Among older couples, the male partner is generally the principal driver when couples drive together. However, if and when the male partner is unable to drive, it is often left to the female partner to take on this role. This may be a stressful experience for many older women who do not have up-to-date driving experience and the confidence to get behind the wheel. Furthermore, a lack of experience and confidence may put women at higher risk of crash involvement (Oxley et al., 2006; Oxley & Fildes, 2004).

1.3.2.4 Older adults in the next two decades

Alsnih and Hensher (2003) examined the effect of the increasing population of older adults and how this affects mobility and other factors. First, they discussed the concept of chain trips, which is defined as a sequence of trips that involve multiple purposes and destinations, i.e. home-shops-friends-shops-home. The increase in chain trips will satisfy many individual's desire to increase efficiency when travelling however it will also increase the attractiveness of using the private car versus public transport (Hensher & Reyes, 2000, cited in Alsih & Hensher, 2003). Other effects of the increasing population of older adults cited were the potential increase in environmental pollution due to increase in short trips, as a and so catalytic converters won't be activated so more atmospheric pollution via carbon dioxide emissions and increased congestion on roads.

Furthermore, it appears that, both currently and in the future there are subgroups of the elderly that will experience significant mobility consequences. Rosenbloom and Winsten-Bartlett, (2002) cautioned that, despite the decline in poverty rates of the elderly, there will be significant subgroups that will neither be well off nor healthy. These groups include older African Americans and older women. Reasons why older women will have fewer resources (and therefore compromised mobility) than men include the following:

- Many older women live alone.
- Women who will be 85 years old in two decades will have had fewer children, and therefore fewer people to provide assistance.
- Women who have children will still experience difficulty getting assistance as their children are likely to be busy raising their own families.
- Women will be less likely to have the resources to be able to buy assistance or services they need as they face mobility problems.

1.4 SUMMARY

Various definitions of mobility can be found in the literature, however many definitions do not acknowledge the health-related benefits of mobility. As a result, many studies take a one-dimensional approach to assessing mobility through travel demands. In the context of transport studies, mobility is generally measured through travel behaviour. Poor mobility places a substantial impact on the individual, family, community and society and there is good evidence of the link between reduced mobility and a reduction in QoL. Further research needs to investigate ways to develop an operational concept of mobility, and improve the QoL for people who are forced to cease driving. This will be different for those who have driven and cease driving compared to those that have never driven, and different for driving men and women. The elderly are not a homogenous group and demographics, behaviours and travel patterns and needs are likely to change in the years ahead. Further research is required to understand more fully the effects of age, gender and driving status on mobility, to strengthen our understanding of the link between compromised mobility and poor QoL, and how to increase QoL following reduced mobility.

2 ASSESSING AND MANAGING OLDER DRIVER SAFETY: THE FACTS AND MYTHS

This Chapter takes as its starting point, the recent OECD Working Group report on older road user safety and mobility issues (OECD, 2001). It addresses seven topics and for each topic, presents both a commonly held ‘myth’ associated with that topic and also a ‘fact’, based on the best available research evidence. For each topic, the appropriate material from the OECD report is presented in summary form, complemented by additional material published since the initial report – and occasionally, by earlier material that was either not included in the OECD report or justified fuller treatment. Although a full literature search was undertaken as part of this report, the material presented in this chapter represents the key findings in the research literature and is not intended as a complete listing of all appropriate work.

2.1 CRASH INVOLVEMENT

Fact: Oldest drivers have the highest risk of casualty crash involvement per distance driven.

Myth: Older drivers are unacceptably unsafe.

2.1.1 Findings from the OECD Working Group

The OECD Working Group provided an array of crash data to demonstrate the difficulties in reaching any overall assessment of older drivers’ crash risk. As a starting point, they examined older drivers’ per capita fatality rates based on US Fatality Analysis Reporting System (FARS) data for 1997, National Highway Transport Safety Administration (NHTSA) (see Table 1.)

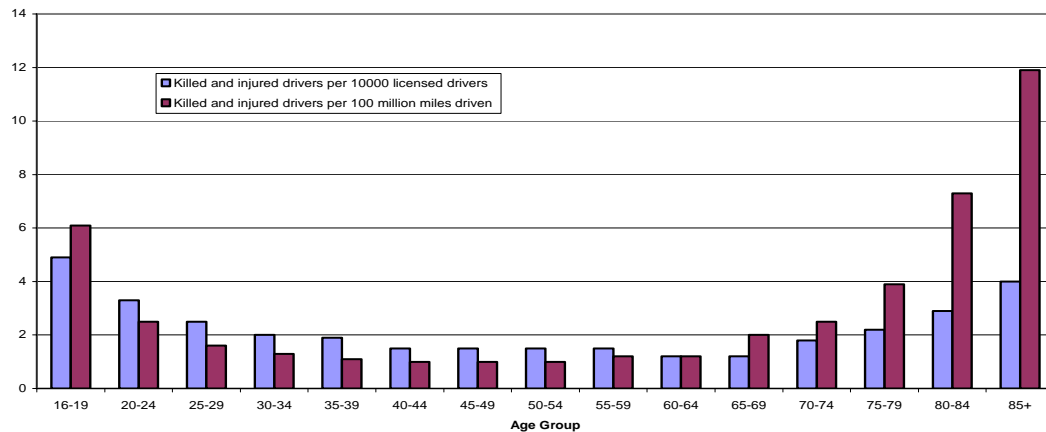
Table 1: Number of driver fatalities and fatality rate per 100,000 persons by age (US, 1997)

Age Group	Car Drivers	
	Number	Rate
0-14 years	78	0.1
15-24 years	5,797	15.8
25-64 years	14,338	10.3
65-74 years	1,956	10.6
75-84 years	1,750	14.9
85+ years	584	14.9
All 65+ years	4,290	12.7
All 75+ years	2,334	14.9
All ages	24,503	9.2

Source: FARS, NHTSA.

The conclusion appeared to be straightforward. Per capita fatality rates were high during the first years of independent driving, declined for drivers aged 25-64 years and then increased thereafter. Drivers aged 75 years and older had fatality rates close to those of the youngest drivers.

The Working Group, again using 1997 US data, explored different ages' fatality risk¹ using two different exposure measures. The rates per licensed driver and per distance driven are shown in Figure 1.



Source: FARS, NHTSA

Figure 1: US driver fatalities by age, relative to licensed drivers and mileage driven

The age-related risk increase in fatalities was reasonably minor per licensed driver: drivers aged 85 years and older had just over double the risk of being killed or injured in a road crash relative to the safest driver age group. However, there was a sharp, age-related risk increase in deaths once distance driven was used as the basis, such that the oldest drivers had around twelve times the risk of being killed. These two crash rates have frequently led to the conclusion that older drivers become more dangerous with age, but compensate by driving less.

The Working Group recognized that there are 'certain methodological difficulties' (OECD, 2001, p.44) in interpreting the risk curves in Figure 1, and particularly the curve based on distance driven:

- Fatalities represent only a relatively small proportion of the total road safety burden and provide an inadequate indicator of total crash risk, especially for older drivers. Casualty crash analyses, even those encompassing casualties of all severity, have a sampling bias: the so-called 'frailty bias', which exaggerates any apparent age-related risk increase.

¹ The report claims that the data shown in Figure 1 (Figure 3.3 in the report) pertain to both fatalities and injuries arising from road crashes. Given the different crash rates per exposure measure, it is likely that only fatalities have been included.

- While distance driven is generally regarded as a robust exposure measure, it fails to take into account several important factors (especially the amount and location of driving), the net effect of which is also to exaggerate age-related risk increase.

The Working Group concluded thus:

“... none of the measures presented in Figure [1] permit straightforward conclusions about whether drivers’ individual risk of overall accident involvement changes with age. Older drivers’ apparent over-representation in fatality and perhaps serious injury data cannot be interpreted to indicate a heightened accident proneness, due to both a frailty bias in data collection and limitations in the exposure measurements currently available.” (OECD, 2001, p.45).

2.1.2 Findings from the research – the frailty bias

The OECD Working Group’s recognition of frailty as a major contributor to older drivers’ involvement in crashes is well supported by the research.

It has been long recognized that older adults’ biomechanical tolerances to injury are lower than those of younger persons (Viano et al., 1990; Evans, 1991; Mackay, 1998), primarily due to reductions in bone strength and fracture tolerance (Dejeannes & Ramet, 1996; Padmanaban, 2001). Therefore the energy required to produce an injury reduces as a person ages (Augenstein, 2000) and thus increases the likelihood of serious injuries among older drivers involved in a crash. This results in a larger share of older drivers’ crashes being included in casualty databases, thereby contributing to an apparent over-representation in crashes.

There have been various attempts to correct for the frailty bias when assessing older drivers’ crash risk, with the subsequent estimates of the role of fragility varying considerably according to the different statistical procedures. As one example, Li, Braver and Chen (2003) used US FARS data and a national probability sample of all crashes (both non-casualty and casualty) to compute correction factors (see Table 2).

Li et al. (2003) estimated that after due statistical correction, older drivers’ (and especially older female drivers’) over-representation in fatalities could be explained mainly by fragility. For older drivers, fragility accounted for around 60-90 percent of the excess death rates – with excessive crash involvement due to other factors being largely restricted to drivers aged 80 years or older. For these male and female drivers, the death rates due to other crash-related factors were five times to six times those of the safest groups.

Arguably the most valid approach to correcting for fragility, is to consider total crash involvement: that is, all casualty and non-casualty crashes. In practice, this cannot be done, due to crash data limitations:

“... we road safety researchers do not know the size of our own field of study. We do not even know the number of injury accidents or the number of those injured.” (Harris, 1990, p. 371).

As a general rule, the less severe the crash, the greater the likelihood that the crash does not appear in the usual official crash databases – with many databases being restricted to casualty crashes only.

Table 2: Quantifying the role of fragility in older driver road deaths

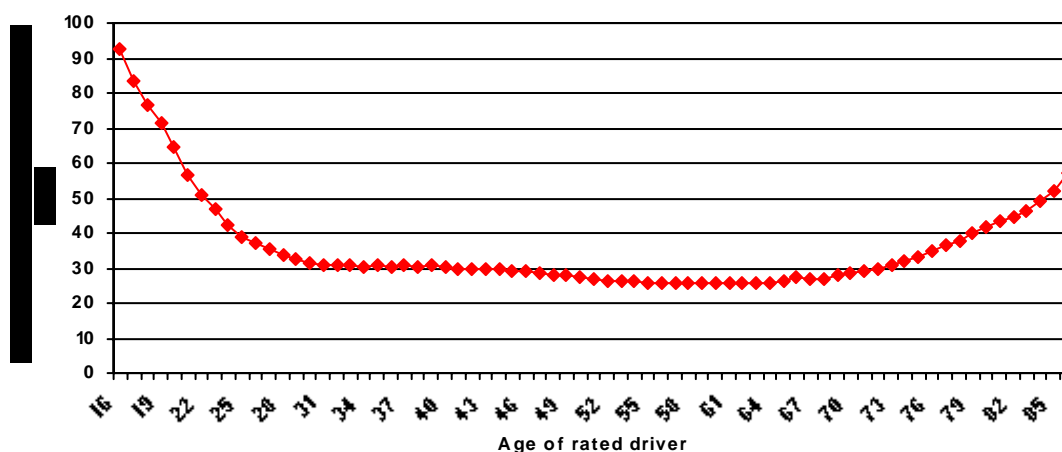
Gender of driver	Age of driver	Overall risk of death per distance travelled	Risk of death per distance travelled – due to fragility	Risk of death per distance travelled – due to excessive crash involvement	% of risk of death per distance travelled – due to fragility
Male	65-69	1.3	1.0	0.3	74
	70-74	2.2	1.9	0.3	87
	75-79	4.4	2.8	1.6	64
	80+	13.0	7.4	5.6	57
Female	65-69	1.9	1.7	0.2	88
	70-74	3.4	2.7	0.7	79
	75-79	6.0	4.2	1.8	70
	80+	13.6	8.6	5.0	63

Source: Li et al., 2003

Note: Risks have been expressed as ratios of the 30-59 driver age groups' death rates.

Insurance claim databases often contain more comprehensive collections of crashes than databases based on conventional collection methods. Insurance data have an additional advantage in that crash records have frequently been assessed in detail to determine each participant's extent of fault in causing the crash. As an example, Figure 2, based on a comprehensive sample of US insurance data, shows the at-fault crash involvement of different driver age groups, measured by other-vehicle claims per 1,000 insured vehicle years. 'Other-vehicle claims' relates to the numbers of claims received from other vehicles in multi-vehicles crashes of any severity (both casualty and non-casualty) for the years 2002-04.

This approach attempts both to counter the fragility bias and to restrict to crashes to those drivers who have been judged responsible for the crash. Some major qualifications to the insurance data notwithstanding, Figure 2 provides further evidence that older drivers' involvement in crashes is substantially reduced once the frailty bias (and, in this instance, crash responsibility) are taken into consideration. The above curve suggests that drivers aged 85 years, while having an increased at-fault involvement in both casualty and non-casualty crashes combined, have a crash risk just over double that of the safest group.



Source: Insurance Institute for Highway Safety
Notes: Claims relate only to vehicles manufactured between 2001-2004;
'Rated drivers' is the person who is considered to represent the
greatest loss potential, associated with the insured vehicle.

Figure 2: Insurance claims per 100,000 insured vehicle years and age of driver

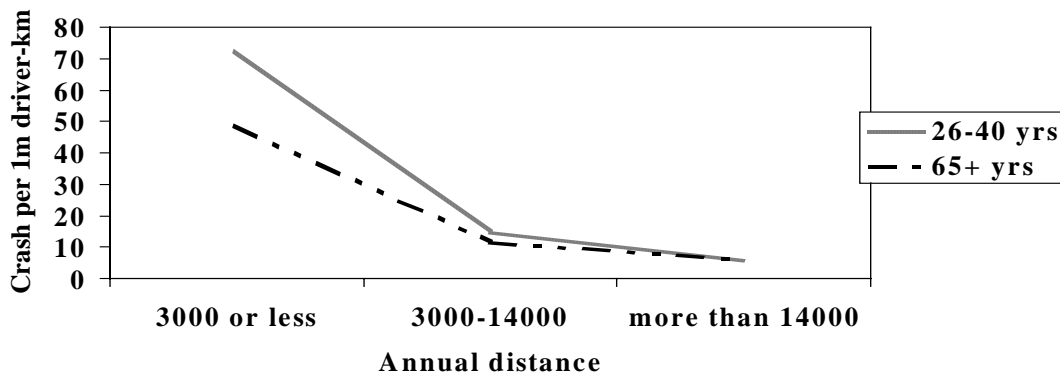
2.1.3 Findings from the research – the low mileage bias

While crash rates per distance driven are generally seen as a robust measure for demonstrating older drivers' crash risk, this measure is increasingly being called into question. It has been long known that independent of age, drivers travelling greater distances will typically have reduced crash rates per kilometre, compared to those driving shorter distances (Janke, 1991). As older drivers typically drive less distance per trip and make fewer trips, Janke warned licensing administrators against becoming overly alarmed about older drivers' apparent high crash risks based on per distance crash rates, without controlling for different annual driving distances.

Hakamies-Blomqvist, Raitanen and O'Neill (2002) have empirically demonstrated this finding by using Finnish travel survey data to compare older and young middle-aged drivers' crash rates. The authors first categorized the older and middle-aged drivers according to their extent of annual driving and then compared per-kilometre crash rates for the two age groups, controlling for the different annual driving distances (see Figure 3). When older drivers were compared with younger drivers who had driven equivalent annual mileages, there was no age-related increase in crashes per distance driven. The apparent age-related risk as per Figure 1, was attributed to differences in yearly driving distances and not to age per se, a phenomenon that the authors called 'low mileage bias'. These findings "cast serious doubt on any previous reports of age differences in accident risk per distance driven." (p 274).

Both the original study by Hakamies-Blomqvist et al. (2002) and the first replication by Fontaine (2003) using French data, were based on relatively small datasets (1,080 and 913 respondents, respectively). In addition, the low numbers required that fairly broad age ranges be compared: for example, Hakamies-Blomqvist et al. defined older drivers as aged 65 and above. With the customary risk curves suggesting that

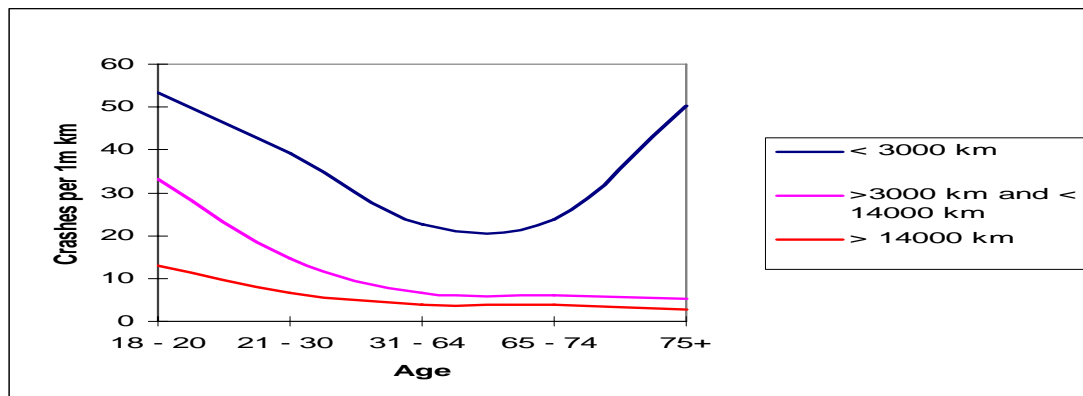
increases in crash risk become apparent only from around age 75 years onwards, it is possible that the broad age ranges used by Hakamies-Blomqvist et al. may be only partly reflecting the oldest drivers' risk factors.



Source: Hakamies-Blomqvist et al., 2002

Figure 3: Annual driving distances and crash rates per 1 million driver-kilometres, by age

Langford, Methorst and Hakamies-Blomqvist (2006) have used travel survey data from a sample of 47,502 Dutch drivers to confirm the earlier demonstrations of the 'low mileage bias'. Figure 4 shows the association between age of driver and crash involvement, controlling for annual distance driven.



Source: Langford et al., 2006

Figure 4: Annual crash involvement for different driver ages, controlling for annual mileage

After being matched for yearly driving distance, most drivers aged 75 years and above were safer than drivers of other ages. The only age-related increase in crash involvement was for low mileage drivers (comprising just over 10 percent of older drivers in the survey), where the sustained decline in crash involvement until around 75 years of age, was reversed for the oldest drivers. However these increases were not statistically significant and must be regarded as indicative only.

It was concluded that “different driver age groups can be compared in terms of per-distance crash rates only after allowance has been made for driving distance differences ... (When this has been done) as a group, older drivers were as safe or safer than other age groups.” (Langford et al., 2006, p. 576). In recognizing that a minority of older drivers may be unacceptably unfit to drive, it was urged that any licensing assessment programs be restricted to these drivers.

2.1.3.1 Explaining the low mileage bias

Janke (1991) attributed the mileage/crash association at least in part to different driving locations. For example, high mileage drivers are more likely to use freeways and multi-lane divided roadways with limited access. By implication, low mileage drivers do more of their driving on local roads and streets, which have more potential conflict points and hence higher crash rates per unit distance. Janke noted that there were 2.75 times more crashes per mile driven on non-freeways than freeways. Hakamies-Blomqvist et al. (2002) also pointed to different amounts of freeway and non-freeway driving as explaining the mileage/crash association, while holding open the possibility of other contributing factors.

For older drivers with their well-documented difficulties in negotiating intersections (OECD, 2001), urban travel is even more likely to result in crashes (Keall & Frith, 2004a) – a finding which could partly explain low mileage older drivers’ indicative extra crash risk (Langford et al., 2006).

There is a second possible explanatory factor. Some older drivers in response to a perceived decline in driving performance restrict their driving as a safety and/or comfort measure (see Section 2.3.6 of this Chapter). These drivers would be expected to have more medical conditions and greater functional difficulties leading to reduced driving skills, relative to drivers with higher mileages – and intuitively, a higher probability of crashing per distance driven. This factor is likely to affect older drivers particularly, and may also contribute to any extra crash risk for low mileage older drivers.

Keall and Frith (2004a) have demonstrated that, while the proportion of driving distance on urban roads generally decreases as annual distance driven increases, low mileage older drivers have the highest proportion of urban driving even relative to low mileage drivers from other age groups. They have also argued that, for older drivers, other factors including a decline in driving competence may have an impact on driving patterns and the risk of crash involvement.

Langford et al. (2006) investigated the possible association between annual driving distances and fitness to drive, as assessed across a range of measures. The results support the proposition that, at least for the older age groups (drivers 80 years or older), low mileage drivers were characterised by reduced fitness to drive. When compared to high mileage older drivers, low mileage drivers were significantly more likely to:

- Report a deterioration in driving skills.
- Report a greater range of health conditions and functional limitations.

- Perform poorly on off-road tests of driving ability.
- Fail an on-road driving test.

2.1.4 Conclusions

Older drivers have a higher risk of fatal and casualty crash involvement per distance travelled, relative other driver age groups. While mainly US data have been used to demonstrate this high level of crash involvement, the finding is true for most Western societies. However, risk curves of the type shown in Figure 1, while demonstrating the level of crash involvement, do not explain the reasons for that involvement. Categorically, Figure 1 does not prove that older drivers become less fit to drive as they age.

When the per-distance crash rates were further investigated, it was found that there were at least two factors which required consideration:

- Older drivers' physical frailty and hence vulnerability to injury in the event of a crash; and
- The association between high crash involvement and low driving distance – itself probably due to high levels of urban driving, and (in the case of older drivers), reduced fitness to drive amongst the low mileage group.

Once these factors have been considered, older drivers as a group are at least as safe as drivers of other ages. There is no evidence that most older drivers have unacceptable fitness to drive, however 'unacceptable' might be defined – with any evidence of unacceptable levels of fitness to drive being restricted to a small proportion (very tentatively, just over 10% of all older drivers).

2.2 VULNERABILITY

Fact:	Once involved in a crash, older drivers are most likely to be the victims.
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Myth:	Older drivers represent a serious road safety threat to others.
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2.2.1 Findings from the OECD Working Group

The OECD Working Group cited evidence from a number of sources that showed that older drivers were the most likely to be injured in any crash. This propensity to death or injury was attributed to two factors: their physical frailty which resulted in greater injury at the time of crash and reduced resilience in recovering from those injuries; and their crash patterns (typically being struck in the side of their car at an intersection crash).

The Group also stressed that older drivers did not present a special threat to others in terms of absolute numbers of casualty outcomes and were involved in much smaller numbers of accidents resulting in deaths or injuries to other road users.

2.2.2 Findings from the research – older drivers as a crash risk to others

The evidence since the OECD report further confirms that older drivers are most likely to be their own victims in the event of a crash and do not pose an unacceptable risk to other road users.

Zhang, Lindsay, Clarke, Robbins and Mao (2000) analysed fatal and serious injury crashes on Ontario public roads between 1988 and 1993, involving drivers aged 65 years or older. They found that approximately 80 percent of fatalities and serious injuries occurred to the older drivers themselves, with the remaining 20 percent being incurred by either their passengers or other road users.

Dulisse (1997) used 1991 linked police and hospital data from Wisconsin to investigate whether older drivers posed a heightened risk to others, defined as persons outside of the driver’s vehicle. His results based on two-unit crashes are shown in Table 3.

Table 3: Older drivers’ crash risk to others (1991 data)

Crash outcomes affecting others in crashes with drivers of the specified age groups	Age of driver (years)			
	16-64	65-74	75-84	85+
Number of deaths	388	21	8	3
Deaths per 100 million driver miles	0.96	0.82	1.0	3.58
Excess number of deaths (relative to the 16-64 years age group)	0.0	-3.66	0.26	2.19
Number of hospitalisations	2321	130	76	21
Hospitalisations per 100 million driver miles	5.76	5.08	9.44	20.0
Excess number of hospitalisations (relative to the 16-64 years age group)	0.0	-17.4	29.6	11.9

Dulisse concluded that relative to drivers aged 16-64 years, drivers aged 65-74 represented a reduced risk to other road users in terms of absolute numbers of deaths or serious injuries. In terms of distance driven and again relative to drivers aged 16-64 years, drivers aged 75-84 imposed a very slight excess risk of deaths and approaching a doubled risk of injuries, while drivers aged 85 years and above imposed almost a four-fold excess risk of both deaths and injuries. Looking at drivers aged 75 years and older however, the excess deaths and excess injuries to others amounted to 0.5 percent and 1.6 percent of all deaths and injuries to others, respectively.

It was also recognised that these straightforward analyses may be obscuring other crash factors that distort older drivers’ true risk to others – in particular, sex of driver, types of vehicles in the crash, type of road, whether at an intersection and the speed limit at the crash scene. When these factors were controlled for through statistical modelling, Dulisse concluded that “it is reasonable to conclude that these data suggest

that crashes involving older drivers are not more probable than crashes involving drivers under age 65 to result in (deaths or) serious injuries to other road users.” (Dulisse, 1997, p. 579).

Dellinger, Kresnow, White and Sehgal (2004) used 1992-94 data also from Wisconsin, taking the crash outcomes of drivers aged 35-59 as the standard. The authors examined two-vehicle crashes only and defined ‘others’ as all other non-driver road users involved in each crash. Since fault information was not available in regard to these crashes, the injury outcomes were divided equally between the two drivers involved in each crash. The death and injury outcomes per driver age group are shown in Table 4.

Table 4: Older drivers’ crash risk to others (1992-94 data)

Crash outcomes affecting others in crashes with drivers of the specified age groups	Age of driver (years)					
	16-19	20-34	35-59	60-74	75-84	85+
No. of deaths over 3 years	76.0	251.0	240.5	47.5	29.0	3.5
Deaths per 100 million driver miles	0.60	0.18	0.13	0.12	0.37	0.41
Excess deaths (relative to the 35-39 years age group)	60.1	76.2	0.0	-2.5	19.1	2.4
No. of A&E transfers over 3 years	5737.5	14312.0	12313.5	3209.5	1282.5	215.0
A&E transfers per 100 million driver miles	45.64	10.33	6.44	8.09	16.34	25.29
Excess A&E transfers (relative to the 35-39 years age group)	4927.4	5390.9	0.0	654.2	771.1	160.2

Note: Fractional deaths and injuries are due to casualty outcomes being ‘divided’ between the drivers involved in crashes.

The authors concluded that the per-distance death and injury rates pertaining to others, were higher for drivers aged 75 years and above, relative to drivers aged 35-59 years – but were substantially lower than the rates for drivers aged 16-34 years. At the same time, older drivers’ excess contribution to crash-related mortality and morbidity affecting others was low, representing 3.3 percent of fatalities and 2.5 percent of A&E transfers. The authors suggested that older drivers’ per-distance crash rates may be at least partly due to the frailty of their passengers and their higher use of riskier roadways, as distinct from being automatically attributed to reduced fitness to drive.

Braver and Trempel (2006) have used multiple crash databases to estimate the per-driver risk to four categories of road users: the drivers themselves, their passengers, the occupants of other vehicles involved in two-vehicle crashes and non-occupants in one-vehicle crashes. Drivers aged 35-59 years were used as the reference group in the calculation of rate ratios (RRs). Looking specifically at older drivers, the results were as follows:

- Fatalities – for drivers aged 75 and above, significantly raised RRs were observed only for driver deaths (RR=3.02) and for their passengers (RR= 2.52) – with around three-quarters of the latter themselves being 75 years or older. The RRs for other vehicle occupants and for non-occupants were significantly lower (RR = 0.62 and 0.9, respectively).
- Non-fatal injuries (crashes reported by police) – for drivers aged 75 and above, there was a slight but significantly raised RR for driver injuries (RR=1.16). The RRs were not significantly different from the reference group for their passengers, for other vehicle occupants and for non-occupants, (RRs = 0.86, 1.1 and 0.93, respectively).
- At-fault insurance claims – for drivers aged 75 and above, there were significantly raised RRs for others’ injury claims and property damage claims (RRs = 1.2-1.8 and 1.3-2.09, respectively).

The authors were unable to explain the difference in non-fatal risk to other road users, when comparing police and insurance data. However it is possible to conclude from the data overall, that drivers aged 75+ years pose the greatest risk of death or injury to either themselves or their passengers – with frailty being a major likely contributor in both cases. At the same time, their risk to other road users is either no higher or only somewhat higher than expected, depending on the data sources used.

2.2.3 Conclusions

Older drivers do not pose an excessive threat to other road users.

Once involved in a crash, older drivers are likely to be the ones either killed or injured. The next largest group consists of older drivers’ passengers, themselves likely to be elderly. Older drivers appear as the greatest threat to other road users when death and casualty outcomes are calculated on the basis of driver miles – but even here, the excess deaths and injuries to others typically account for only a minute proportion of the total road toll.

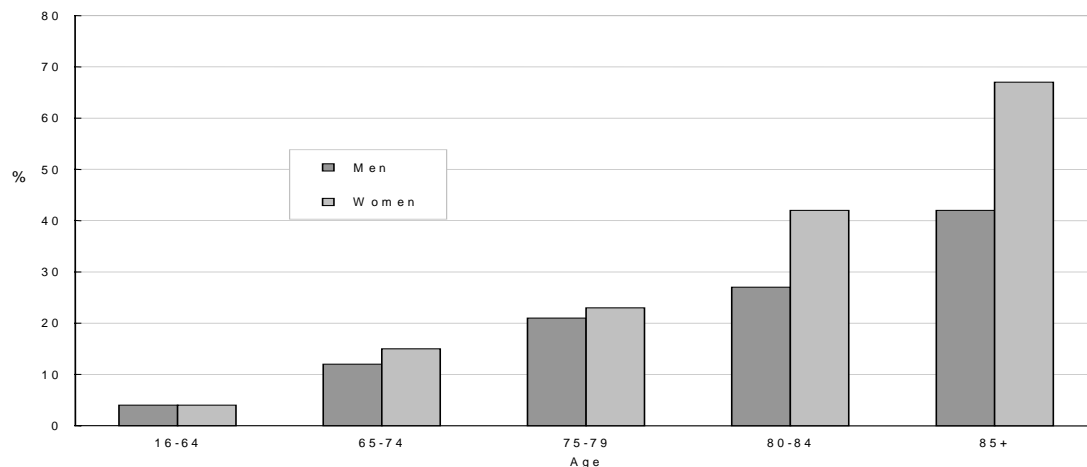
2.3 MEDICAL CONDITIONS AND FUNCTIONAL DECLINE

Fact:	Old age is associated with the onset of medical conditions and substantial functional decline.
Myth:	This widespread decline means that many older drivers should cease driving.

2.3.1 Findings from the OECD Working Group

The OECD Working Group presented a mixed message in regard to the association between ageing, medical conditions, functional impairments and safety implications.

On the one hand, it claimed that around one-third of all people of retirement age are disabled in some way and that there was a well-recognized association between ageing, the onset of disability and as a result, mobility difficulties. To demonstrate this association, it pointed to data from Great Britain (see Figure 5).



Source: OECD, 2001

Figure 5: Percentage of people in Great Britain reporting mobility difficulties of any sort, 1996

Based on this data, two-thirds of all women and over one-third of all men aged 85 years or older, have reported mobility difficulties of some sort. On the other hand, at present most people can expect to maintain an active largely disability-free life well into their 70s, as shown in Figure 6.

A critical factor in interpreting the association between ageing, medical conditions, functional impairments and safety implications, relates to whether a cohort effect can be expected: that is, whether the emerging cohorts of older people, who can expect increased longevity, can also expect commensurate (or even greater) years of disability-free life. The limited available evidence suggests that future cohorts are likely to enjoy considerably enhanced health, although much of this improvement may relate to moderate rather than severe disability.

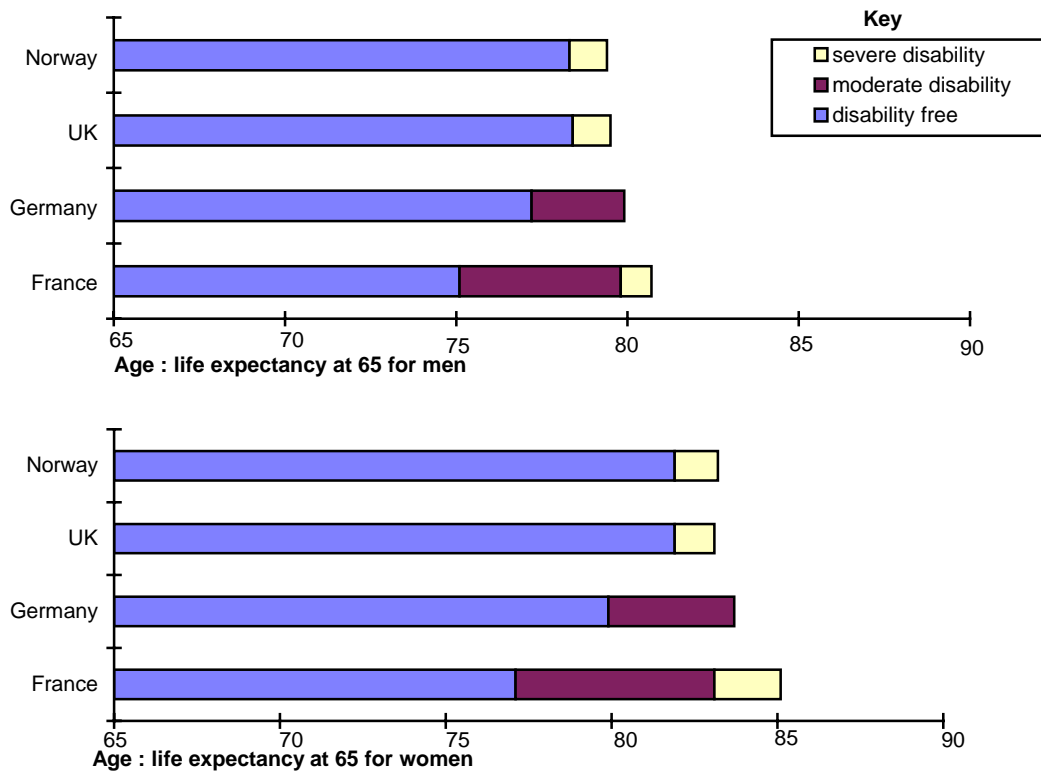
The Group concluded:

“Nonetheless, absolute increases in the number of disabled older people can continue to be expected. Although individual conditions rarely show a strong correlation with crash involvement, collectively they can make driving and other forms of mobility more difficult and place some older people at increased risk of crash involvement. ... under the best of conditions, it is (also) likely that by 2030 there will be substantial numbers of older people suffering from disability to the extent that their mobility is threatened.” (OECD, 2001, p. 25).

The Working Group summarized the evidence relating to specific medical conditions and crash risk, thus:

“Much of the risk that has been generalised for all older drivers may in fact be attributable to specific sub-groups with functional deficits linked to certain illnesses that become more prevalent with age, especially illnesses leading to cognitive deterioration, such as the different dementias. ... It has (also) been suggested that several other medical conditions, such as epilepsy and insulin-treated diabetes have been suggested to increase a driver’s accident risk ...

Many of these conditions are not as strongly associated with ageing as are the various forms of dementia. In addition, for many medical conditions, conclusive evidence of increased risk in traffic is still limited.” (OECD, 2001, p.49).



Source: Oxley, 1998, cited in OECD, 2001

Figure 6: Life expectancy and the onset of disability in four European countries

Older drivers’ propensity to modify their driving patterns at least partly in response to age-related changes in certain performance areas, was also noted. Many of these changes (driving more slowly, selecting longer time gaps, attempting to perform tasks in sequence rather than simultaneously) were viewed as protective, in response to perceived driving difficulties. The Working Group also recognized that especially older drivers with cognitive difficulties may not adopt these protective driving patterns.

2.3.2 Findings from the research – the link between ageing and medical conditions

There is widespread agreement that even ‘normal ageing’ is associated with the onset of medical conditions, many of which have safety implications. For example, Hakamies-Blomqvist, Sirén and Davidse (2004) identified arthritis, heart diseases, arterial hypertension, diabetes and the various forms of dementia as common age-related conditions. They also argued that the safety implications were often difficult to assess, not the least because some conditions led to a reduced driving exposure and hence reduced crash possibility.

Other researchers have attempted to quantify the association between medical conditions and crash risk by means of literature reviews. Recent examples include Dobbs (2001), who identified an array of conditions which may serve as ‘red flags’ for increased crash risk (see Table 5 for a full listing).

Table 5: Medical conditions as ‘red flags’ regarding driving safety

General Condition	Specific condition
Visual Impairments / Illnesses	Low vision (20/200 to 20/50) Cataracts Colour Vision Defects Contrast Sensitivity Diabetic Retinopathy Glaucoma and Field Loss Monocular Vision Macular Degeneration
Hearing	Hearing impairment
Cardiovascular disease	Coronary Heart / Artery Disease Disturbances of Cardiac Rhythm Congestive Heart Failure Abnormal Blood Pressure
Cerebrovascular disease	Transient Ischaemic Attacks Cerebrovascular Accident (CVA) (Stroke)
Peripheral Vascular Diseases	Peripheral Vascular Diseases
Diseases of the Nervous System	Seizures Narcolepsy Sleep Apnoea
Respiratory Diseases	Asthma Chronic Obstructive Pulmonary Other Pulmonary Conditions (not specified)
Metabolic Diseases	Diabetes Mellitus Thyroid Disease
Renal Disease	Chronic Renal Failure
Musculoskeletal Disabilities	Musculoskeletal Disabilities
Psychiatric Disease	Psychiatric or Emotional Conditions
Medication / Drugs	Anti-depressants Anti-histamines Drugs prominently affecting the central nervous system

Source: Dobbs, 2001

Charlton, Koppel, O’Hare, Andrea, Smith, Khodr, Langford, Odell and Fildes (2004) reviewed the available research evidence and, using stringent empirical criteria, also identified a set of conditions with statistically significant elevated crash risks (see Table 6).

Table 6: Summary of medical conditions and associated crash risk

Condition	Relative crash risk
Alcohol abuse and dependence	2.1-5.0
Cardiovascular disorders	1.1-5.0
Dementia	2.1-5.0
Epilepsy	1.1-5.0+
Multiple sclerosis	2.1-5.0
Psychiatric disorders	1.1-5.0
Sleep apnoea	2.1-5.0+
Glaucoma	1.1-5.0

Source: Charlton et al., 2004

While the crash risks shown have usually been calculated for drivers of all ages, they serve as a useful indicator of older drivers’ additional crash risk, provided that they have contracted one or more of these conditions.

Other researchers have conducted their own studies. For example, McGwin, Sims, Pulley and Roseman (2000) in a case-control study of older drivers in Alabama, found that several medical conditions and medications were associated with crash involvement. Medical conditions showing a significant association were heart disease and arthritis (female drivers only) and medications included nonsteroidal antiinflammatory drugs, angiotensin converting enzyme inhibitors anticoagulants – while calcium channel blockers and vasodilators were significantly associated with reduced risk. Other conditions and medications showed an indicative increase in crash risk.

Vernon, Diller, Cook, Reading, Suruda & Dean (2002), based on licensing, medical and crash data for almost 2 million drivers of all ages in the State of Utah 1992-96, found that fully licensed drivers with specific single medical conditions had significantly higher at-fault crash risk, as follows:

- diabetes: relative risk = 1.46 (1.36-1.58);
- pulmonary: relative risk = 1.26 (1.06-1.50);
- neurological: relative risk = 2.20 (1.71-2.84);
- epilepsy: relative risk = 2.02 (1.80-2.27);

- learning, memory: relative risk = 3.32 (1.84-5.99);
- psychiatric: relative risk = 1.85 (1.69-2.01);
- alcohol and drugs: relative risk = 2.22 (1.25-3.94);
- visual acuity: relative risk = 1.52 (1.38-1.68);
- musculo-skeletal: relative risk = 1.84 (1.14-2.98).

2.3.3 Findings from the research – the link between ageing and vision

The various visual capacities have an apparent relevance to safe driving, which may explain why many jurisdictions around the world require vision testing as part of their licensing assessment requirements, especially but not only for older drivers. In her summary of visual impairments and older drivers' crash risk, Owsley (2004) points out that while visual acuity is the most frequently tested aspect of vision, its association with crash risk is weak and cannot effectively identify high-risk older drivers. Her explanation for this is two-fold:

- Visual acuity is but one component even in the context of vision, which contributes to safe driving. Other factors, especially the simultaneous use of central and peripheral vision together with the capacity to detect and process critical ingredients from a visually cluttered array while in motion, are not tested by licensing authorities' conventional screening instruments.
- Many drivers with acuity impairments have ceased driving, either voluntarily or at the direction of the licensing authority, while others may have restricted the amount of driving. In these scenarios, the testing requirements may be assumed to have safety benefits, not evident in research studies restricted to active drivers.

Other research studies have concentrated upon the safety implications of peripheral vision and visual field loss. While there is sizeable variation in the results, with many studies failing to show that impairments can be associated with poorer driving performance and particularly crash risk, Owsley argues that these findings need to be interpreted with caution. Apart from possible procedural and methodological differences across the studies, it may be that the (usually) gradual onset of these conditions has led to a range of compensatory behavioural adaptations: for example, increased head and eye movements.

After reviewing the studies relating to visual impairment, Owsley (2004) reached the following conclusion:

“Because driving is a complex visual-cognitive task, it is unlikely that an assessment of visual-sensory impairment and the diagnosis of eye disease would alone be sufficient to identify people at elevated risk for crash involvement. Visual information processing skills, not only visual-sensory thresholds, have face value for the execution of safe driving practices.” (p. 47).

Tests that target visual-processing skills were considered to have the most potential in this context, rather than tests solely measuring visual thresholds (see Section 2.4.3.2 for a discussion of the Useful Field of View test.)

2.3.4 Findings from the research – the link between ageing and cognition

Owsley (2004) in her summary of the research findings relating to cognitive impairments noted that drivers with impaired cognition, regardless of the aetiology, are at least twice as likely to be involved in crashes, with the exact measure of risk varying across studies – and could be as high as 18x, relative to unimpaired older drivers (in Klavora & Heslegrave, 2002). Studies focussing on specific cognitive domains have found that crash involvement, poor on-road performance and poor simulated driving performances are linked to attention problems, impairments in visual search and spatial memory.

Looking at dementias and Alzheimer's Disease specifically – a form of dementia that accounts for more than one-half of all dementia cases (Klavora & Heslegrave, 2002) – Owsley reported that between 30 percent and 40 percent of drivers with this condition are likely to be involved in a motor crash. Another study has estimated that around 50 percent of all aged drivers killed in road crashes were suffering from Alzheimers Disease (Johansson et al, 1997, cited in Hakamies-Blomqvist et al., 2004).

The incidence of the various dementias remains open to question – with a common estimate being around 4 percent of the population aged 75 years and older (Freund & Szinovacz, 2002; Erkinjuntti 1988, cited in Hakamies-Blomqvist et al., 2004).

Hakamies-Blomqvist et al. (2004) have reported that while dementias result in cognitive impairments that can reduce some important driving skills, they are degenerative conditions that in their early stages are often both mild in impact and difficult to detect – whether by the individual driver or by others, including medical practitioners. As noted by Owsley (2004), this has led to controversy about when drivers with dementia should be required to stop to driving, with the proposition that those who are only mildly affected should be allowed to continue driving. For example, O'Neill, Bruce, Kirby and Lawlor (2000) have noted that studies based on samples of drivers taken from dementia clinics, often show a high association with crash risk: in contrast, quasi-prospective studies show less pronounced risk during the early stages of the condition – to the point that “in the first two years of dementia, the risk approximates that of the general population.” (p. 185).

2.3.5 Findings from the research – the link between ageing, medical conditions, functional impairments and crash risk

The linkage between medical conditions and crash risk can be best explained by the changes in sensory, perceptual, cognitive, psychomotor and physical functioning, prompted by the various medical conditions. Stutts and Wilkins (2003) summarized much of the research in this area thus:

“As a group, older drivers have poorer visual acuity, reduced nighttime vision, poorer depth perception, and greater sensitivity to glare; they have reduced muscle strength, decreased flexibility of the neck and trunk, and slower reaction times; they are also less able to divide

their attention among tasks, filter out unimportant stimuli, and make quick judgements.” (p. 431).

An attempt to show the relationship between age-related impairments and driving performance is shown in Table 7.

Table 7: Age-related impairments and driving problems

Age-related Impairments	Driving Problems
Increased reaction time. Difficulty dividing attention between tasks	Difficulty driving in unfamiliar or congested areas
Deteriorating vision, particularly at night	Difficulty seeing pedestrians and other objects at night, reading signs
Difficulty judging speed and distance	Failure to perceive conflicting vehicles. Accidents at junctions
Difficulty perceiving and analysing situations	Failure to comply with yield signs, traffic signals and rail crossings. Slow to appreciate hazards
Difficulty turning head, reduced peripheral vision	Failure to notice obstacles while manoeuvring. Merging and lane changes
More prone to fatigue	Get tired on long journeys
General effects of aging	Worries over inability to cope with a breakdown, driving to unfamiliar places, at night, in heavy traffic
Some impairments vary in severity from day to day. Tiredness	Concern over fitness to drive

Source: Suen & Mitchell, 1998

2.3.6 Findings from the research – the role of self-regulation in countering changes in functional performance.

The full impact of the linkage between ageing, medical conditions, functional decline and reduced driving skills upon crash involvement has been mitigated thus:

“The weight of the evidence...appears to indicate...a reduction in elders’ driving skills resulting from various declines that come with age... . However, this reduction in skills does not necessarily translate into a higher crash rate over any given period of time for elderly drivers as a group, because of the group’s characteristic compensatory behaviours and voluntary limitations of their driving.” (Janke, 1994, p.26.)

Many older drivers are aware of some functional decline and accordingly adjust their driving patterns to avoid travel under conditions which are perceived to be threatening or which otherwise cause discomfort (Evans, 1988; Eberhard, 1996; Smiley, 2004; Preusser, Williams, Ferguson, Ulmer & Weinstein, 1998; McGwin & Brown, 1999). In particular, the onset of various visual difficulties has been associated with a

reduction in or cessation of driving (for a brief overview, see Satariano, MacLeod, Cohn & Ragland, 2004). As examples of self-regulation, older adults typically choose to reduce their exposure by driving fewer annual kilometres, making shorter trips and making fewer trips by linking different trips together (Benekohal et al., 1994; Rosenbloom, 1995, 2004). Older drivers have also been found to limit their peak hour and night driving, restrict long distance travel, take more frequent breaks and drive only on familiar and well lit roads (Ernst & O'Connor, 1988; Smiley, 2004).

For a comprehensive overview of self-regulation and common changes in older drivers' driving patterns, see Charlton, Oxley, Fildes, Oxley, Newstead and O'Hare (2003). As noted by these authors:

“... it may not be entirely accurate to label such behavioural adaptations as ‘compensation’. While these changes may reflect a behavioural adaptation to age-related changes in performance levels, other explanations are possible, such as mature judgements about road use, lifestyle choices, and personal preferences brought about by changes in employment status, place of residence and proximity to services. Even younger drivers might avoid driving in darkness or during peak traffic periods if not forced to by their circumstances.” (p. 7).

The common strategy for investigating the relationship between functional impairments and changes in driving patterns, is to identify drivers who have either reduced their driving or ceased driving altogether and to determine the factors responsible for those changes. This issue was discussed in detail in Section 1.3.2.3. Briefly, it is generally reported in the literature that retirement, difficulties in some driving situations, availability of alternative transport and changing health are major reasons for driving reduction and cessation (e.g., Raitanen et al., 2003; Charlton et al., 2006; Ragland et al., 2004).

Although self-regulation does not entirely prevent older driver crashes, it is effective in that the “moderate functional changes related to normal ageing do not appear to lead to a discernible increase in crash risk.” (Janke, 1994). Smiley (2004) has claimed:

“Older drivers have a general awareness of their diminishing capabilities and make numerous appropriate ... adaptations to compensate. ... The success of older driver adaptation is shown by the fact that when their greater frailty is taken into account, absolute involvement rates, calculated per 1 million drivers, remain at the level of middle-aged drivers.” (p.41).

A critical issue relating to self-regulation is whether this mechanism is used by all impaired older drivers. A study of 401 crash-involved, high-risk older drivers by Stalvey and Owsley (2000), suggests that self-regulation can be missing at least for some sub-groups of older drivers. While all participants had some level of visual impairment, the majority did not acknowledge either this condition or the consequent impact on driving. Over three-quarters of this high-risk group did not self-regulate by avoiding driving situations that placed the highest demand on visual processing abilities and the majority rarely performed specific alternative driving strategies. The older adults in the sample perceived the seriousness of crash involvement but did not see themselves as susceptible. The authors concluded by arguing a case for an educational intervention that promotes self-regulation and the use of compensatory strategies amongst older drivers, as one means to ensure continued and adequate levels of both mobility and safety.

Stutts, Wilkins and Schatz (1999) reported that some older adults continue to drive ‘in spite of everything’, do not recognise, much less accept, their driving limitations, feel

a responsibility to provide transportation, often blame their driving problems on others and are generally hesitant to ask for help from family or friends. They also found that others give up driving prematurely. These drivers, particularly females, stated that they never really enjoyed driving, were uncomfortable with today's driving environment, and had a spouse who was readily available to drive them places. Many were dissatisfied with their dependence and limited mobility, and believed that they were in danger of losing their driving skills.

2.3.7 Findings from the research – using crash epidemiology to explore unfitness to drive and crash responsibility.

As a group, older drivers have a distinct crash pattern. The OECD Working Group (2001) described older driver crash features thus:

“A larger share of older driver accidents involve collisions with another vehicle. They have a smaller share of single-vehicle and speed-related accidents. Older drivers tend to be legally at fault in their collisions. A greater proportion of older drivers' crashes occur at intersections, where typically the older driver is turning against oncoming traffic with right-of-way on the main road. On the other hand, older drivers' small share of accidents per number of licensed drivers probably reflects their slow, conservative and cautious driving style. ... Older drivers are “under-represented” in single-vehicle accidents involving loss of control or collisions due to speeding or risky overtaking. For those aged 80 years and over, the percentage of angle collisions, typically involving intersection situations, is more than double that of the youngest group. The high percentage of angle collisions where the older driver is hit from the side by an oncoming vehicle is another factor that explains why older drivers tend to be the ones injured in their accidents.” (pp. 47-48).

This pattern has been repeatedly confirmed by crash data from many Western countries (Fildes, Corben, Kent, Oxley, Le & Ryan, 1994; Preusser et al., 1998; Clarke, Forsyth & Wright, 1998, 1999; McGwin & Brown 1999; Zhang et al., 2000; Larsen & Kines, 2002; Abdel-Aty & Radwan, 2000; Li et al., 2003). As two examples:

- Preusser et al. (1998) examined US fatality data for 1994 and 1995 to show that relative to drivers aged 40-49 years, drivers aged 65-69 years were 2.26 times more at risk of fatal multiple-vehicle crashes at intersections, rising to a relative risk of 10.62 for drivers aged 85 years and above. These heightened crash risks increased further for particular intersection characteristics (for example, when uncontrolled or governed only by a stop sign), for particular traffic manoeuvres and for particular driver errors.
- In an analysis of 1996-1999 Australian fatal crash data, Langford and Koppel (in press) showed that older drivers' crashes were predominated by their difficulties with intersection negotiation. Fifty percent of older driver crashes were at intersections, compared to 21 percent of crashes involving middle-aged drivers. The composite picture showed a strong over-representation in crashes resulting from older drivers either attempting to turn across oncoming vehicles or across vehicles coming from an adjacent direction or attempting to enter an intersection at the same time as a vehicle from an adjacent direction.

In noting older drivers' propensity for intersection crashes, the OECD Group asked why this group's strategies which were so effective at avoiding other crash types,

failed in this instance (OECD, 2001). It arrived at a dual explanation. First, older drivers – many in response to some decline in functional performance – have become skilled in easing the driving task, especially by driving slower. However, at intersections this self-pacing often breaks down and older drivers are forced to perform under a time pressure that, for some, may exceed their capacities. Second, successfully negotiating an intersection represents one of the most complex driving situations, given the range of tasks that need to be mastered. These unduly high demands for divided attention and multiple processing may be excessive for some older drivers. It follows from this that older driver would be overly responsible for their crash involvement at intersections.

The related issues of crash responsibility and crash causation are complex. It is generally recognised that most, if not all, crashes have several causes: that is, there is a chain of events or circumstances leading to the crash and its outcomes, the absence of any one of which might have either prevented the crash or reduced its severity. Dulisse (1997a), for example, argued against any analysis of crash responsibility, claiming that all drivers by virtue of their presence on the road pose a risk to other drivers and thus bear some responsibility for any crash. As a specific example, older drivers, by undertaking much of their driving on local urban roads rather than freeways, are more likely to be involved in multi-vehicle crashes although not necessarily 'at-fault'.

Further, the process of attributing crash responsibility may be invalid. For example, older drivers have fewer possibilities of defending their pre-crash actions due to greater mortality and authorities may be biased against very young and very old drivers in attributing blame (Hakamies-Blomqvist, 1993; Elliott, Elliott & Lysaght, 1995).

The multiple causes of crashes and possible biases in judging crash responsibility, remain as qualifiers to most of the research findings in this area. Notwithstanding, researchers have used the concept of crash responsibility for a number of purposes, particularly to highlight specific human and other failures. The data sources used in research studies into crash responsibility have varied from police traffic accident reports (Claret, del Castillo, Moleón, Cavanillas, Martín & Vargas, 2003; Williams & Shabanova, 2003), linked databases (Cooper, 1990; Yanik & Monforton, 1991; Verhaegen, 1995) and in-depth crash investigations (Hakamies-Blomqvist, 1993). Other studies have also attributed driver errors such as misperception, misjudgements, or failures to give-way as contributing particularly to older driver crashes (Cooper, 1990; Elliott et al., 1995; Preusser et al., 1998; Schlag, 1993; Stamatiadis, Taylor & McKelvey, 1991; Transport Research Board, 1988). Reference is also made to Figure 2, based on at-fault insurance claims provided by data provide by Insurance Institute for Highway Safety.

The common finding from these reports is that older drivers are more likely to be judged responsible for their crashes than other drivers. The relative risk of older drivers being judged responsible varied across studies, data sources, crash types, age parameters and comparison groups but as a broad finding, the measure ranged from around 1.5 times to three times. As an example, Langford, Koppel, Andrea and Fildes (in press) showed from linked police and insurance crash databases in an Australian State, that relative to middle-aged drivers, drivers aged 65 years and older were 1.5 times more likely to be judged by both sources as responsible for their crashes. It was

estimated that had older drivers' crash responsibility been the same as middle-aged drivers', there would have been around a 4 percent reduction in all casualties. Given the impending growth in older driver numbers, this additional crash responsibility could be associated with up to 10 percent of casualty crashes during the next few decades. It remains to quantify the road safety implications of this excess responsibility.

2.3.8 Conclusions

The association between ageing, the onset of medical conditions, subsequent functional decline, driving patterns, crash risk, crash patterns and crash responsibility, is complex and is still only partly understood.

On the one hand, there is general agreement that normal ageing results in the onset of medical conditions and functional impairments, many of which would be expected to result in reduced driving skills and increased crash risk and involvement. Older drivers' crash patterns – and especially the predominance of intersection crashes, where the total range of perceptual, motor and cognitive tasks is considered to be at its highest – and their increased likelihood of being responsible for their crashes, is consistent with this expected decline in driving skills.

On the other hand, it seems that for most older drivers, this linkage is weakened if not broken by the role of self-regulation. Perhaps in recognition of their various limitations and driving difficulties, perhaps for other reasons, older drivers tend to alter their driving habits: for example by driving less and under more comfortable and usually safer conditions. Arguably as a result of this mechanism, specific medical conditions, functional impairments and additional crash responsibility have only modest associations with crash involvement. In presenting this argument however, it needs to be noted that the role of health factors in prompting self-regulation, at least as reported by older drivers, seems to be modest – with much of the change attributable to a reduced need for driving.

The major concern in relying upon self-regulation as an adequate mechanism for managing older driver safety, appears to lie in identifying and countering impaired older drivers who for various reasons fail to self-regulate. Demented or otherwise cognitively impaired older drivers emerge as a leading (but not sole) concern in this context.

2.4 FITNESS TO DRIVE

Fact: Some older drivers are unfit to drive.

Myth: Most unfit older drivers can be adequately identified through age-based licensing assessment.

2.4.1 Findings from the OECD Working Group

The OECD Working Group accepted that normal ageing was likely to be accompanied by moderate functional changes – but argued that as a result particularly

of self-regulation, these moderate changes were unlikely to lead to a discernible increase in overall crash risk. Crashes at intersections were recognised as an exception to this general position of safety: the complex traffic environment at intersections and the range of perceptual and cognitive tasks demanded of drivers, often combined to produce a ‘testing of the limits’ type of task.

However the Working Group came out strongly against age-based assessment programs of the type managed by many licensing authorities, as an effective means to identify any at-risk sub-groups of older drivers who were not adequately self-regulating. Its opposition was based in part on operational practicalities, illustrated by the following hypothetical example:

- Assume that the ‘acceptable’ risk of a serious crash is 1 per 100,000 drivers a year;
- Assume that a factor is targeted that doubles the crash risk, making it 1 per 50,000 drivers a year;
- Assume that a test with 100 percent sensitivity and specificity for finding drivers with this risk factor has been developed;
- To prevent just one crash, 50,000 at-risk drivers would have to cease driving;
- 49,999 ex-drivers would then use other, perhaps less safe modes of travel and may run a greater risk of serious crashes than they did in their cars.

The Group also pointed to the two evaluations of older driver assessment programs necessary for licensing purposes, available at the time of the report’s publication. Both evaluations showed that jurisdictions with regular assessment of older drivers as a condition for continued licensing, were unable to demonstrate any crash reduction benefits when compared to jurisdictions with no regular assessment programs. At the same time, these programs were associated with a high level of licence surrender as a preference to being assessed, interpreted as meaning that the safer, more conscientious drivers were being deterred from continuing to drive.

The Group’s summary of age-based mandatory assessment programs was thus:

“The outcome of such procedures is mixed. On the one hand, they reduce the overall exposure of older drivers and therefore reduce crashes of older drivers (perhaps at the cost of increased crashes amongst other older road user groups). On the other hand, they appear to lead to premature cessation of driving and a substantial loss of mobility, with detrimental ramifications including increased depressive symptoms and sometimes a range of social and health disadvantages” (p. 83).

As part of this summary, the Group examined the available research evidence relating to the sensitivity (the capacity to ‘fail’ at-risk drivers) and specificity (the capacity to ‘pass’ safe drivers) of the various assessment programs. It reported that “it has been impossible to obtain sensitivity and specificity measurements for any of the known older-driver testing programmes. In all likelihood, such measurements have not been made.” (OECD, 2001, p. 81). If this is true, it follows that licensing authorities are using assessment programs, the basic validity of which is unknown.

2.4.2 Age-based mandatory assessment programs as part of general licensing procedures to identify at-risk drivers.

Many licensing jurisdictions around the world attempt to manage the safety of older drivers through age-based mandatory assessment programs as a condition for continued re-licensing and driving. While there are no standard protocols for assessment, at a mass level there is usually some combination of medical testing and on-road testing, with many other options for individual assessment (including reviews by medical boards or by specialists such as occupational therapists). This section of the report covers only mass assessment procedures.

As already discussed, the emerging research suggests that for older drivers as a group, much of their high crash involvement is attributable to physical frailty and the amount of annual driving rather than to functional impairment or reduced driving skills. While the latter factors may be pertinent to a minority of older drivers, there is little evidence to suggest that the age-based mandatory assessment procedures used by many licensing authorities older drivers are effective in identifying these drivers.

Since the release of the OECD report, two Australian research studies have assessed the effectiveness of the different licensing systems in Australia by examining older drivers' casualty crash rates across the different jurisdictions.

In the first study (Langford et al., 2004a), drivers aged 80 years and above in jurisdictions with age-based mandatory assessment programs, were compared to drivers in Victoria, where there was no mandatory assessment program. It was concluded that on a per-population basis, Victorian drivers were at least as well performed as drivers from elsewhere in terms of both fatal and serious injury crash involvements. On a per-licence basis, Victorian drivers were consistently better performed than drivers from other jurisdictions – and the differences for serious injury involvement were statistically significant.

However, it was noted that some older people maintain their driving licences but rarely if ever drive. Further, the proportion of inactive licence-holders might be higher in Victoria relative to jurisdictions with periodic licence assessment, where inactive drivers may more readily either surrender or lose their licences. The failure to control for possible differences in active-driver levels across jurisdictions may have disguised possible safety benefits associated with mandatory assessment.

Consequently, a second study (Langford et al., 2004b) compared the casualty crash involvement rates of drivers aged 80 years and older in the cities of Melbourne, Victoria (no regular assessment) and Sydney, New south Wales (regular medical and on-road assessment), this time using population, number of licences held, total distance driven and time spent driving as exposure measures. Results showed that while there was no difference in crash risk for older drivers based on population, Sydney drivers had higher casualty crash involvement than their Melbourne counterparts on per-licence and time spent driving bases – and for both rates, the differences were statistically significant. A similar trend based on distance travelled, was only of borderline statistical significance.

The findings from Australia are consistent with overseas research, including both studies cited in the OECD report. More recently, the different licensing procedures for

older drivers in the United States have been investigated to find a possible association with differences in older driver fatality rates (Grabowski et al., 2004). Regression techniques were used to study the effects of the following variables related to state laws: (a) laws mandating in-person renewal of licence; (b) laws mandating vision tests; (c) laws mandating on-road tests; and (d) duration of the licence renewal period. It was found that the only variable that had any significant association with a lowered fatality rate was in-person licence renewal, only for drivers aged 85 years or more. It was concluded that “more stringent state licensure policies such as vision tests, road tests, and more frequent licence renewal cycles were not independently associated with additional benefits.” (Grabowski, Campbell & Morrissey, 2004, p. 2,840).

The common finding that current licence procedures are ineffective in identifying older drivers with heightened crash risk attributable to functional impairments, seems to be generally accepted. As a result, at least some of the proponents of mandatory assessment recognize that the assessment procedures need to be improved. Consider for example the stance taken by Stamatiadis, Agent and Ridgeway (2003):

“... safety gains might be achieved by implementing additional procedures for older drivers. The first step might be to require that drivers older than 75 renew their driving licences every 2 years. A second step would be to use vision screening tests that include a set of questions to be given at licence renewal for older drivers. ... renewal examiners the discretion to require road testing as deemed necessary is recommended as a third step.” (p.53).

These proponents contend that the continuation of mandatory assessment is necessary for high risk elderly drivers but recognize the necessity for “a test with sufficient technical efficacy to reliably and economically separate safe senior drivers from those who are clearly more dangerous.” (Fitten, 2003, p. 2130). The same author however claims that it would be both premature and inadvisable to undertake this program in the absence of such tests, conceding that the required tests are not yet available.

2.4.3 Review of the evidence showing the validity of the individual assessment protocols.

While there is little evidence to support the safety benefits of the mass age-based assessment procedures used by most licensing authorities, some specific protocols available show a statistically significant association between assessment results and either crash risk or proxy measures (usually driving performance). The following review of the validity of the on-road and off-road protocols is restricted to procedures applied to large groups of older drivers and specifically excludes assessments conducted at an individual level (for example, by occupational therapists).

2.4.3.1 On-road assessment

In 1999 New Zealand introduced an on-road test specifically designed to assess the types of driving situations most likely to result in older driver crashes. Drivers aged 75 who passed this test were allowed to continue driving for a further five years – after which they were required to be re-tested at age 80 and every two years thereafter. In the event of failing, each driver was allowed to re-sit the test as frequently as desired (with drivers having made up to six attempts before passing). Based on the population of older drivers tested during the first three years of operation, Keall and Frith (2004b) found that 78 percent of drivers passed on their

first attempt. Each driving test failure that occurred prior to an eventual pass, was associated with a 33 percent increase in the odds of crash involvement during the next two years. Their conclusion: “drivers with a higher failure rate in the driving test were failing because of deficiencies in their performance of the driving task, which in turn relate to higher crash involvement rates. Very few studies to our knowledge have managed to quantify such associations.” (p. 116).

One other validation of on-road testing relates to the DriveABLE™ Road Test, based on a standardized driving course designed to allow the assessment of those driving errors best able to discriminate between medically impaired and healthy older drivers. Driving errors are scored in terms of ‘hazardous errors’ (where the driving evaluator or other road users accommodate the driving error to avoid a crash or dangerous situation) and less serious errors (‘discriminating errors’). Analyses both during the development of the test and in the field – based on participants from 9 centres in Canada and 3 centres in the United States – show that both types of driving errors are strongly associated with driver competence declines (DriveABLE™ Technical Manual Version 3.0)

No other evaluations of on-road driving tests against crash risk were found in the research literature.

2.4.3.2 Off-road assessment

There are also off-road tests of fitness to drive, characteristically serving as screening devices. Screening devices are generally used to ‘rule out’ or ‘rule in’ a given condition (McCarthy & Mann, 2006) and frequently result in a three-level outcome: for example, ‘present’, ‘absent’ and ‘uncertain/requiring further assessment’. They are also often used in conjunction with other assessment procedures.

Arguably, the three leading off-road screening tests currently in use in North America are DriveABLE™ In-Office Test (DriveABLE Inc., Edmonton, Canada), the Useful Field of View (UFOV) test and Roadwise Review (in large part, based on the test previously known as the Gross Impairments Screening Battery of General Physical and Mental Abilities). These three tests have been assumed to have the best credentials in terms of available validation evidence.

DriveABLE™

The DriveABLE™ In-Office Test was designed in Canada and comprises six computer-based tasks using touch screen and button push responses. Tasks include motor speed and control, span of attentional field, spatial judgement and decision making, speed of attentional shifting, executive function and judgement of complex driving situations (a series of videos of traffic sequences, including hazards about which the participant is required to make judgements). The overall DriveABLE™ score is a predicted probability of a given candidate failing the Road Test.

All drivers in the Canadian and US studies used to validate the DriveABLE™ Road Test, also completed the In-Office testing. Results from these drivers have also been used to validate the DriveABLE™ test battery against on-road results. In the Canadian multi-centre study, the false negative rate was 12 percent, the false positive

rate was 1 percent. In the United States multi-centre study, the false negative rate was 4 percent, the false positive rate was 3 percent.

Neither the DriveABLE™ In-Office nor the DriveABLE™ Road Tests have been directly evaluated against crash involvement.

UFOV

The UFOV is a touch-screen computer-based test that consists of three sub-tests. In Sub-test 1, participants are required to respond to an image of either a car or a truck flashed onto the centre of the screen, followed by a distracter screen. Participants are then required to indicate which image was presented (car or truck) by touching the screen over the correct image. In Sub-test 2, participants are again required to identify an image in the centre of the monitor screen, while locating a car simultaneously displayed in the periphery. This is followed by a distracter screen. Two screens then appear requiring participants to indicate which image was presented centrally and where the car in the periphery was located. Sub-test 3 is the same as Sub-test 2 except that the car displayed in the periphery is embedded in a field of 47 triangles or distracters. For all three tasks, participants' performance is assessed according to quickness of response. In addition a composite score is possible, expressed as a percent reduction of useful field of view.

Ball, Owsley, Sloane, Roenker and Bruni (1993), using a sample of 294 drivers aged 55 to 90 years, assessed eye health status, visual sensory function, the size of the useful field of view (measured by UFOV) and cognitive status – all of which measures were related to at-fault crash involvement during the previous five years. The sample was stratified and deliberately did not represent the overall older driver population in regard to either age or crash involvement: for example, 33 percent had no crash involvement, 49 percent had been involved in 1 to 3 crashes and 18 percent in 4 or more crashes.

Table 8 shows that UFOV performance could identify with accuracy, crash-involved older drivers.

Table 8: UFOV threshold score and crash involvement

UFOV Category	Crash category	
	1 or more crashes	No crashes
UFOV reduction >40%	142	25
UFOV reduction ≤ 40%	18	109

Based on the stratified sample of 294 respondents and using the above cut-off points, the UFOV had:

- 89 percent sensitivity (i.e., given that a subject was crash involved, there was a .89 probability of a UFOV score less than 40%).

- 81 percent specificity (i.e., given that a subject was not crash involved, there was a .81 probability of a UFOV score greater than or equal to 40%).
- 85 percent positive predictive power (i.e., given that a subject had a UFOV score less than 40%, there was a .85 probability of crash involvement).
- 86 percent negative predictive power (i.e., given that a subject had a UFOV score greater than or equal to 40%, there was a .86 probability of no crash involvement).

Owsley, McGwin and Ball (1998) used a sample of drivers aged 55-87 years to identify visual risk factors for crash involvement. Based on results from a battery of visual processing tests and a comprehensive eye examination, it was found that the only significant associations with injurious crash involvement were for UFOV measures and the presence/absence of glaucoma. Looking at UFOV measures and after controlling for a range of factors through logistic regression, the odds ratios of visually impaired older drivers (as measured through the UFOV) being in injurious crashes rose from 5.2 (for a 22.5-40% UFOV reduction) to 21.5 (for a 60% or greater reduction) The reference group for these calculations consisted of drivers in injurious crashes with a UFOV reduction of less than 22.5 percent.

Owsley, Ball, McGwin, Sloane, Roenker, White, Overley and Todd (1998) used a cohort of 294 drivers aged 55 to 87 years at recruitment to identify whether visual and other measures were associated with crash involvement. Participants were recruited from all licensed drivers in an area of Alabama to ensure a specified balance in regard to age and extent of crash involvement in the previous five years. Participants were given an assessment protocol in 1990, which covered the following areas: visual sensory function, visual attention and processing speed, cognitive function and eye health, aspects of driving of driving exposure and demographic and health information. The UFOV was amongst the tests used. It was found that 56 of the older drivers were involved in at least one crash during the three years following assessment. Only one variable – provided by the UFOV – was identified as having a statistically significant association with crash risk: older drivers with 40 percent or greater reduction in their useful field of view were 2.2 times more likely to have incurred a crash during the follow-up period (95% CI, 1.2-4.1). The authors' conclusion: "With the identification of a significant visual function risk factor for an older driver's risk of crash involvement, there is reason for optimism that developing a test battery to identify high-risk older drivers is a realistic goal." (Owsley et al., 1998, p. 1085).

Road Review

The test consists of ten measures of functional capacity which can be completed in approximately 20 minutes. Six screening procedures address perceptual-cognitive abilities and four screening procedures address physical abilities. The tests are a mixture of pen-and-paper tasks, performance tasks and tasks completed by using a touch-screen computer. Participants' performance on each of the sub-tasks is classified as being 'average or above' or 'below average' according to criteria developed by the test developers. The overall score is the number of sub-tasks on which they scored 'average or above', with higher scores indicating better performance.

Staplin, Lococo, Gish and Decina (2003) studied the functional performance of 1,876 licensed drivers aged 55 years or older against three levels of crash data and three levels of convictions for moving violations. Among the crash analyses, the strongest relationships with functional status were uniformly found when examining at-fault crashes only. Six of the measures – the Motor-Free Visual Perception Test/Visual Closure subtest, Trail-making Part B, Delayed Recall, Useful Field of View subtest 2, the Rapid Pace Walk sub-test and the Head/Neck Rotation sub-test – were significantly associated with at-fault crash involvement over the time-span. Looking at both retrospective (one year only) and prospective at-fault crash involvement, statistically significant relative risks (based on peak valid odds ratios) ranged from 2.48 to 4.96. Reduced associations were also found with moving violations.

An equivalent procedure was used in a follow-up study (Staplin, Gish & Wagner, 2003), using only the six sub-tests that had hitherto shown a significant association and extending the post-test time span by an additional twelve months. Significant associations were again obtained at least for five of the sub-tests (using the authors' same criteria for statistical significance: that is, odds ratios of at least 2.0) but as a general finding, the magnitude of the individual associations had declined. The conclusion was that:

“... the predictive value of functional tests appears to decrease over time, particularly for the perceptual-cognitive measures. ... The impact of these findings on programs and policies is to underscore a need for periodic re-evaluation, spaced at the shortest practical intervals but not more than two years apart, in order for functional capacity screening to be applied effectively by licensing authorities ...” (Staplin et al., 2003, p. 389).

2.4.4 Conclusions

2.4.4.1 Age-based mandatory assessment programs

There is little evidence to support the continued existence of assessment programs of the type used by licensing authorities as a condition for continued licensing. This finding that should cause little surprise, given the at most, modest role which reduced fitness to drive is generally considered to have in the so-called ‘older driver problem’.

An implication arising from the research is that any licensing program aiming to manage the safety of older drivers can be justified only if it is restricted to sub-groups of at-risk drivers, rather than treating all older drivers as a single group. It has been shown that only low-mileage older drivers have elevated crash rates relative to other age groups, with medium and high mileage older drivers being at least as safe as drivers of other ages. As there is also evidence that the low mileage group is characterized by reduced fitness to drive, it may be that this group could be an early target for targeted assessment. However it cannot be assumed that low mileage older drivers represent a homogeneous group: for example, while some may have restricted their driving as a safety measure arising from perceived and actual driving limitations, others may drive short distances solely because of reduced travel needs.

Further, the nature of any safety management program remains open to discussion. On the one hand, the elevated individual per-distance crash risk of the lowest mileage older drivers might be regarded as unacceptably high, prompting a call for more stringent assessment as a pre-condition for further licensing. On the other hand, it

needs to be recognised that the lowest mileage older drivers represent only some 10 percent of all older drivers, accounting for only a very small proportion of the total road toll. Further, the evidence is consistent with this sub-group having already restricted their amount of driving in response to perceived and actual driving difficulties. The result of this reduction in driving is to produce a high crash risk over distance driven but a very low crash risk per licensed driver.

If it is still considered necessary to review this sub-group's capacity to continue driving, it is urged that any review be conducted through more strategic means than across-the-board age-based mandatory assessment: for example, through assessment targeting only older (and if appropriate, other) drivers who have shown some evidence of having an elevated crash risk. The licensing systems currently being developed in the US (Janke & Eberhard 1998) and in Australia (Fildes et al, 2000, 2004) are recommended as appropriate options.

2.4.4.2 On-road and off-road assessment

Clearly there are several on-road and off-road assessment protocols which have a statistically significant association with either crash involvement or driving performance. However the strength of the reported associations is often difficult to assess, particularly when expressed in terms of odds ratios. While an odds ratio can be regarded as the equivalent of a relative risk in some circumstances (namely, when the proportion of crash-involved subjects is small relative to those not in crashes), in many instances this step cannot validly be taken.

The key question tackled by Staplin et al (2003, p. 390) was: 'how much more likely is it that drivers will be involved in a crash if they fail a test than if they pass a test?' Answering this question represents a valuable and necessary first step in developing a useful assessment tool. The studies relating either on-road or off-road test performance against crash involvement, usually report only modestly elevated relative risks. Relative risks of this magnitude have little value by themselves to licensing authorities and others responsible for the management of older driver safety. With due acknowledgement to the line of reasoning followed by the OECD Working Group (see Section 2.4.1), consider the following:

Assume a driving population:	n = 300 000*
Assume the number of drivers aged 75+ years:	n = 13 000*
Assume the annual number of drivers aged 75+ years in casualty crashes:	n = 70 *
Assume 1 in 3 drivers aged 75+ years have 40% or greater reduction in their UFOV:	n = 4 300 ⁺
Assume crash risk for drivers aged 75+ years with 40% or greater reduction in UFOV:	= 2x ⁺
This means:	
Crash rate for drivers with less than 40% reduction in their UFOV	= 35/8700
	= 0.004

$$\begin{aligned} \text{Crash rate for drivers with 40\% or greater reduction in UFOV} &= 35/4300 \\ &= 0.008 \end{aligned}$$

* Based on actual licensing and crash data from an Australian jurisdiction (Tasmania).

+ As given in Owsley et al. (1998)

Assuming that drivers with 40 percent or greater reduction in their UFOV were deemed unacceptably unsafe, each year 4,300 drivers would be removed from the road to save 35 crashes – 4,265 (99%) of whom would have driven without crash involvement.

It is further argued that if performance on on-road and off-road assessment tools is to be useful to road safety practitioners and licensing authorities, the results need to be expressed not just in terms of relative risk but also in terms of specificity, sensitivity and positive and negative predictive powers, ultimately against crash risk. This additional step has been taken by Ball et al. (1993), who reported that the UFOV returned very impressive scores in regard to sensitivity and specificity for the sample of drivers used in the study. The replication of these findings using larger samples representative of the older driver population, would establish this test as a very useful instrument. However the line of reasoning demonstrated above, based in part on the Owsley et al. (1998), results in unacceptably low sensitivity and specificity measures.

Data has been made available to allow the predictive powers of DriveABLE™ In-Office Test to be calculated, against driving performance on the DriveABLE™ Road Test. The test’s strong predictive powers enable it to perform the valuable function of substituting for an actual on-road test – the ‘gold standard’ for driving capability relied upon by many licensing authorities. In the final analysis however, authorities need to be able to justify their decisions in terms of demonstrable and quantified crash risk: this remains to be done for this test.

Hakamies-Blomqvist et al. (2004) described general age-based screening of fitness to drive as a ‘Jack-in-the box’ safety measure, liable to emerge in specific situations but lacking any demonstrable safety benefits. A major reason for this ineffectiveness was:

“While certain older drivers undoubtedly have higher risk of accident than others, and in some cases for age-related reasons (such as dementing illnesses whose incidence grows with age), it is difficult to find correlations between single functional measures and risk, and even the most carefully done studies ... end up with correlations so low that they cannot be used as decision criteria.” (p. 59).

The bulk of current evidence relating to test validity based directly on crash risk, confirms this conclusion.

2.5 LICENCE REMOVAL

Fact: Removing an older person’s driving licence reduces crash risk as a driver.

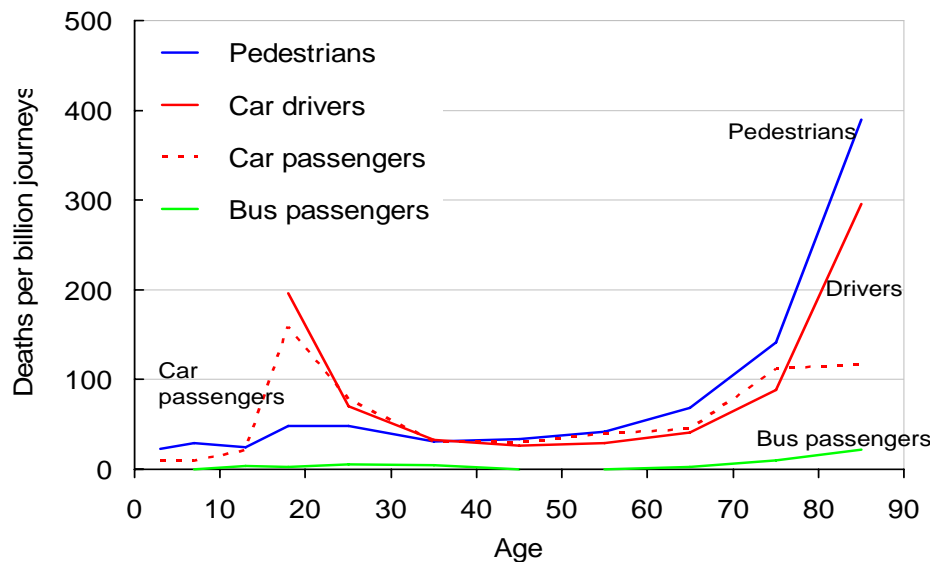
Myth: Removing an older person’s driving licence improves safety as a road user.

2.5.1 Findings from the OECD Working Group

In addition to pointing out the inability of licensing assessment programs to identify at-risk older drivers, the OECD Working Group also pointed to the likelihood of many older people being prompted to surrender their licences rather than undergo the testing process. It is axiomatic that this loss of licence effectively protects an individual against crash involvement as a driver, a factor offered as the explanation for any crash reductions that might be associated with age-based mandatory assessment programs.

It also concluded that cessation of driving might mean transferring to a riskier travel mode. This conclusion was based on two sets of evidence.

First, older people are at greater risk as unprotected road users than they are as car occupants. Figure 7 shows the fatality rates per journey for pedestrians, drivers, car passengers and bus passengers, analyzed by age and based on 1998 data from Great Britain.



Source: Mitchell, 2000 (taken from OECD, 2001).

Figure 7: Fatality rate per journey, Great Britain 1998

From the mid-50s onwards, each pedestrian trip has a greater risk of fatality than do trips as car occupants or as bus passengers – with each bus trip invariably involving at least one trip as a pedestrian. If cessation of driving results in increased trips as a pedestrian rather than as a car occupant, it follows that an individual’s overall crash involvement may increase.

The second set of evidence for contending that cessation of driving might mean transferring to a riskier travel mode, rests upon an evaluation of the licensing systems in Sweden (no age-based assessment) and Finland (mandatory age-based assessment). It was found that Finland had a higher fatality rate amongst unprotected older road users than Sweden, arguably the result of an increase in the number of older pedestrians who had lost their licences (OECD, 2001). It was concluded:

“... whatever their safety risk as drivers, older people are at greater risk of death if they walk or cycle rather than use the private car. ... The data ... allow for concluding that policies that cause old car drivers to become pedestrians or, more rarely, cyclists are likely to increase the total number of road accident fatalities. This is because travel as a pedestrian or bicyclist is more dangerous per journey than is travel as a car driver. (It should be noted, however, that a different pattern exists with regard to total casualty outcomes per journey. In that case, car trips are more hazardous than other transport modes, with the exception of cycling).” (p. 46).

2.5.2 Findings from the research: premature cessation of driving

While it is difficult to find any demonstrable safety benefits of mandatory testing, one other outcome is clear. Many drivers allow their licences to lapse rather than undergo mandatory assessment (Hakamies-Blomqvist & Wahlström, 1998; Levy, 1995). Figure 8 shows the numbers of drivers in Queensland, Australia who failed a medical assessment for licensing purposes, compared to the numbers who decided against sitting for the assessment, thereby effectively surrendering their licences (Oxley et al., 2003). In Queensland, licence renewal requires a medical assessment once every five years from the age of 75 onwards.

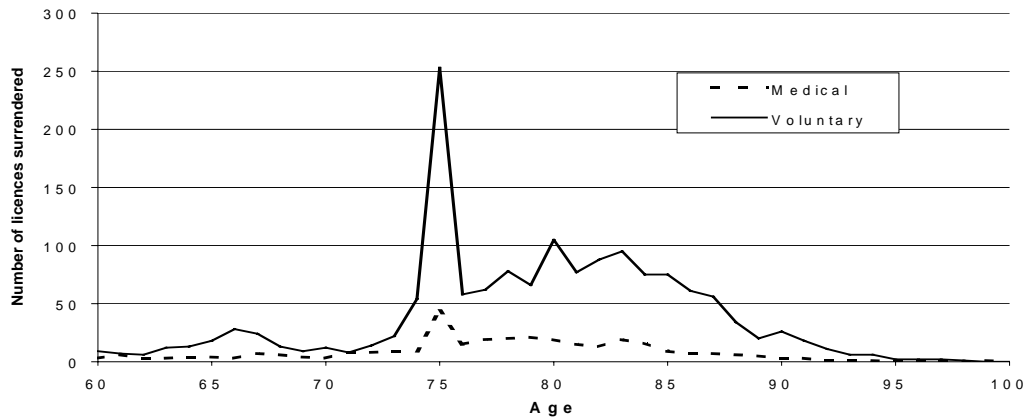


Figure 8: Number of medical and voluntary surrenders of licence in Queensland

A second Australian study (Langford et al., 2004a) also showed that jurisdictions with mandatory assessment procedures experienced a substantial drop-off in licensing rates at and after the age of assessment (see Figure 9).

Until approaching age 80, the New South Wales licensing rates were between two and five percentage points below the Victorian rates (no mandatory assessment). From near age 80 onwards (the age at which mandatory assessment procedures commenced in New South Wales), this difference immediately widens to around fifteen percentage points for most of the older age groups. At the oldest extreme, people in Victoria aged 90 or above have around four times the licensing rate relative to their New South Wales counterparts.

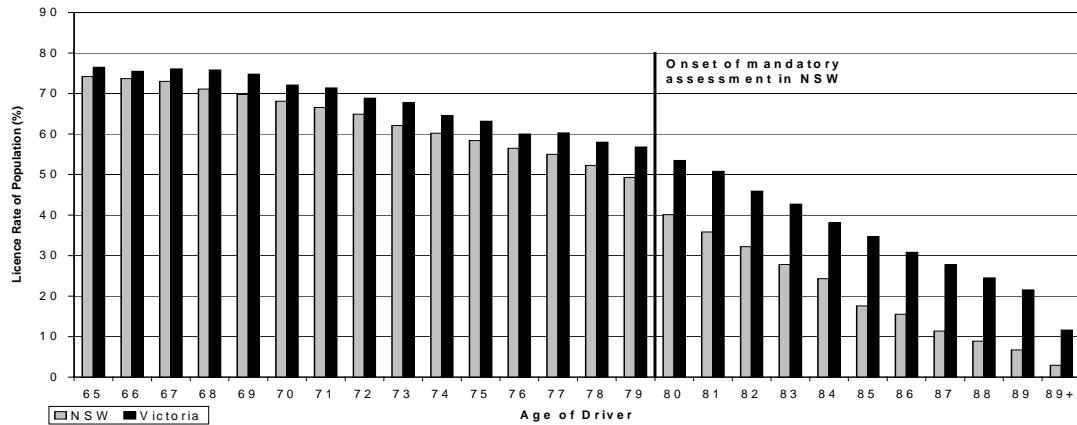


Figure 9: Victorian and New South Wales licensing rates per population

2.5.3 Findings from the research – transfer to riskier travel modes

No further research on this issue was found.

2.5.4 Conclusions

It is axiomatic that any premature cessation of driving in response to licence assessment requirements, will result in reduced risk of death or injury in a road crash, at least as a driver. However, given the review of the safety outcomes associated with mandatory age-based assessment programs in the previous section of this chapter, these reductions must be very modest. On the other hand, it is likely that those ceasing to drive and subsequently undertaking more trips as a pedestrian, could well be putting themselves at increased risk of crash involvement.

2.6 IMPACT OF LICENCE REMOVAL

Fact: Removing an older person’s driving licence results in loss of independent mobility and quality of life.

Myth: Older people who can no longer drive, can readily use other forms of transport.

2.6.1 Findings from the OECD Working Group

The OECD report also showed that for many older people, driving was the easiest form of transport to use (see Table 9).

These data suggest that there are many older people particularly from age 78 onwards, who if forced to cease driving, would have greater difficulties using other transport modes, particularly walking. A 1992-98 British travel survey reached a similar conclusion: 39 percent of people aged 65 years or older experience at least some

health-related mobility difficulties, and that driving a car was associated with the least number of problems.

Table 9: Problems using different transport modes by different age groups, Norway, 1997-98

Age groups	Problems related to walking (%)		Problems related to the use of public transport (%)		Problems related to the use of a car as a driver (%)	
	Men	Women	Men	Women	Men	Women
57-63 years	9	20	5	15	8	10
64-70 years	11	28	6	18	5	12
71-77 years	16	33	7	17	3	13
78+ years	32	47	10	27	8	18
Number of respondents	991	1097	991	1097	991	1097

Source: The Norwegian NTPS 1997-98 (taken from OECD, 2001).

In advancing a case for extending older people's driving for as long as was compatible with specified safety requirements, the Working Group provided a further argument: "... it has been well established that loss of mobility can have serious consequences for older people. Loss of independence and its adverse effects on an individual's sense of well-being may carry greater weight than any risk of harm from traffic accidents." (OECD, 2001, p. 81).

2.6.2 Findings from the research – difficulties with different transport modes

No further research on this issue was found.

2.6.3 Findings from the research – impact of cessation of driving

The OECD Working Group's claim that cessation of driving can lead to a range of detrimental consequences, including increased depressive symptoms and other social and health disadvantages, rested primarily upon two pieces of research (Marottoli, Mendes de Leon, Glass, Williams, Cooney, Berkman & Tinetti, 1997; Marottoli, de Leon, Glass, Williams, Cooney, & Berkman, 2000). There is substantial further confirmation of this position. While this issue is discussed in more detail in the following Chapter, a brief discussion is warranted here.

Forfeiture of driving privileges, whether voluntary or involuntary is considered a major loss for many older adults in terms of social identification, control and independence. Even curtailment of driving usually means relying on others for transportation, incurring potential inconveniences of public transportation, or reducing the number of trips. The prospect of reduction and ultimate cessation of driving evokes a level of fear among the elderly that seems to have a negative effect on their psychological outlook regarding their future QoL (Harper & Schatz, 1998). Most

studies have shown that coping with the loss of driving privileges can be devastating and that losing a licence can be associated with an increase in depression, loss of self-confidence and status, and in extreme cases, can lead to an early death (Persson, 1993).

2.6.4 Conclusions

A number of countries around the world now view deaths and serious injuries arising from road crashes, as morally unacceptable outcomes. Road safety practitioners elsewhere continue to regard the further lowering of the road toll as their primary professional objective. While safe travel needs always to remain as an essential goal for any society, the quest for safety needs to recognise that mobility is critical to carrying out life's activities. Continued mobility (which for many people, older and younger, means access to a private car), requires policies that achieve an acceptable balance between safety and access to critical services and amenities.

2.7 THE FUTURE

Fact:	There will be a substantial increase in the numbers of older drivers over the coming decades.
Myth:	It can be confidently assumed that they will behave the same as today's older drivers.

2.7.1 Findings from the OECD Working Group

The OECD Working Group tapped a wide range of demographic data to illustrate the greying of Western society. Figure 10 for example, shows the projected percentage of the population aged 65 years or older for all OECD member countries, 2000-2050.

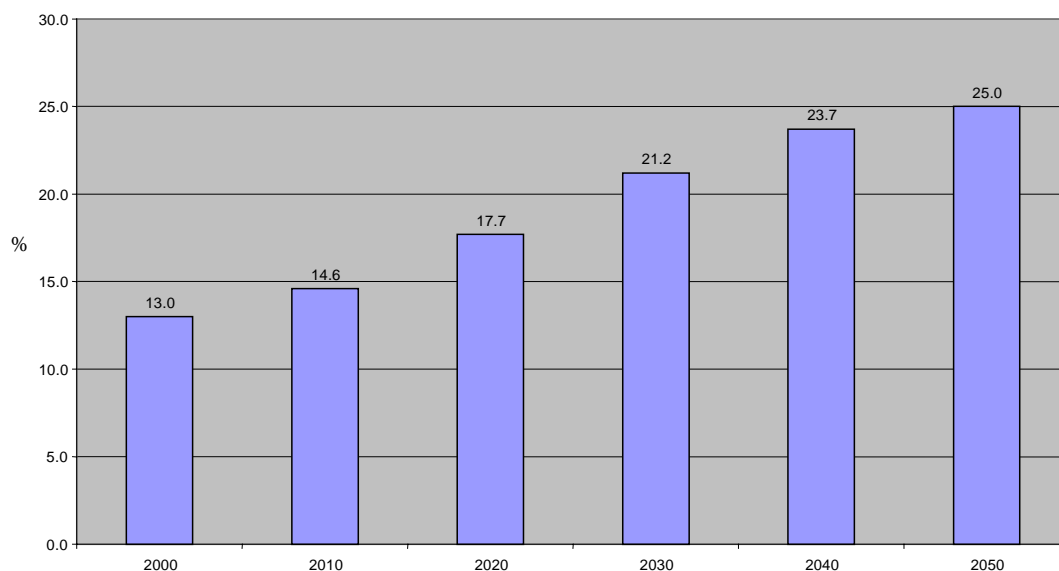
In most OECD countries the proportion of people aged 65 years or older is expected at least to double by 2050. The 'old-old' proportion of the population (those aged 80 years or more) is expected at least to triple by 2050 in most countries.

However it was noted that future cohorts of older drivers are likely to differ from today's drivers in regard to both the environment in which they will be driving and their own needs, capabilities and behaviours.

Examples of possible cohort and related differences noted throughout the report include:

- Family structures will change, with aged baby-boomers likely to have fewer (if any) children, less likely to have a spouse and less likely to have an immediate family to act as care-givers.
- Baby-boomers are likely to be more affluent, better educated, more politically active and more likely to pursue their needs vigorously – including their high expectations with regard to maintaining personal mobility.

- Baby-boomers are likely to be healthier and more active – including prolonged involvement in both employment and leisure activities.
- Baby-boomers are more likely to be licensed in their old age, more accustomed to driving their own cars and less willing to rely on other forms of transport.
- The increased spread of technology, together with future cohorts’ familiarity with it, will have wide ranging implications – from assistance with the driving task, to reduced travel needs, to more flexible and responsive alternative transport options.
- The future driving environment is likely to change (or continue to change) dramatically. Examples include: improved road infrastructure, perhaps specifically in response to older driver needs; improved vehicle crashworthiness and crash avoidance features; changes in traffic volumes and speed; and changes in the concentration of older drivers on the road.
- Baby-boomers’ crash patterns may also change – with particularly the predominance of intersection crashes being progressively pushed out to later and later ages.
- Current gender differences in older driver driving and crash patterns are likely to diminish, if not totally disappear.



Source: US Bureau of the Census, 2000, (taken from OECD, 2001)

Figure 10: Projected percentage of the population aged 65 years or older for all OECD member countries, 2000-2050

The existence of these possible differences prevents any straightforward projection of travel and crash trends based on current older drivers. While some of the differences may well act to reduce current crash rates (for example: increased health may mean

reduced driving problems while technological advances may result in reduced crashes and injuries), other factors may serve to increase crash levels (for example: increased mobility expectations and long-held reliance on the private car).

2.7.2 Findings from the research – older driver cohort differences

No further research on this issue was found.

2.7.3 Conclusions

If road safety practitioners and others are to respond adequately to the growth in the number of older people over the next few decades, a number of conditions are necessary. As a starting point, there is the need for a sound understanding of the present issues, validated as far as possible by empirical evidence. There is also the need to anticipate how those issues will appear in the future, given their interaction with emerging differences over the time span.

Current formulations of older driver safety issues are in partial accordance with these conditions. The research into the current situation proceeds and has already led to some fundamental re-shaping of many initial notions. There is widespread recognition that the emerging cohorts will be different from today's older drivers, in regard to their individual health, their expectations as they age and especially, their travel demands. However cohort studies, arguably the most effective means of identifying and responding to emerging differences, are relatively rare and currently at least, make few appearances in the research literature. This is considered to be a serious limitation in our capacity to respond proactively to the challenges and benefits of an ageing society.

2.8 SUMMARY

This Chapter has outlined seven facts and myths about the 'older driver problem' in an attempt to dispel some of the myths regarding the risks older drivers pose on the road and how their safe mobility can be managed. It is argued that, once amount and type of travel is taken into account, the majority of older drivers are at least as safe as drivers of other ages, and they are able to and can adjust their driving behaviour to suit their changing abilities, i.e., they self-regulate. However, there is a small proportion older drivers who appear to be unacceptably unfit to drive.

It is also argued that age-based mandatory assessment programs are ineffective in identifying and managing at-risk drivers. Most importantly, such programs compromise the mobility of many older drivers. Premature driving cessation, brought about by such licensing systems, result in reduced mobility and a possible safety disbenefit – those who cease driving are likely to undertake more trips as pedestrians (a much more riskier form of transport than driving).

3 METHODS TO INCREASE MOBILITY FOR THE ELDERLY

This Chapter presents the identified measures that aim to improve the safe mobility of older road users. These fall into three broad categories: behavioural and educational measures, infrastructure and road design improvements, and vehicle design improvements. Each of these groups of measures can have a positive influence on traffic participation, safety, mobility and associated QoL. As indicated previously, where applicable, the effectiveness of measures is also discussed.

Maintenance of ongoing safe mobility for older road users requires careful consideration by governments, policy makers, and the community. Older people are less mobile than the general population and the evidence suggests that many experience problems getting out and about, particularly if driving is not a viable option. It follows that the provision of safe travel options is a vital factor in maintaining their mobility. It is therefore essential to combine knowledge about the benefits of these transport modes with crash risk and vulnerability to serious injury in order to develop policies and initiatives to assist ongoing mobility.

3.1 MEDICAL AND OTHER REHABILITATION

3.1.1 Findings from the OECD Working Group

The Working Group recognized the association between ageing and the onset of numerous medical conditions which in turn could lead to driver impairment, cessation of driving and reduced mobility (both as a driver and as a user of other transport options). It also recognised that at least some of these medical conditions (including arthritis, cataract, stroke, dementia and perhaps a range of sensory conditions) could be managed so as to maintain adequate mobility and safety.

The Working Group also recommended a protocol for those disabling conditions not readily susceptible to rehabilitation, consisting of the following steps:

- Determine whether the condition has functional consequences that are relevant to mobility and the use of transport options.
- If so, determine whether functional consequences necessarily lead to increased injury risk or whether the individual can compensate for any impact.
- If substantial injury risk remains, determine and, where feasible, implement countermeasures to reduce the risk.
- If there is still a heightened injury risk, balance the costs of this risk against the cost of any consequent reduction in the individual's mobility.

The Group further claimed that older people rarely seek advice on remediation of their health status prior to altering their mobility behaviour – especially, cessation of driving. It subsequently urged that improved healthcare facilities be established to ensure maximum mobility and social inclusion in the event of medical impairment.

The Group explicitly warned against medical assessment being relied upon as a primary means to determine driving ability in most cases – arguing that the functional consequences of a condition rather than the medical diagnosis per se, determine fitness to drive.

3.1.2 Findings from the research

It is well documented that increase in age results in a subsequent increase in medical conditions and impairments, and that older adults' mobility is often compromised due to medical conditions. Approximately one-third of all people in retirement age are disabled, and it is likely that by 2030 substantial numbers of older people will be disabled in such a way that will reduce their mobility (OCED, 2001). It is therefore important to identify methods to increase the mobility of older adults with medical conditions. However the evidence for these types of interventions is quite limited. The following section reviews the evidence for medical conditions and impairments and how these impact on mobility.

Medical conditions that affect the mobility of elderly include cognitive impairment (dementia), vision impairment (cataract), diabetes mellitus, epilepsy, musculoskeletal disorders (arthritis), neurological conditions (Parkinson's disease, multiple sclerosis), psychiatric illness (depression), and respiratory disorders (emphysema) (Charlton, et al., 2004).

In their review of the influence of chronic illness and impairments on crash involvement of drivers, Charlton et al. investigated the methods that aim to manage the medical condition in order to reduce crash risk, but also to promote mobility. Whilst the review relates to all drivers, the findings still serve as a useful indicator for older drivers. They found that, contrary to what might be expected of well-established treatments, some treatments actually increased crash risk (e.g., benzodiazepines and antidepressants used to treat psychiatric disorders), whilst some actually lowered the crash risk to the same level as that of drivers without the disorder (e.g., the treatment of sleep apnoea). Other treatment measures included specific license restrictions or conditions, for example the requirement that a driver who has lost a limb is only permitted to drive whilst wearing prosthesis. However, the review generally found extremely limited evidence available on the treatment of medical conditions and their effectiveness in managing crash risk. Charlton et al., (2004) made a range of recommendations including the development of reliable methods to identify and refer those who are potentially at risk as a result of medical conditions, promote public awareness about crash risks for medical conditions, review licensing guidelines for fitness-to-drive, and investigate the role of ITS technologies to enhance driver safety.

It should be pointed out that the Charlton et al., (2004) review is concerned with the relationship between medical conditions and impairment and crash risk, which is not the same issue as the relationship between medical conditions and mobility in older adults. More research is required to understand how medical conditions and associated functional impairment affects mobility.

Glaucoma is the leading cause of vision impairment affecting two million older Americans (Owsley & Ball, cited in Adler, Bauer, Rottunda, & Kuskowski, 2005). Adler et al. conducted a survey of 52 older drivers with glaucoma and a control comparison group of 147 older drivers in order to assess how travel patterns and driving cessation is effected by glaucoma. Compared with the control group, drivers with glaucoma were significantly more likely to alter their driving behaviour and patterns with regard to night-time driving, on freeways, and in unfamiliar areas. Drivers with glaucoma did not predict that they would be forced to give up driving due to their disease.

Baldock, Mathias, McLean and Berndt (2005) assessed 90 adults' self-reported driving behaviour and also tested their functional ability using a battery of functional tests and on-road tests. Participants were aged between 60 and 91. They measured self-regulation of driving through a section of the questionnaire that focussed on avoiding certain driving situations. Of the 90 participants, 68 passed the test, 8 were recommended to have lessons, and 14 failed the test. They identified risk factors for inadequate driver self-regulation by comparing functional tests that were more strongly related to driving performance and functional tests that were more strongly related to self-regulation. They found that older drivers with poor contrast sensitivity, poor speed information processing and poor visuospatial ability were less likely to self-regulate despite that poor performance on these tasks affected driving performance. Further, drivers had a tendency to restrict their driving when they were suffering declines in visual acuity despite the lack of a relationship between visual acuity and the ability to drive.

Wood and Carberry (2004) investigated the impact of cataracts and cataract surgery on driving performance and assessed whether any changes in driving performance (assessed on a closed-road circuit) could be predicted by self-reported perceptions of vision and driving (assessed using the Activities of Daily Vision Score). Visual acuity and contrast sensitivity were also measured. Twenty-eight older drivers with bilateral cataracts and 18 age-matched controls with normal vision were assessed. For the cataract group, driving and vision performance was measured prior to cataract surgery, after surgery on the first eye, and after surgery on the second eye. The control group was assessed on three separate occasions. Participants with cataracts had significantly poorer performance on the driving circuit compared to the control group. In contrast, participants with cataracts improved significantly on the driving performance task following cataract extraction, and their performance was similar to the control group. Self-reported changes in driving performance were not strongly related to actual changes in performance on the driving circuit. These findings indicate that surgery to extract cataracts can result in a significant improvement in driving performance to levels similar to normal drivers, and these improvements cannot be predicted by self-perceived measures such as the Activities of Daily Vision Score.

One of very few studies discussing the link between medical conditions and loss of independence and mobility was by Lyman, McGwin, and Sims (2001). Specifically they assessed the association between chronic medical conditions, functional, cognitive and visual impairments and driving difficulty and behaviour in a sample of 901 Mobile County residents aged 65 and over. Those drivers reporting a history of falls, kidney disease or stroke were more likely to report difficulties driving, and thus

mobility issues. Similarly, a history of kidney disease was associated with low mileage. Further, low annual mileage was associated with cognitive impairment. They found that older drivers with a functional impairment were more likely to report driving less than 4 days per week. Lyman et al. (2001) argued that interventions should be designed to increase mobility of older adults with impairments, citing education on prevention of falls and assistance with determining ways to compensate for functional impairments as possible interventions. Overall they concluded that more research is required to understand the factors that negatively affect driving independence and mobility in older adults.

3.1.3 Summary

The research indicates that drivers suffering from medical conditions and impairments associated with glaucoma, kidney disease, stroke, falls and cognitive impairment, often to lead to a reduction in driving and a subsequent loss of mobility. Interventions including surgery on cataracts have shown a significant increase in driving performance. Education on compensatory strategies for functional performance impairments may also improve mobility. However more detailed analysis should investigate the effect of interventions on older adults' mobility.

3.2 DRIVER EDUCATION AND TRAINING

Educational and training programs designed to promote safe driving strategies for older drivers have become a popular approach for addressing the safe mobility of older drivers.

3.2.1 Findings from the OECD Working Group

The Working Group pointed out that, in many OECD countries, agencies (usually either the licensing authorities or commercial enterprises) offer refresher or re-training courses which target older drivers. Some of these courses are classroom-based, while others include referral options for detailed psycho-physical assessment and/or provide on-road refresher courses.

3.2.2 Findings from the research – education and training programs

The research suggests that there is a real need for awareness, education and training programs with a particular focus on ways older drivers can adopt safe driving practices in order to reduce crash risk and maintain mobility. Education and training to improve the driving practices of older drivers is central to current international thinking about this group's safe mobility and there is increasing international recognition of the benefits of these programs. It is claimed, for instance, that if older people are able to adopt safer driving practices, then this will have a protective effect on crash risk, will benefit mobility and there would be less need for them to have to submit to periodic licence re-testing. This would represent a substantial community saving. Moreover, there is evidence that problems related to lack of knowledge/or driving experience can be overcome through training and/or education (McKnight,

1988). This may be especially true for the current cohort of older drivers, many of whom had little formal driving education (Goggin & Keller, 1996).

In addition, in cases where training is not able to overcome the deficiency itself (for example, a medical condition), there is some evidence suggesting that education can assist older drivers compensate for the effects of the deficiency by suggesting compensation mechanisms such as minimising the amount of driving done under conditions that impose a heavy perceptual and cognitive load (e.g., avoiding extensive driving in complex environments or driving in an unfamiliar environment: Kostyniuk, Streff & Eby, 1998; Persson, 1993); enlisting the cooperation of others to help share the driving load (e.g., having a passenger navigate or read the road signs: Kostyniuk, et al., 1998; Persson, 1993); and exercising alternatives to reduce perceptual and cognitive load (e.g., using less-travelled roads: McKnight, 1988).

Here, current older driver training and self-assessment resources which attempt to identify and overcome specific problems or deficiencies experienced by older drivers by actually correcting them, or to help older drivers identify their problems and learn how to compensate for them are reviewed (see Table 10). A more detailed description of the older driver re-training programs is outlined first, followed by a description of older driver self-assessment instruments.

The 55-Alive/Mature Driving program developed by the American Association of Retired Persons (AARP) was the first comprehensive nationwide program designed to address the special needs of older drivers (Seaton, 1979). This program was developed as an eight-hour driver improvement/classroom refresher course in response to older drivers' lack of information, because many began driving prior to the testing process for licensure (Hunt, 1993). The program provides drivers aged 50 and older with information about the effects of aging on driving, compensation techniques, rules of the road, and defensive driving techniques. Several evaluations have been conducted on the program's effectiveness. In 1982, McKnight, Simone and Weidman randomly divided volunteers into two groups: one group received the AARP training right way and the other served as the control group, receiving their training only after the evaluation was finished. The authors found that drivers who received the training had significantly higher knowledge scores compared to the control group and that it was retained during the entire evaluation period (14 months). However, there were no significant differences in self-reported traffic crashes (verified through police reports) between the trained and untrained participants.

Bédard, Isherwood, Moore, Gibbons and Lindstrom (2004) evaluated the 55-Alive program of the AARP that had been adapted for Canadian drivers by the Canadian Safety Council. Specifically, the authors were interested in whether older drivers who received the training would have better scores on a driving evaluation than drivers who did not receive the training. After completing the cognitive screening, 65 participants aged 55 years and older completed an on-road driving evaluation (where possible scores ranged from 0 to 100), after which they were block randomized into training (treatment) or waiting (control) groups based on the baseline driving evaluation scores, age, and gender. Participants in the treatment group attended two half-day sessions covering topics such as self-assessment, vision/ hearing, normal driving situations, hazardous driving environments, the vehicle, alcohol and medication, and driver decisions. After the driver re-training sessions, participants were tested once more with the on-road test. Those in the control group completed

their second driving evaluation and were then offered the re-training sessions. The second evaluations took place approximately two months after the first evaluations. The authors reported an increase in the driving scores of participants between the first and second evaluations. However, the difference between the control ($M = 3.46$, $SD = 6.72$) and intervention groups ($M = 4.02$, $SD = 7.11$) did not reach statistical significance ($t [63] = 0.32$, $p = 0.747$); both groups improved. The authors noted a statistically significant inverse relationship between baseline scores and change driving scores ($r [63] = -0.42$, $p = 0.001$); participants who scored lower at baseline experienced greater improvements at follow up. The authors concluded that although they were not able to demonstrate a statistically significant impact of the intervention, the overall increase in driving scores suggests that an initial driving evaluation may underestimate the actual driving ability of many older drivers. Furthermore, although older drivers may have lower driving scores initially, they have the ability to improve on these scores. The authors suggested that these findings should encourage us to explore diverse approaches to improve driving safety.

Most recently, Bédard, Porter, Marshall, Polgar, Weaver and Riendeau (2006) evaluated an older driver re-training program that combined the 55-Alive program and two on-road training sessions with a driving instructor. In this study, drivers aged 65 years and over were stratified according to age, gender and baseline driving evaluation scores (based on a standard government licensing exam), and then randomly assigned to a wait-list control group or an intervention group. Participants in the intervention group took part in two half-day seminars emphasising safe driving (based on the 55-Alive program) and had two forty-minute on-road training sessions with a licensed driving instructor, in their own vehicle. The intervention group also completed a short quiz regarding safe driving issues at the beginning and end of the seminar sessions (maximum score = 15, where higher scores are better) to determine their knowledge change. All participants then completed the on-road evaluation (based on demerit points, where lower scores are better). The authors reported that the intervention group had a reduction of 40.5 demerit points on the on-road evaluation, whereas the control group only had a reduction of 17.5 demerit points. In terms of those participants who participated in the seminar sessions, the mean quiz scores increased from 66 percent at the beginning of the seminar to 86 percent at the end of the seminar. The authors concluded that the combination of an in-class and on-road education program improved knowledge of safe driving issues and actual driving in many older drivers, and therefore these results suggest that some older drivers are not currently driving at their optimal level. The authors suggested further work to determine if drivers who improved their driving skills go on to experience a reduction in their actual crash risk.

The Safe Driving for Mature Operators program, developed by the American Automobile Association (AAA) in 1986, provides general driving-instruction material, as well as tests for night vision, ability to see under glare conditions, and reaction time. Consisting of three half-day sessions, it is the only program that provides advice on specific techniques for improving driving performance and provided an opportunity to practice these techniques in actual traffic during the final session (McKnight, 1988). The effectiveness of the SAFE Driving for Mature Operators program was assessed as part of an evaluation of several countermeasures to improve driving performance of older drivers, including physical therapy, perceptual therapy, driver education, and traffic engineering improvements (see

Ashman, Bishu, Foster & McCoy, 1994). The program resulted in an overall improvement in driver performance of 7.9 percent, as measured by driver performance on the road. However, relatively small subgroup sizes within an overall sample of 94 make it difficult to reach meaningful conclusions based on these results.

In 2004, Owsley, McGwin, Phillips, McNeal, and Stalvey conducted a randomised controlled study to determine whether an individualised educational program that promoted strategies to enhance driver safety reduced the crash rate of high-risk older drivers. The authors defined high-risk drivers as drivers with a visual impairment, at least moderate levels of driving exposure and had a recent crash. A total of 403 drivers aged 60 and older were randomly assigned to usual care (comprehensive eye examination) or usual care plus an individually tailored and administered educational intervention promoting safe driving strategies. The authors reported that the intervention group did not differ significantly from the usual care group in terms of their crash rate per 100 person-years of driving (RR: 1.08, 95% CI: 0.71-1.64) and per 1 million person-miles of travel (RR: 1.40, 95% CI: 0.92-2.12). The intervention group reported more avoidance of challenging driving manoeuvres and self-regulatory behaviours during the follow-up than did the usual care only group ($p < 0.0001$). The authors concluded that consistent with the findings from the earlier study by McKnight et al. (1982), the educational program did not enhance driver safety, although it was associated with increased self-regulation and avoidance of challenging driving situations and decreased driving exposure by self-report.

Another type of older driver training involves the speed of processing (Staplin & Hunt, 2004). There is an abundance of evidence that older adults' visual-processing speed can benefit from perceptual and/or speeded task training (Kramer, Larish & Strayer, 1995; Kramer, Larish, Weber & Bardell, 1999). For example, Roenker, Cissell, Ball, Wadley and Edwards (2003) recently evaluated the effects of UFOV training on older adults' driving performance. In this study, drivers aged between 55 and 86 years participated in either a: speed-of-processing training program ($N = 48$), a traditional driver training program performed in a driving simulator ($N = 22$), or a low-risk reference group ($N = 25$). Before training, immediately after training or an equivalent time delay, and after an 18-month delay, each participant was evaluated in a driving simulator and completed a 14-mile (22.5-km) open-road driving evaluation. The results showed that the speed-of-processing training, but not simulator training, improved a specific measure of UFOV, transferred to some simulator measures, and resulted in fewer dangerous manoeuvres during the driving evaluation. The simulator-trained group improved on two driving performance measures: turning into the correct lane and proper signal use. Similar effects were not observed in the speed-of-processing training or low-risk reference groups. The authors concluded that the findings from their study confirm the link between processing speed deficits to driving performance failures by older drivers. In addition, the authors concluded that their data suggest that these processing deficits can be ameliorated through speed of processing training and that this improvement results in safer driving behaviours that are durable for at least 18 months.

The team at MUARC has recently commenced a study to develop, trial and evaluate an innovative awareness, education and training package aimed to improve the adoption of safe driving practices and therefore improve mobility amongst older drivers in Australia. The package will incorporate three complementary components,

i) a one-day workshop/group presentation, ii) a supporting educational booklet, and iii) computer-based self-assessment and/or training tools for older drivers. The three components will, collectively, be designed to:

- Raise awareness amongst older drivers of the issues surrounding older driver safe mobility.
- Provide information on the effects of ageing on driving performance and crash risk.
- Inform older drivers about ways that they can maintain safe driving (addressing issues specific to both male and female drivers).
- Identify tools suitable for use in group workshops for self-assessment of functional abilities and driver re-training in skills.
- Provide information on reduction and cessation of driving and alternative transport options.

3.2.3 Findings from the research – self-assessment

For the older driver who seeks to independently examine his or her own skills, or is encouraged by family members or other concerned individuals to do so, there are several self-assessment instruments available (Eby, Trombley, Molnar & Shope, 1998). Self-assessment instruments offer many potential benefits to older drivers. The greatest potential benefit is that the self-assessment is conducted in an environment chosen by the individual, providing both a confidential and non-threatening source of information about the individual's ability to drive. As such, those who may be resistant to having their abilities assessed by someone else may be more willing to engage in self-assessment. The self-assessment process may also facilitate discussion within families about older driver mobility. Because self-assessment instruments must be easy to use without outside help, people may use the assessment instrument and get feedback more frequently, and thus be more likely to discover deficits at an earlier stage.

The two most widely distributed self-assessment instruments are paper and pencil tests that are designed to increase self awareness of driving abilities, and to educate and motivate drivers to adopt compensatory driving strategies, if necessary. The first of these, created by the AAA Foundation for Traffic Safety, is called Drivers 55 Plus: Check Your Own Performance (based upon research by Malfetti & Winter, 1987). This self-assessment is a 16-page booklet comprising three sections. The first section contains 15 self-report questions regarding driving behaviours, vision and health. The second section instructs drivers on how to compute a composite score for the survey and explains what the score means. The third section, the majority of the booklet, consists of suggestions older drivers can use to improve their driving performance. Discussion in these sections is organised around the 15 survey questions and includes several related safety tips. Also included are recommendations for restricting driving and warnings for older drivers to prepare for the day when they can no longer drive.

The second self-assessment instrument is distributed by the AARP and is called Older Driver Skill Assessment and Resource Guide: Creating Mobility Choices. The AARP's (1992) self-assessment is a 24-page booklet that combines survey items and hands-on, self-administered tests. For example, visual search time is tested by a self-timed exercise (Trail Making A). The instrument is organised into sections that allows self-assessment of reaction time, attention, vision, near-crash experiences, and driving behaviour. Throughout the instrument are educational statements that inform readers about automotive safety equipment and tips for safer driving. Also included are tips for vehicle maintenance, self-restriction suggestions, and safe driving-related behaviours. The booklet concludes with information about the AARP 55 Alive driver retraining course (described earlier) and a list of telephone numbers for transportation departments, motor-vehicle divisions, and agencies for the ageing in each State.

An extensive search of the literature revealed that the validity and effectiveness of these two self-assessment instruments in educating older drivers or improving traffic safety have never been evaluated.

A more recently developed self-assessment instrument for older drivers is the Driving Decisions Workbook (Eby, Molnar & Shope, 2000). The workbook has two purposes: First, for drivers willing and able to assess their own driving abilities, the workbook can provide feedback for making good driving decisions by increasing self-awareness and general knowledge, and by suggesting appropriate driving restrictions and clinical evaluations. Second, it can increase general awareness of age-related declines in driving abilities for generating discussion with peers and within families. The workbook was developed by the authors to improve on the existing AAA and AARP instruments. First, the authors expanded the scope so that the instrument covered not only vision, cognition, reaction time, crashes, and traffic citations, but also medical conditions and medication use, while also providing more detail on driving-related issues. Second, the paper-and-pencil workbook format allows users to answer questions on various topics and receive immediate feedback, based on their individual answers – thus avoiding the need to calculate scores (as in AAA's instrument) or self-administer diagnostic tests (as in AARP's instrument). Third, the questions are organised to allow easy discovery of potential problems by grouping questions related to a certain assessment area together on a single page, as well as grouping related assessment areas in close proximity. In this way, drivers may be able to discover problem areas that would not be readily apparent through a different organisational structure.

In 2003, Eby, Molnar, Shope, Vivoda and Fordyce assessed whether the Driving Decisions Workbook increased self-awareness and general knowledge among 99 licensed drivers aged 65 years and above. A secondary aim of the study was to determine if problems identified by drivers in the workbook related to problems they had with actual driving. The workbook was administered along with a questionnaire and a road test. After completing the workbook, the majority of participants (77%) indicated that they were more aware of changes that can affect driving. In addition, 14 percent reported that they had discovered a change in themselves of which they had not been previously aware. The correlation between the overall workbook score and the overall road test score was positive and statistically significant ($r = 0.30$, $p < 0.05$): As the number of potential problem areas identified by the workbook increased, the number of problems observed during the road test also increased. The authors

suggested that the workbook may be a useful self-assessment and educational tool for older drivers, in that it may encourage them to drive more safely and/or to seek clinical assessment.

The final older driver self-assessment instrument identified in the literature is the AAA Roadwise Review: A Tool to Help Seniors Drive Safely Longer (Sherrets & Staplin, 2006). This instrument was designed to provide an initial screening to older drivers who may have a concern about their driving abilities but question whether they require an in-depth assessment. Available on CD-ROM, this tool allows older individuals to measure in the privacy of their own home the eight functional abilities shown to be the strongest predictors of crash risk among older drivers. The abilities tested in Roadwise Review include:

- Leg Strength and General Mobility – necessary to control acceleration and braking.
- Head/Neck Flexibility – essential in checking blind spots, lane changes or merging.
- High Contrast Visual Acuity – needed to identify pavement markings, as well as detect many types of hazards in or near the road.
- Low Visual Acuity – vital for driving in low visibility conditions such as dusk, rain or fog.
- Working Memory – important in following directions, remembering traffic rules and regulations, and using information on highway guide signs.
- Visualization of Missing Information – helps a driver recognize hazards even when seeing only part of the picture.
- Visual Search – safe driving requires the ability to quickly find and recognize traffic signs and landmarks.
- Useful Field of View – ensures drivers can pay attention to what is happening right in front of them while also noticing safety threats at the edge of their field of view.

At the conclusion of each of the eight skill tests, a summary of results is displayed along with advice as to what the older driver should do. Depending on the level of impairment, a user may be referred to a physician, occupational therapist or certified driving rehabilitative specialist. For example, poor results on a vision test might suggest visiting an optometrist. If the older driver does not have a measurable loss in safe driving ability, he/she will be asked to use their results as a baseline against which they can measure future changes in driving health.

The authors have reported that drivers with a significant loss in the functional capabilities tested by Roadwise Review are 2 to 5 times more likely to cause a motor vehicle crash than drivers without losses in these key safe driving abilities.

The value in promoting self-regulation and an awareness of changing functions amongst older drivers particularly through developing instruments to assist in self-assessment or self-screening, has been recognized by many workers in this area. However, as warned by Molnar and Eby (2005) and Staplin, Lococo, Stewart and Decina (1999) individuals can only use self-assessment instruments if they are free of any serious cognitive impairment. Since cognitive impairment is likely to be related to elevated crash risk in the older population (Foley, Wallace & Eberhard, 1995; Stutts, Stewart & Martell, 1998), some people in need of assessment may not be able to self-assess. An additional limitation is that users must be motivated to answer questions honestly and consider the feedback seriously. Lack of motivations could prevent self-assessment by many of those in need of assessment. Another limitation of self-assessment is that whenever people are asked to self-report about themselves, accuracy can be compromised for a number of reasons. Inaccurate responses may lead to inappropriate feedback from the self-assessment.

Table 10: Summary of older driver educational, training and self-assessment resources

Name	Format/Type	Target Audience	Description	Source/Availability
Older Driver Education Programs				
AARP 55-alive/Mature Driving Course	Driver improvement/ education workshop & Website	Older drivers (50+ years)	Eight-hour education program designed to provide older drivers with information about effects of ageing on driving, compensation techniques, rules of the road, and defensive driving techniques.	www.aarp.org/families/driver_safety/driver_ed/
AAA: Safe Driving for Mature Operators Course	Driver improvement/education workshop and Website	Older drivers	Eight-hour sessions covering ageing effects on driving and reviews safe driving practices (looking far ahead, signalling, leaving a safety margin, a review of signs, signals and pavement markings, use of safety belts, and effects of medicine and alcohol on driving)	www.aaapublicaffairs.com/Main/Default.asp?SectionID=&SubCategoryID=6&CategoryID=3&ContentID=107&
Mature Driver Retraining Workshop (Traffic Improvement Association)	Driver improvement/education workshop and Website	Older drivers (55 + years)	Eight-hour driver safety course with optional on-road driving test. Program consists of a classroom review using 'AAA Safe Driving for Mature Operators' course material and psychophysical testing to allow individual to evaluate his/her own abilities. Psychophysical testing includes simple reaction time; visual capabilities (acuity and depth perception) and visual attention (UFOV). Within the driving course, instructor provides feedback on possible problem areas in the driver's driving behaviour and offers suggestions for improvement.	www.tiami.org/maturedriver.asp
National Safety Council Defensive	Driver improvement/education workshop and	Older drivers (55 + years)	Coaching the Mature Driver was developed specifically to teach older drivers defensive driving techniques how to compensate for the	secure.nsc.org/train/course.cfm?id=88

Driving Course: Coaching the Mature Driver	Website		physical and cognitive changes	
Driver Self Assessment Tools				
AAA Drivers 55 Plus: Check Your Own Performance	Self evaluation booklet	Older drivers	16-page booklet contains 15 self-report questions regarding driving behaviours, vision & health. Booklet also consists of suggestions older drivers can use to improve their driving performance. Discussion in these sections is organised around the 15 survey questions and includes several related safety tips. Also included are recommendations for restricting driving and warnings for older drivers to prepare for the day when they can no longer drive.	www.aaafoundation.org/home/
AARP Older Driver Skill Assessment and Resource Guide: Creating Mobility Choices	Self evaluation booklet	Older drivers	24-page booklet that combines survey items and hands-on, self-administered tests. Throughout the instrument are educational statements that inform readers about automotive safety equipment and tips for safer driving.	www.aarp.org
Driving Decisions Workbook	Self evaluation booklet	Older drivers	Goal of the workbook is to increase driver's self-awareness and general knowledge about driving-related declines in abilities, and recommend compensation and remediation strategies for extending safe driving	www.umtri.umich.edu/library/pdf/2000-14.pdf
AAA Roadwise Review: A Tool to Help Seniors Drive Safely Longer	Interactive CD-ROM, instruction book	Older drivers; rehabilitation specialists	User-friendly software for older adults to test their own performance at home on measures of functional ability validated as predictors of at-fault crashes. Provides personalised feedback based on results and how to seek additional help	www.aaapublicaffairs.com/

3.2.4 Summary

Despite calls for increased attention to older driver training and education needs, and the growing popularity of approaching older driver safety through education and training, evaluations of older driver education and skill enhancement programs are limited and quite varied in content. In order to increase the mobility of the elderly, the Working Group pointed out that the elderly need to be informed of the following issues:

- How to and where to seek alternative transport options.
- The decline in sensory and cognitive abilities, mental impairment, and problems coping with traffic and the effect of illness on mobility.
- The effect of alcohol, drugs and prescribed medication on driving ability.
- Optional extras or special features to consider when choosing a car (such as powered mirrors).

Based on the evidence reviewed, other information to incorporate into a 'skills/education' package could include:

- Information regarding vehicles' crashworthiness.
- Information regarding the benefits of vehicle safety features, such as airbags and electronic stability programs (ESP).
- Information regarding the benefits of intelligent transport systems, such as route navigation systems, night vision enhancement systems etc.
- Information to assist older drivers to make good driving decisions by increasing self-awareness and general knowledge, and by suggesting appropriate driving restrictions and clinical evaluations.

The Working Group also pointed out that the design of training courses should acknowledge that the elderly are a heterogeneous group. Training courses should therefore:

- Take into consideration the various road user groups (e.g. motorists, cyclists, pedestrians).
- Be designed based on locality (designing courses within a specific locality).
- Take into consideration gender, and age differences in the mobility of the elderly population.

3.3 SAFER VEHICLES

This section describes opportunities for reductions in older occupant fatalities and serious injuries and improved older driver mobility through improved vehicle crashworthiness, vehicle adaptations and in-vehicle ITS developments.

3.3.1 Findings from the OECD Working Group

The Working Group recognised that increased physical frailty and hence vulnerability to injury in the event of a crash, was an almost inevitable component of ageing. Accordingly, it stressed the need for older drivers and their passengers to be in vehicles with the maximum crashworthiness – which meant both special features (for example seat belts and airbags) and ideally, larger vehicles. It was also recognised that older occupants, because of their frailty, would benefit from the latest technological developments: for example, intelligent restraint systems able to adjust for lighter and older occupants, dual-stage airbags to reduce the impact of airbag aggressivity and active head restraints to minimise whiplash and other injuries.

The Working Group anticipated that impending improvements in older people's health notwithstanding, there will be substantially increased numbers of disabled older people seeking to remain mobile. Key means to maintain maximum mobility through continue driving included:

- Adapting the basic design and features of the private vehicle to better accommodate older drivers generally and specifically those with particular impairments. A wide range of options were considered – ranging from altering the doorframe height, width of door aperture, seat height, door sill height, floor-well depth and provision of swivel seats to allow better entry and exit; features to make driving easier such as power steering, automatic transmission and easier adjustment of the seat, steering wheel and mirrors; and use of specific adaptive equipment such as a steering wheel knob and special mirrors.
- Improved design of public transit vehicles and taxis, especially to better allow for older passengers' difficulties in entering and leaving these vehicles (including more extensive provision of hand-holds and use of ramps and lowered floors).

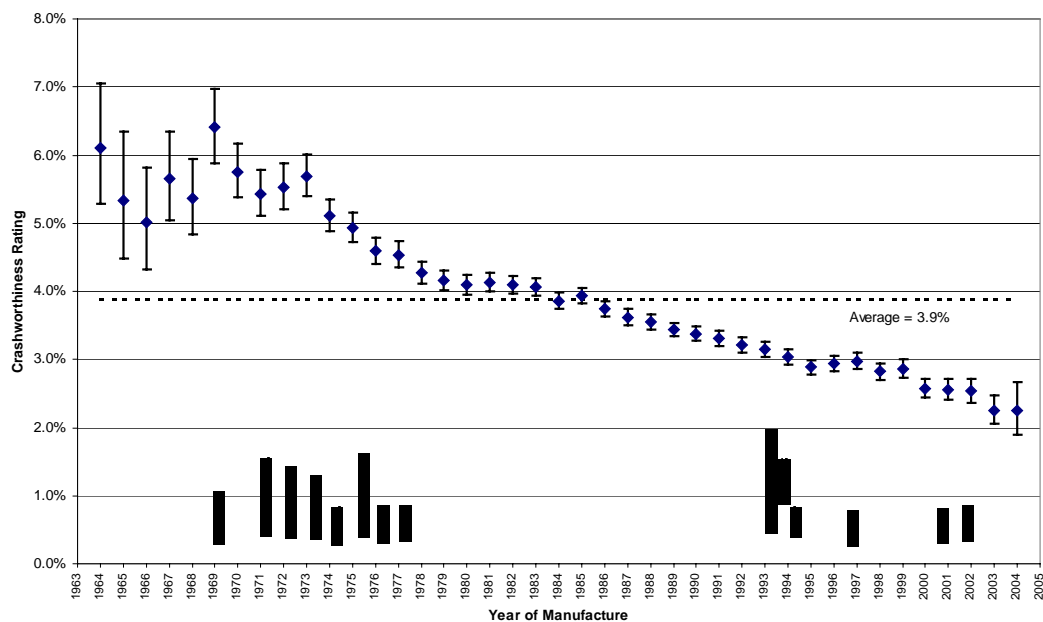
The Working Group also pointed to the ongoing role that technology could play in achieving the optimum balance between mobility and safety for older people as car drivers. Looking specifically at in-vehicle ITS technologies, the report pointed to a range of crash-avoidance and other options, including improved sensing systems, intelligent cruise control, enhanced visual imaging, route guidance systems and automated in-vehicle emergency call ('Mayday') units. It also warned that these technologies would need to be tailored to the changed abilities and preferences of older drivers rather than be set at a standard younger-driver level.

3.3.2 Findings from the research – crashworthiness and occupant protection

Vehicle crashworthiness has significantly improved over the past 40 years (Newstead, Watson & Cameron, 2006). The crashworthiness estimates and their confidence limits are plotted for each year of manufacture in Figure 11.

Figure 11 shows general and significant improvement in vehicle crashworthiness with increasing year of manufacture over the years considered. Specifically, little improvement can be seen in the years 1964 to 1969 followed by rapid improvement over the period 1970 to 1978 with a plateau from 1979 to 1985. Significant gains were measured over the period 1985 to 1995 with a further plateau from 1995 to 1999. There is evidence of further

significant gains from 2000 with vehicles manufactured over the period 2000 to 2004 being statistically significantly safer on average than those manufactured before 1999.



Source: Newstead et al., 2006

Figure 11: Crashworthiness by year of manufacture (with 95% confidence limits)

Older driver crash data suggests that injuries involving rib and sternum fractures and chest complications are more common among older car occupants (OECD, 2001). In their current state of development, seat belts are beneficial, overall, to older occupants. However, in some crash circumstances, they may also contribute to the incidence of chest injuries (Fildes & Charlton, 2004). Recent developments suggest that this drawback is well on its way to being resolved, by the use of a ‘force limiting feature’, which controls the maximum restraining force exerted by the shoulder belt (OECD, 2001).

In addition, crash data suggesting that older drivers may be particularly vulnerable to injury from impact with the steering wheel have prompted the development of driver airbags to mitigate life-threatening injuries. Airbags are designed as a safety supplement to seat belts and especially to provide additional protection against injury from the steering wheel. The effectiveness of airbags in mitigating severe injuries and the substantial reduction in harm associated with their use (Fildes, Deery, Lenard, Kenny, Edwards-Coghill & Jaconsen, 1996) is likely to be even greater for older drivers given their increased frailty (OECD, 2001).

Given older drivers’ additional needs for protection in the event of a crash due to their frailty, the purchase of modern vehicles with maximum occupant protection is a paramount countermeasure. One option, therefore, to improve older car occupants’ safety in a crash is to ensure they are in a superior crashworthy vehicle. It is apparent that a more recent car (with improved safety technology such as airbags and better safety belt systems) offers increased potential for them to avoid severe injuries in a crash. However, it appears that this policy is not currently followed by older drivers. In an analysis of fatal crashes in Australia 1996-1999, for example, drivers aged 75 years and older were more likely to be driving older vehicles; 51 percent of older drivers in fatal crashes were known to be in cars 11 years or older, compared to 30 percent of middle-aged drivers (Langford et al., 2006).

A survey of Victorian older drivers (Charlton, Andrea, Fildes, Oxley, Morris, Langford & Johnson, 2002) identified factors that influenced older drivers when purchasing a vehicle. They reported that features related to comfort and ease of driving were important to older drivers, as was vehicle handling. Most importantly, they reported that safety features that improve occupant protection in a crash were poorly understood and misconceptions about features such as airbags were common. The authors concluded that there was a need to address gaps in knowledge and misconceptions and to encourage older drivers to purchase vehicles that have the potential to reduce frequency and severity of injury outcomes and maintain mobility for older drivers. Langford and Oxley (2006) added that stronger promotion of crashworthiness as a key factor in purchasing a vehicle represents a meaningful passive measure to maintain safe mobility amongst older drivers. Indeed, new car assessment programs such as EuroNCAP in Europe and ANCAP in Australia that test the crashworthiness of most major current car models by conducting barrier crash test under laboratory-controlled conditions may include a component that targets older drivers.

3.3.2.1 Vehicle Mass

The effect of vehicle mass on crashworthiness in frontal crashes is well documented (Evans, 1994). Newtonian physics dictates that impact force in a crash is a function of a vehicles travel speed (squared), its mass and the mass of other vehicles it strikes. Occupants in a vehicle with a mass of 800kgm that hits another head-on at the same travel speed but with a mass of 1600kgm will experience twice the impact force than those in the heavier vehicle, all things being equal (Fildes & Charlton, 2004).

These benefits are expected to be even greater for older occupants. Another solution, therefore, to improve the risk of serious injury in a crash for older people is to travel in the heaviest vehicle they can handle and afford. Obviously, this has other implications in terms of environmental effects, price, ease of driving and difficulties in manoeuvring and parking (Fildes & Charlton, 2004). Nevertheless, there's no escaping the mass effect when involved in a crash (Evans, 1991).

In addition to the force-limiting seat belts and supplementary airbags, advances likely to be especially relevant for older occupants include (Pike, 1989):

- Intelligent restraint systems that are capable of adjusting for lighter, older occupants.
- Dual-stage airbags to minimise aggressive airbag contacts in moderate crashes.
- Integral seat and seat belts to optimise fit of the belt to the occupant.
- Active head restraints to minimise soft tissue injury to the neck.
- Side airbags to protect head and chest in a side collision.
- Active head restraints to minimise whiplash injuries to the neck.
- Floor structural improvements and airbags to better protect the ankles and feet.

3.3.3 Findings from the research – vehicle adaptations

Vehicle designers have predominantly focussed their vehicle designs around young adult anthropometry and performance, which means that often the ergonomic specifications of modern vehicles do not necessarily take into account the needs of older people (Charlton, Fildes & Andrea, 2002). The OECD Working Group (2001) identified a wide range of vehicle adaptations that could better accommodate older drivers in general, as well as those older drivers with age-related functional impairments, and therefore enable older drivers to maintain their mobility for longer. These vehicle adaptations include:

- Altering the doorframe height, width of door aperture, seat height, door sill height, floor-well depth and provision of swivel seats to allow better entry and exit for older occupants.
- Altering driving features to make driving easier such as power steering, automatic transmission and easier adjustment of the seat, steering wheel and mirrors; and use of specific adaptive equipment such as a steering wheel knob and special mirrors.

In addition, the Working Group recognised that older people often use other types of vehicles and therefore there is a need for improved design of public transit vehicles and taxis, especially to better allow for older passengers' difficulties in entering and leaving these vehicles (including more extensive provision of hand-holds and use of ramps and lowered floors).

3.3.4 Findings from the research – crash avoidance strategies

The most effective way to avoid older occupant injuries is to prevent the crash in the first place. To date, most in-vehicle interventions have focussed on preventing injury through improved crashworthiness, but certain means of increasing the ability to avoid a crash have been introduced.

In order to identify potentially useful in-vehicle interventions or equipment for older drivers, Suen & Mitchell (1998) listed the known impairments and associated driving problems that drivers tend to develop as they age and possible interventions or equipment to address these problems (see Table 11).

In addition, as noted by Langford and Mitchell (2003), with the further development of ITS applications, it is likely that other technologies are likely to be beneficial for older drivers. For example, Intelligent Speed Adaptation devices may be beneficial to older drivers, both through preventing other drivers using excessive speeds that mislead older drivers at intersections, and also by reducing speed automatically on the approach to 'give way' and 'stop' signs at junctions. Similarly, the development of small, low cost, radars for road vehicles will make possible a range of systems for obstacle detection, headway control and collision warning that should have great potential for older drivers.

In looking to in-vehicle ITS options as a potential solution to the older driver safety problem, it is also necessary to look at specific aspects of older driver crashes to determine if these in-vehicle interventions or equipment options could be used efficiently to reduce older driver's crash risk. In 2003, Langford and Mitchell examined the 1999 Australian crash fatality file (Australian Transport Safety Bureau) to identify aspects of older driver (aged 75 years and older) crashes which could potentially be controlled by in-vehicle ITS

systems. The results are provided in Table 12, with older drivers compared to drivers aged 40-55 years.

Table 11: Age-related impairments, driving problems and in-vehicle interventions or equipment assistance

Age-related Impairments	Driving Problems	In-vehicle interventions or equipment assistance
Increased reaction time, difficulty dividing attention between tasks	Difficulty driving in unfamiliar or congested areas	Navigation/route guidance
Deteriorating vision, particularly at night	Difficulty seeing pedestrians and other objects at night, reading signs	Night vision enhancement, in-vehicle signs
Difficulty judging speed and distance	Failure to perceive conflicting vehicles, crashes at intersections/junctions	Collision warning, automated lane changing
Difficulty perceiving and analysing situations	Failure to comply with yield signs, traffic signals and rail crossings, slow to appreciate hazards, difficulty in complex traffic manoeuvres, such as lane changing and merging	In-vehicle signs and warnings, intelligent cruise control, automated lane changing and merging
Difficulty turning head/neck, reduced peripheral vision	Failure to notice obstacles while manoeuvring/reversing, lane excursion, difficulty merging and lane changes	Blind spot/obstacle detection, rear collision warning, automated lane keeping, changing and merging
More prone to fatigue	Get tired on long journeys	Intelligent cruise control, Automated lane following
General effects of aging	Concerns over inability to cope with a breakdown, driving to unfamiliar places, at night, in heavy traffic.	Emergency callout (mayday), vehicle condition monitoring
Some impairments vary in severity from day to day. Tiredness	Concern over fitness to drive	Driver condition monitoring

Table 12: Aspects of older driver crashes and ITS implications, Australia

Crash Aspects	% of older drivers	% of drivers (40-55 yrs)	In-vehicle ITS Implications
More likely to be responsible (multi-vehicle crashes)	84.7	32.7	Suggests that reducing older driver errors through ITS facilities will have substantial crash savings.
More likely to involve 'failure to see other road user' (responsible drivers in multi-vehicle crashes)	54.0	15.4	Front, rear and side collision warning devices relevant.
More likely to occur at intersection	64.0	21.2	Front, rear and side collision warning devices relevant. Note also an in-the-pipeline vehicle/infrastructure system, whereby a driver approaching an intersection is warned whether the next gap in the on-coming traffic is sufficient to allow crossing that stream into a side street (Oxley 1996).
More likely to involve attempted right-hand turn (responsible drivers in multi-vehicle crashes)	36.0	7.7	
More likely to occur during daylight hours (responsible drivers in multi-vehicle crashes)	92.0	73.1	Vision enhancement systems may have limited relevance while current driving patterns persist.
More likely to be killed once in a fatal crash (all drivers in crashes)	74.7	46.5	Stresses importance of using all appropriate in-vehicle crash-avoidance devices. Also stresses importance of smart restraint and occupant protection systems.
More likely to survive until admitted to hospital (all drivers in crashes)	39.8	5.9	Stresses the importance of emergency callout (mayday) systems to ensure earliest possible medical attention.
Less likely to occur in a modern vehicle - 5 or less years (all drivers in crashes)	11.5	38.9	Indicates that there will be difficulties in getting ITS options delivered promptly to older drivers.
Less likely to involve drink driving - BAC \geq 0.05 (responsible drivers in multi-vehicle crashes)	2.0	13.5	Indicates that alcohol-interlocks will have little direct impact on older drivers' safety.
Less likely to (possibly/definitely) involve speed	6.0	26.9	Indicates that speed-alert and speed-control systems will have little direct impact (although they may protect older drivers from other drivers).

Source: Langford & Mitchell, 2003

Note: '%' refers to the proportion of older drivers in fatal crashes measuring positively for the specified aspect.

Based on these figures, Langford and Mitchell (2003) concluded that crash avoidance systems, together with the emergency callout (mayday) system, have the potential to have a direct impact upon older drivers' involvement in fatal crashes. In addition, the authors noted:

- Older adults are proportionally slower than younger adults when the complexity of the tasks being performed increases (McDowd & Craik, 1988; Welford, 1977; Inui, 1997; Sit & Fisk, 1999) and the complexity of some traffic situations, such as unfamiliar or congested traffic conditions, may overload older drivers and cause errors in judgements (Fildes, Pronk, Langford, Hull, Frith & Anderson, 2000; Hakamies-Blomqvist, 1993; Stamatiadis et al., 1991). As noted by Suen and Mitchell (1998), navigation or route guidance systems and intelligence cruise control may well have a generalised safety benefit in reducing driving demands, providing advanced warning of lane changes and of slowing traffic - as well as possibly reducing per-trip driving exposure (Regan, Oxley, Godley & Tingvall, 2001).
- Older drivers also have disproportionately more (non-fatal) crashes while reversing, due to restricted head movements and reduced vision. Rear collision warning systems are relevant in this context, with other technologies to avoid reversing cross-path crashes currently undergoing development.
- Older drivers are also involved frequently in (non-fatal) rear-end crashes, both as the striking and (more frequently) struck driver. High-mounted brakelights that flash during rapid deceleration may reduce the incidence of older drivers being struck and forward collision warning systems together with intelligent cruise control may reduce the frequency and severity of crashes in which the older driver is the striking party.

Despite the potential benefits associated with various ITS applications, very few studies have examined the effectiveness of ITS applications on older driver safety and mobility.

As outlined previously, navigation or route guidance systems offer considerable promise for reducing older drivers' cognitive load and therefore potentially reducing their crash risk in complex traffic situations (Suen & Mitchell, 1998). Barham, Alexander, Ayala and Oxley (1994) examined the benefits and safety implications of route guidance systems for 35 older drivers aged over 65 years with and without a route guidance system called *Travelpilot*. The system did not enhance the safety of drivers and was rated as easy to use. Some participants said they would travel more if they had an in-vehicle navigation assistance system. Campbell, Kinghorn and Kantowitz (1995) found that initial reluctance by older drivers to use a navigation system known as *TravTek* diminished as they gained more experience with it. It seems that, until they have adequate experience, older drivers may in general be reluctant to use new technologies. In the same study, older drivers interacted with navigational information that was either 100 percent or 77 percent accurate and were not able to use the more accurate information as efficiently as younger drivers. In another part of the study, a delay was introduced between the presentation of a message and recall of it. This produced a performance decrement for the older group relative to the younger group. These findings would indicate that age-related cognitive limitations such as information processing ability and working memory capacity affect an older driver's ability to use these systems as efficiently as a younger driver. Another study found that older drivers looked more frequently and for longer at in-vehicle displays than younger

drivers (Scialfa, Ho, Caird & Graw, 1999, cited in Caird, 1999). Again, these findings most likely relate to slowed information processing abilities and limitations in working memory capacity.

Oxley (1996) also investigated the effectiveness of in-vehicle navigation systems for older drivers as part of a European Union DRIVE II project called EDDIT (Elderly and Disabled Drivers and Information Telematics). In this study, half of the older participants ($n = 15$) navigated their way along public roads without in-vehicle navigation support, while the other half ($n = 15$) used one of three commercially available in-vehicle navigation assistance systems. Professional driving assessors rated the driving performance of the two groups. There was no statistically significant improvement in safe driving performance for the ITS-assisted group relative to the unassisted group, and navigation systems that required significant attention caused drivers to reduce speed and steer off course. As the complexity of route guidance increased, basic driving task performance declined, this being more so for older drivers. Few older drivers reportedly found the navigation systems distracting, and virtually all participants felt comfortable using the systems and felt safe while doing so. Drivers preferred auditory instructions in addition to visual guidance for both the route guidance and rear collision warning systems. They were more relaxed when there was visual as well as auditory information. On average, 35 percent of older drivers said they would travel to new, unfamiliar, places with the in-vehicle navigation assistance systems and 7 percent said they would drive more frequently.

Oxley (1996) also investigated the effectiveness of other ITS technologies such as vision enhancement systems and mayday systems and reported that these two technologies were likely to improve older driver mobility and safety. Participants found the vision enhancement system easy to use and more than 60 percent of drivers said they would use the systems to drive at new times.

Two studies have investigated the effectiveness of vision enhancement systems for night time driving for older drivers (Oxley, 1996; Ward, Stapleton & Parkes, 1996). The Oxley study concluded that these systems are likely to enhance the safety of older drivers in darkness, in that the vision enhancement systems (both ultraviolet and infrared) seemed to improve the visibility at night of pedestrians and roadway guidance features, although no data supporting this claim were provided in the study. Ward et al. (1996) tested gap acceptance and time-to-coincidence (TTC) judgements in a laboratory environment using videotaped thermal images taken from a far (8 to 13 metre) infrared sensor. Gap acceptance was taken to mean 'will my vehicle fit through this gap?' Sixteen participants from two age groups (under 25 and over 55) saw two types of night driving scenarios (gap acceptance and TTC) which were videotaped previously (and simultaneously) using visible light and infrared cameras. The participants sat inside a car and the videos were displayed on a projection screen in front of them. Driver responses with infrared images (drivers tapped on the brake if the gap was judged to be too small) showed a greater number of correct rejections than with normal night time viewing. In other words, drivers, including older drivers, were more able to respond accurately to gaps that were of an inadequate size with the vision enhancement system than without it.

Improvements to vehicle design can also reduce the severity of injuries to older pedestrians and cyclists in the event of a collision (Oxley, Corben, Fildes, O'Hare & Rothengatter, 2004a). Pedestrian protection features built into vehicles can be very effective in preventing serious and fatal injuries in impacts at moderate speeds, particularly the design of frontal structures to provide 'optimum' crash conditions. Recommendations by Oxley et al. (2004a) include:

- Continued development of test procedures to assess protection capabilities of vehicles for pedestrians and cyclists, and development of test specifications for all new vehicles.
- Improved design of bumpers to reduce lower limb injuries.
- Improved design of bonnet leading edge to reduce upper leg and pelvis injuries.
- Improved bonnet and windscreen design to reduce upper body and head injuries.
- Discourage the use of large, aggressive vehicles in the vehicle fleet.
- Consideration of banning rigid bull-bars from on-road vehicles.
- Development of less aggressive bull-bars.
- Development of in-vehicle ITS technologies to assist drivers detect and avoid collisions with pedestrians and cyclists, such as speed alerting and limiting devices, vision enhancement and rear collision warning technologies.
- Continued and expanded requirement of use of daytime running lights.

3.3.5 Summary

There are several technologies currently available that offer some promise to maintain safe mobility for older road users. However, as noted by Fildes and Charlton (2004), it is clear that they need to be evaluated on road or road-like environments. This is particularly the case as many of these ITS devices have not been developed or tested for vulnerable road users (Regan et al., 2001). In addition, given the limited amount of scientific evidence regarding their effectiveness, more research is needed to better understand the ways that these technologies enhance or comprise older drivers' driving, as well as their ability to make safe decisions or driving errors in different driving environments. It will be critical to approach the development of ITS solutions for older drivers in a systematic way, considering both crash types of older drivers and their abilities/impairments and driving/self-regulation patterns. This is an area of urgent research for the future to ensure that the current avalanche of new safety technology is optimal for the road users it is supposedly targeted to be of benefit for. This research needs to encompass analytical studies focussing on the most effective human-machine interface and examining the behavioural consequences of such technologies, separately as well as in conjunction with each other. In particular, the research needs to examine the consequences of technology for differing age and gender groups as well as other vulnerable members of society who are regular road users. Without such research, we are likely to be overrun with a smorgasbord of new safety developments that may well have unforeseen safety disbenefits.

3.4 ROAD INFRASTRUCTURE

Road design plays a major role in the long-term mobility and safety of older road users. It is suggested that current design of the road environment may contribute to the level of risk that older road users face on the road, particularly because of the combination of complex road environments and diminished functional abilities. While current design features are

unlikely to be the primary cause of many older driver crashes, design changes to create a more forgiving road environment will have substantial mobility and safety benefits. Moreover, as the population ages, it will become increasingly important to design roads that will accommodate the needs and capabilities of older road users. A number of engineering solutions offer the potential for addressing many of these problems and they should be given high priority in the years ahead as the population ages. It should be noted that a safer road environment for older road users also means a safer road environment for all-aged road users.

3.4.1 Findings from the OECD Working Group

The Working Group identified possible improvements to the road infrastructure from several perspectives. These included:

- In response to many older drivers' reduced perception and longer reactions times, improved design features (for example larger and more conspicuous signage and line markings, increased lighting, raised channelisation for turns at intersections, dedicated turn lanes and more prominent traffic lights incorporating protected across-traffic turns). Many of these features have been treated in two highway design handbooks prepared specifically in response to older driver needs (Fildes Corben, Morris, Oxley, Pronk, Brown & Fitzharris; 2000; Staplin, Lococo & Byington, 1998).
- Improved infrastructure for older pedestrians, including better footpath quality, provision of central median pedestrian refuges, kerb extensions, improved pedestrian access to shopping and commercial areas, pedestrian-only areas and timely and convenient crossing facilities incorporating the latest technology.
- The growing use of motorized wheelchairs is also placing increasingly urgent demands upon the road infrastructure. While the existing networks of footpaths and pedestrian areas can sometimes cater to these and other small motorized vehicles, this is not always so: narrow or non-existent paths, breaks in the footpath network, rough or soft surfaces and high kerbs all represent barriers to safe mobility in this context.
- Safer facilities for older cyclists were also urged, at least in those areas where cycling is traditional. The recommended facilities included separate bike paths and separated bike lanes along streets and roads, provided that these provisions were accompanied by improvements to locations where bicycle traffic crossed or merged with motor traffic.
- Road and roadside infrastructure also needs to support the use of public transport – for example by providing either level access or ramps and elevators for transit stops, by providing adequate rest areas with seating and by providing accessible and easy-to-use ticket windows and fare-vending machines.

The Working Group recommended that, at the very least, road design standards need to reflect the requirements and functional performance of all categories of road users and all age groups – and cannot be restricted to the abilities of a fit young adult driver.

3.4.2 Findings from the research – improved roads for drivers

Road design and operation features need to exhibit better visibility and higher conspicuity characteristics to compensate for the inherent functional performance limitations of the ageing driving population. Road and traffic engineers, therefore, have a significant role to play in improving the mobility, comfort and safety of older drivers. In particular, they need to:

- Be aware of the declining physical and mental abilities of the older driver population.
- Appreciate how these changing abilities affect the driving task/
- Modify design and maintenance standards to enable older drivers to cope more easily with the increasingly complex task of driving.

In most Western countries, road design manuals outline design criteria for the geometric design of roadways and are based on available literature, and sound engineering principles and practice. However, for the most part, these criteria have been developed primarily in regard to the performance capabilities of the 85th percentile ‘design driver’, that is, fit and relatively healthy young adults (Waller, 1991; Fildes, Oxley, Corben & Langford, 2004; OECD, 2001) and therefore make little, if any, allowance for older drivers’ performance. In order for the road system to operate efficiently and safely, design criteria must match the characteristics and abilities of the drivers that use it. However, it seems that, for the most part, the system is unforgiving for older drivers. The notion of providing a ‘crashworthy’ system is one that is now receiving attention world-wide. Traditional safety models have stressed a balance between safety and mobility. More recent models, however, such as ‘Vision Zero’ in Sweden, ‘Sustainable Safety’ in The Netherlands and the ‘Safe System’ approach in Australia view safety as **the** most important determinant in the provision of the road-transport system. These models argue that the road-transport system can only be safe and afford appropriate mobility when the road infrastructure is designed and operates in a way that explicitly recognises that humans do make errors and designs crashes that are within the human tolerance of the most vulnerable road users to violent forces so that death and serious injuries can be prevented. Effectively, this means designing the roads appropriately for the most vulnerable road users by reducing travel speed or providing improved protection of those road users most at risk through infrastructure and other design and operational changes.

Given that the road system may not adequately take account of age-related changes, it is no surprise that older road users report difficulties using the system. Surveys of older road users have found that they have difficulties reading street signs, crossing intersections, turning at intersections, merging into traffic, following road markings, responding to traffic signals, and driving under poor lighting conditions (Benekohal, et al., 1992; Fildes, Lee, Kenny & Foddy, 1994). Over two-thirds of all casualty crashes involving older drivers occur on urban roads, predominantly in low-speed zones, with one-half of all their crashes occurring at intersections (Langford, Koppel, Andrea and Fildes, in press). What is required is recognition that older drivers’ needs differ from their younger counterparts and that design criteria need to take account of these differences. It is likely that changing road features to accommodate some of these difficulties can have an immediate impact on mobility and safety of older road users, preventing crash occurrence and reducing the severity of crashes that do occur. A committee in the US (Transportation Research Board, 1988) recognised over a decade ago that the road system can be better designed to

accommodate the needs and abilities of older road users and initiatives have been developed to achieve a safer system for older drivers in the US (Staplin et al., 1998). In Australasia, too, there is increasing support for a system that is more forgiving of the difficulties experienced by older road users (Fildes et al., 2000; Oxley, Fildes, Corben & Langford, 2006). An improved system will undoubtedly also improve safety for all-aged drivers.

Four broad traffic environments were identified as being problematic for older drivers (Fildes et al., 2004). First, geometric features of at-grade intersections are considered. Intersections and a wide range of roadway features play a role in the risk of collision for older drivers. Second, interchanges are considered because of the problems that older drivers experience when undertaking merging, weaving and lane change manoeuvres. Third, roadway curvature and passing zones are considered. In these environments, too, older drivers experience problems in detecting curves and maintaining lane position. Last, construction/work zones are considered because unexpected hazards on the road can be problematic for older drivers whose reaction, decision-making and response times are generally slow.

3.4.2.1 At-grade intersections

Intersections are an important but potentially dangerous part of the roadway system and reflect older drivers' most serious crash problem area (Stamatiadis et al., 1991; McKnight, 1996; Oxley et al., 2006). In a national US analysis of crash data, Hauer (1988) found that 37 percent of fatalities and 60 percent of injuries experienced by older drivers occur at intersections. Preusser et al. (1998) argued that drivers aged 85 years and older were 10.6 times more at risk of being involved in multiple-vehicle crashes at intersections than younger drivers (aged between 40 and 49 years). Even at impact speeds within legal limits in these environments, older vehicle occupants risk serious injuries (Oxley & Corben, 2002).

One of the principal concerns for older drivers is negotiating intersections because they present a driver with many points for possible conflict with other road users, often at high speeds and with minimal time to respond, and a lack of adequate in-vehicle crashworthiness opportunities. At a complex intersection requiring integration of a great deal of visual information, quick interpretation of the most important stimuli constitutes a difficult task for older drivers and may result in inaccurate perception of the approach of vehicles or even disregard of important perceptual cues altogether (Salthouse, 1991; Madden, Connelly & Pearce, 1994; Brébion, Smith & Ehrlich, 1997).

Benekohal, Resende, Shim, Michaels and Weeks (1992) surveyed older drivers in the US on intersection driving difficulties. They found that the following activities become more difficult for these drivers: reading street signs; driving across an intersection; finding the beginning of a left-turn (equivalent to right-turn in Australasia); making a left-turn at an intersection (right-turn in Australasia); following pavement markings; and, responding to traffic signals. They also found that the following intersection features become more important to drivers as they age: lighting; pavement markings; number of left-turns (right-turns in Australasia); width of travel lane; lane guides (channelisation) for turns; and, size of traffic signals.

Oxley et al. (2006) described a crash 'black-spot' site analysis that examined the relationship between intersection design features and the older driver crash experience in Australasia. Older driver crash 'black-spot' sites were identified by road authorities in four

jurisdictions. Locations were ranked according to the number of crashes involving older drivers (crashes involving at least one older driver aged 65 years or more). Over 400 crashes at 62 sites were selected for closer retrospective investigation. The study found that the vast majority of older driver crash ‘black-spot’ locations were intersections (97%), with the relative risk consistently and considerably higher for older drivers compared with younger drivers at these intersections. Further, the problem of gap selection was a factor in over three-quarters (76%) of the crashes. The study also attempted to identify the likely role that road design played in older driver crashes. The top three design features of intersections that were judged to have a strong association with the older driver crashes included that lack of use of separate signals to control movements in each turn lane, restrictions in available sight distance at right turn intersections, and an insufficient perception-reaction-time distance for intersection sight distances. Recommendations included provisions of roundabouts at intersections controlled by ‘stop’ or ‘give-way’ signs, introducing fully-controlled turning signals at intersections controlled by traffic signals, and improving sight distance through the removal of vegetation and roadside furniture (such as utility poles, signs) that obstruct the view of approaching traffic, adoption of design guidelines that specify higher values of perception-reaction time; provision of offset turning lanes; provision of gentle grades and horizontal alignment; provision of advance warning signs at intersections with poor sight distance; and speed reduction measures on intersection approaches.

Classen, Shechtman, Stephens, Davis, Bendixen, Belchior, Sandhu, Justiss, Posse, McCarthy and Mann. (2006) investigated the impact of improved intersection design on the driving performance of young (25-45 years) and senior (65-85 years) drivers using kinematics measures from an instrumented vehicle and on-road evaluations. The improved intersections were based on the proposed highway design guidelines to increase the safe driving ability of older drivers from the FHWA. The results showed that compared to the unimproved intersections, drivers made fewer total errors on all the improved intersections. The findings suggest that the FHWA guidelines for implementing safe road conditions are helpful for safer driving, and that overall, the safe mobility older and younger drivers alike may benefit from roadways with these safety features.

3.4.2.2 Freeway interchanges

Freeways are becoming more common within and between major cities and are constructed to accommodate increasing traffic capacity. Freeways are often characterised by a high safety level when compared with other types of highways in rural and urban locations (Staplin et al., 1998; Oxley, Corben, Koppel, Fildes, Jacques, Symmons & Johnston, 2004b), and the benefits of interchanges accrue through a reduction in road crashes, traffic delays, fuel consumption, exhaust emissions and, in some cases, traffic noise.

Grade-separated intersections (i.e., interchanges) are provided when one or more of the intersecting roads are freeways or expressways. The ultimate purpose of any interchange is to distribute conflicting traffic effectively and eliminate a crossing conflict without necessarily prohibiting any of the desired traffic movements. Access to freeway carriageways is limited to selected intersecting roads at which an interchange is constructed with specially designed ramps to carry turning traffic and allow traffic to enter and leave the freeway with minimum interference to through traffic. That is, the merging and diverging manoeuvres, which occur in the freeway lane adjacent to the ramp, desirably should take place at the speed of the freeway traffic stream, and without interference to it.

There is some concern that freeway interchanges have design features that can result in significant safety and operational problems, particularly for older drivers (Taylor & McGee, 1973; Lunenfeld, 1993).

It seems that older drivers experience particular problems at freeway interchanges. Staplin and Lyles (1991) found that drivers over 75 years were over-represented as the driver at fault in merging and weaving crashes near interchange ramps. With respect to violation types, the older driver groups were cited most frequently for failing to give way and for improper use of lanes. Similarly, Harkey, Huang and Zegeer (1996) found that older drivers' failure to give way was the most common contributing factor to older driver freeway crashes. As the proportion of older driver freeway travel has risen in the past (Lerner & Ratté, 1991), and is likely to continue rising in the future, it is relevant to consider geometric design of interchanges that can assist older drivers negotiate freeway travel in a safer manner.

Malfetti and Winter (1987) reported that older drivers on freeway acceleration lanes merged so slowly that traffic was disrupted, or they stopped completely at the end of the ramp instead of attempting to approach at the speed of the traffic flow before entering it. Knoblauch, Nitzberg and Seifert (1997) also noted that when entering a freeway, older drivers are particularly prone to rear-end collisions with vehicles ahead while looking upstream. Similarly, when leaving freeways, older drivers experience difficulty in reading and comprehending signs, with resultant excessive speed reduction while still on the freeway, inadequate warning, and stopping in inappropriate places.

Merging onto the freeway was identified by older drivers as the most difficult manoeuvre during freeway driving (Lerner & Ratté, 1991). A number of improvements were identified by older drivers in Lerner and Ratté's study including the elimination of weaving sections and short merge areas which would facilitate the negotiation of on-ramps at interchanges. Improvements identified to ease the exit manoeuvre included better graphics, greater use of sign panels listing upcoming exits, and other methods to improve advance signing for freeway exits. In addition to experiencing problems at interchanges, older drivers experience other problems driving on freeways including lane changing, congestion, trucks, discourteous drivers, high speed, poor signage and getting lost (Lerner & Ratté, 1991; Staplin & Lyles, 1991; Knoblauch et al., 1997).

Recommendations for improving freeway interchange geometric design to help accommodate the problems experienced by older drivers include channelisation and delineation of acceleration lanes, advance signing to warn motorists of interchanges, traffic control devices to assist lane choice and prohibit wrong way movements, and adequate lighting at interchanges (Fildes et al., 2004).

3.4.2.3 Other road environments

Horizontal Curves

Horizontal curves present problems for drivers, as evidenced in the over-representation of single-vehicle crashes at, or near, curves (Johnston, 1982, 1983; Zegeer, Stewart, Reinfurt, Council, Neuman, Hamilton, Miller & Hunter, 1990; Neuman, 1992; Haworth, Vulcan, Bowland & Pronk, 1997).

Successful curve negotiation depends upon the choice of appropriate approach speed and adequate lateral positioning through the curve and it appears that perceptual factors play an

important role in crashes on curves. These factors include poor anticipation of vehicle control requirements on approach and on the curve, inadequate perception of the demands of the curve, and inadequate appreciation of the degree of hazard associated with a given curve.

Fildes, Leening and Corrigan (1989) recommended that several critical geometric aspects should be addressed to improve safety on horizontal curves on rural roads. These include an upgrading of the quality of road surface, an increase in curve radius (suggesting that curve radii below 500m are undesirable for safe speed perception), provision of adequate vision by clearing trees and shrubs close to the edge of the curve, road delineation treatments such as markings, guide posts and reflectorised pavement markings to emphasise the change in direction of the road surface, speed zoning at hazardous curve locations, and perceptual countermeasures.

The current design guidelines attempt to improve the visibility of road curves, particularly those that are sub-standard, by providing a range of treatments similar to those recommended by Fildes et al. (1989). Treatments normally used at sub-standard horizontal curves may include the provision of one or more of the following; guide posts, pavement markings and raised pavement markers (especially to indicate separation lines) warning signs, advisory speed signs and directional hazard markers and guard fencing.

In assessing curvature of the road, road designers assume that drivers are sensitive to changes in the curve's radius and will make appropriate changes to their speed and lateral position on the approach to and during the curve. Design guidelines, therefore, are based on the need to provide drivers with enough detection and recognition time, perception-reaction time, decision and response time, time to perform brake and accelerator movements, manoeuvre time and (if applicable) time to shift gears.

However, the specifications of these treatments have typically been based on driving performance of the entire driving population with bias towards the performance of younger drivers. These standards, therefore, do not consider age differences in driving performance such as slower reaction time or other performance declines consistently demonstrated in research on older driver response capabilities. Diminished visual performance, physical capabilities, cognitive performance and perceptual abilities may combine to make the task of negotiating horizontal curves more difficult for older drivers. Indeed, there is some evidence to suggest that horizontal curves present problems for older drivers. In his analyses of crash data in Michigan in the US, Lyles (1993) found that older drivers were much more likely than younger drivers to be involved in crashes where the drivers were driving too fast for the curve or were surprised by the curved alignment.

Fildes et al. (2004) proposed that guidelines address the safety and performance of older drivers as they negotiate roadway curvature, and focussed on three design elements including enhanced edgelines, provisions of centre-line raised pavement markers, and minimum lane and shoulder width.

Passing zones

The passing manoeuvre on two-lane roads is a complex and important driving task, requiring many stages of driver performance and a lengthy section of road to complete the manoeuvre. The ability to pass a slower moving vehicle is influenced by a variety of factors including the volumes of through and opposing traffic, the speed differential

between the passing and passed vehicle, the road geometry (particularly available sight distance), and human factors such as driver reaction times and gap acceptance characteristics.

Research on overtaking crashes is comparatively rare, despite the frequency and severity of these types of crashes. Clarke, Ward and Jones (1998) showed that overtaking crashes accounted for 8 percent of fatal road crashes in Nottinghamshire, England and that their crash severity index (the proportion of cases resulting in death or serious injury) is over 20 percent. In Australia, too, Armour (1984) found that overtaking is involved in about 10 percent of rural casualty crashes. These rates are much higher than the 3-4 percent of such crashes in the US (Khasnabis, 1986), which probably reflects the much greater length and usage of multi-lane, divided roads in that country.

The provision of safe overtaking opportunities can therefore have a large effect on traffic operations on two-lane roads by decreasing the interactions between faster and slower vehicles and therefore reducing crash risk (Kaub & Berg, 1988). For many years, overtaking lanes have been provided on unsustainable grades where some vehicles experience a problem maintaining desired speed. Overtaking lanes, however, are becoming more common at locations other than on unsustainable grades where maintaining desired speed is not a vehicle performance characteristic. Overtaking improvements are mainly used to increase capacity and level of service by reducing congestion and delay. They also provide safety benefits as well as improved quality of service resulting from reduced driver frustration and stress, particularly on rural roads.

Extended roadway sections with severe sight restrictions and inadequate passing opportunities pose a real problem for drivers of all ages. The inability of drivers to pass slower moving vehicles on these roads causes increases in delay, conflict and hazard. On a two-lane rural road, overtaking vehicles must overtake slower vehicles by entering the opposing lane. Therefore, an overtaking opportunity requires a sufficiently large gap in the oncoming traffic for an overtaking manoeuvre, plus the distance travelled by that vehicle, plus a safety margin. This type of manoeuvre, therefore, requires a series of complex information processing and decision-making skills, which makes this kind of manoeuvre one of the most demanding and risky operations performed by drivers, and especially older drivers.

Three recommendations were made by Fildes et al., (2004) addressing the design of overtaking lanes to accommodate the declining abilities of older drivers, including provision of maximum intervals of 5km, minimum passing zone length, and minimum passing sight distance.

Construction Zones

Vehicle travel through roadway construction or maintenance work zones is known to be hazardous. Crash analyses consistently show that crash rates increase about two-fold on road segments containing work zones than on the same road segment before the zones were implemented (Doege & Levy, 1977; Graham, Paulsen & Glennon, 1977; Garber & Woo, 1990; Pigman & Agent, 1990; Hawkins, Kacir & Ogden, 1992). In the US, the number of annual vehicle-related fatalities in roadway work zones averaged about 770 between 1995 and 1999, and the average number of persons injured each year is about 40,000 (<http://www.wzsafety.tamu.edu>).

Whenever a work zone is created on an existing road, it represents an unexpected change in visual features, path, speed, and, occasionally detouring off the normal route. Most importantly, the closure of a lane during construction or maintenance work can create many potential safety problems. Lane closures require the driver to make behaviour adjustments, such as reducing speed and/or changing lanes. High-volume and/or high-speed roads with construction zones are particularly hazardous and great problems can occur when two or more lanes of traffic must be warned sufficiently in advance so that drivers may travel safely through the one lane passing through the work zone. It is therefore important that work zone traffic control provides adequate notice to drivers describing a condition ahead, the location and the required driver response. The potential for crashing in a work zone can be reduced by improving the application of traffic control devices in and on the approach to work zones (Bernhardt, Virkler & Shaik, 2001).

It seems reasonable to suppose that older drivers will experience exaggerated difficulty in detecting and negotiating work zones. They may experience difficulty in rapidly discerning the correct travel path in work zones, mainly because they must respond to temporary pavement markings that are often in competition with pre-existing markings and/or misleading informal cues provided by variation in the surface characteristics of the road, shoulder or median. Age-related deficits in visual search/scanning, anticipating unexpected events, allocating attention to the most relevant aspects of novel situations and information, and negotiating a complex environment extraction can disadvantage older drivers in acquiring the most critical messages conveyed by signs and pavement markings in a visually complex road environment.

Current standards for warnings and traffic control on the approach and throughout work zones, therefore, may place older drivers at greater risk when negotiating work zones. Fildes et al. (2004) suggested that the provision of advance warning signs and channelisation in these environments can accommodate the needs of older drivers.

3.4.3 Findings from the research – improved roads for pedestrians and cyclists

Walking and cycling are important modes of transport for many older adults, particularly in many European and developing countries. The safe mobility of older pedestrians and cyclists is compromised to a large extent by the design and operation of the road-transport system. Many of the problems stem from the fact that the road system is generally designed for vehicles, and mainly for young, fit and healthy road users. The growing complexity of the road environment, particularly the dominance of vehicles, high speed and traffic volumes on many roads used by pedestrians and cyclists place high demands on an older person's adaptability. Therefore, older pedestrians and cyclists experience many problems using the transport system, largely because it does not adequately accommodate their special needs and capabilities.

Many design features seem to be lacking in consideration of the needs of pedestrians and cyclists. These include lack of convenient crossing facilities; fast walk cycles for pedestrian crossings, poor legibility of road signs, difficult entries/exits on public transport, poorly designed cycle lanes especially through intersections, poorly designed signal phasing at intersections that can disadvantage pedestrians and cyclists, and high speed limits on roads frequented by older pedestrians and cyclists (Oxley, Dewar & Fildes, 2004c; Oxley et al., 2004a). In addition, little thought is given to the ergonomic requirements of older adults who experience difficulty in walking and cycling. For instance, the placement of resting places, kerb height, amount and height of steps, slopes of

ramps, pavement width, and quality and maintenance of bicycle paths and footpaths all need to consider the physical limitations of older adults (Oxley et al., 2004a; 2004c).

While pedestrian/cyclist-priority residential zones have been introduced in many European countries, their use is not widespread in developing and highly motorized countries. Environmental beautification has also contributed directly to pedestrian and cyclist safety in Europe, with innovative designs of bicycle paths, footpaths, landscaping with trees, shrubs and flower and planter boxes, however, again, these practices are not common in developing countries such as India and China and highly motorized countries such as Australia and the US, particularly in strip shopping in busy arterial roads (OECD, 2001). The introduction of lower speed limits in residential streets and busy pedestrian/cycling areas in the order of 30-40km/h will undoubtedly also lead to improved pedestrian and cyclist safety. Nevertheless, there is still much that can be achieved in infrastructure and road design to increase the safety of older pedestrians and cyclists and there needs to be more emphasis in designing safe road environments to facilitate their safe mobility.

Oxley et al. (2004a) highlighted some road design improvements for older pedestrians and cyclists:

- Measures to moderate vehicle speeds in high pedestrian and cyclist activity areas, including:
 - setting of speed limits of 30 km/h but not more than 50 km/h,
 - extensive use of traffic-calming techniques,
 - use of perceptual countermeasure treatments, and
 - use of in-vehicle and out-of-vehicle ITS technologies.
- Introduction of measures to separate or restrict vehicular and non-vehicular traffic in high pedestrian and cyclist activity areas, including provision of:
 - vehicle-free or vehicle-restricted pedestrian/cyclist zones,
 - a well-designed bicycle network of tracks, paths and lanes,
 - a well-designed footpath network, and
 - barriers or guardrails at unsafe mid-block locations.
- Provision of crossing facilities suited to older pedestrians' needs, including:
 - well-placed locations,
 - consideration of signalised facilities over unsignalised facilities,
 - extending walking speed value to between 0.91 m/s to 1.0 m/s,
 - consideration of 'Puffin/Pussycats' devices,
 - consideration of measures to reduce confusion about clearance phases,
 - consideration of facilities for visually impaired pedestrians, and

- inclusion of marked cross-walks in high-risk locations to reduce vehicle approach speeds.
- Introduction of measures to reduce the complexity of intersections and road lengths. Improved intersection design to include treatments that increase conspicuity of pedestrians and cyclists, allow for slower walking and cycling, and establish right-of-way, including:
 - provision of leading green phases for pedestrians,
 - consideration of ‘Puffin/Pussycats’ and ‘TRCS’ devices,
 - extension and widening of footpath in conjunction with painting of crosswalks and bicycle lanes,
 - consideration of setting back holding lines for vehicles and advancing holding lines for bicycles,
 - provision of warning signs to drivers to give-way to pedestrians and cyclists, especially while negotiating turns at intersections,
 - installation of pedestrian- and cyclist-friendly roundabouts, and
 - installation of medians to separate bi-directional traffic.
- Provision of facilities at public transport stops including passenger safe zones and provision of a free-area on cycle paths.

3.4.4 Summary

In sum, the complexity of the road environment can place increasing demands on an older person’s adaptability, while ageing can diminish the capacity to cope with such situations (Oxley, 2000) placing older drivers at a ‘double’ disadvantage. The general decline in performance as a result of the normal ageing process means that at least some older road users will experience extreme difficulties in coping with the demands of the current road system, particularly at complex intersections.

The increasing numbers and proportions of older road users on the roads in the decades ahead will pose many challenges to road designers and traffic engineers, who must ensure a safe system while maintaining operational efficiency. There is a need to take effective action to reduce risk levels of older road users by designing roads that accommodate their needs and capabilities. Recognition of the fact that the road transport system does not explicitly take the older road user into consideration is a first step toward adjusting the system to the needs and abilities of older people.

Road design plays a major role in the long-term mobility and safety of older road users. In most Western countries, road design manuals outline design criteria for the geometric design of roads and are based on available literature and sound engineering principles and practice. However, for the most part, these criteria have been developed primarily in regard to the performance capabilities of fit and relatively healthy young adults and therefore make little, if any, allowances for older drivers’ performance. It is suggested that current design of the road environment may contribute to the level of risk that older drivers face on

the road, particularly because of the combination of complex road environments and diminished functional abilities. In order for the road system to operate efficiently and safely, it must be more forgiving of older drivers, matching design criteria with the characteristics and abilities of drivers that use it. Moreover, as the population ages and becomes more mobile, it will become increasingly important to design roads that will accommodate the needs and capabilities of older road users.

A number of engineering solutions offer the potential for addressing many of these problems and they should be given high priority in the years ahead as the population ages. It is likely that changing road features to accommodate some of the difficulties older drivers experience can have an immediate impact on mobility and safety of older road users, preventing crash occurrence and reducing the severity of injury in the event of a crash. It should be noted that a safer road environment for older road users also means a safer road environment for all-aged road users.

3.5 PUBLIC TRANSPORT AND OTHER TRANSPORT OPTIONS

Maintaining and improving public transport systems, and raising the awareness of alternative transport options amongst older drivers will be a key factor in increasing the mobility of the elderly.

3.5.1 Findings from the OECD Working Group

The Working Group stressed the importance of maintaining older people's mobility by having alternative transport options other than the car, especially after cessation of driving. It also recognized that the availability and use of alternative transport modes differs greatly between countries. As an example of international differences: between 1997-99 in Britain, people aged 70+ made 35 percent of trips on foot, 29 percent of journeys as a car driver, 20 percent as a car passenger and 12 percent as a bus passenger (DETR, 2000); in contrast, older Americans make only about 6 percent of their journeys on foot and 2 percent by public transport, with the car being the dominant mode of transport (Rosenbloom, 2004). The extent to which older people use alternatives to the car was also shown to vary within countries: for example, there are relatively more car trips in rural areas compared to city areas and conversely, bus usage (and availability) declines substantially as population density diminishes.

The Working group pointed to the need for a family of services or transport options, including:

- Conventional public transport services that are easy to use and, if possible, accessible to passengers in wheelchairs.
- Bus service routes using small vehicles that pick-up and discharge passengers close to journey origins and destinations to reduce walking distances to/from stops, at the expense of a longer travel time. Easily accessible vehicles with specially trained staff, allow time in the schedule for passengers to board and alight without feeling rushed.
- Conventional taxis, often with user-side subsidies to reduce the fare to little more than that charged for a bus journey.

- ‘Dial-a-Ride’ services for passengers who need door to door travel, require assistance at the start and end of their journey, who may need help during a journey and/or who use a wheelchair that cannot be accommodated by a taxi or accessible bus.
- Accessible pedestrian infrastructure to allow access to the available public transport and taxi services, and the freedom to make journeys wholly on foot or by wheelchair or scooter.

It was also recognized that useage of these services relied upon strong promotion, including the presentation of information in a form readily comprehensible to older people.

3.5.2 Findings from the research

An Australian report by the Royal Automobile Club of Victoria (RACV) recently summarised their research on the transport and mobility services for those unable to drive (Harris & Tapsas, 2006). Much of this research concerned the mobility needs of the elderly. Harris (cited in Harris & Tapsas, 2006) conducted a small qualitative and quantitative survey of 125 people, aged 65+ who had recently ceased driving. The most common form of transport was relying on lifts from others (85%), and taxis (82%). Most respondents were able to access buses, although only half of those who had access would use them (43% using whilst 83% had access). One in five respondents used trains or community transport.

Difficulty using formal public transport alternatives was also assessed. Older people found taxis the easiest form of public transport to use, though problems associated with using taxis were being able to afford the fare, and getting a taxi that would be able to do a very short trip. Thirty-eight percent of respondents indicated that they had difficulty using buses, including stepping on and off the bus, and walking on the bus and to the bus stop. Twenty-six percent of respondents reported difficulties using trains, including walking to the station, standing on and stepping off the train. Twenty-six percent of respondents reported difficulty in walking. Interestingly, almost half of the respondents indicated that they had no difficulties in using transport alternatives; this was more likely to be the case for respondents who were living with another family member who could drive. Difficulty of completing tasks was also assessed. Tasks that were most difficult included visiting family (57%), visiting friends (50%), and getting to special events and functions (e.g., funeral, christening) (44%). Harris also found that over 30 percent of respondents found it hard to carry out essential tasks such as shopping for groceries and getting to medical appointments.

The RACV report highlighted the need for an integrated mobility system in Victoria, outlining that public transport services in rural areas is limited, and remote areas have generally no public transport services at all. Other studies have indicated that as many as 48 percent of those living in rural Victoria aged over 65 do not have access to any public transport (Corcoran, James, & Ellis, 2005, cited in Harris & Tapsas 2006).

Furthermore, it was argued that the public transport system in Victoria’s capital of Melbourne was inadequate when compared to international best practice systems, and also with other capital cities in Australia in terms of coverage. It was revealed that buses solely service over two thirds of public transport in Melbourne. The average frequency of buses

during peak hour is 40 minutes, average evening finishing time is 7pm, and only 18 percent of services operate on a Sunday (Currie, 2004, cited in Harris & Tapsas, 2006).

A survey by Kostyniuk and Shope (2003) of elderly Michigan drivers and non-drivers revealed that 60 percent of respondents reported never using public transport on a regular basis at any point in their life. This finding clearly demonstrates the strong reliance on the car as the primary mode of transportation. For non-drivers, nearly two-thirds rely on obtaining rides from relatives and friends cars. They are likely to have little or no experience with public transport, and as such many are unaware of what services are available in their neighbourhoods.

The Independent Transport Network (ITN) is a privately run (with partial support through government sponsorship) system operating in Portland, Maine in the USA. The manager and motivator for this system is Ms. Kathy Freund who established the system several years ago and continues to actively promote and support its existence. The ITN system essentially involves fit older people driving unfit older people around as a form of taxi service. Chauffeurs are volunteers, scheduled for a limited period each week to act as both drivers and support people for those less able to drive themselves in attending to their daily needs. Users pay an annual (minimal) subscription to join the program and a small contribution to each trip to help cover costs. ITN reports that the numbers of participants continues to grow annually and it is expected to be self-sufficient in the years ahead. The participants generally like the system as it is less threatening for older people and allows them to establish a new social network.

The Beverly Foundation (2001) assessed programs such as the ITN. They surveyed 236 people who were associated with devising and maintaining supplemental transportation programs (STP's) for the elderly in the U.S. The many varied programs pertained to one or many of the following four service models:

1. Services that provide only transportation (sole-service programs).
2. Services that provide a range of services which includes transportation (multi-service programs).
3. Services involving contracts with external transportation providers (contract programs).
4. Services that co-ordinate transportation for many organisations (co-ordinating programs).

Respondents indicated that the programs were mainly operating in either rural areas or a mix of rural/urban areas. Most programs were non-profit organisations with Government as their main funding source, operated door-to-door service, used mainly by the elderly, or the elderly and people with a disability. The most common response for trip purpose were medical appointments and any purpose. Responses regarding drivers' conditions were commonly paid and volunteers, and reservation policies were generally either same day or 24 hours notice. A large proportion of the programs (69%) did not entail a fee. Problems associated with the programs were generally difficulties recruiting drivers and financial funding.

This survey on STP's provided no indication on the number of elderly people using STP's. A more recent survey (Collia & Giesbrecht, 2003) found that, of the 24 percent of

respondents aged 65+ reporting a medical condition that limited their ability to travel, only 12 percent used STP's. A comparison of STP usage and gender found that elderly women were twice as likely to use special transportation services than elderly men.

Two major issues concerning the use of taxis have been outlined by Fildes et al. (2002). The first is that whilst many taxi subsidy programs exist, including those in Victoria, Australia, many programs cannot keep pace with demand so only the most needy applications are funded. It has been estimated that only approximately 75-80 percent of applications met current criteria for inclusion into the system. It should be noted that inability to hold a driving licence is not a factor that determines eligibility to the system. The second issue is that older adults generally do not like using taxis for several reasons. They often feel threatened by the aggressive manner of many taxi drivers and have some concern for their personal security. Moreover, many of the current elderly generation have grown up through difficult financial times and find it difficult to pay as you go for transportation. Indeed, many of them see taxis as a luxury they cannot afford, when in reality, they may well be better off using taxis than owning their own car.

A subsidised taxi system that is more readily available, therefore, would help offset some of these concerns and provide a real alternative transport system for those less able to drive themselves, and in turn promote the mobility of older adults. This would be particularly useful for those living in rural and remote areas where public transport is practically non-existent and the car the only real alternative to getting around. In addition, the next generation of older drivers have grown up with the car and taxis and are more likely to be willing users of the system.

Another option for the provision of alternative transport for those unable to drive is the establishment of a private coordinated alternative transportation network. A workshop on alternative mobility for older people was conducted by the RACV in Victoria, Australia in 1998 to identify what systems (if any) were currently available and popular among older people. Results from this workshop showed that there were a number of systems in use around the State although they were generally uncoordinated and often failed to meet the needs of the older people generally. A number of recommendations came from this workshop including the need for government to take a coordination role in the provision of these services to maximise the benefits for older people seeking alternatives to the car.

It would be useful to develop a pilot program of an ITN type system in Victoria and to evaluate its benefits, costs and acceptance as a demonstration program. We understand there have been one or two attempts to establish such a system in Victoria but they do not seem to have been thoroughly evaluated or promoted widely. Again, this demonstrates the need for government to take a coordination role in the provision of these services to maximise the benefits for older people seeking alternatives to the car.

In support of alternative transport options, there is a real need to raise the awareness of the availability of these options amongst older adults and their families/caregivers and promotion of their use. Indeed, Yassuda et al. (1997) noted that currently there is little societal support to assist individuals cope with this major decision in the later years of life and there is a great need for a specific educational intervention to aid senior drivers and their families with the physical, social and psychological implications of driving cessation. Suen and Sen (2004) added that often an older person's mobility problems starts with a lack of suitable transportation as an alternative to driving and that most older people perceive transit to mean only buses and trains and many lack the knowledge or confidence to use traditional public transportation. They also point out that the infrequent use of public

transport by the elderly may be because it does not match their needs, it is too difficult to use physically, or psychological factors predispose older people against public transportation.

There is a range of resources in the US, designed to assist older drivers and their families to recognise driving difficulties and identify ways to maintain mobility. For example, the AAA Foundation for Traffic Safety provides a number of educational initiatives aimed at older drivers and those concerned about them (spouses, children, neighbours, etc) including: *How to Help an Older Driver: A Guide for Planning Safe Transportation*; and, *Concern About an Older Driver? A Guide for Families and Friends*. The AAA have also initiated the Senior Driving Awareness Program aimed to assist older drivers and provide resources to improve driving, provide awareness of alternative transportation and to assist drivers in deciding when to stop driving. It includes an innovative volunteer service (*Driving Decisions for Seniors*) designed to help older adults with the emotional, social, and practical aspects of making the decision to stop driving. This service assists older people and their families with:

- Retaining driving privileges for as long as safely possible.
- Promoting independence in the mobility decision making process.
- Understanding, locating and using appropriate alternative transportation when safe driving is no longer possible including shared driving, walking, biking, private and public transport.
- Coping with the emotional distress and life changes that often accompany driving cessation.
- Educating older people and their families on mobility options and providing opportunities for input into the development of new or alternative transportation.
- Providing public input to assist in the development, enhancement, and planning of public and alternative transportation.

The AARP, too, provide a number of independent living kits on transportation including: the *Creating Mobility Choices Handbook*; and, the *Transportation Independent Living Kit*.

Oxley and Fildes (2000) developed a handbook for older drivers in the Australian Capital Territory, Australia, who may be considering retiring from driving. This handbook is an educational tool for older drivers, their friends and families to assist in this process and yet maintain some mobility. It focuses on providing information about driving and safety, on the processes involved in retiring from driving, particularly the issues of when and how to retire, and aims to provide information on alternative transport and mobility options for older drivers. While there have been no formal evaluations of the effectiveness of this resource, anecdotal evidence from older drivers themselves suggests that they find the information useful, particularly in assisting in planning their retirement from driving and alleviating some of the mobility consequences of not driving.

Suen and Sen (2004) further argue that making transportation meet the mobility needs of ageing people is a difficult task, particularly because the traditional transportation planning philosophy tends to be supply (operator) oriented. They argue that few planners consider

the difficulties the elderly have when using transit services, nor what can be done to overcome the difficulties.

3.5.3 Summary

While it is acknowledged that driving is the major form of transport for the elderly, a substantial proportion use alternative transport options. Moreover, given that many older drivers will, at some point, need to consider driving cessation, there is a real need to provide new and different kinds of public transport options that are viable, affordable, accessible, safe and co-ordinated. This will require policy makers to implement a range of mobility services that may include different kinds of traditional transit, a subsidised taxi service, independent transport networks, door-to-door community transport services, carpooling schemes, volunteer driving programs and new forms of demand services. It is important to examine, critically, older people's travel needs and abilities from their perspective, perhaps to provide innovative, tailored and individualised transport solutions.

Moreover, there is a need for resources, information and training programs to assist a smooth transition from driving to non-driving. This process needs to be managed well, so that older drivers can give up driving yet maintain their mobility, independence, self-esteem and QoL successfully. Resources that provide information on ways to retire from driving gracefully and information on alternative transport options can play a major role in alleviating some of the stress and trauma typically associated with this decision.

3.6 OPTIONS FOR WALKING, CYCLING AND SMALL MOTORIZED VEHICLES.

Walking and cycling are major modes of transport for many older adults, walking is a component of most trips, and these forms of transport have obvious benefits for health and well-being of individuals and the environment. Small motorised vehicles are also becoming more popular as a means for mobility amongst those who find walking and cycling difficult.

3.6.1 Findings from the OECD Working Group

The Working Group indicated that in some European countries, some 30-50 percent of trips are made entirely on foot. In addition to identifying road infrastructure improvements which would result in safer walking, the Working Group also made limited reference to a series of education and training options for improving older pedestrian safety. Facilities for those reliant on assisted walking, that is walking with a cane or other walking aid or with a guide dog or travelling in a wheelchair, should be considered in conjunction with the needs and facilities for pedestrians. For example, paths should be well-surfaced and well-lit, in order to increase the mobility of pedestrians and assisted walkers.

The Working Group recognised that in at least some countries (particularly in Europe), cycling was a viable alternative transportation option for older people. However they also recognised that due to the frailty and increased crash risk of the elderly, that this option should be encouraged only when there were excellent infrastructure and other provisions.

The substantial mobility advantages offered to disabled and other older people by motorized wheelchairs and other small motorized vehicles were acknowledged by the

Working Group. These vehicles are designed for short-distance trips in urban areas – to shops, cinemas, social venues, etc. However as their popularity increases, it has become evident that they pose their own particular safety issues. According to the Working Group, the categorisation of unlicensed vehicles such as motorised scooters and golf carts is still being debated. There is also a need for suitable infrastructure if these forms of transport are to be encouraged, particularly in rural areas. Safety issues include:

- Usage beyond their design capabilities. Particularly in rural areas where transport alternatives to the car are limited, there is the reported tendency for motorised scooters to be used for reasonably long trips invariably along major traffic routes. These vehicles offer only limited occupant protection and as an unexpected addition to vehicle mix on often high-speed roads, place their occupants in a very vulnerable position.
- Much of the road infrastructure even in urban areas does not cater for the widespread use of motorised scooters. As noted by the OECD Expert group, difficulties include:
 - Where footpaths are available, uneven, discontinuous or soft surfaces constitute a barrier to mobility. Ramps are required when moving from the roadway over the kerb to the footpath, constructed so that they do not cause the wheelchairs or scooters to tip.
 - Median pedestrian refuges and pedestrian crossings are often of insufficient width to accommodate both a wheelchair or scooter and pedestrians, potentially leaving people stranded in traffic lanes in the path of vehicular traffic.
 - Routes need to be complete otherwise wheelchair and scooter users may end up encountering a hazardous situation or an insurmountable obstacle blocking further movement.
 - Street furniture and signage may be placed so as to make progress difficult, as well as obscuring the view of approaching traffic.
- The proliferation of motorised wheelchairs and scooters requires a regulatory framework to ensure that the vehicles released on the market are of an acceptable design standard.

3.6.2 Findings from the research – walking and cycling

Non-motorised modes of transport are increasingly becoming more popular, especially for short trips and, in many ways, walking and cycling are beneficial to individuals and the community. These forms of transport increase fitness, health and longevity, and decrease societal costs associated with ageing, illness and disease and with motorised travel, including environmental aspects such as pollution and congestion (Oxley et al., 2004a). Both walking and cycling are physical activities and there is evidence to suggest that physical activity in advancing age has far-reaching benefits for physical and psychological well-being and decreases the risk for chronic disease (e.g., diabetes and heart disease), mortality from cardiovascular disease and other associated diseases in older age (Visser, Plujm, Stel, Bosscher & Deeg, 2002; Wannamethee, Shaper & Walker, 1998). Moreover, regular daily activities such as walking, sport participation and household activity in older

age have positive effects on cognitive functioning, particularly showing functional and mobility decline (Binder, Schechtman, Ehsani, Steger-May, Brown, Sinacore, Yarasheki & Holloszy, 2002; Wang, van Belle, Kukull & Larson, 2002).

While the health and environmental benefits of walking and cycling over motorised modes are well documented and these forms of transport are actively promoted in many European countries (ETSC, 1999; Wittink, 2001; Forward, 1998) as well as in Australasia (e.g., <http://www.vicfit.com.au/walk>, <http://www.ltsa.govt.nz/road-user-safety/walking-and-cycling/framework.html>), and it is important to maintain ongoing mobility for older road users, the research is clear about the need to provide a safe environment for pedestrians and cyclists to travel.

Older pedestrians and cyclists experience many problems using the transport system and this is reflected in the types of crashes they are involved in. Like older drivers, they are over-represented in crashes in complex traffic environments such as at intersections, in fast and heavy traffic, on multi-laned roads and when performing a complex manoeuvre.

Unfortunately, the needs of pedestrians and cyclists are often overlooked in transport planning. However, there is growing support for programs that encourage walking and cycling and provision of safe and comfortable environments in which to walk and cycle. A new research program, supported financially within the European Union COST Action framework is being undertaken to investigate Pedestrians' Quality Needs (Methorst, 2006). Over 50 researchers from more than 35 institutes in 25 countries including European countries, Australia, and the US, are involved in the project. The main objective of the study is to provide an essential contribution to systems knowledge of pedestrians' quality needs and the requirements derived from those needs, thus stimulating structural and functional interventions, policy making and regulation to support the walking conditions across the EU and other involved countries. Specific aims are to:

- Improve the understanding of pedestrians' quality needs with regard to public space, the transport system, and the social, legal and political context.
- Develop a new paradigm for implementation of more effective and efficient policy measures and future research.
- Provide an accessible knowledge base and easy-to-use auditing scheme that enables authorities and possibly interest groups to tackle, prevent and prioritise current and future problems regarding pedestrian mobility and presence in public space.
- Stimulate partners to innovate tools and disseminate knowledge that helps shed new light on the issue and stimulate new initiatives that provide for safe mobility of the pedestrian.

Pucher and Dijkstra (2000) examined walking and cycling behaviour in Europe (the Netherlands and Germany) and the US. They noted the main reasons for the large proportion of Europeans' making trips on bicycles and walking in comparison to Americans:

- More compact land-use patterns, making an average trip in a European city half as long as the average trip in a US city.

- Programs that have promoted cycling and walking and in some cases restricted car use making it far more convenient to walk or cycle than drive.
- Higher cost of owning a vehicle in Europe.
- Traffic education of car drivers and non-drivers.
- Investment in infrastructure:
 - Many bike lanes and paths which provide completely separate rights of way for cyclists.
 - Designated streets which have a strict right-of way policy for cyclists over cars.
 - Traffic calming measures that include low-speed limits and in some cases cars are required to travel at walking speed.
 - Reduced parking space for cars and a dramatic increase in parking rates particularly in city centres.
- Traffic enforcement measures designed so that in the event of a collision involving a car with a pedestrian or bicyclist the car driver is almost always found to be partly at fault (driver is entirely at fault if the collision involves elderly or children).

It is clear that promotion of and substantial use of walking and cycling as modes of travel means that the elderly not only maintain their mobility and independence in travel, but also continue to gain important cardiovascular exercise essential for physical well-being. Pucher and Dijkstra (2000) concluded that in the US there is limited support for measures that discourage motor vehicle use, however the European experience should serve as an example to promote walking and cycling.

Meeting the mobility and safety needs of older people in the future will require a comprehensive strategy, one which will encompass policy at all levels and include educational and awareness initiatives, improving vehicle design, and ensuring a safe and comfortable road environment in which to walk and cycle (Oxley et al., 2004a). Educational, awareness and behavioural change programs are aimed at providing information to road users regarding safe practices to adopt to participate in traffic safely. While their effects on crash risk are rarely evaluated, they are regarded as an essential component of any strategy and are, reportedly, well-received by many older community members. There are two main recommendations supporting the use of educative tools to promote safe practices:

- Continued development and support for community awareness and educational campaigns to increase adoption of safe walking and cycling practices;
- Continued development and support for programs that promote the continuation of safe driving for as long as possible are recommended, along with development and support of alternative transport options.

Moreover, introduction of legislation to enforce adoption of safe practices, supported by mass media campaigns have been successful in bringing about behavioural change. Despite the (largely unsubstantiated) claims that mandatory helmet use is associated with loss of civil liberties and can have an adverse effect on bicycle usage, there is clear and consistent

evidence that wearing of head protection reduces the incidence and severity of head and neck injuries. Oxley et al. (2004a) also recommended that:

- Careful consideration should be given to legislation for mandatory helmet, coupled with mass media to promote helmet use among all aged cyclists.

3.6.3 Findings from the research – wheelchairs and motorised scooters

Motorised scooters are increasing in popularity as older and disabled people strive to maintain active, independent lifestyles. While they afford good mobility, particularly for short trips, safety concerns have been raised in a number of forums because scooters are starting to be viewed by older people as an alternative to the motor vehicle, rather than as an aid for those who experience difficulty walking long distances.

The emergence of scooter use has provided a challenge to road designers and road safety experts. First, the environment is poorly matched to the use of motorised scooters. Footpaths have different surfaces and gradients, are often not aligned appropriately for scooters and are often too narrow (Dolling, 2002). This creates problems for other footpath users, particularly older pedestrians, but also may force scooter users to drive on the road – an unsafe alternative. Moreover, many older adults who are deemed unfit to drive may choose to use a scooter as their main travel mode. While mobility is maintained, there is concern that many older scooter users may not have the functional abilities to operate a scooter in a safe manner, particularly if they are driving on the road (MUARC, 2006). Currently, in most jurisdictions around the world, there is no licensing requirement for the use of a scooter as it is considered a pedestrian device. Berndt (2002) argued that, to assume the scooter is a sensible alternative to a car when a person has had their licence revoked suggests a naïve understanding of the usual causes of a driver's licence suspension.

3.6.4 Summary

Safe, convenient and comfortable walking and cycling is a key to local mobility. However, it seems that many older pedestrians and cyclists experience problems using the transport system. While there is growing support for programs that encourage walking and cycling, the provision of a safe and comfortable environment is often overlooked and therefore little investment in infrastructure for these road user groups is given, particularly in highly motorised countries.

Motorised scooters, too, are increasing in popularity amongst the elderly and disabled and are fast becoming an alternative for driving. While they afford substantial mobility for many older adults who find walking difficult, there are safety concerns. Like for pedestrians and cyclists, the system is not designed for use of scooters and they pose a danger not only to drivers of scooters (use of scooters on the road) but also for other users of footpaths, especially older pedestrians.

3.7 OTHER MEASURES

Other measures identified in the literature include land use, and the emergence of internet shopping.

3.7.1 Findings from the OECD Working Group

The Working Group recognized that mobility and transport needs are strongly influenced by land-use patterns. Given that ageing is often accompanied by a range of mobility restrictions, land-use planning that aims to reduce the amount of travel needed to access services, facilities and social networks was seen as being of particular benefit to older people.

The Working Group reached the following conclusions:

- In most developed countries, older people live in suburban settings and age in place – a practice considered essential to contain the costs of an ageing population. However shopping, financial, medical, and other services in suburban centres often require trips beyond walking distance from the home.
- If ageing in place is to work in current communities, especially when car use is no longer an option, adequate alternative transport is needed if older people’s mobility and independence are not compromised.
- For the future, changes to land-use planning policies and especially residential development patterns, are needed to allow services and facilities to be developed in closer proximity to older people’s places of residence. Compact communities with locally available facilities are best suited to the needs of older people.
- At the regional and local levels, more liveable communities are achievable through better integration of transport and land-use planning. The patterns of land-use development that are suitable for ageing populations are very similar to those required for environmental sustainability.
- Although new developments offer greater opportunities for responding to the needs of older people, urban redevelopment projects have also been shown to be practical and economically feasible. Communities need to consider retrofitting developments to improve the mobility of those older people ageing in place.
- It was recommended that for future planning, task teams be formed to co-ordinate research on the implications of an ageing society for future land-use patterns. Specifically the following aspects should be investigated and reported upon:
 - Identify the locations of the present and future older populations
 - Compile an inventory of current needs for daily living by older people
 - Develop means to improve the transport modes that encourage sustainability
 - Develop easy-to-use techniques for local land-use planning projects
 - Identify different types of physical and perceived barriers to older people’s mobility and develop countermeasures
 - Determine the extent to which financial measures (taxation, subsidies, compensation) affect car use

- Develop education programs for planners and national, regional and local authorities.

3.7.2 Findings from the research – land-use

Methorst (2003) discussed the issues of spatial planning and mobility for vulnerable road users and noted that almost no research has been conducted into the relationship between spatial characteristics and safe mobility of vulnerable road users and that statements about this relationship, while generally accepted, are based on the thoughts and beliefs of experts and are rarely supported by empirical research. Based on ‘best professional judgement’ Methorst listed a number of planning principles that ensure the safe mobility of vulnerable groups (primarily focussing on pedestrians, but can be applied to other vulnerable groups such as older drivers) as follows:

- Restrict the needs for long trip distances.
- Prevent conflicts between vulnerable groups and motorised traffic.
- Prevent the occurrence of complex situations.
- Prevent unintended use of the infrastructure and the public space.
- Prevent misunderstandings about function.

Rosenbloom and Ståhl (2002) discussed environmental, safety, mobility and land-use issues amongst the elderly. They noted that the elderly prefer to ‘age in place’, that is, live independently in residences selected in earlier stages of life and that this will create large concentrations of older people who may well face substantial mobility constraints when they can no longer drive. More importantly, they pointed out that traditional planning efforts in both the transportation and community design arenas have tended to underestimate or even ignore the contribution of older adults to land-use problems, assuming that i) the relatively low licensing and travel rates seen among the elderly in the past will continue into the future, and ii) denser communities with greater mixtures of land uses can and do meet the needs of older adults. They argue that, whether a community can meet the mobility needs of older people is a result of the interaction of a number of factors including: the accessibility, availability and range of transport options; the safety and security of the public environment; the dimensions of the homes in which people are ageing; and how a range of public and private services are offered or delivered to older adults.

Giuliano et al. (2003) reported a similar trend, arguing further that the suburban concentration of the elderly has made ageing in place a less than satisfactory situation for many elders by isolating them through lack of transportation. In their assessment of ways to better address the travel patterns of the elderly by transit and land-use policy, they suggested that promoting more transit-friendly, mixed-use communities will increase local accessibility, but current preferences for travel in the private vehicle, low-density living environments, and the phenomenon of ageing in place suggest that such strategies will play a limited role in addressing mobility problems of the elderly. They further argued that, safer cars and transportation facilities, behavioural adjustments, and development of paratransit options more competitive with the private vehicle may be more effective strategies for addressing mobility of the elderly.

3.7.3 Findings from the research - use of Internet shopping

It is clear that there has been a substantial rise in use of the Internet in the past decade, and one area of expansion has been purchasing goods online. Research suggests that communication and social barriers that many older adults suffer due to isolation may be overcome through Internet usage as it is a novel vehicle of communication and is becoming more accessible to older adults (Hutchison, Eastman, & Tirrito, 1997, cited in White, McConnell, Clipp, Branch, Sloane, Pieper, & Box, 2002). Indeed the OECD Working Group noted the social role that the Internet may play for older adults and that this may be even more important than for others, but also pointed out that studies are yet to document the impact of technology on travel.

A detailed search of the literature indicates that technically this is still the case, however a study on e-shopping and its impact on travel behaviour in the Netherlands by Farag, Dijst, and Lanzendord (2002) provided some general preliminary findings. Using an online survey and data from the 1998 Netherlands National Travel Survey, they investigated the impact of sociodemographic variables such as time pressure and residential environment on e-shopping, compared the characteristics of in-store shopper to e-shoppers, and identified the characteristics of people who spend most time shopping based on residential environments. The most common items bought through e-shopping were books, CDs and computer equipment and accessories. While finding no effect of time pressure on propensity to shop online, their results indicated that e-shoppers were more likely than in-store shoppers to:

- Be male.
- Be aged between 25 and 55 years.
- Have a higher level of education and high income.
- Be members of households with two or more members.
- Be employed.

Conversely, those spending more time undertaking in-store shopping were more likely to:

- Be female.
- Be aged 60 and above.
- Have a low level of education.
- Have low or medium income.
- Be households without children.
- Be housewives, pensioners or unemployed.
- Be living in more urbanised areas, particularly core and medium-sized cities and growth centres.

Whilst this study indicates that e-shopping by older adults is currently quite low, others have predicted that, even as soon as 2007, older adults can be expected to account for

almost 25 percent of online retail spending (Pael, & Peach, 2003, cited in Curch & Thomas, 2006). Research also indicates that training older adults to use the Internet can increase their overall psychosocial well-being. White et al. (2002) trained a sample of older adults in basic electronic tasks (email, searching the WWW) against a control group sample who received no training. Follow-up interviews revealed that 60 percent of the trained participants continued to use the Internet at least weekly, and they experienced decreased, although not statistically significant decrease, loneliness and depression compared to the control group. The authors cited many social benefits that the Internet offers, amongst them the ability to travel to places that older adults they can no longer get to due to physical limitations as one major benefit.

Recently, Curch and Thomas (2006) surveyed 20 older adults, aged between 60 and 87 years in Oneonta, New York about their shopping experiences. Several interesting themes emerged from this qualitative research in relation to mobility and its effect on travel behaviour. The five major themes were:

1. Access – all participants generally shopped at local major shops and the mall. Specifically where they went in the mall and the major chains depended on location and convenience, production range and selection, and price. Those who took the bus found reported more difficulty getting around however the majority of participants drove a car to the shops. One participant mentioned shopping on the Internet for clothes, and 25 percent purchased from catalogues.
2. Mobility – which was defined as negotiation of a store environment both physically and socially. The physical layout of the store was an issue cited by most participants, in that they had to walk through the entire store to buy just one or two items. Participants were also more likely to prefer to ask for assistance from a customer service operator compared to tracking down a price scanner.
3. Lifestyle – shopping for many participants was a social activity, citing that they enjoy window shopping and browsing. The balance of healthy eating and cost was an issue cited by most participants, also many participants read labels and the content of food that they wanted to buy.
4. Economics – many participants mentioned that the price of items had risen and many items were seen as being too expensive to buy. As a result many pay attention to sales and bargains and will alter their shopping day to get the best value for money
5. Perception of change – many participants reported a change in their shopping experience in terms of age and life situation. Many participants also reported making fewer trips generally going once a week compared to two or three times in the past.

The authors noted that these themes are not new, but they argued they had elaborated on many previous findings and enhanced our understanding of the relationships between shopping and mobility.

3.7.4 Summary

While it is recognised that land-use patterns strongly influence mobility and transport needs, it is also clear that there is little focus on the mobility needs of the elderly amongst land-use planners. It was suggested that communities should be planned in such a way to allow a range of accessible and available transport options, to ensure the safety and security of the public environment, and to deliver a range of public and private services appropriately to the elderly. It was also pointed out that current preferences mean that any strategies aimed to increase local accessibility are limited and that perhaps more emphasis should be placed on provision of safer road users, vehicles and roads to address the mobility needs of the elderly.

While the research on internet shopping and the elderly is sparse, there is some evidence that Internet shopping may play a role in the future psychosocial well-being and travel behaviour of the elderly.

4 SUMMARY AND RECOMMENDATIONS

This review has explored the issues surrounding the safe mobility of older road users, discussing older people's mobility needs, identifying the implications of driving reduction and cessation on mobility in later life and addressing the association between reduced mobility and QoL. It has also identified and described measures for managing the safe mobility of older road users.

The evidence is clear that, for older adults who cease driving, QoL is reduced, and that poor mobility places a substantial impact on the individual, their family, the community and the society. Furthermore, the evidence suggests that there are subgroups that are more likely to suffer more pronounced mobility consequences including women and financially disadvantaged groups.

Chapter 2 outlines and discusses seven facts and myths about the 'older driver problem' in an attempt to dispel some of the myths regarding the risks older drivers pose on the road and how their safe mobility should be managed. It is argued that, once amount and type of travel is taken into account, older drivers are at least as safe as drivers of other ages, and that only a small proportion (around 10%) of older drivers are unacceptable unfit to drive. Moreover, older drivers do not pose an excessive threat to other road users. In fact, they (and their passengers, who are likely to also be elderly) are more likely to be killed or seriously injured, once involved in a crash. With regard to fitness to drive, it is argued that, while there is evidence that some medical conditions and associated functional impairments may result in a decline in driving skills, most adults adjust their driving behaviour to suit their changing abilities, i.e., they self-regulate.

It is also strongly argued that age-based mandatory assessment programs are ineffective in identifying and managing at-risk drivers. Little evidence was found to support the continued existence of assessment programs of the type used by licensing authorities as a condition for continued licensing. Most importantly, while it is difficult to find any demonstrable safety benefits of mandatory testing, such programs compromise the mobility of many older drivers, particularly females. Some older drivers allow their licenses to lapse rather than undergo mandatory assessment. Premature cessation of driving results in reduced mobility and a possible safety disbenefit – those who cease driving are likely to undertake more trips as pedestrians (a much more riskier form of transport than driving). It was also noted that driving is the safest and easiest form of transport and many older people experience difficulty using other transport modes, particularly walking. It is argued that continued mobility (which means access to a private car) requires policies that achieve an acceptable balance between safety and access to critical services and amenities.

Chapter 3 identifies measures that can improve the safe mobility of older road users. The evidence suggests that the provision of safe travel options is a vital factor in maintaining mobility and it is argued that, unless there is a fundamental reconsideration of the traffic and transport system to ensure that the mobility and safety needs of older road users are met, the problems and risks associated with ageing will worsen in the coming decades.

4.1 RECOMMENDATIONS

A co-ordinated approach is required that encompasses innovative strategies and initiatives to manage the mobility of older road users. Measures fall into four broad categories: safer

road users, safer vehicles, safer roads and provision of safe and accessible alternative transport options and recommendations are summarised here.

Strategies addressing safer road users include: a re-consideration of licensing re-assessment procedures; behavioural and educational measures such as medical and other rehabilitation; and, driver education and training. It is recommended that:

- It be recognised that most older drivers, particularly through self-regulation, can be relied upon to manage adequately their own safety as drivers.
- Accordingly, licensing authorities treat these older drivers no differently than drivers from other age groups.
- It be recognised that a small proportion of older drivers, especially but not only those suffering from dementia, cannot be relied upon to sufficiently self-regulate their driving behaviour and thus represent an unacceptable crash risk.
- For these drivers, the first priority should be to restoring functional performance where possible through to an acceptably safe level, through rehabilitation and training.
- For drivers who cannot be returned to safe driving levels, consideration be given to the introduction of more valid and acceptable license re-assessment procedures. These procedures should not be age-based but based on functional ability, involve only those drivers suspected of being at-risk, and use valid assessment instruments to determine fitness to drive. A critical feature of this recommended licensing approach is that most older drivers will not be re-assessed. This will reduce the current high levels of premature driving cessation prompted by age-based mandatory licence re-assessment systems and will contribute positively to older people's QoL by enabling them to meet their required levels of mobility.
- Educational and training programs be developed to raise awareness of changing abilities among older road users and their families and caregivers, and to promote safe driving, walking and cycling strategies. Such programs should acknowledge that the elderly are a heterogeneous group and be designed accordingly.

It is recommended in regard to safer vehicles that:

- Strategies addressing the purchase and use of vehicles with high crashworthiness and occupant protection standards be developed.
- Improvements to vehicle crashworthiness be further encouraged, particularly with regard to testing programs that include a component specifically addressing older driver safety.
- Continued development of ITS technologies that may improve the safe mobility of older drivers, be undertaken. Such technologies should ensure that they are optimal for targeted users and may include (but are not limited to) force-limiting seat belts, supplementary airbags, vehicle adaptations to make driving more comfortable and easier, and crash avoidance technologies such as speed alerting and limiting devices, cruise control devices, navigation systems, vision enhancement and rear collision warning devices.

- Continued development of frontal structure design of passenger vehicles to provide 'optimum' crash conditions for pedestrians, also be undertaken. Such features include improved testing programs with components that target pedestrians, improved design of bumpers, bonnet leading edges, and windscreen, discouragement of large aggressive vehicles and rigid bull-bars and development of ITS technologies to assist drivers detect and avoid pedestrians such as speed alerting and limiting devices, vision enhancement and rear collision warning technologies.

It is recommended in regard to safer roads that:

- Road design and operation standards be adopted that reflect the needs and capabilities of older road users.
- Consideration be given to improved environments that older drivers experience difficulty negotiating. This includes improved intersections, freeway interchanges, horizontal curves, passing zones and construction zones.
- Consideration be given to improved environments for pedestrians and cyclists. This includes consideration of measures to moderate vehicle speeds, separation of vulnerable road users and motorised traffic where appropriate, provision of facilities suited to older pedestrians' and cyclists' needs, introduction of measures to reduce the complexity of travel environments, and provision of facilities and public transport stops.
- Consideration be given to improved infrastructure and land-use to facilitate accessibility and availability of transport options, to ensure the safety and security of the public environment, and to deliver a range of public and private services appropriately.

It is recommended in regard to alternative transport provisions that:

- Consideration be given to providing improved public transport options that are viable, affordable, accessible, safe and co-ordinated.
- A range of new and different kinds of mobility services that are tailored to the needs of older adults be considered. These may include subsidised taxi services, independent transport networks, door-to-door community transport services, carpooling schemes, volunteer driving programs and new forms of demand services.
- Resources be developed to promote the use of and raise awareness of alternative transport options amongst older drivers and their families/caregivers.
- Consideration be given to the continued development of programs that support walking and cycling including resources to promote these activities and provision of a safe and comfortable environment in which to walk and cycle.
- Consideration be given to the emerging issues surrounding the use of motor scooters including improved design standards, improved road design to cater for widespread use of scooters.

Older road user safety and mobility is currently enjoying much research and examination, with many individual aspects being scrutinized by individual research programs world-wide. In addition to generally commending current research trends, two prime new research priorities are recommended:

1. Assessment of safe road users, road and vehicles as they affect older driver safe mobility, within an integrated 'safe system' framework (as being developed in Sweden, the Netherlands and Australia).
2. Changes in driving behaviour amongst older adults (partly but not totally 'self-regulation') appear to be a key factor in determining mobility, safety and licensing needs. These changes give rise to a series of research questions:
 - Can older drivers be relied upon to manage their crash risk through self-regulation?
 - If not, which older drivers do not, or cannot?
 - What are the most productive strategies for developing the effective self-regulation behaviours amongst older drivers?
 - How feasible is it to use self-regulation as a principle mechanism for maintaining older driver safe mobility, as an alternative to total driving cessation?

These two research priorities are recommended as key avenues to assist older drivers maintain safe mobility. Any findings arising from these two broad research options would be strengthened if based on international comparisons of different practices, programs and developments.

4.2 CONCLUSIONS

Older people continue to have travel needs after retirement and the private vehicle is likely to remain the dominant and safest mode of transport for the elderly. Moreover, to most older people, driving represents a symbol of freedom, independence and self-reliance, and having some control of their life.

Poor mobility places a substantial burden on the individual, family, community and society and there is a real need for consideration of the transportation needs of older adults at all levels to support ongoing mobility for older road users. This review has highlighted the poor understanding of the mobility needs of older adults, and the lack of appropriate systems to manage their safe mobility. It also identified the measures that can have a positive influence on traffic participation, safety, mobility and associated QoL.

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