USING THE SAFE SYSTEM APPROACH TO KEEP OLDER DRIVERS SAFELY MOBILE

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In 2003, Australian road transport jurisdictions collectively accepted that the greatest road safety gains would be achieved through adopting a Safe System approach, derived from Sweden's Vision Zero and the Netherlands' Sustainable Safety strategies. A key objective of all three approaches is to manage vehicles, the road infrastructure, speeds, road users and the interactions between these components, to ensure that in the event of crashes, crash energies will remain at levels that minimize the probability of death and serious injury. Older drivers pose a particular challenge to the Safe System approach, given particularly their greater physical frailty, their driving patterns and for some at least, their reduced fitness to drive. This paper has analyzed the so-called 'older driver problem' and identified a number of key factors underpinning their crash levels, for which countermeasures can be identified and implemented within a Safe System framework. The recommended countermeasures consist of: (1) safer roads, through a series of design improvements particularly governing urban intersections; (2) safer vehicles, through both the promotion of crashworthiness as a critical consideration when purchasing a vehicle and the wide use of developed and developing ITS technologies; (3) safer speeds especially at intersections; and (4) safer road users, through both improved assessment procedures to identify the minority of older drivers with reduced fitness to drive and educational efforts to encourage safer driving habits particularly but not only through self-regulation.

Key Words: Older drivers, Fitness to drive, Crash risk, Road safety countermeasures, Safe mobility

1. INNOVATIVE APPROACHES TO ROAD SAFETY

The traditional road safety approach accepts that while safety is always a primary consideration, safety is effectively traded-off at the point where mobility options are unacceptably threatened. The traditional approach thus implicitly assumes that some measure of road trauma is both acceptable and inevitable. This view is increasingly being questioned. For example, Sweden has developed the 'Vision Zero' approach, a fundamental principle of which is to view any level of death or serious injury from the road system as unacceptable to a civilized society. In addition, the Netherlands has developed 'Sustainable Safety' as a closely related approach, with the aim of creating a traffic system in which no crash can result in serious injury or death.

Both philosophies state that the transport system should be designed and should operate in a way to ensure that the probability of death and serious injury in the event of a crash will be minimized. Meeting the mobility and safety needs of road users generally and vulnerable groups (including older people) specifically, can be achieved by better managing crash occurrence and crash energy. This can be achieved by providing safer vehicles, safer roads and safer road users and recognising the interactions between these three components in a comprehensive way.

In Australia, national road safety programs are developed and coordinated by Austroads, a federation of State and Territory road transport jurisdictions. In 2003, Austroads accepted that the greatest road safety gains would be achieved through adopting a Safe System approach, a strategy derived from Sweden's Vision Zero and the Netherlands' Sustainable Safety approaches. While this paper focuses on the Australian Safe System approach and context, the identified countermeasures are equally pertinent to other road safety strategies that emphasise the minimization of death and serious injury through providing a safe transport system.

2. BACKGROUND TO THE SAFE SYSTEM APPROACH

Australia's road toll reached its peak during the 1970s, when the death rate exceeded 30 per 100,000 population. A concerted program of road safety countermeasures, which was then progressively developed, resulted

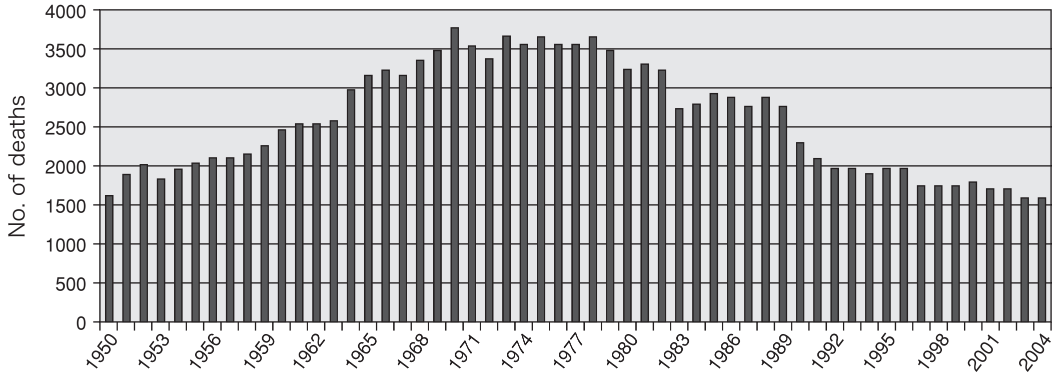

Fig. 1 Road fatalities in Australia, 1950-2004

in the rate dropping to below 10 per 100,000 population by the mid-1990s. In 1975, Australia's road death rate was some 45% above the median value for all Organisation for Economic Co-operation and Development (OECD) countries, but from 1990 onwards it has been consistently below this marker[1]. Australia's road deaths statistics from 1950-2004 are shown in Figure 1.

The decline in the absolute number of road deaths may be attributed at least in part to the development of a new, more systematic approach to tackling road safety issues, based on 'Haddon's matrix'[2], a version of which is presented in Table 1. The individual countermeasures in the matrix have been selected from those introduced in Australia from around 1970 onwards[1].

The approach represented by Haddon's matrix which was successfully implemented in Australia, "helped to shift injury prevention away from an early, naïve preoccupation with … pamphlets and posters to modifying the environments in which injuries occur"[3]. While the view of the road safety problem expanded to include vehicle and road factors, human behaviour and personal responsibility still remained a critical consideration.

Table 1 Principal road safety countermeasures in Australia, 1970 onwards, arranged in Haddon's matrix

Phase	Host (human)	Vector (vehicle)	Physical Environment	Sociopolitical Environment
Pre-crash	1. Introduction of random breath testing in Victoria (1976), and thereafter in other jurisdictions. 2. Introduction of intensive road safety advertising (1989). 3. Introduction of speed camera programs (1990).	General improvements to vehicle handling and control (improved braking systems, speed control devices, electronic stability control etc).	1. Introduction of 50 km/h speed limits in urban residential areas (1998-2004). 2. On-going road and other infrastructure improvement programs.	1. The National Ten point Plan (implemented 1990 onwards.) 2. The series of National Road Safety Strategies (1992 onwards). 3. Australian Rural Road Safety Action Plan implemented (1996). 4. A series of State and Territory Road Safety Strategies, especially from the 1980s onwards
Crash	1. Wearing of seat belts compulsory throughout Australia (1973). 2. Compulsory wearing of bicycle helmets throughout Australia (1992). 3. Improved vehicle crashworthiness.	1. Series of Australian Design Rules, providing better occupant protection (1969 onwards). 2. Motor Vehicles Standards Act (1989).	1. First of the national black spot programs launched (1990). 2. Other on-going road and infrastructure improvement programs, including increased provision of clear zones and frangible poles.	
Post-crash	Prompter provision of emergency medical services.		1 Automatic post-crash emergency mayday systems. 2. Increased use of mobile telephones and geographical positioning devices.	

Table 2 Estimated reductions in serious casualty crashes attributable to various sources, Victoria, 1990-1996

	Victorian road toll reductions (%)						
	1990	1991	1992	1993	1994	1995	1996
Contribution of speed camera traffic infringement notices	10	11	11	11	11	11	11
Contribution of speed and driver concentration publicity	5	7	7	7	6	7	6
Contribution of drink-driving program	9	9	10	10	10	10	10
Contribution of above behavioural road safety programs	**22**	**25**	**25**	**25**	**25**	**25**	**25**
Contribution of increased unemployment	2	12	15	16	14	10	10
Contribution of reduced alcohol sales	3	6	7	9	8	9	10
Contribution of Accident Blackspot treatments	2	3	3	5	6	6	6
Reduction in serious casualty crashes from 1989	**27**	**39**	**43**	**46**	**44**	**43**	**43**

Note: The individual percentage impacts cannot be arithmetically totalled, due to the multiplicative nature of the model.

Behavioural countermeasures were considered to be responsible for a large proportion of the road safety success enjoyed up until the early 1990s. Table 2 provides estimates of the contribution of the main factors influencing road trauma trends in the State of Victoria, 1990-1996[4].

Taking 1990 as an example, speed and driver concentration publicity contributed 5% (almost one-fifth) of the 27% reduction in serious casualty crashes, 1989 to 1990. Speed camera activities contributed 10% and the combination of drink driving enforcement and publicity (which could not be separated) contributed a further 9% of the reduction. Combined, these behavioural coutermeasures accounted for a 22% reduction in serious casualty crashes (representing 81% of the total reduction). For the remainder of the study period however, the impact of the various behavioural coutermeassures plateaued, with further crash reductions relative to the 1989 level being attributable to other, mainly economic factors[4].

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Equivalent activities to those shown in Table 2, were also being implemented to varying extents in other Australian jurisdictions with varying degrees of effectiveness.

The approach used by Haddon and others has been invaluable, first in providing a scientific approach to road safety and secondly, in emphasizing that behavioural interventions need to be complemented by other factors (particularly vehicle and road countermeasures). However the plateau in the national road toll from the mid-1990s (see Figure 1) suggested the need for a fresh approach to tackling road safety problems. In addition, while behavioural countermeasures remain as valuable tools to increase safety, these strategies often require a long period of time until the benefits can be realised. Engineering countermeasures in particular can modify the physical environment of the transport system to provide quick and effective mobility and safety benefits.

3. AUSTRALIA'S SAFE SYSTEM APPROACH

The Safe System strategy[5] accepts that while many crashes can be prevented, some will continue to occur despite efforts to the contrary. A key task of the Safe System therefore is to manage vehicles, the road infrastructure, speeds, and the interactions between these components, to ensure that when crashes do occur, crash energies will remain at levels that minimize the probability of death and serious injury. An overview of Austroads' Safe System approach is given in Figure 2[5].

The Safe System approach does not dismiss individual road user responsibilities and behavioural countermeasures but explicitly points to these aspects as supporting components of the system. Road user components include admittance to the system (especially graduated licensing schemes for young drivers), compliance with road rules, strengthened sanctions to control unlicensed driving, im-

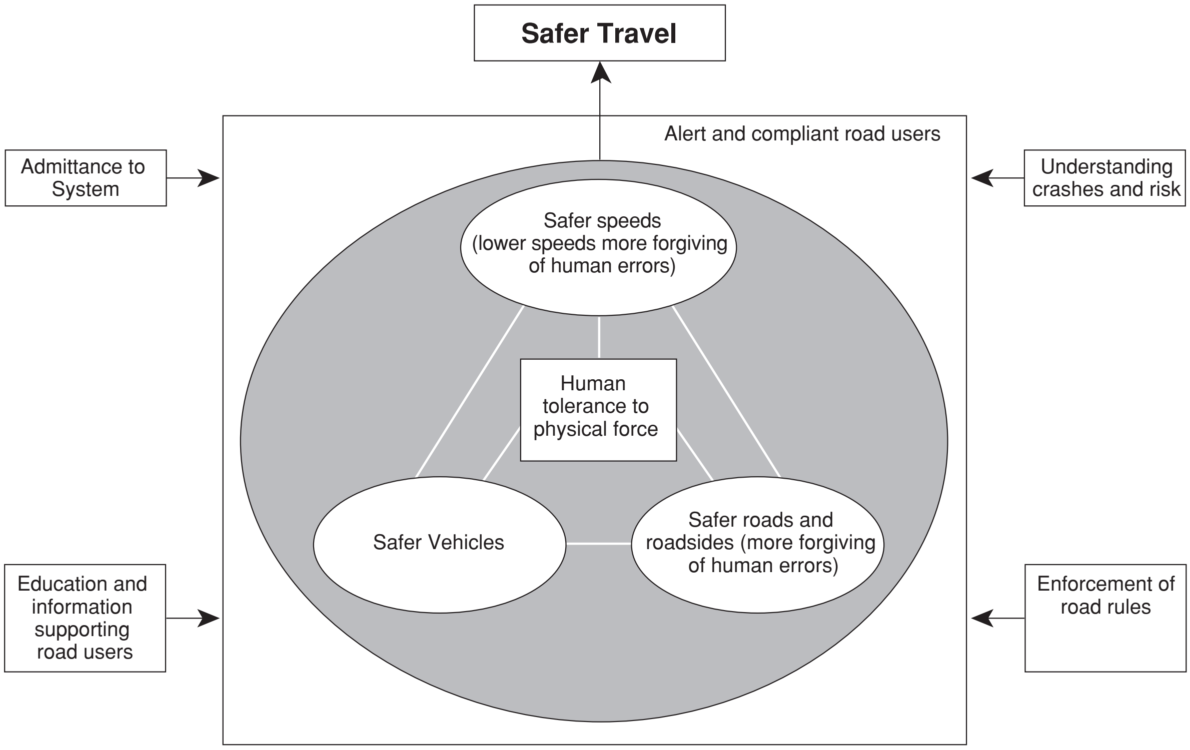

Fig. 2 Australia's Safe System approach to road safety

proved assessment of fitness to drive in the face of medical conditions and functional declines, and information and education to support safe use of the transport system.

The importance that the Safe System approach places on safer roads and safer vehicles in particular, is reflected in the current national road safety strategy. The strategy anticipates that the target of a 40% reduction in road deaths from 9.3 per 100,000 people (1999) to 5.6 (2010), will be achieved thus[1]:

Proportion of the target reduction	
Safer roads	48%;
Safer vehicles	25%;
Safer road users	23%;
New technology	5%.

In round terms, it is expected that three of every four deaths prevented will be due to safer roads and vehicles.

4. THE 'OLDER DRIVER PROBLEM'

Size of the problem

Based on road fatality patterns in Australia from 1996-1999, drivers aged 70 years and above have accounted for between 70 and 100 deaths per year, representing between five and six percent of all road fatalities[6]. While this currently represents a reasonably modest proportion of the road toll, projections based on pending demographic changes and changes in older driver licensing rates and driving patterns suggest that older driver fatalities will at least double over the next thirty or so years[7].

A transport system which aspires to achieving Safe System objectives cannot ignore either the current or especially, the expected older driver fatality (and other casualty) levels.

Crash risk

While the exact measurement of older drivers' crash risk varies according to the particular measures used,

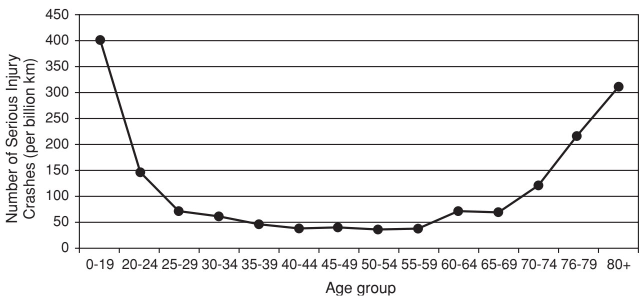

Fig. 3 Age of driver and fatal and serious injury crashes per distance travelled, Australia, 1996

their risk is greatest when based on per distance travelled. Figure 3 shows the age of driver and fatal and serious injury crashes per distance travelled, Australia, 1996[7].

Risk curves of the type in Figure 3, which show heightened crash risk particularly for drivers aged around 75 years and above, are characteristic of most Western societies[8].

5. EXPLAINING THE 'OLDER DRIVER PROBLEM'

5.1 Frailty

It has been long recognized that older adults' biomechanical tolerances to injury are lower than those of younger persons[9-11], primarily due to reductions in bone strength and fracture tolerance[12,13]. The amount of energy required to produce an injury reduces as a person ages 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 quantify the impact of frailty when explaining older drivers' crash risk, with some variation in the subsequent estimates, according to the methods and data used. As a recent example, it was estimated that, fragility accounted for around 60-90% of the excess death rates amongst older drivers – with excessive crash involvement due to 'other factors' being largely restricted to drivers aged 80 years or older[14]. For these oldest male and female drivers, 'other factors' accounted for 37% to 43% of their overall fatal crash involvement.

Another consequence of older drivers' frailty is that they and to a lesser extent, their (usually elderly) passengers are more likely than other vehicle occupants to be injured or killed in the event of a crash[15-17].

5.2 Location of driving

Drivers travelling longer distances will typically have lower crash rates per kilometre, compared to those driving shorter distances[18]. As older drivers typically drive less distance per trip and have lower accumulated distances, 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 and her colleagues[19] empirically tested this hypothesis by using Finnish survey data to compare older and young middle-aged drivers' crash rates, controlling for annual distances driven. When older drivers (65 years and older) were compared with younger drivers (26-40 years) who had equivalent driving exposure, there was no age-related increase in crashes per distance driven. The apparent age-related risk was attributed to yearly driving distances, in accordance with the reasoning by Janke, and not directly to age.

Both Janke and Hakamies-Blomqvist and her colleagues attributed the mileage/crash association at least in part to different driving locations. High mileage drivers are more likely to use freeways and multi-lane divided roadways with limited access: low mileage drivers do more of their driving on local roads and streets, which have greater number of 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. Urban travel is even more likely to result in crashes for older drivers[20], given their well-documented difficulties in negotiating intersections[8].

5.3 Reduced fitness to drive

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 identified arthritis, heart diseases, arterial hypertension, diabetes and the various forms of dementia as common age-related conditions[21]. Stutts and Wilkins[22] 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.

An attempt to show the relationship between age-related impairments and driving performance is shown in Table 3.

The full impact of the association between ageing, medical conditions, functional decline and reduced driving skills upon crash involvement is mitigated by older drivers themselves:

> 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 neces-

Table 3 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 and Mitchell (1998).

> sarily 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[23].

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[24-28]. 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[29-31]. 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[26,32].

Although self-regulation does not entirely prevent older driver crashes, it is effective in keeping older driver crash rates at 'normal' levels. Smiley 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 driver[26].

While self-regulation may be reducing older drivers' crashes below expected levels, there is evidence that at least some older drivers are not regulating. For example, Stalvey and Owsley[33] found that over three-quarters of a visually-impaired, high-risk group of older drivers did not self-regulate and did not see themselves as particularly susceptible to crashing.

There is further evidence from crash data that at least some older drivers – whether because of 'normal ageing' or because of more severe medical conditions and functional impairments – are at heightened crash risk as a result of reduced fitness to drive. This evidence is best considered in two stages.

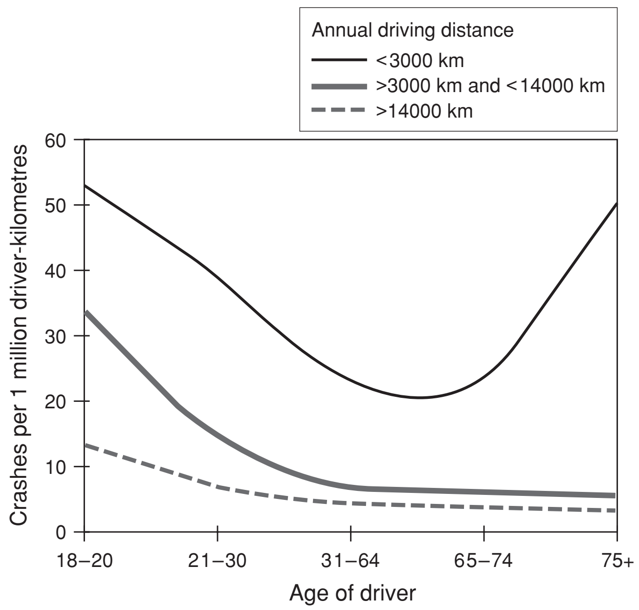

Fig. 4 Annual crash involvement for different driver ages, controlling for annual mileages

First, Langford, Methorst and Hakamies-Blomqvist[34] used travel survey data from a sample of 47,502 Dutch drivers to confirm the earlier demonstrations of the Low Mileage Bias[21,23]. Figure 4 shows the association between age of driver and crash involvement, controlling for annual distance driven.

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% 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 were regarded as indicative only.

Secondly, Langford et al.[34] followed up the hypothesis that low-mileage older drivers' indicatively high crash risk may be at least partly due to reduced fitness to drive. Data from a sample of almost 1,000 New Zealand older drivers confirmed that drivers who travelled low mileage had more crashes per distance driven than drivers with higher mileage, and the differences were statistically significant in most instances. The data also showed that low mileage drivers were more likely to report a reduction in their driving performance and to report a range of health and medical conditions. Further, the low mileage drivers also performed less well on two of three off-road tests of fitness to drive and on an on-road driving test. For many of the measures of health, functional performance and driving fitness, the differences between the lowest and highest mileage drivers were statistically significant.

5.4 Conclusions about the 'older driver problem'

Older drivers as a group have a heightened casualty crash involvement per distance travelled – and in such crashes are more likely than other participants to be injured or killed. Older drivers as a group are more likely to have some level of functional impairment and, at least intuitively, a reduction in some driving skills. However this latter factor is considered to have only a modest role in all older driver crashes, due to older drivers' propensity to self-regulate, thereby reducing driving exposure (particularly to difficult or otherwise uncomfortable driving situations).

In explaining older drivers' heightened casualty crash involvement per distance travelled, the research suggests that in addition to many of the usual factors affecting drivers of all ages, the following have a particular role:

- for almost all, physical frailty;
- for many, a high level of urban driving;
- for some, reduced fitness to drive.

6. COUNTERING THE 'OLDER DRIVER PROBLEM' IN A SAFE SYSTEM CONTEXT

Countermeasures aimed at the total driving population would also be expected to have safety benefits for older drivers. However, older drivers, at least because of their greater physical frailty and their particular driving and crash patterns, also warrant specific consideration. The countermeasures within a Safe System framework considered in this section have been restricted to those that target the older driver problem and fall into two categories: those aimed at preventing crashes ('active' countermeasures) and those aimed at reducing the severity of crash outcomes ('passive' countermeasures).

These countermeasures have been considered in relation to each of the individual components of the Safe System (safer roads, safer vehicles, safer speeds and safer road users). However, it needs to be recognized that the Safe System approach also considers the interactions between these components. For example, the appropriate travel speed limit required to minimize the risk of death and serious injuries along a given road segment will not necessarily be uniform for all segments and roads of that type: the appropriate travel speed will be determined by the road infrastructure, the nature of roadsides and especially, the extent of separation of opposing traffic flows and road user groups, the traffic and road user mix and the types of road user behaviour along that segment.

6.1 Safer roads

Older driver crashes are predominantly an urban problem.

In round terms, 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[35]. This pattern, and particularly the predominance of intersection crashes, has been widely confirmed, both in Australia[33,36,37] and elsewhere in the world[14,27,28,38-42].

There have been many research studies which have examined older drivers' difficulties with road design features[8]. In both the US[43] and Australia[44], engineering handbooks have been prepared which contain design recommendations for making the driving task easier and safer for older drivers, especially at intersections. Road infrastructure aspects requiring design improvements for older drivers, taken from the US handbook, are listed in

Table 4 Aspects of design improvements taken from the U.S. older driver highway design handbook

I. INTERSECTIONS (AT GRADE)	
Intersecting angle (Skew) Receiving lane (Throat) Channelisation Intersection sight distance Left-turn lane geometry, signing, delineation Edge treatments Curb radius Traffic controls for left-turn movements	Traffic controls for right turn movements Street name signage One way/wrong way signage Stop- and yield-controlled intersection signage Traffic signal performance issues Fixed lighting installations Pedestrian control devices
II. INTERCHANGES (GRADE SEPARATION)	
Exit signing and delineation Acceleration/deceleration lane design	Fixed lighting installations Traffic controls for prohibited movements
III. ROADWAY CURVATURE AND PASSING ZONES	
Pavement markings and delineation, curves Pavement width, curves	Advance signing for sight restricted locations Passing zone length and passing sight distance
IV. CONSTRUCTION/WORK ZONES	
Advance signing for lane closure Variable message signing practices Channelisation practices	Delineation of crossovers/alternative paths Temporary pavement markings

Table 5 Top ranked 20 road design features associated with older driver crashes at the 62 inspected crash sites

Road Design Feature	Applicable	Relevance	Rating
Lack of separate traffic control signals	50%	45%	23%
Limited/restricted sight distance at right-turns	68%	33%	23%
Value < 2.5s for Perception-Reaction-Time (PRT)	90%	25%	23%
Restricted sight distance and lack of right-turn offsets	66%	15%	10%
Absence of receiving lane and minimum shoulder width	61%	13%	8%
Inadequate lane definition	48%	17%	8%
Unsuitable traffic signal lamps for older drivers	34%	24%	8%
Lack of minimum sight distance above 65km/h	18%	36%	6%
Lack of full-control traffic signal (no red arrows)	56%	9%	5%
Lack of left-turn channelisation and pedestrian refuge	35%	14%	5%
Lack of common overhead signing	66%	7%	5%
Lack of upstream signing with minimium 3sec preview	29%	11%	3%
Failure to use larger retro-reflective STOP and YIELD signs	40%	8%	3%
Lack of advanced warning for restricted sight distance intersections	16%	20%	3%
Lack of advanced warning for poor visibility STOP signs	2%	100%	2%
Lack of raised channelisation of high luminance	27%	6%	2%
Lack of DIVIDED HIGHWAY CROSSING signs at one-way intersections	26%	6%	2%
Tapered acceleration and deceleration lanes	29%	6%	2%
Intersecting roads = 75deg angle of intersection	19%	8%	2%

Notes: 1. Vehicles in Australia travel on the left-hand side of the road, opposite to the US and Europe.
2. The weighted figure (for each road design feature) was calculated by multiplying the percentage of sites where the given design feature was theoretically applicable by the percentage of sites where the given design feature was considered to have actually contributed to older driver crashes at that site. In other words, each design features was weighted for exposure and crash involvement at these older driver 'black-spot' sites.

Table 4.

Oxley et al.[45] have conducted in-depth analyses of older driver behaviour at 62 'blackspot' (high-crash) locations around Australia and New Zealand, ranked by regional jurisdictions according to the number of older driver crashes over a five-year period. Intersections accounted for 97% of all locations. The investigators concluded that while intersection design was rarely the primary cause of the crashes, improved design would have had substantial safety benefits. The top 20 design features associated with the total of 400-plus older driver crashes and their rated importance in reducing these crashes, are given in Table 5.

As a response to these design factors, the investigators recommended greater use of roundabouts, fully controlled right-turn (equivalent to left-turn in the US and Europe) phases at intersections controlled by traffic lights and a range of other design features, for which there are reliable estimates of effectiveness for drivers in general. Some evidence exists about their ability to not only reduce crash numbers but also injury severity.

Most of these recommendations have yet to be evaluated for their safety benefits specifically for older drivers. However a preliminary evaluation of driver behaviour through improved intersections in accordance with some of the US design handbook recommendations[46] concluded that:

> … the FHWA guidelines for implementing safe driving are helpful for safer driving. Overall it seemed that young and older participants, alike, may benefit from roadways with these safety features, yielding critical information for engineers, planners, policymakers, and others involved in the design of roadway systems to enhance safe driving.

6.2 Safer vehicles

Older drivers' frailty is a major determinant of crash outcomes.

Vehicle crashworthiness may be defined as an estimate of a driver's risk of being killed or admitted to hospital once involved in a crash where at least one person is injured or one vehicle is towed away. Current vehicles, as a group, are twice as safe (as measured by crashworthiness) as vehicles manufactured some thirty years earlier[47].

When these researchers considered the crashworthiness of individual vehicle models, they found substantial variation in the ratings:

- the safest model had less than one-half the risk of death or serious injury in a tow-away crash, compared to vehicles with average crashworthiness;
- the least safe model had more than double the risk of death or serious injury in a tow-away crash, compared to vehicles with average crashworthiness;
- the least safe model had more than five times the risk of death or serious injury in a tow-away crash, compared to the safest model.

Given older drivers' additional need for protection in the event of a crash due to their frailty, the purchase of modern vehicles with maximum crashworthiness ratings is a paramount countermeasure. However it appears that this policy is currently not followed by many older drivers. In an analysis of fatal crashes in Australia 1996-99[34], drivers aged 75 years and older were more likely to be driving older vehicles: 51% of older drivers in fatal crashes were known to be in cars 11 years or older, compared to 30% of middle-aged drivers.

A survey of Victorian older drivers which identified factors that influenced older drivers when purchasing a vehicle[48], concluded:

> … features related to comfort and ease of driving were important to older drivers, as was vehicle handling. Safety features that improve occupant protection in a crash were poorly understood and misconceptions about features such as airbags were common. The results indicate a need to address gaps in knowledge and misconceptions and to encourage older drivers to purchase vehicles that have the potential to reduce the frequency and severity of injury outcomes.

Stronger promotion of crashworthiness as a key factor in purchasing a vehicle therefore represents a meaningful passive road safety countermeasure that has been far from fully exploited. The Australian New Car Assessment Program (ANCAP)[49] tests the crashworthiness of most major current car models by conducting barrier crash tests under laboratory-controlled conditions. The primary purpose of the program is to provide consumer information on relative vehicle safety in crashes. Because a vehicle can be tested as soon as it is released for sale, ANCAP targets primarily consumers of new vehicles with the program claiming to cover around 80% of the new vehicle market. The promotion of vehicle crashworthiness as part of ANCAP may warrant special targeting of older drivers.

Table 6 Aspects of older driver crashes and ITS implications, Australia

Crash aspects	% of drivers aged 75+ years	% of drivers aged 40-55 years	In-vehicle ITS Implications
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. Vision enhancement systems may have limited relevance.
More likely to occur at intersection and More likely to involve attempted right-hand turn (responsible drivers in multi-vehicle crashes)	64.0 36.0	21.2 7.7	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 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 >=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).

Note: '%' refers to the proportion of drivers – either 'all drivers in crashes' or 'responsible drivers in multi-vehicle crashes' – measuring positively for the specified aspect.

Older drivers have a distinct crash epidemiology.

Langford and Mitchell[50] examined 1999 fatal crash data for Australia to identify aspects of older driver crashes which can potentially be controlled by either active or passive ITS technology. The results are given in Table 6, with older drivers compared to drivers aged 40-55 years.

As noted by Regan et al.[51], it is currently impossible to measure the crash reductions arising from the range of ITS applications. Many ITS developments have been in place for too short a time and have been implemented on too restricted a scale to enable meaningful analysis of changes in crash patterns. At best, road safety benefits can be estimated only through indirect means: for example, through changes in driving behaviour, whether on a simulator, a test track or on-road.

6.3 Safer speeds

Older drivers generally drive at or below posted speeds.

The Safe System strategy treats speed reductions mainly as a complementary measure to road-based improvements, especially in treating high-risk sections of the road network where there are no immediate engineering options. The accompany current National Action Plan calls for a wider array range of measures, including a review of the adequacy of prevailing speed setting practices in managing risk.

Given older drivers' characteristic slow travel speeds, often as part of their self-regulation, speed policies within the Safe System approach are likely to have only a modest impact upon their own speed choices. However, any reduced speeds are likely to lessen older driver crash involvement and reduce the severity of crash outcomes, if only because of the slower speeds of other drivers. In particular, effective steps in reducing all drivers' speeds when travelling through intersections (whether by means of lowered posted speeds or by traffic-calming measures) would have disproportionately high benefits for older drivers.

6.4 Safer road users

A minority of older drivers have reduced levels of reduced fitness to drive.

It is suggested that older drivers whose reduced fitness to drive puts them at an unacceptable crash risk (however 'unacceptable' might be defined), require a more strategic, multi-level assessment system managed by licensing authorities.

Research suggests that age-based 'across the board' mandatory assessment is ineffective from safety and mobility perspectives. After weighing the limited evidence available to it, an OECD Expert Group[8] reported that "mandatory medical assessment of all drivers at a certain age to detect those who are unfit to drive is neither cost-efficient nor beneficial" (p83). This stance has been confirmed by later research[52-54]. It was generally concluded that mandatory licence re-testing schemes have no demonstrable road safety benefits – and may even result in an increased concentration of unsafe drivers on the road.

There are no rational grounds for implementing mandatory age-based testing of driving fitness for a group, the large majority of whose members are demonstrably as safe as or safer than drivers of other ages. At the same time, it appears that a minority of older drivers require assessment. Attempts to identify these high-risk drivers should focus upon those drivers giving some preliminary evidence of being at risk, without involving all older drivers in a formal assessment process. The proposed licensing model for managing older driver safety currently being developed and trialled in Australia[7,55] complies with this stance. The model's features include:

- the establishment of a network of community notification sources, whereby only drivers suspected to have a high crash risk are identified and referred to the licensing authority for formal assessment. It is proposed that notification sources include general practitioners, police, family and friends – as well as older drivers themselves;
- the use of multi-tiered assessment, involving general practitioners, occupational therapists and other health specialists at more elaborate levels of assessment;
- the use of assessment instruments of known validity for testing safe driving.

Older drivers with reduced levels of reduced fitness to drive, are not always aware either of their limitations or the crash implications.

Most Australian jurisdictions conduct education programs, directly targeting either older drivers through workshops and handbooks or their doctors through in-service seminars. These programs are similar to overseas endeavours delivered through a variety of formats[56-58] and generally aim to assist older drivers to:

- assess their health, functional performance and driving skills;
- develop a better understanding of their crash risk;
- adjust their driving habits to reduce their crash risk – either through reduced exposure particularly to challenging situations or (in the extreme cases), through total cessation.

These educational efforts are fully consistent with the Safe System emphasis upon informed road users. However it needs to be recognized that not all older drivers might be responsive to these efforts and ultimately, other more direct measures may be necessary (for example, through referral to licensing authorities for assessment).

7. SUMMARY

Two principal objectives of Australia's 'Safe System' approach to road safety are the prevention of crashes and where this fails, the management of crash energy to prevent the occurrence of deaths and serious injuries while using the transport system. Older drivers pose a particular challenge in this context, given particularly their greater physical frailty, their preponderance of urban driving and for some at least, their reduced fitness to drive. An additional challenge lies in maintaining their safe mobility for as long as possible, in light of these factors.

This paper has analyzed the so-called 'older driver problem' and identified a number of key factors underpinning their crash levels, for which countermeasures can be identified and implemented within a Safe System framework. The recommended countermeasures consist of: (1) safer roads, through a series of design improvements particularly governing urban intersections; (2) safer vehicles, through both the promotion of crashworthiness as a critical consideration when purchasing a vehicle and the wide use of developed and developing ITS technologies; (3) safer speeds especially at intersections; and (4) safer road users, through both improved assessment procedures to identify the minority of older drivers with reduced fitness to drive and educational efforts to encourage safer driving habits particularly but not only through self-regulation.

The application of Safe System countermeasures will enable current and future older drivers to continue driving in relative safety, ensuring adequate access to the services and facilities as necessary to older people as to others.

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