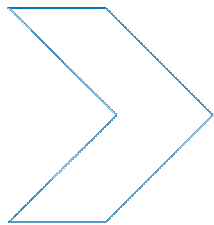


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Older drivers: Crash involvement rates and causes

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ABSTRACT

This report presents an analysis of the claims that older drivers are over-represented in road crashes and an examination of the nature of the 'older driver problem' in so far as it exists. Four different types of crash rates (crash numbers, crashes per head of population, crashes per licensed driver, crashes per distance driven) are considered, with emphasis placed on problems in interpretation of the various crash rates and what information can be derived from each of them. It is concluded that the crash rates of most importance are total crash numbers and crashes per licensed driver, neither of which were found to feature an over-representation of older drivers. Also addressed in the report is the question of whether the increase in crash rates per distance driven might be a phenomenon associated with older drivers as a whole, or one associated with specific subgroups of older drivers whilst the remainder maintain the relatively low crash rates of middle-aged drivers. Although there are arguments to support the claim that there are high risk subgroups of older drivers, it is nevertheless concluded that high risk older drivers cannot be identified in mass crash data. A third section of the report contains an analysis of a sample of crashes involving older drivers that were investigated as part of an in-depth study into rural road crashes. The factors other than the driver which contributed to the occurrence of the crashes are discussed, illustrating the importance of appropriate road infrastructure for reducing older driver crashes.

KEYWORDS

Aged driver, Accident rate, Accident analysis

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Summary

Older drivers, when compared to those in younger age groups, have relatively few crashes. They are only over-represented in crashes when adjustments are made for distances driven by drivers in different age groups. This over-representation in crashes per distance driven is given a great deal of emphasis in the literature but, for practical purposes, the two most important indices of crash involvement are total crash numbers and crashes per licensed driver, neither of which show an over-representation of older drivers. Older drivers, relatively speaking, do not contribute greatly to overall crash numbers, and crash rates per licensed driver suggest that the re-licensing of most older drivers should be a routine process. The increased crash rate per distance driven, on the other hand, is difficult to interpret because of the possibility that it is produced by cohort effects and the 'low mileage bias'. The possibility that older drivers have an increased crash rate per distance driven because they restrict their driving would mean that this increased crash rate is due to behaviour that actually reduces their overall likelihood of having a crash (i.e. fewer crashes because of a reduction in exposure).

If there is a problem regarding older drivers, it is that they are more susceptible to injury. This results in older drivers being over-represented in crashes of high injury severity. This greater likelihood of suffering serious or fatal injuries in a crash is sufficient justification for a specific focus on reducing the crash rates of older drivers.

Crash involvement among older drivers has been linked to a number of medical conditions and functional deficits (i.e. deficits in vision, cognition, attention, or physical functioning). This would appear to make it likely that older drivers affected by such conditions and deficits would constitute high risk subgroups of the older driver population. This, in turn, should result in the crash involvement of older drivers being concentrated among such 'high-risk' drivers. However, although those older drivers who are involved in crashes are more likely to crash again in a subsequent time period, it is not possible to identify 'high-risk' older drivers in mass crash data. This is because of the rarity of crashes for individual drivers. Most older drivers, in a time period of five years, will be crash-free and very few will have more than one crash. Also, the nature of the Poisson distribution means that, due to chance effects, drivers with a 'normal' crash risk could have three or more crashes in a year, while many drivers with a significantly higher risk of crashing could remain crash-free in the same time period. The practical significance of this is that involvement in a crash for an older driver is not likely to be indicative of the need for assessment of fitness to drive. Identifying those whose fitness to drive should be assessed is best done through medical channels.

It is also important to bear in mind that crashes are multi-determined events. An investigation of a sample of rural crashes involving older drivers demonstrated the role of vehicular and, particularly, road environment-related factors in crash causation. Of particular interest was the over-involvement of older drivers in intersection crashes. In many instances, the nature of the intersection was likely to have contributed to the crash. Improvements to intersections, which have since been made to a number of the sites at which the investigated crashes occurred, will improve their safety for all road-users but may disproportionately assist older drivers.

To summarise, the increasing emphasis on the importance of maintaining the mobility of older adults means that it is timely to consider the different methods of calculating crash rates with regard to older drivers. The results suggest that older drivers are not over-represented in crashes but that they are more susceptible to injury in the event of a crash. This means that older adults are still of concern in the road safety context and that focusing specifically on reducing older driver crashes should still be a priority. The inability to identify older drivers with an increased risk of crashing from mass crash data suggests that at-risk older drivers are best identified through medical channels. Older driver crashes may also be reduced disproportionately to those of drivers in other age groups by making intersections easier to use.

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1 Introduction

The relative crash risk of older drivers (those aged over 65) has become the focus of a great deal of attention in recent years, due to the recognition that the driver population in developed countries is ageing (OECD, 2001). Analyses of crash data typically find an increased risk of crash involvement per distance driven for older drivers (Frith, 2002; Lyman, Ferguson, Braver, & Williams, 2002; Ryan, Legge, & Rosman, 1998), and so it is argued that older drivers are a road safety problem and interventions are needed to reduce their risk of crashing.

This report presents an analysis of these claims and an examination of the nature of the 'older driver problem' in so far as it exists. The different types of crash rates (crash numbers, crashes per head of population, crashes per licensed driver, crashes per distance driven) are considered, with emphasis placed on problems in interpretation of the various crash rates and what information can be derived from each of them. Also addressed in the report is the question of whether the increase in crash rates per distance driven might be a phenomenon associated with older drivers as a whole, or one associated with specific subgroups of older drivers whilst the remainder maintain the relatively low crash rates of middle-aged drivers. A third section of the report contains an analysis of a sample of crashes involving older drivers that were investigated as part of an in-depth study into rural road crashes. The factors other than the driver which contributed to the occurrence of the crashes are discussed, illustrating the importance of appropriate road infrastructure for reducing older driver crashes.

2 Crash rates and age group

2.1 Introduction

There are four different rates that are typically reported with regard to crashes by age group. These are total crash numbers, crashes per head of population, crashes per licensed driver and crashes per distance driven. In this section, police-reported crash data for South Australia for the period 1994 to 1998 are analysed in terms of these four rates, with emphasis placed on the relative crash rates of older drivers.

2.2 Method

2.2.1 Crash data

The study was based on an analysis of data recorded in the Traffic Accident Reporting System (TARS) database maintained by the Traffic Information Management Section of Transport SA (now the Department for Transport, Energy and Infrastructure). The TARS database is a record of all road crashes in South Australia that are reported to the police. Crash participants are required to report their crash to the police if the crash results in a person being injured or if it causes property damage in excess of a specific threshold. Prior to January 1, 1998, crashes in which property damage exceeded \$600 in non-injury crashes were required to be reported to the police. After this date, the threshold increased to \$1,000. The details of all crashes in South Australia matching the injury or property damage criteria are entered into the TARS database. The variables contained within the database refer to a number of characteristics of the crash, including those of the drivers (e.g. age, sex, blood alcohol concentration), the vehicles (e.g. type, year of manufacture), the roads (e.g. speed limit, road surface), the nature of the crash itself (e.g. vehicle movement, crash type), the environment (e.g. lighting conditions, weather conditions), and the outcome of the crash (e.g. injury severity, damage estimate).

Crash data for the years 1994 to 1998 inclusive were chosen for this analysis. The year 1998 was chosen because it was the most recent year for which the database was complete when this study was conducted, whilst 1994 was chosen as the first year because a period of five years was thought to provide an adequate time frame in which to obtain a representative sample of crash data.

In order to analyse the crash data in terms of the age group of drivers involved in the crashes, it was necessary, because of the structure of the TARS database, to base the analysis on crash-involved drivers rather than crashes. This means that for crashes in which there was more than one driver/vehicle, the details of the crash would be represented more than once in the data extracted from TARS for analysis. Crash-involved drivers were chosen for inclusion in the analysis only if they were driving a car or car derivative (station wagon, panel van, utility). This was done to exclude data for different subgroups of drivers (e.g. motorcyclists, truck drivers) whose characteristics may differ from other motorists in ways that might have affected the results if included. Motorcycle riders involved in crashes, for example, have been found previously to be disproportionately young males (Holubowycz, Kloeden, & McLean, 1994).

The age groups for which the crash data were analysed were: under 16, 16-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, 85 and over, and age unknown. Although South Australia does not permit the licensure of those under 16, there were a number of crashes involving drivers under the age of 16. Other than the preliminary statistics for crash numbers, drivers under the age of 16 were excluded from subsequent analyses because these drivers represent a subgroup of those aged under 16 who, by the very act of driving when the crash occurred, were breaking the law, and who had not officially demonstrated the minimum skill level and knowledge necessary for a licence.

2.2.2 Population data

Estimates of the South Australian population for the different age groups in June of each year from 1994 to 1998 were obtained from Australian Bureau of Statistics (ABS) publications (Australian Bureau of Statistics, 1997, 1998, 1999). These data were used to determine an estimate of the average annual population over the five years for each age group. This average population was used to calculate the crash rate per head of population for each age group.

2.2.3 Driver licensing data

Driver licensing data were obtained from Registration and Licensing (now Driver and Vehicle Licensing), a section of Transport SA (now the Department for Transport, Energy and Infrastructure). Requests were made to Registration and Licensing for the number of licensed drivers in South Australia, broken down by age group, for each year from 1994 to 1998 inclusive. These data, however, were only available for December 1999. Although determining crash rates per licensed driver using licensing data from a year after the end of the time period being studied is not ideal, it is assumed that any biases introduced by the use of the 1999 data would be small and would not have a meaningful effect on the results of comparisons across age groups.

2.2.4 Driving exposure data

Driving exposure data, in terms of kilometres driven by South Australian drivers, were obtained from the Australian Bureau of Statistics. The data were derived, on request, from the Australian Bureau of Statistics Survey of Motor Vehicle Use (Cat No 9208.0) for the 12 months ending 31st June, 1998. The Surveys of Motor Vehicle Use are designed to collect information regarding the amount of driving done in different types of vehicle, rather than by different types of driver. That is, they are vehicle-based rather than driver-based surveys. The surveys report on a sample of vehicles and report the number of kilometres driven in the vehicles. The only information about drivers that is sought is the age and gender of those who drive a sampled vehicle and the proportion of the total distance travelled by the vehicle for which each driver is responsible. Therefore, the Australian Bureau of Statistics data refer to the average number of kilometres driven by drivers in a particular sampled vehicle. The data do not take into account the possibility that some drivers may drive multiple vehicles and may, therefore, underestimate the number of kilometres driven by some of the drivers in the sample. For the purposes of this chapter, in which only relative comparisons across different age groups are of importance, rather than absolute figures, it is assumed that drivers in different age groups do not systematically differ from each other in terms of the extent to which they spread their driving between different vehicles.

The information requested from the Australian Bureau of Statistics was for passenger vehicles only. This subset of vehicles includes cars, station wagons, hatchbacks, passenger vans or minibuses with fewer than ten seats, sports utility vehicles with fewer than ten seats, and campervans. Taxis, motor cycles, trucks and buses were excluded. This subset of vehicles matches closely those chosen from the TARS database for inclusion in the analysis.

2.3 Results

To determine the extent of crashes in South Australia involving older drivers, the following section provides details of the number of crashes recorded in the TARS database for the specified age groups in the years from 1994 to 1998. This is followed by details of the crash rates for these age groups in terms of the number of persons in the population, the number of licensed drivers, and the average number of kilometres driven per year.

2.3.1 Crashes by age group

In the years 1994 to 1998 in South Australia, there were 331,590 drivers of passenger vehicles (as described above) who were involved in crashes reported to the police¹. The age of the driver was known to the police in 260,361 (78.5%) cases. The number of drivers in each age group is shown in Table 2.1, which reveals that, with increasing age (excluding those under the age of 16, who were not licensed drivers), there was a decrease in the number of drivers involved in crashes. These data therefore indicate that older drivers are involved in fewer crashes than younger drivers.

Table 2.1
Age of crash-involved drivers in South Australia, 1994 to 1998

Age group	Number of crashes	Percent of known
<16	209	0.1
16-24	73,645	28.3
25-34	58,062	22.3
35-44	49,600	19.1
45-54	35,658	13.7
55-64	19,833	7.6
65-74	15,142	5.8
75-84	7,275	2.8
85+	937	0.4
Unknown	71,229	-
Total known	260,361	100.0
Total	331,590	

2.3.2 Crashes per head of population

The mean estimated population for each of the specified age groups in South Australia from 1994 to 1998 is provided in Table 2.2. As can be seen, there were substantial differences in the populations of the age groups. The population in different age groups decreased with increasing age over 44, with 7.5 per cent of people aged over 74 and less than two per cent aged over 84.

¹ Drivers involved in multiple crashes were counted separately for each crash. Therefore, the number of *different* drivers involved in crashes in South Australia in 1994 to 1998 would be less than 331,590. For the purposes of this section, the number of crash-involved drivers in an age group refers to the number of instances of crash involvement for drivers in the age group.

Table 2.2
Mean estimated population in South Australia, 1994 to 1998, by age group

Age group	Age group total	Percent of total
16-24	185,025	16.0
25-34	221,681	19.2
35-44	225,051	19.5
45-54	188,220	16.3
55-64	130,701	11.3
65-74	118,853	10.3
75-84	67,661	5.8
85+	19,537	1.7
Total	1,156,729	100.0

As some age groups comprised a greater share of the population, these age groups would be expected to have comprised a greater share of the population of crash-involved drivers. Therefore, to gain a better indication of the likelihood of drivers in different age groups being involved in crashes, crash rates were adjusted according to these population differences (i.e. number of crashes divided by population, calculated for each age group). The percentages of the population in each age group who were involved in a crash between 1994 and 1998 are presented in Figure 2.1 (data are provided in the Appendix, Table 1). As noted earlier, for the purposes of this study, two crashes involving the same driver were counted as two separate crash-involved drivers. This would have resulted in an overestimate of the percentage of the population who had experienced a crash in the study period.

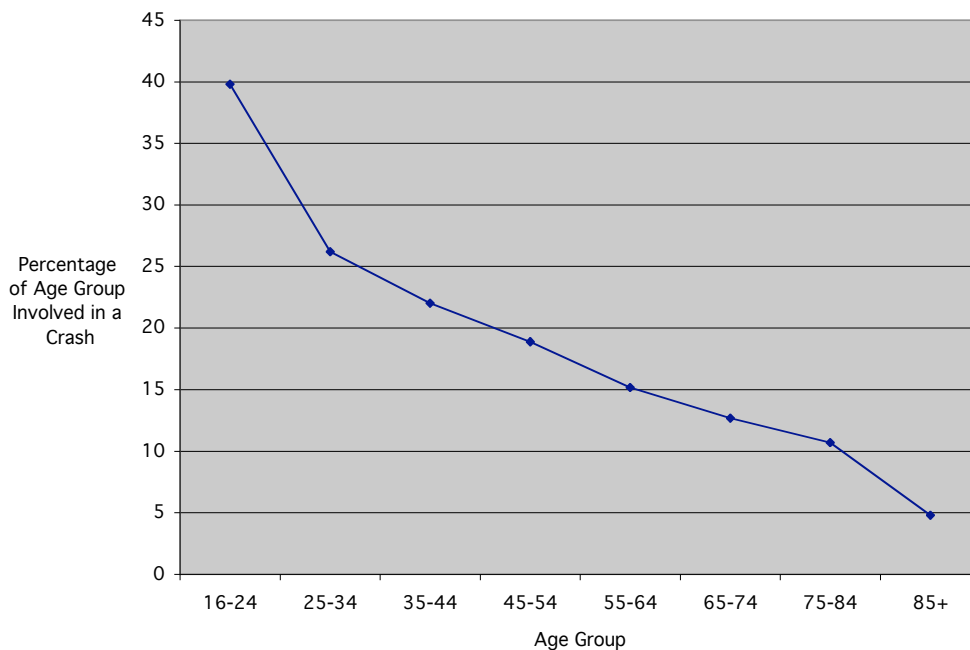


Figure 2.1
Crash-involved drivers per head of population in South Australia from 1994 to 1998, by age group

The rates of crash involvement adjusted for population again show that younger drivers were over-represented in crashes compared with middle-aged and older drivers. The lowest rates of crash involvement were for the oldest age groups. This association between aging and decreased crash involvement does not appear to be as strong, however, as when population differences across groups are not taken into account (see previous section).

2.3.3 Crashes per licensed driver

The number of licensed drivers in 1999 in each age group is provided in Table 2.3. As can be seen, there was a decrease in the number of licences held in South Australia with increasing age, after a peak in the group aged 25 to 34. The smallest number of licensed drivers was for those in the over 84 age group. It also needs to be noted that the proportion of total licence holders over 65 (13.9%) was less than the proportion of older persons in the population (17.8%), indicating that older people were less likely to hold a driver's licence than the rest of the driving-age population.

Table 2.3
Number of licensed drivers in South Australia, 1999, by age group

Age group	Age group total	Percent of total
16-24	129,162	15.4
25-34	178,027	21.2
35-44	175,167	20.9
45-54	147,437	17.6
55-64	92,418	11.0
65-74	72,582	8.7
75-84	38,880	4.6
85+	4,781	0.6
Total	838,454	100.0

These differences across age groups in licensure rates need to be taken into account when calculating driver crash rates for the different groups. Figure 2.2 displays the crash rates in the five year period 1994 to 1998 per licensed driver for each age group (refer to the Appendix, Table 2 for data). The rates of crash involvement per licensed driver follow a similar pattern to the rates expressed in terms of crashes per head of population (refer to Figure 2.1).

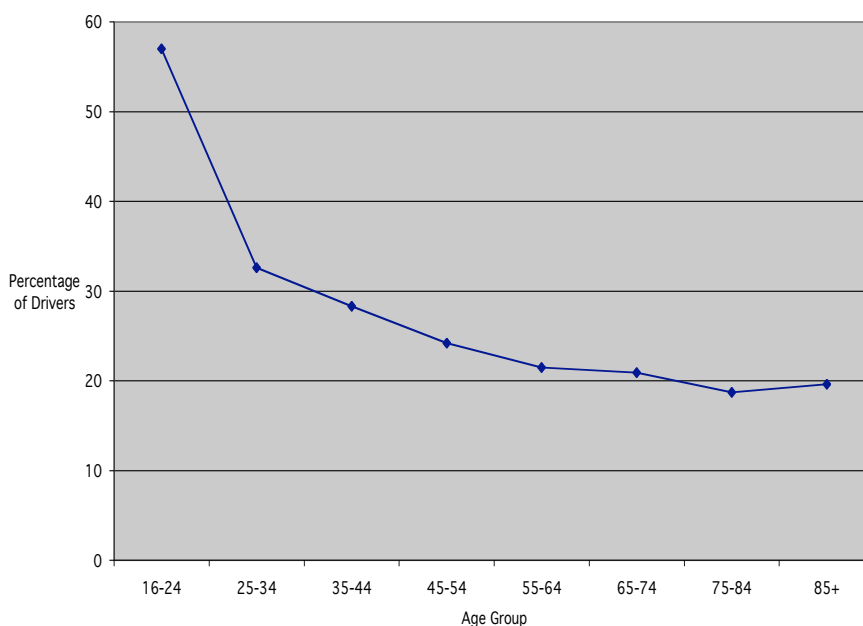


Figure 2.2
Percentage of licensed drivers involved in crashes in South Australia from 1994 to 1998, by age group

Again, older drivers had lower crash rates than drivers in younger age groups, with drivers aged 75 to 84 having the lowest rates of all. These data therefore indicate that older drivers still have lower crash rates than younger drivers when differences in licensing rates are taken into account.

It is also useful to break down the data for crashes per licensed driver according to crash injury severity. Figure 2.3 provides the ratio of crash-involved drivers in each age group to the number of crash-involved drivers in the 75 to 84 age group (the group with the lowest level of crash involvement) for each level of crash injury severity (refer to the Appendix, Tables 3 to 7 for data). Figure 2.3 shows that the rate of fatal crashes was lowest for middle-aged drivers (aged 45 to 54) and that the fatal crash rate for drivers aged over 84 matched that of drivers in the youngest age group. For crashes resulting in hospital admission, the lowest rate was for drivers aged 55 to 64, with small increases in the crash rate for drivers aged over 64. This suggests that older drivers are more likely to be involved in crashes of high injury severity. One unexpected result shown in Figure 2.3 is that the highest ratios between younger drivers and the 75 to 84 age group for crash involvement per licensed driver were for crashes resulting in injuries requiring treatment from a private doctor (rather than for property damage only crashes). This suggests that older drivers are under-represented in this crash injury severity category. One possible explanation for this is that when older vehicle occupants are injured in a crash, they are more likely to be taken to a hospital for treatment as a precautionary measure. When young or middle-aged occupants have minor injuries, they are more likely to be advised that seeing a private doctor for treatment would be adequate.

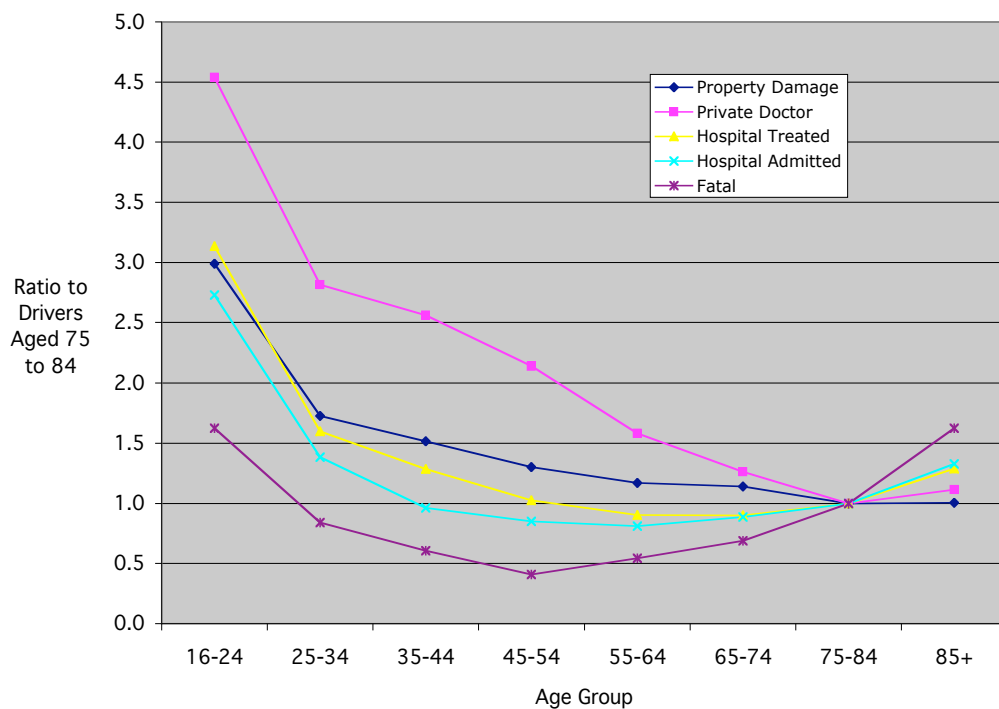


Figure 2.3
Crash-involved drivers per licensed driver in South Australia from 1994 to 1998, by age group and crash injury severity, compared to drivers aged 75 to 84

2.3.4 Crashes per kilometre driven

The number of kilometres driven by the average driver in each age group in the 12 months to July 1998 is shown in Figure 2.4 (refer to the Appendix, Table 8 for data). It can be seen that a reduction in driving occurred for those aged over 74. The group of drivers aged between 65 and 74 drove approximately the same number of kilometres per year as middle

and late middle-aged drivers (aged 35 to 64), but those aged in the 75 to 84 year old group drove only half as much as drivers in these age groups, while the average number of kilometres driven per year by those aged over 84 was reported by the Australian Bureau of Statistics to be zero. This clearly understates the annual driving done by those in this age group and must merely be taken as an indication that the amount of driving done is very low.

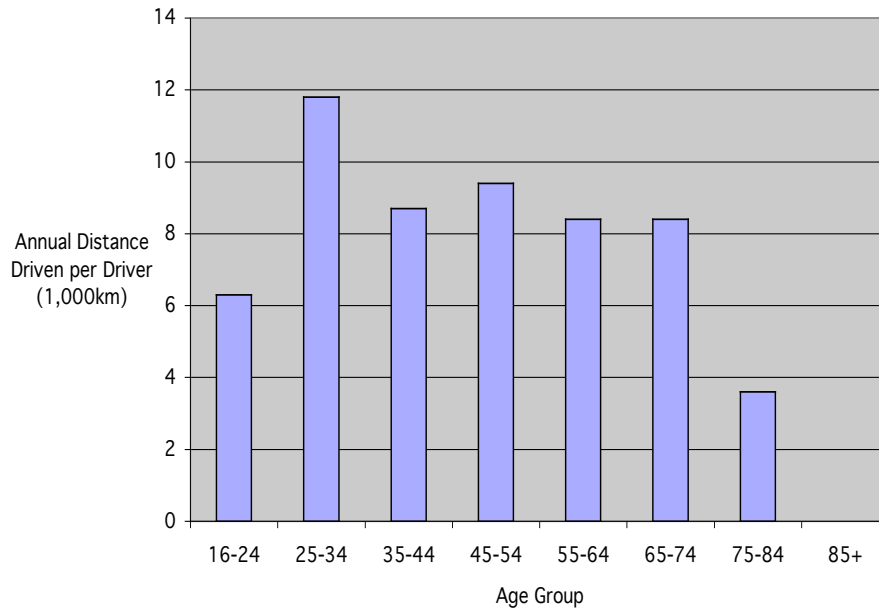


Figure 2.4
Average kilometres driven (x 1,000) by drivers in South Australia in the 12 months 1997-1998, by age group

These differences in the amount of driving done by drivers across the age groups need to be considered when calculating crash rates for these groups. In order to calculate crash rates per distance driven, the total number of crashes for each age group occurring in the years 1994 to 1998 (refer to Table 2.1) were divided by five to derive a yearly crash average. This number was then divided by the total number of kilometres driven per year by the drivers in each age group (the average number of kilometres driven as shown in Figure 2.4, multiplied by the number of licensed drivers in each group as shown in Table 2.3) in the 12 months to July 1998. As the resulting crash numbers are small, the crash rate is best expressed as crashes per million kilometres driven. The results are shown in Figure 2.5 (refer to the Appendix, Table 9 for data). The crash rates for drivers aged over 84 are not shown because, as noted earlier and shown in Figure 2.4, the average number of kilometres driven each year by drivers in this age group was reported by the Australian Bureau of Statistics to be zero.

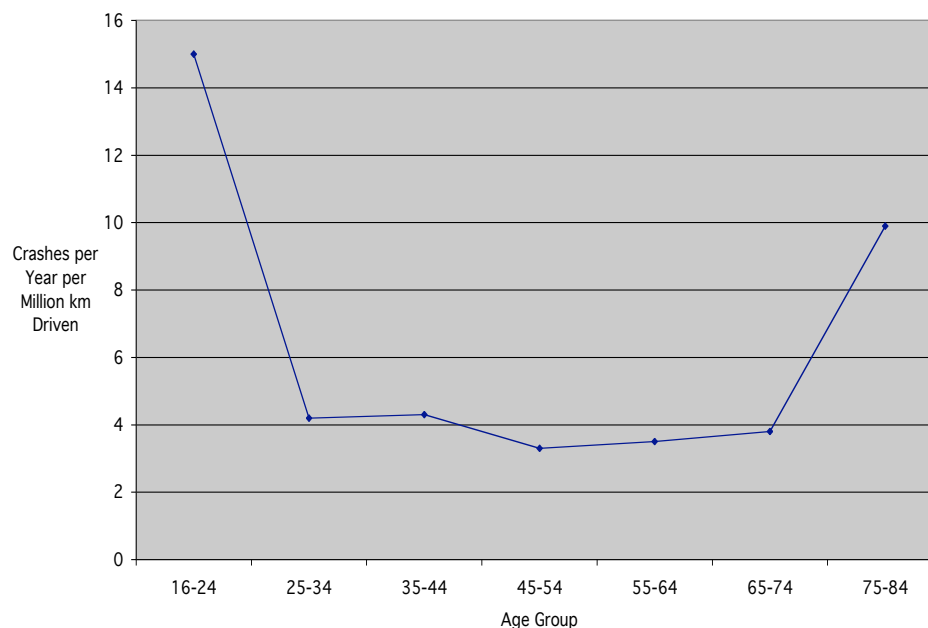


Figure 2.5
Crash-involved drivers per million kilometres driven
in South Australia from 1994 to 1998, by age group

As can be seen in Figure 2.5, young drivers aged under 25 had the highest crash rate per distance driven. The second highest crash rate was that of older drivers, aged over 74. All other groups of drivers, aged between 25 and 74, had crash rates that were approximately equivalent. Drivers aged over 84 are likely to have had a higher crash rate per kilometre driven than the young drivers, given the very low amount of driving done by this group, but this rate was unable to be computed. Nonetheless, the data indicate that a detrimental effect of aging on the risk of crash involvement is most apparent when crash rates are expressed in terms of crashes per distance driven.

2.3.5 Summary

The preceding sections have shown that older drivers (aged over 64) were involved in relatively few crashes compared with younger drivers (aged under 65), and also had lower crash rates than younger drivers after adjusting for differences between the specified age groups in terms of population, and the number of licence holders. After adjusting for differences in the amount of driving done by each of the age groups, it was found that crash rates were reasonably constant for those aged between 25 and 74. Higher crash rates were found only for those drivers under the age of 25 and over the age of 74. When crash rates per licensed driver were analysed in terms of crash injury severity, it was found that older drivers were over-represented in crashes resulting in fatal injuries.

2.3.6 Discussion

The pattern of crash involvement by age whereby older drivers have relatively few crashes overall but higher crash rates per distance driven is a familiar one, with similar findings previously reported in Australia (e.g. Ryan et al., 1998), the United States (e.g. Lyman et al., 2002) and Europe (e.g. OECD, 2001). As the relative crash risk of older drivers appears different according to the manner of analysing the crash data (i.e. the type of crash rate calculated), the manner of interpretation of the results is of great importance.

If one is interested in the extent of any 'older driver problem', the most appropriate figures to consult are the number of crashes by age group. Table 2.1 shows that older drivers had

fewer crashes than drivers in younger age groups. More specifically, crash involvement declined with increasing age (beyond the 16 to 24 year age group), and drivers over the age of 64 comprised less than 10 percent of crash-involved drivers in South Australia over a five year period. Furthermore, there were three times as many crash-involved drivers aged 16 to 24 as were aged over 64. These figures indicate that older drivers, relatively speaking, do not contribute greatly to crash numbers in South Australia.

If one is concerned with the re-licensing of older drivers, then the appropriate crash rate to consider is that of crashes per licensed driver. Figure 2.2 shows that older drivers have crash rates per licensed driver that are comparable with middle-aged drivers, those regarded as the safest on the road. This suggests that the re-licensing of most older drivers should be a routine affair and that screening of older drivers should be concerned with identifying significant health problems. In the absence of such problems, older drivers should be presumed to be safe drivers.

Despite the importance of overall crash numbers and crash rates per licensed driver, the crash rate that is discussed most often is that of crashes per distance driven. Figure 2.5 shows the usual "U-shaped curve" of crash risk by age that is so consistent across different jurisdictions that Frith (2002, p205) has called it 'ubiquitous'.

There has been considerable debate concerning the appropriate interpretation of the high crash risk of older drivers per distance driven. A number of authors have claimed that the high risk is an artefact. One basis for this claim is that the higher risk is due to the higher likelihood that older adults will be injured in a crash, the so-called "frailty bias". According to this argument, the greater susceptibility to injury of older adults makes it more likely that a crash featuring an older driver will result in an injury and be serious enough to be reported to police. This, in turn, means an increased likelihood that the crash will feature in official road crash databases (Evans, 1988, 2000; Hakamies-Blomqvist, 1998, 2002, 2003; Maycock, 1997; Pike, 1989). In the present study, the effects of this frailty bias would be reduced by the use of all police-reported crashes, thus including crashes only resulting in property damage in addition to those resulting in injuries. Inspection of Figure 2.3 reveals the difference in the results that would be obtained if only injury crashes of a specific severity were analysed.

Another basis for the claim that the higher crash rate per distance driven for older drivers is an artefact is that it reflects a cohort effect, such that older cohorts may have had an increased risk of crashing even at a younger age. Increases in risk reported in cross-sectional comparisons may be due to failure to control for these effects (Hakamies-Blomqvist, 1996). The present study involved the use of cross-sectional data only and so the results may be affected by cohort differences in crash risk.

A final explanation of the higher crash rate per distance driven for older drivers in terms of artefacts is that it reflects a "low mileage bias." Older drivers are known to drive fewer kilometres per year than drivers in younger age groups and it has previously been established that, irrespective of age, gender or other demographic characteristics, drivers who drive less record more crashes per distance driven than those who drive more (Daigneault, Joly, & Frigon, 2002a; Hakamies-Blomqvist, 1998, 2002, 2003; Hu, Jones, Reuscher, Schmoyer Jr, & Truett, 2000; Janke, 1991; Maycock, 1997; OECD, 2001). Janke (1991), for example, found that low mileage drivers were involved in more crashes per mile driven than those with high mileage, and attributed this to the different levels of mileage driven by these two groups on roads where there are few crashes per mile. Specifically, Janke noted that there were 2.75 times more crashes per mile driven on non-freeways than freeways. Those who drive longer distances, Janke argued, are likely to amass much of their elevated yearly mileage on freeways, which feature a division of traffic travelling in different directions and limited access from other roads.

Eberhard (1996) pointed out that older drivers do disproportionately more of their driving on local roads, rather than freeways, and so encounter disproportionately more intersections, congestion, confusing visual environments, signs, and signals. Similar to Janke (1991),

Hakamies-Blomqvist (2002) claimed that drivers who drive long distances per year tend to travel long distances on freeways without encountering intersections, where there is a greater risk of crash involvement. By driving further on freeways, high mileage drivers are able to improve their crash risk per distance driven ratio because they are driving long distances with few situations of potential traffic conflict.

Maycock (1997, p63), noting that older drivers often deliberately reduce their driving, described as “perverse” the possibility that one effect of this could be an increased crash rate per kilometre driven. He added that it “would be ironic indeed, if older drivers were to be singled out for remedial attention on the per kilometre basis because of their compensatory behaviour” (Maycock, 1997, p63). O’Neill (2002, p113) goes further, claiming that the higher crash rate per distance driven of older drivers, compared to middle-aged controls “is often quoted by the media and those seeking research grants: it is of academic interest as long as older drivers drive a lower mileage than younger drivers.”

In conclusion, the two most important indicators of crash involvement by age group are overall crash numbers and crashes per licensed driver. The former indicates the extent to which the age group contributes to a jurisdiction’s crash numbers, while the latter indicates the risk associated with granting a licence to a typical member of the age group. Older drivers, as shown in the present study, have fewer crashes than drivers in younger age groups and, per licensed driver, are no more likely than middle aged drivers to be involved in crashes. This is largely due to reduced driving by older drivers, which also manifests itself as an increased risk of crashing per distance driven.

Given that the two measures of crash involvement above do not indicate an increased crash risk for older drivers, the question becomes whether this segment of the driving population is still deserving of special attention. There *is* a good reason why older drivers still warrant special attention and that reason is their physical frailty. When crash rates are analysed separately for different levels of crash injury severity (Figure 2.3), it can be seen that older drivers are over-represented in crashes of high severity. This is due to a greater susceptibility to injury, and has been previously been reported in the literature (Cerelli, 1989; Evans, 1988; Lyman, McGwin Jr, & Sims, 2001; McKelvey & Stamatiadis, 1989; Ryan et al., 1998). Older drivers, therefore, to be as safe as drivers in younger age groups, must maintain lower than average crash rates. Their need to avoid crashes is greater because of their greater likelihood, given a crash, of being seriously or fatally injured. For this reason, there is justified interest in trying to develop means for identifying older drivers at greater risk of crashing. The following section discusses this topic.

3 At-risk older drivers

3.1 Introduction

The declines in crash rates per licensed driver that occur from youth to middle age do not continue into old age. Older drivers have a crash rate per licensed driver similar to that of middle age drivers. Older drivers do have a higher rate of crashes of high injury severity but this is due to greater susceptibility to injury. Given that older drivers are more likely to be seriously and fatally injured in road crashes, it is desirable that those with an elevated risk of crashing are identified, either so that their licences can be removed, or attempts made to improve their driving, or encouragement be given to restrict their driving to less dangerous situations. This section is concerned with whether it is possible to identify sub-groups of older drivers with an elevated risk of being involved in a road crash.

3.2 Medical conditions and functional impairments

It has been previously established that declines with age in cognitive abilities vary markedly between individuals (Daigneault et al., 2002a; Hakamies-Blomqvist, 1998; Klavora & Heslegrave, 2002). In a similar way, it is possible that drivers, too, 'age' at different rates (Cushman, 1996). It is possible that there are subgroups of older drivers with a high risk of crashing, while the remainder are able to use their years of driving experience to maintain a low risk. The presence of subgroups of older drivers with an elevated crash risk could mean that the distribution of crash risk for older drivers is bimodal or multi-modal rather than normal (Hakamies-Blomqvist, 1998), a notion supported by the finding that most older drivers have crash-free records (Evans, 1991).

The possibility that there are high risk subgroups of older drivers is intuitively appealing, given that, with increasing age, there are increases in the number of drivers affected by medical conditions that may affect driving (Hull, 1991; Janke, 1994; Klavora & Heslegrave, 2002; Luszcz, 1999; OECD, 2001; Reuben, Silliman, & Traines, 1988; Vernon et al., 2002; Wallace & Retchin, 1992; Waller, 1991). There have been a number of reviews of the medical conditions that affect driving (Baldock, 2004; Holland, Handley, & Feetam, 2003; Janke, 1994) and it will suffice here to note that conditions which increase in prevalence with age and which can affect driving performance include various eye diseases (cataract, glaucoma, macular degeneration, diabetic retinopathy), dementia, cerebro-vascular accidents (or strokes), cardiovascular diseases, diabetes mellitus, arthritis, Parkinson's Disease and seizure disorders. Medications taken to treat medical conditions may also have side effects that are detrimental to safe driving (Ray, Gurwitz, Decker, & Kennedy, 1992).

It has been argued, however, that to find explanations for the increased crash risk of subsections of the older driver population, it is more appropriate to look at drivers' functional abilities rather than take an inventory of medical conditions with which they have been diagnosed (Marottoli et al., 1998; OECD, 2001; Sims, Owsley, Allman, Ball, & Smoot, 1998; Wallace & Retchin, 1992; Waller, 1992; White & O'Neill, 2000). There are a number of reasons for this suggestion.

The first reason is that, among those with a specific medical diagnosis, there is substantial variation in the severity of the illness (Marottoli, 2002; Wallace & Retchin, 1992). In addition to different levels of severity, there can be marked differences across drivers in the progression of these conditions (Klavora & Heslegrave, 2002; Wallace & Retchin, 1992). There may also be different complication rates, clinical manifestations, and treatment response rates (Wallace & Retchin, 1992).

A second reason is that many older drivers have multiple medical conditions and it is the combination of different conditions that can impair functioning sufficiently to compromise driving ability (Dobbs, Heller, & Schopflocher, 1998; Klavora & Heslegrave, 2002; Marottoli,

2002; Wallace & Retchin, 1992; Waller, 1992). This may occur even when the manifestations of each of the separate conditions are minor (Marottoli, 2002).

Therefore, although medical conditions and medications can be linked to negative driving outcomes, it may be more useful to assess the functional abilities of drivers when trying to identify older drivers who are likely to have a higher than normal crash risk. The functional abilities necessary for safe driving include vision (visual acuity, contrast sensitivity, visual fields, various others), physical functioning (head-neck flexibility), cognitive functioning (mental status, visuospatial and constructional abilities, memory, speed of information processing) and attention (switching, selective and divided attention) (Baldock, 2004).

Given that the functional abilities that affect the driving performance and crash risk of older drivers are well-established, it should be possible to identify subgroups of older drivers who are responsible for the majority of crashes involving drivers in this age group. The following section examines this possibility.

3.3 Are there crash-prone older drivers?

If there are crash-prone subgroups of older drivers in the driving population, then analysis of the licence records of older drivers should reveal subgroups with multiple crashes. That is, one of the best predictors of older driver crashes should be previous crash involvement.

A study of drivers aged over 60 in Quebec, Canada by Daigneault, Joly and Frigon (2002b) was conducted to look at whether previous convictions or crashes were better predictors of subsequent crashes. The six-year driving records of over 400,000 drivers were analysed and comparisons made between the first and second three-year periods. To predict crashes in the second three-year period, it was found that crashes in the first three years were a better predictor than convictions for traffic violations. It is also worth noting that 89 percent of licensed drivers over 60 recorded no crashes in the six years for which licence records were analysed (Daigneault et al., 2002b).

Similar findings were reported in a study by Foley, Wallace and Eberhard (1995) that involved analysis of the police-reported crashes of 1,791 drivers aged 65 or over in Iowa, USA. Using a data period of five years, it was found that drivers who crashed in the first two years were twice as likely to crash in the remaining three. Again, it is worth noting the crash-free records of the majority of the older drivers. Of the 1,791 drivers in the study, 1,585 (88.5%) were crash-free, and of the 206 who crashed within the five year period, 85 percent crashed only once (Foley et al., 1995).

A smaller study in Alabama, USA that was designed to identify the predictors of crash involvement among 174 drivers aged over 55 (Sims, McGwin Jr, Allman, Ball, & Owsley, 2000) similarly found that a crash in the previous five years was associated with double the risk of crashing in the five year study period. A study by Owsley et al. (1998), also in Alabama, specifically looked at visually impaired drivers. In a sample of 294 drivers aged over 55 whose driving records were followed for three years, those who had crashed previously were twice as likely to have a subsequent crash.

Taylor, Ahmad and Stamatiadis (1994) used data from driving records in Michigan, USA in order to develop a profile of crash-prone drivers. The study showed, similarly to Daigneault et al. (2002b), that few crash-involved older drivers had had previous convictions for traffic violations. Up to 92 percent of crash-involved drivers aged over 80 had recorded no violations in the five years preceding their crashes. However, Taylor et al. also claimed that crashes were not a good predictor of subsequent crashes. After age 65, only 27 percent of drivers involved in one crash had a second one, and 26 percent of those who had a second crash had a third (Taylor et al., 1994).

The evidence seems to indicate that older drivers who crash in a given time period are more likely than non-crash involved older drivers to have a crash in a subsequent time period, yet the evidence also indicates that very few drivers, in a period of five or six years, have a

crash and very few have more than one crash. These seemingly paradoxical findings reflect the nature of crash data. For any individual driver, crashes are rare events (Hakamies-Blomqvist, 2003; Ranney, 1994; Stutts, Stewart, & Martell, 1998). Stutts et al. (1998) argued that crashes only occur to less than six percent of licensed drivers in any given year, and so even a relatively strong risk factor - one that doubles or triple the probability of a crash - will only identify drivers with a 10-20 percent likelihood of crashing in the next year. Thus, 80 to 90 percent of these drivers with increased risk of crashing will be crash-free in any given year.

Evans (2004) considers the notion of 'accident proneness' within a discussion of the Poisson distribution (the data distribution that most closely represents drivers' crash involvement levels). Evans describes the distribution of crash involvement you would expect if the typical driver has a probability of 0.0625 of having a crash in any given year. If all drivers share this exact crash risk, the Poisson process produces a distribution in which 93.92 percent of drivers have no crashes in a year, 5.88 percent have one, 0.18 percent have two, and 0.004 percent have three or more. Actual data for California from Peck, McBride and Coppin (1971), with the average crash probability being 0.0625 crashes per year per driver, showed that 94.14 percent of drivers had no crashes, 5.50 percent had one, 0.34 percent had two, and 0.024 percent had three or more. Therefore, in the real distribution, which includes drivers with different crash risks, there were six times as many drivers with three or more crashes. Evans argues that 1/6 of the drivers with three or more crashes were likely to have been average drivers who were unlucky, while the other 5/6 were likely to have arisen from a segment of the population with an above average crash risk. However, it is not possible, based on crash frequency data, to determine which of the drivers involved in three or more crashes were unlucky and which of the drivers were affected by a high crash risk. Evans also notes that this randomness, which results in some drivers of average crash risk having three or more crashes in a year, also results in a large percentage of high risk drivers surviving a year crash-free (Evans, 2004).

3.4 Summary and conclusions

Given that there are medical conditions and functional impairments that increase in prevalence with age, and which have been found to be associated with increased levels of crash involvement, you would expect higher rates of crash involvement for older drivers overall. That this is not the case suggests that there are subgroups of older drivers with a higher than average crash risk, with the remaining older drivers maintaining the relatively low crash risk of middle-aged drivers. This is difficult to investigate using mass crash databases, however, because of the rarity of road crashes for individual drivers. Driver crash involvement levels in short time periods are best approximated by the Poisson distribution. The characteristics of this distribution mean that it is possible for low risk drivers to record multiple crashes in the same period of time in which high risk drivers are crash free. The practical ramification of this is that an older driver being involved in a crash is not a good basis for identifying that driver as one whose fitness to drive should be assessed. Identification using medical channels is likely to be more equitable and beneficial.

4 Causal factors contributing to older driver crash involvement

4.1 Introduction

Crashes are multi-determined events, with contributing factors including those related to drivers, roads and vehicles. Given the susceptibility to injury of older adults and the consequent importance of reducing the likelihood of older drivers being involved in a crash, it is desirable that research and countermeasures do not focus solely on the fitness to drive of older adults. For example, particular road configurations may increase the likelihood that older drivers make particular errors or may exacerbate the likely negative consequences of particular errors.

This section of the report considers a sample of rural road crashes involving older drivers that occurred between 1998 and 2000 and that were investigated in depth by members of the then Road Accident Research Unit (now Centre for Automotive Safety Research). The aim of this analysis is to note the various factors (driver, road, vehicle) that contribute to causing older driver road crashes. Almost all crashes involve a degree of driver error but many also involve road factors that increase the likelihood that drivers make such errors.

4.2 Method

The crashes discussed in this section of the report were investigated as part of the In-Depth Research into Rural Road Crashes study that ran from 1998 to 2000 (Project Number 97/TS/077). The aim of that study was to use in-depth investigation of rural road crashes to collect information on the factors which contribute to crash and injury causation.

RARU staff attended crashes to which an ambulance was called and which occurred on public roads outside the metropolitan area but within 100 km of Adelaide. On-call times for crash investigation included all seven days of the week, plus Thursday and Friday nights until midnight. These times were chosen following an examination of the time of day and day of week distribution of calls for an ambulance to attend road crashes in the study area in the previous year. Some fatal crashes that occurred outside of the on-call times were able to be investigated on the day following the crash if the scene had been marked up by the South Australian Police Major Crash investigators. This resulted in a bias in our sample towards fatal crashes. The inclusion criterion of an ambulance being called to the scene of the crash also meant that crashes resulting in property damage only (that is, no injury) were under-represented in our sample. However, there were a number of instances in which an ambulance was called before it became known that no-one in the crash had been injured, thus resulting in the inclusion of some property damage only cases in the study sample.

The information collected for each crash included:

- photographs of the crash scene and vehicles involved
- video record of the crash scene and vehicles in selected cases
- examination of the road environment, including traffic control measures
- a site plan of the crash scene and vehicle movements in the crash
- examination and measurements of the vehicles involved
- interviews with crash participants, witnesses and police
- information on the official police report
- information from Coroner's reports
- injury data on the injured crash participants

4.3 Results

4.3.1 General

A total of 236 rural road crashes were investigated as part of the study. Of these, 41 (17.4%) involved at least one driver who was aged 65 years or more. These 41 crashes form the sample of crashes to be discussed in this report. Table 4.1 shows the crash types for the crashes in which at least one older driver was involved. For comparison, the crash types for the remaining 195 crashes investigated are also shown.

Table 4.1
Crash type by age of driver, rural in-depth crash investigation study

Crash type	Age group			
	Drivers aged < 65		Drivers aged > 64	
	Number	Percent	Number	Percent
Single vehicle	99	50.8	6	14.6
Head on	34	17.4	5	12.2
Right turn	26	13.3	20	48.8
Rear end	16	8.2	1	2.4
Right angle	13	6.7	7	17.1
U-turn in front	5	2.6	1	2.4
Side swipe	2	1.0	1	2.4
Total	195	100.0	41	100.0

The most common crash type for older drivers was the right turn crash, encompassing approximately half of the sample (compared with 13% for crashes not including any older drivers). Right angle collisions were also over-represented in older driver crashes, indicating a general increase in the likelihood of crashes at intersections, rather than midblock locations. Crashes that did *not* include any drivers aged over 64 were most likely to be single vehicle crashes, again encompassing approximately half of the sample (compared with 15% for older driver crashes). Head-on collisions were also over-represented in crashes *not* involving older drivers, which is consistent with the over-representation of single vehicle crashes, as both single vehicle and head-on collisions in rural areas tend to result from loss of control of the vehicle. Therefore, the older driver crashes investigated, relative to those crashes not involving any older drivers, were more likely to involve multiple vehicle collisions at intersections rather than loss of vehicular control.

Table 4.2 shows the level of crash injury severity of the crashes for those involving older drivers and those that did not, based on the highest level of injury severity for all participants in a crash. For example, a crash in which two people were treated at hospital and one was admitted to hospital would be classified as 'hospital admission' in Table 4.2.

The only difference between the two groups of crashes is that those involving older drivers include an over-representation of fatal crashes while those involving only drivers aged under 65 include a corresponding over-representation of crashes resulting in hospital admission of one or more crash participants. This suggests that impacts severe enough to result in injuries requiring hospital admission for drivers under the age of 65 were severe enough to fatally injure older drivers. It must be noted that crashes involving only drivers aged under 65 could have included vehicle occupants over the age of 65. Therefore, the results shown in Table 4.2 understate the greater susceptibility to injury of older adults.

Table 4.2
Crash injury severity by age of driver, rural in-depth crash investigation study

Crash injury severity	Age group			
	Drivers aged < 65		Drivers aged > 64	
	Number	Percent	Number	Percent
Fatal	40	20.5	14	34.1
Hospital admission	66	33.8	10	24.4
Hospital treated	55	28.2	11	26.8
Private doctor	6	3.1	0	0.0
Minor injury	10	5.1	2	4.9
No injury	18	9.2	4	9.8
Total	195	100.0	41	100.0

4.3.2 Right turn crashes

There were 20 crashes involving older drivers that occurred when the driver of a vehicle attempted to turn right across the path of another vehicle. Of particular note is that the older driver was the driver of the right-turning vehicle in 18 of these 20 crashes. In the two remaining crashes, the older driver did not appear to have contributed to the causation of the crash. The 18 crashes in which the older driver was turning right will now be described and the contributing causal factors discussed. The crashes are numbered according to the crash numbers used in the original Rural In-Depth Crash Study. The numbers reflect chronological order.

Crash R003:

A 65 year old driver was attempting a right turn onto a highway to travel north in his semi-trailer when a sedan travelling south on the highway struck the side of the trailer. The police decided that the driver of the semi-trailer was at fault for having failed to give way. It is likely, however, that the driver of the sedan also contributed to the crash. She was a young driver, having only held a provisional licence for six months, and was reported by the front seat passenger of her vehicle to have been exceeding the speed limit prior to the crash.

Crash R006:

An 83 year old driver of a sedan travelling south on a rural highway turned right across the path of an oncoming sports utility vehicle that was travelling north. Both the driver of the sedan and his 76 year old left front seat passenger died as a result of the crash. The driver of the sports utility vehicle reported having a number of medical conditions that may affect driving but there was no reason to suspect that these played any role in the crash.

Crash R012:

A 67 year old driver of a sedan turned right from the stem of a T-junction onto a national highway to travel south west. He failed to give way to an oncoming car that was travelling north east and which struck his car on its right side. In addition to driver error, the main factor contributing to this crash was the layout of the junction.

This junction had recently been redesigned. A five fold increase in the reported crash rate, and an increase in the severity of the crashes, resulted from the design change. The junction was subsequently the subject of a special investigation by the then Road Accident Research Unit at the request of Transport SA. From that investigation, and the investigation of another case (R109), several problems became apparent.

The first problem is that the terminating road joins the through road on the outside of a curve. Traffic travelling north on the through road, a National Highway, is required to negotiate a right curve as it nears the junction. This results in the drivers of vehicles attempting to turn right onto the through road (to travel south) experiencing difficulties in,

first, detecting the presence of the northbound traffic (which approaches from the right), and secondly, determining the approximate travel speed of this northbound traffic. Detection of the northbound traffic can be difficult because the curve can result in it being obscured by southbound traffic or the A pillar of the vehicle as it approaches the through road on the stem of the T-junction. Adding to the difficulty in detecting the presence of the northbound traffic is the problem that in the background of the turning driver's view, there is a road carrying vehicles that have split from northbound traffic in a Y junction a few hundred metres prior to the T-junction. Particularly at night, it is difficult for drivers at this T-junction to determine if northbound traffic is continuing on the through road or travelling off onto the other leg of the Y junction. Often, drivers are not aware that a vehicle is approaching on the through road until it is well into the curve.

Another problem is that drivers are often confused about to whom they must give way. The dedication of a separate lane for vehicles travelling south after they have turned right at the junction means that those drivers only have to give way to northbound traffic and traffic turning right into the stem of the T-junction, a manoeuvre which occurs rarely. However, observations at the junction revealed that many drivers also give way to southbound through traffic, unnecessarily delaying traffic waiting behind them, and also distracting their attention from the main task of giving way to the right. Adding to this is the fact that the stem of the T-junction is a left curving road which tightens as it gets closer to the through road. This means that drivers must concentrate on negotiating the curve in the road they are travelling on as well as devoting attention to whether traffic on the through road requires them to give way. The difficulty of these competing demands is illustrated by tyre marks on the right kerb on the approach to the junction.

The cars turning right at this junction are required to enter a southbound acceleration lane divided by a narrow concrete medians from the through traffic approaching from both the right the left. When this lane ends, they must merge with the traffic on their left. The acceleration lane at this location is problematic for a number of reasons. First, many drivers do not like turning into the acceleration lane at the same time as heavy vehicles are travelling, on their left, in the southbound lane. Secondly, the superelevation of the through road means that vehicles on the stem of the T-junction could not see the layout of the junction as they approached it. A clear view of the entrance to the acceleration lane is not possible until a driver has steered his vehicle half way across the northbound lane. Thirdly, the adverse camber of the entrance to the acceleration lane causes problems for articulated heavy vehicles turning into it. Due to the low lateral stability of such vehicles, drivers feel the need to turn more slowly into the acceleration lane than is acceptable, increasing the time that the vehicle spends blocking the northbound lane. Fourthly, the requirement for vehicles to merge with traffic on their left at the end of the left curving acceleration lane causes difficulties for many drivers. Visibility can be restricted, particularly in the case of towing vehicles, due to the road curving to the left at this point. Some drivers feel compelled, in times of heavy traffic, to stop at the end of the acceleration lane. Although some of these problems were not directly related to the crash, they are components of the poor layout that characterises this junction, many aspects of which are contrary to the code of practice for the design of intersections (National Association of Australian State Road Authorities, 1988).

Since the time when R109 occurred, there has been another fatal crash at this junction. Again it involved a vehicle attempting to turn right from the stem of the T-junction being struck on the driver's door by a vehicle approaching from the right on the through road. The elderly male driver of the car turning right was killed in the collision and the elderly female front seat passenger spent approximately ten weeks in hospital. This crash occurred despite some additional work having been conducted at the junction. Specifically, the approach of the stem of the T-junction had been straightened and the level of the terminating road was raised in an attempt to improve visibility of the intersection for the drivers of vehicles turning onto the through road. Since that time, the speed limit of the through road for vehicles travelling north has been reduced to 80 km/h.

Crash R042:

An 84 year old driver turned right at a T-junction to travel south on a rural highway but failed to give way to another vehicle travelling north. The failure of the driver to give way appropriately can be partly attributed to restricted vision available to the driver of northbound traffic. A truck was parked on the side of the road near to the junction. The presence of this truck meant that the driver of the car wishing to turn right from the stem of the T-junction was unable to see traffic approaching from the right. In order to see the traffic, the driver moved out into the roadway and then reversed back again when he saw cars approaching. When he tried this a second time, there was no time to reverse back before his car was struck by another car at right angles on the driver's side doors.

Crash R062:

A 78 year old driver initially travelling west on a rural highway turned right across the path of an oncoming vehicle, resulting in his sedan being struck on the left side by another car. The 88 year old left front seat passenger died as a result of the collision. There did not appear to be any road or vehicle factors contributing to this crash. The driver of the turning vehicle was aware of the oncoming vehicle and admitted to misjudging the turn.

Crash R082:

A 78 year old driver of a car attempted to turn right from her driveway onto a rural highway and was struck by a car approaching from her right. The road into which the driver was turning was marked with a double centre line and so was not an appropriate place to make such a turn. The reason for the double centre line is that the road segment at which the driveway is situated is curved, with the driveway on the outside of the curve. Despite the curved road, the driver should have been able to see the other vehicle approaching.

Crash R090:

An 88 year old driver of a car initially travelling north west attempted to turn right into a rural road from a national highway. His car was struck on the left side by an oncoming car travelling south east on the national highway. One factor possibly contributing to this crash was the low conspicuity of the oncoming vehicle. It is possible that the older driver did not see the oncoming car (a maroon Holden Commodore sedan) because of the background of dark trees on an overcast day. (See also R204)

Crash R097:

A 66 year old driver of a car attempted to turn right out of a car park and onto a rural highway to travel north. Her car was struck on the right side by a sports utility vehicle travelling south on the rural highway. In this case, the older driver's vision of the oncoming traffic was restricted by signs and a fence. This necessitated the driver moving her vehicle forward into the roadway in order to get an unimpeded view of the traffic, which precipitated the crash. However, her vision of oncoming traffic would not have been impeded if she had chosen an appropriate place to exit the car park. The place chosen by the driver to exit the car park was actually marked with an arrow pointing into the service station. The exit was placed further along the road.

Crash R101:

A 71 year old driver of a car travelling north attempted to turn right from a rural highway into a rural road but was struck on the left side by a motorcycle travelling south on the highway. The driver of the car had seen the motorcycle but misjudged the time available to complete the turn. It is possible that the speed of the motorcycle, and thus the turning time, was difficult for the driver to judge because of the small visual angle subtended by the motorcycle.

Crash R118:

A 73 year old driver travelling east on a rural highway attempted a right turn into a rural road when his car was struck by another car travelling west on the rural highway. The driver had diet-controlled mature-onset diabetes and thought that he may have been suffering symptoms of diabetes at the time of the crash. Following the crash, he obtained a prescription for oral hypoglycaemic medication. The driver appeared to be only speculating that his medical condition played a role in the crash, probably seeking an explanation for how he could have made the turning error.

Crash R124:

A 69 year old driver of a car initially travelling north on a national highway attempted to turn right across the path of an oncoming car but was struck on the left side. The 70 year old left front seat passenger of the turning car died as a result of the collision. The older driver in this crash misjudged the turn but this failure to choose an appropriate gap in which to turn was at least partially attributable to the driver of the other vehicle travelling in excess of the speed limit (Computerised reconstruction of the crash determined a travel speed of 123 km/h in a 110 km/h speed zone).

Crash R133:

A 77 year old driver of a car initially travelling west attempted to turn right onto a rural highway in order to travel north but was struck on the right side by a large truck travelling south. The driver of the car died as a result of the collision. Again, there appeared to be no factors other than driver error that contributed to the crash.

Crash R143:

A 77 year old driver of a car initially travelling west attempted to turn right from the stem of a Stop Sign-controlled T-junction onto a rural highway to travel north but was struck on the right side by a car travelling south on the rural highway. In addition to driver error, the confusing layout of the junction would have been likely to have contributed to this crash. The layout of the junction is similar to that of the junction in crash R012, although there are some differences. The T-junction at which crash R143 occurred sits at the base of a down slope on the through road for traffic approaching from the north. The stem of the T-junction is straight, and the through road is straight. It is governed by a Stop sign, and the acceleration lane is divided from the through road, not by a concrete median, but by a rumble strip. Some of the problems possibly responsible for this crash have already been discussed in relation to R012, such as confusion regarding where the driver must look to give way before turning. However, additional problems in this case arise from the downward slope of the through road to the right of the driver on the stem of the T-junction. The downward slope can result in vehicles accelerating as they approach the junction, which would increase the difficulty of judging their travel speeds for drivers wishing to turn right across their path. The slope could also make it harder to stop in the event of the need for emergency braking. The presence of the slope would also require that once vehicles have turned right onto the through road, they accelerate on an up slope. Any problems associated with this, however, would be minimised by the fact that, unlike the other junction, vehicles in the acceleration lane are not required to merge into one lane with traffic on their left. It is noteworthy that this junction was the site of another crash of this type investigated as part of the Rural In-depth Crash Investigation study (R166).

Crash R192:

A 77 year old driver of a car initially travelling south attempted to turn right from the Give Way sign-controlled road onto a rural highway in order to travel west but was struck on the rear left side by a car travelling west on the highway. The older driver in this case had steered his car onto the marked shoulder on the far side of the highway before attempting to merge with westbound traffic. However, a car travelling west on the highway had veered onto the same shoulder in order to avoid colliding with the turning car, and thus struck the

turning car before rolling down an embankment. The driver of the turning car, who was a local resident and regularly used these roads, stated that he and almost everyone else who executes the same right turn he did in the crash, deliberately turn firstly into the marked shoulder before merging with westbound traffic. Our team of investigators noticed that many vehicles, particularly heavy vehicles such as trucks, do precisely this whenever they turn at this intersection. This is done so that they can use the length of the shoulder to accelerate up to 100 km/h on the upward sloping road. Without performing this manoeuvre, it would be extremely difficult, especially for heavy vehicles, to turn right at this intersection to travel west, without holding up westbound traffic while they attempt to accelerate to the speed limit. Therefore, the intersection causes problems for motorists because it lacks an acceleration and merging lane dedicated for those vehicles turning right, and because vehicles turning right to travel west are required to accelerate up to 100 km/h on an up slope. In case R192, the motorist on the intersecting road did not realise that the right turning car was going to turn onto the shoulder before merging. This caused this driver to veer to the left in an attempt to miss the car which he perceived to be turning into his path without giving way. It is noteworthy that the marked shoulder at this intersection was the site of another crash investigated as part of the Rural In-depth Crash Investigation study (R158). It must also be noted that the car on the intersecting road that struck the older driver's car was travelling in excess of the speed limit (Computerised reconstruction of the crash determined a travel speed of 112 km/h in a 100 km/h speed zone).

Crash R194:

An 80 year old driver of a car initially travelling west attempted to turn right onto a national highway to travel north but was struck on the right side by a semi-trailer travelling south. The collision resulted in the deaths of the driver of the car and the 81 year old left front seat passenger. No factors other than the car driver's error appear to have contributed to the crash.

Crash R197:

A 78 year old driver of a car initially travelling west attempted to turn right from a Give Way sign-controlled road onto a national highway to travel north but was struck on the right side by a semi-trailer travelling south on the national highway. The driver of the car died as a result of the collision. Again, no factors other than the car driver's error appear to have contributed to the crash.

Crash R204:

An 80 year old driver of a car initially travelling north west on a national highway attempted to turn right into a rural road but was struck on the left side by a car travelling south east on the highway. As was the case for R090, one factor possibly contributing to this crash was the low conspicuity of the oncoming vehicle. It is possible that the older driver did not see the oncoming vehicle (a maroon Holden Commodore sedan) because of the background of dark trees on an overcast day. It is noteworthy that this crash and R090 both involved an older driver not seeing, and turning across the path of, an oncoming vehicle on an overcast day, and at the same intersection, with the same background of dark trees behind the oncoming vehicle. The oncoming vehicle, in both cases, was a maroon Holden Commodore sedan.

Crash R216:

A 69 year old driver of a car initially travelling west on a rural highway attempted to turn right into a rural road to travel north west but was struck on the left side by an oncoming vehicle travelling east. The older driver's car subsequently rotated and struck a third car waiting on the rural road to turn right onto the rural highway. The 67 year old left front seat passenger of the older driver's car died as a result of the collision. Although the driver made an error in electing to turn when it was unsafe to do so, there were a number of problems with this junction that increased the likelihood of crashes occurring at the site.

The older driver in R216 claimed that he was unable to see the vehicle travelling east towards the junction. It is possible that the vision of the driver of the turning car, when looking for oncoming traffic, was restricted by high grass on the median dividing the road and by a sign on the median that was of sufficient size that at its distance it subtended a visual angle sufficient to momentarily hide a car behind it. Although the grass on the median was long and due to be mowed, it is unlikely that it contributed significantly to the causation of the crash. The sign that restricted the driver's view of the junction was on the off ramp from the nearby freeway. It displayed information regarding the prohibition of horses, pedestrians and bicycles on the freeway. The different elevation of the two sides of the road may also have contributed to the difficulty experienced by the driver in detecting the oncoming vehicle.

An audit of this junction was carried out for Transport SA by two CASR staff members, in response to a high crash rate (15 reported crashes between the start of 1997 and the end of 1999). A number of problems were identified with the junction and several recommendations were made by the auditing team. Since the audit, the junction has undergone substantial changes, and all movements are now governed by a roundabout.

4.3.3 Right angle crashes

Right angle crashes are defined here as those in which two vehicles approaching on different roads collide at an intersection and neither of the two vehicles are engaging in turning manoeuvres at the time of the crash. There were seven right angle crashes involving older drivers that were investigated as part of the Rural In-depth Crash Investigation study. The factors contributing to their occurrence are discussed below.

Crash R008:

A 76 year old driver of a van that was travelling on a rural highway failed to stop at a signalised railway crossing and collided at right angles with a southbound train. The crossing was located shortly after a right curve in the road. The driver of the van negotiated the curve and then veered to the left to avoid a stationary vehicle waiting at the crossing. The van struck a guardrail before continuing through the crossing and into the side of the train. The main reason for this crash occurring appears to have been sun glare compromising the vision of the driver as he steered around the right hand bend (the crash occurred at 7:40am). There were signs warning drivers of the right curve (a 45 km/h Advisory Speed sign) and of the railway crossing but the driver may have failed to detect them due to the glare. It is known that with age, there is greater susceptibility to glare (Klein, 1991; Shinar & Schieber, 1991). The failure of the driver to take appropriate caution meant that he had insufficient time to brake when confronted with the stationary vehicle and railway crossing just around the bend in the road.

Crash R060:

A 65 year old driver was travelling north on a rural road when his car was struck by another car that was travelling east and proceeding into the intersection without giving way at the Give Way sign. Therefore, in this crash, the driver of the other car was legally at fault. However, in addition to driver error, there were road factors that contributed to the occurrence of the crash. The driver of the car faced with the Give Way sign did not have a clear view of vehicles approaching on the intersecting road because of bushes along the property boundary, and therefore should possibly have been faced with a Stop sign instead. An additional problem is that at this location, traffic on the less used, unsealed road has priority over that on the more heavily trafficked, sealed road. Given the nature of the two roads, and particularly their juxtaposition, drivers on the road with the Give Way sign are not going to expect to encounter a vehicle on the intersecting road when passing through the Give Way sign. Drivers on an unsealed road, however, when approaching a junction with a sealed road would be far more likely to comply with a sign requiring them to give way. The failure on the part of the driver faced with the sign to give way may also have been partly

due to the faded road markings at this location. In particular, the Give Way line facing the driver in this crash was very faded.

Crash R069:

A 70 year old driver of a van travelling north on a rural highway drove straight through a Give Way sign at a four-way intersection and struck the left side of a car travelling west. The driver of the van died as a result of the collision. The failure to give way by the older driver is likely to be due to a medical condition. He had obstructive sleep apnoea, resulting in hypoxia. He had previously fallen asleep while driving and his licence had previously been revoked on medical grounds. His lawyer, acting on his behalf, had successfully argued for the reinstatement of his driver's licence.

Crash R100:

A 73 year old driver of a car was travelling west on a rural highway when the car was struck on the right side by a small truck travelling south on an intersecting road and which proceeded through a Give Way sign. Therefore, in this crash, the driver of the truck was legally at fault. The 33 year old left front seat passenger of the car died as a result of the collision. In addition to driver error, there were vehicle and road factors that contributed to the occurrence of this crash. The brakes on the truck were defective and pumping of the brake pedal was necessary to reduce the speed of the truck. The intersection at which the crash occurred was the same as that of R069. Prior to these crashes, this intersection had been the site of 15 crashes in the previous four years. This had prompted local newspaper articles and a petition from local residents calling for improvements. Following R100, approval was given for the replacement of Give Way signs with Stop signs. Although Stop signs would likely have had no effect in R069, it is possible that they may have saved the life lost in R100. Local police embarked on a period of enforcement of compliance with the Stop signs beginning with a period of cautions only, followed by a period of reporting drivers who disobeyed the signs. Additional to these crash reduction strategies, Federal "Black Spot" funds were used to alter the layout of the intersection. Now, instead of a four way intersection, there are two T-junctions. This was done to ensure that drivers were forced to slow down, because the majority of the crashes at this intersection involved vehicles failing to give way before proceeding through the intersection.

Crash R130:

A 71 year old driver was travelling east on a rural highway when her car was struck on the right side by a sports utility vehicle that was travelling north and proceeded through a Give Way sign. Therefore, the driver of the sports utility vehicle was legally responsible for the crash. The older driver died as a result of the collision.

Crash R157:

An 80 year old driver of a car travelling south east on a rural street proceeded through a Give Way sign and struck a car travelling south west on the intersecting road. In this crash, the presence of a sports utility vehicle parked by the kerb restricted the older driver's vision of traffic approaching from the right on the intersecting road. This resulted in the driver moving his vehicle out into the intersection to get a clear view. When no traffic was approaching from the right, the driver attempted to complete the crossing of the road, unaware of a vehicle approaching from the left. Driver error is the main explanation for the crash but the manoeuvre was made more difficult by the restriction of vision created by the large vehicle parked near the intersection.

Crash R232

An 87 year old driver travelling west proceeded through a Stop sign and her car was struck on the left side by a car travelling north on a rural highway. Restriction of vision also played a contributory role in this crash. The older driver did not detect the vehicle approaching from

her left, despite having stopped at the Stop sign to give way to traffic, because the vehicle was concealed by a crest on that segment of the road.

4.3.4 Single vehicle crashes

There were six single vehicle crashes investigated as part of the Rural In-depth Crash Investigation study that featured an older driver. The factors contributing to these crashes are discussed below.

Crash R017:

A 90 year old driver of a car travelling east on a straight section of a rural highway ran off the road to the right and struck a tree located 2.6m from the roadside. She died as a result of the collision. In this case, it is suspected that the driver's loss of control of the vehicle was precipitated by a heart attack.

Crash R019:

A 75 year old driver of a sports utility vehicle travelling west on a rural highway lost control of the vehicle on a right hand curve, ran off the road to the left, struck a cutting and rolled over. The loss of control of the vehicle in this case was a combination of driver error and slippery road conditions. There had been heavy rain on the day of the crash and gravel from the unsealed road shoulder had washed onto the carriageway. The wet road, combined with the presence of the gravel, would have increased the likelihood that a driver lose control on the curved section of road. The rollover resulted from a combination of the vehicle striking the cutting and one of the vehicle's wheels slipping into a culvert on the roadside.

Crash R056:

A 76 year old driver of a car was travelling north on a straight section of rural highway when the car veered onto the left shoulder. The driver over-corrected and the car yawed back across the road, ran off the road to the right and rolled over. The initial loss of control (the vehicle veering onto the left shoulder) was caused by driver distraction: the driver was having a drink to try and clear her irritated throat. The unsealed shoulder, coupled with the driver's inexperience with power-steering, resulted in further loss of control when the driver attempted to steer back onto the road. This further loss of control caused the car to yaw onto the other side of the road where a collision with trees near the roadside (at a distance of 8.6m) caused the vehicle to roll over.

Crash R121:

An 80 year old driver of a car was travelling west on a straight section of a rural highway when she ran off the road to the left, struck a cutting and rolled over. There did not appear to be any factors beyond driver error contributing to the loss of vehicular control in this crash.

Crash R138:

A 79 year old driver of a car was travelling west on a rural highway when she lost control of the vehicle on a left curve. The car ran off the right side of the road and down an embankment. The cause of this crash was a brief loss of consciousness by the driver, believed to have been associated with hypertension.

Crash R186:

A 75 year old driver of a car was travelling north west on a straight section of a rural highway when she ran off the right side of the road and down an embankment. In addition to driver error, inclement weather conditions would have contributed to the causation of the crash. It was raining heavily at the time and the driver lost control of the vehicle on the wet road.

4.3.5 Head-on crashes

In the Rural In-depth Crash Investigation study, a 'head-on' crash was defined as one in which two vehicles travelling in opposite directions on the same road collided with each other, and neither of the two vehicles were engaged in turning manoeuvres at the time of the crash. There were five such crashes in the study that featured an older driver. The factors contributing to these crashes are discussed below.

Crash R114:

A 67 year old driver of a car was travelling north east on a rural highway when her car was struck by another car that was out of control and travelling in the opposite direction. In this case, the driver of the other car was at fault and there was nothing that the older driver could have done to avoid the collision.

Crash R149:

A 69 year old driver of a car travelling south on a rural highway veered off onto the left shoulder on a right bend, before overcorrecting and steering onto the wrong side of the road where the car struck another car that was travelling north. This second car struck a third car that had been travelling behind the older driver's vehicle. The older driver's car continued down an embankment and struck a fence and tree located approximately five metres from the roadside. There were two road environment factors, in addition to driver error, that contributed to the causation of the crash. The first of these is the lack of a speed advisory sign for the southbound vehicles. The northbound vehicles approaching the bend were faced with a 75 km/h speed advisory sign (the speed limit for the road was 100 km/h) but southbound vehicles had no advisory sign. The other contributing factor was an unsealed shoulder. The driver's attempts to safely steer back onto the carriageway after veering onto the shoulder were hampered by the unsealed surface, and further loss of control led to the vehicle travelling onto the incorrect side of the road.

Crash R175:

An 80 year old driver of a car was travelling north west on a rural highway when she veered off to the left roadside on a right bend. The car struck a guard rail and then travelled onto the incorrect side of the road and collided with a car travelling in the opposite direction. The older driver subsequently accelerated through a fence on the side of a bridge and her car plunged 12 m to the riverside below. The driver died as a result of the crash. No fault for the occurrence of the crash could be attributed to the guard rail that was initially struck by the older driver's car. The roadside environment did contribute to the fatal injuries suffered by the driver, however. The fence on the side of a bridge that supports a roadway 12 metres above a river should be able to prevent a vehicle from crashing through it if the vehicle is travelling at a speed within the normal range of vehicles using that road. The car that crashed in this case was not travelling above the 60 km/h speed limit, yet the fence it struck was clearly inadequate for containing it.

Crash R195:

A 70 year old driver of a utility was travelling south east on a rural highway when it was struck by a motorcycle that was travelling on the incorrect side of the road after the rider lost control on a bend. In this case, the older driver was not responsible for the occurrence of the crash. The motorcycle rider died as a result of the collision.

Crash R200:

A 73 year old driver of a car was travelling north on a rural highway when his car was struck by a southbound motorcycle that had veered onto the incorrect side of the road. In this case, the older driver was not responsible for the collision.

4.3.6 Other crash types

There were three other crashes in the Rural In-depth Crash Investigation Study that featured an older driver. One was a side swipe (R220), one was a U-turn-related crash (R222), and the other was a rear end collision (R233).

Crash R220:

A 66 year old driver of a car struck the side of a sports utility vehicle that was initially travelling in the same direction before turning left into a driveway. A contributing factor to this crash, in addition to driver error, was the sharp angle the driveway made with the road, meaning that a very tight left turn was required to get into the driveway. The driver of the sports utility vehicle indicated to turn left and then veered over to the right in order to be able to turn at enough of an angle to manoeuvre the vehicle into the driveway. The older driver of the following car, after seeing the sports utility vehicle veer towards the right, assumed that the left turn signal was incorrect and that the sports utility vehicle was actually going to turn right. When the sports utility vehicle turned left, the older driver was not able to manoeuvre out of the way.

Crash R222:

A 73 year old driver of a sports utility vehicle was travelling south on a rural highway before moving onto the roadside and attempting a U-turn to travel in the opposite direction. The vehicle was struck in the side by a southbound motorcycle to which the older driver had failed to give way. In this case, the presence of a bend in the road restricted vision of the other vehicle. The older driver could not see the approaching motorcycle because of the bend in the road. This should have alerted the driver to the fact that this was an inappropriate place to select to perform a U-turn, although he may have been basing his decision on the presence of a broken centre line.

Crash R233:

A 69 year old driver was travelling south on a rural highway at night when her car struck the rear of a southbound trailer that was unregistered and without tail-lights, and was being pulled by a tractor. The 83 year old left front seat passenger in the car died as a result of the collision. A major contributor to the occurrence of this crash was the lack of conspicuity of the trailer. Without any tail-lights or retro-reflective markings, it would have been difficult to see at night. It was also of sufficient size to completely obscure vision of the tractor that was towing it.

4.4 Summary

As part of a Rural In-depth Crash Investigation study, CASR personnel conducted at-scene and follow-up investigations of 41 crashes involving drivers aged 65 and over. Comparisons with the remaining 195 crashes in the sample revealed that crashes involving older drivers were more likely to involve collisions at intersections (right turn, right angle crashes) rather than be precipitated by loss of vehicular control (single vehicle, head-on), and were more likely to produce fatal injuries. The greater likelihood of crashes occurring at intersections has been found previously for older drivers (Campbell, 1966; Cooper, 1990; Council & Zegeer, 1992; Hakamies-Blomqvist, 1993; Hauer, 1988; Keskinen, Ota, & Katila, 1998; Partyka, 1983; Preusser, Williams, Ferguson, Ulmer, & Weinstein, 1998; Stamatiadis, Taylor, & McKelvey, 1991; Staplin, Gish, Decina, Lococo, & McKnight, 1998).

Human factors (i.e. driver error) were common contributing factors to the causation of the crashes involving older drivers, as is typically found for crashes in general (Sabey & Taylor, 1980; Treat, 1980). In a number of cases, this driver error was the result of significant impairments associated with medical conditions. However, a number of other factors unrelated to driver error were also found to contribute to the causation of the crash.

In a number of intersection crashes (right angle or right turn), the layout of the road was found to be problematic. Difficulties negotiating intersections that affect all drivers may disproportionately affect older drivers, especially when the road layout makes it difficult to make judgements concerning gap acceptance or to predict the movements of other traffic. It is encouraging that audits have been conducted of, and/or improvements made to, a number of the intersections at which this sample of rural crashes occurred. Intersection crashes were also associated in multiple cases with restrictions of vision of oncoming traffic, or the low conspicuity of other vehicles. There were also instances of poor brakes on another vehicle, inappropriate designation of the priority road, the excessive speed of another vehicle, glare from the sun, and the failure of another driver to give way.

In crashes precipitated by the loss of vehicular control, contributions to the causation of crashes were also made by the presence of an unsealed shoulder and very wet weather, while the severity of the resulting injuries was increased by the location of roadside hazards close to the edge of the road and, in one case, by an inadequate fence on the side of a bridge. In other crashes, contributing factors were the sharp angle of a driveway, restriction of a vision by a bend and the poor conspicuity of a trailer at night.

5 Discussion

Older drivers, when compared to those in younger age groups, have relatively few crashes (see section 2). They are only over-represented in crashes when adjustments are made for distances driven by drivers in different age groups. This over-representation in crashes per distance driven is given a great deal of emphasis in the literature but, for practical purposes, the two most important indices of crash involvement are total crash numbers and crashes per licensed driver, neither of which show an over-representation of older drivers. Older drivers, relatively speaking, do not contribute greatly to overall crash numbers, and crashes per licensed driver suggest that the re-licensing of most older drivers should be a routine process. The increased crash rate per distance driven, on the other hand, is difficult to interpret because of the possibility that it is produced by cohort effects and the 'low mileage bias'. The possibility that older drivers have an increased crash rate per distance driven because they restrict their driving would mean that this increased crash rate is due to behaviour that actually reduces their overall likelihood of having a crash (i.e. fewer crashes because of a reduction in exposure).

If there is a problem regarding older drivers, it is that they are more susceptible to injury. This results in older drivers being over-represented in crashes of high injury severity (see section 2). This greater likelihood of suffering serious or fatal injuries in a crash is sufficient justification for a specific focus on reducing the crash rates of older drivers.

Crash involvement among older drivers has been linked to a number of medical conditions and functional deficits (i.e. deficits in vision, cognition, attention, or physical functioning) (see section 3). This would appear to make it likely that older drivers affected by such conditions and deficits would constitute high risk subgroups of the older driver population. This, in turn, should result in the crash involvement of older drivers being concentrated among such 'high-risk' drivers. However, although those older drivers who are involved in crashes are more likely to crash in a subsequent time period, it is not possible to identify 'high-risk' older drivers in mass crash data. This is because of the rarity of crashes for individual drivers. Most older drivers, in a time period of five years, will be crash-free and very few will have more than one crash. Also, the nature of the Poisson distribution means that, due to chance effects, drivers with a 'normal' crash risk could have three or more crashes in a year, while many drivers with a significantly higher risk of crashing could remain crash-free in the same time period. The practical significance of this is that involvement in a crash for an older driver is not likely to be indicative of the need for assessment of fitness to drive. Identifying those whose fitness to drive should be assessed is best done through medical channels.

It is also important to bear in mind that crashes are multi-determined events. An investigation of a sample of rural crashes involving older drivers demonstrated the role of vehicular and, particularly, road environment-related factors in crash causation (see section 4). Of particular interest was the over-involvement of older drivers in intersection crashes. In many instances, the nature of the intersection was likely to have contributed to the crash. Improvements to intersections, which have since been made to a number of the sites at which the investigated crashes occurred, will improve their safety for all road-users but may disproportionately assist older drivers.

To summarise, the increasing emphasis on the importance of maintaining the mobility of older adults (OECD, 2001) means that it is timely to consider the different methods of calculating crash rates with regard to older drivers. The results suggest that older drivers are not over-represented in crashes but that they are more susceptible to injury in the event of a crash. This means that older adults are still of concern in the road safety context and that focusing specifically on reducing older driver crashes should still be a priority. The inability to identify older drivers with an increased risk of crashing from mass crash data suggests that at-risk older drivers are best identified through medical channels. Older driver crashes may also be reduced disproportionately to those of drivers in other age groups by making intersections easier to use.

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Appendix

Table 1
Crash-involved drivers in South Australia per head
of population from 1994 to 1998, by age group

Age group	Percentage of population
16-24	39.8
25-34	26.2
35-44	22.0
45-54	18.9
55-64	15.2
65-74	12.7
75-84	10.7
85+	4.8
Total	22.5

Table 2
Crash-involved drivers in South Australia per
licensed driver from 1994 to 1998, by age group

Age group	Percentage of drivers
16-24	57.0
25-34	32.6
35-44	28.3
45-54	24.2
55-64	21.5
65-74	20.9
75-84	18.7
85+	19.6
Total	31.0

Table 3
Property damage only crash-involved drivers in South Australia
per licensed driver from 1994 to 1998, by age group,
compared to drivers aged 75 to 84

Age group	Ratio to drivers aged 75 to 84
16-24	3.0
25-34	1.7
35-44	1.5
45-54	1.3
55-64	1.2
65-74	1.1
75-84	1.0
85+	1.0

Table 4
Treated by private doctor crash-involved drivers in South Australia
per licensed driver from 1994 to 1998, by age group,
compared to drivers aged 75 to 84

Age group	Ratio to drivers aged 75 to 84
16-24	4.5
25-34	2.8
35-44	2.6
45-54	2.1
55-64	1.6
65-74	1.3
75-84	1.0
85+	1.1

Table 5
Treated at hospital crash-involved drivers in South Australia
per licensed driver from 1994 to 1998, by age group,
compared to drivers aged 75 to 84

Age group	Ratio to drivers aged 75 to 84
16-24	3.1
25-34	1.6
35-44	1.3
45-54	1.0
55-64	0.9
65-74	0.9
75-84	1.0
85+	1.3

Table 6
Admitted to hospital crash-involved drivers in South Australia
per licensed driver from 1994 to 1998, by age group,
compared to drivers aged 75 to 84

Age group	Ratio to drivers aged 75 to 84
16-24	2.7
25-34	1.4
35-44	1.0
45-54	0.8
55-64	0.8
65-74	0.9
75-84	1.0
85+	1.3

Table 7
Fatal crash-involved drivers in South Australia
per licensed driver from 1994 to 1998, by age group,
compared to drivers aged 75 to 84

Age group	Ratio to drivers aged 75 to 84
16-24	1.6
25-34	0.8
35-44	0.6
45-54	0.4
55-64	0.5
65-74	0.7
75-84	1.0
85+	1.6

Table 8
Average kilometres driven (x 1,000) by drivers in South
Australia in the 12 months, 1997-1998, by age group

Age group	1,000 kilometres driven	Relative standard error (%) [*]
16-24	6.3	26
25-34	11.8	20
35-44	8.7	9
45-54	9.4	15
55-64	8.4	12
65-74	8.4	23
75-84	3.6	27
85+	0.0	0
Unknown	14.9	47
Total	9.2	7

^{*} The relative standard error is the standard error of the estimate expressed as a percentage of the estimate. It shows the percentage error likely to have occurred by sampling.

Table 9
Crash-involved drivers in South Australia per million kilometres driven
from 1994 to 1998, by age group

Age group	Crash-involved drivers per million kilometres driven
16-24	15.0
25-34	4.2
35-44	4.3
45-54	3.3
55-64	3.5
65-74	3.8
75-84	9.9
Total	6.2