Why do older drivers have a high rate of involvement in casualty accidents per distance driven?[1,2]

John Catchpole
Senior Research Scientist, ARRB Group Ltd

ABSTRACT

This study investigated the rate of involvement in casualty accidents per distance driven for Victorian drivers of various ages and the factors that contribute to the over-representation of older drivers in casualty accidents. The study drew on records of all drivers involved in casualty accidents in Victoria from 1998 to 2004, inclusive; and on the Melbourne On-Road Exposure Survey of 2001, which generated estimates of the distance driven on arterial roads in Melbourne by various demographic groups during a typical non-holiday week. The rate of involvement in casualty accidents per distance driven followed a U-shaped curve, being lowest for drivers aged 40-49 years and higher for both younger and older drivers, especially those aged less than 26 and those aged more than 70 years. The study identified a range of environments and manoeuvres associated with over-representation of older drivers in accidents. There is evidence that changing exposure patterns, increasing physical frailty and declining driving competence all contribute to the elevated rate of casualty accident involvement per distance driven for older drivers.

Melbourne On-Road Exposure Survey

Exposure is the opportunity for a road user to be involved in a traffic accident, usually measured by the amount of travel by the road user on the road network. Information about the exposure of various road user groups can be used to calculate accident rates per unit exposure, so that the risk associated with road travel can be compared between road user groups. Since 1984, VicRoads has conducted an irregular series of surveys, known as the Melbourne On-Road Exposure Surveys, to collect information about the exposure of drivers of light passenger vehicles on arterial roads in Melbourne.

The most recent Melbourne On-Road Exposure Survey was conducted in autumn 2001. The survey was conducted on weekdays and weekends, but excluded school holidays and public holidays. Information about drivers and vehicles was collected by teams of two (an observer and an interviewer) at 64 signalised intersections in the Melbourne Statistical Division. The 64 sites comprised two sites in each of Melbourne's 31 Local Government Areas (LGAs) plus two in Docklands. Sites with extremely high or extremely low traffic flows were avoided.

To allow drivers to be interviewed and observations of vehicles and occupants to be made, interviewers pressed the pedestrian call button to stop vehicles at a red signal. For safety reasons, interviewers and observers operated exclusively from the central median and did not step onto the roadway. This meant that sampling was restricted to vehicles in the lane nearest the median, which was often a right turn lane. Most sites were located on primary arterials, since secondary arterials were less likely to have a central median with a pedestrian call button. Among other questions, the interviewer asked the age of the driver. For drivers who refused to be interviewed or did not give their age, the interviewer's estimate of the driver's age was used instead.

---

[1] The author gratefully acknowledges the valuable contributions to the research made by Victoria Pyta, Dr Tanya Styles, Kelly Imberger and Dr Peter Cairney of ARRB and by Pat Rogerson and Tricia Williams of VicRoads.

[2] This paper provides a summary of selected findings from a project carried out by ARRB Group for VicRoads. For a full report of the research, see Catchpole, Styles, Pyta and Imberger (2005).

Apart from assisting the interviewer to collect information about sampled vehicles in the lane nearest the median, the observer also counted all vehicles passing the survey site in all lanes.

Drivers of cars, station wagons, utilities, small 4-wheel drives, multi-passenger vehicles (up to 12 seats) and small 4-wheeled vans were included in the survey. No information was collected about travel by bicycle, motorcycle, bus or truck.

Expansion weights were applied to the counts of sampled vehicles at each site in each LGA to yield estimates of the total distance travelled in the LGA during one week by vehicles and drivers of various types. In the first step, counts of vehicles sampled and drivers interviewed were weighted up to be representative of all vehicles passing the survey site in all lanes during the survey session (using the count of all passing vehicles kept by the observer). Second, data for vehicles passing during the survey sessions conducted at the site at various times were weighted up to be representative of all vehicles passing the site during a full week. In the third step, the number of vehicles passing the survey site during the week was multiplied by the total length of arterial road in the LGA to yield an estimate of the total distance travelled on arterial roads in the LGA during the week[3]. Finally, a correction factor was applied to take account of above average or below average traffic flow at the survey site as compared with the entire arterial network in the LGA (making use of vehicle counts collected by traffic signal controllers at signalised intersections throughout the LGA).

Driving exposure by age group

The survey yielded estimates of the total distance driven on arterial roads in Melbourne in one week by drivers in each of 15 age groups. The estimated weekly distance driven on Melbourne arterials by drivers in each age group was reported by Steer Davies Gleave (2002). These estimates are shown graphically in Figure 1 (on the next page).

The chart shows that drivers aged 35-39 and 40-44 years account for more driving exposure in Melbourne than any other age group. The total distance driven each week by drivers aged 60-64 years is just less than a quarter of the total distance driven by drivers aged 40-44 years. Out of an estimated total of 327.0 million km driven on arterial roads in Melbourne each week, drivers aged 65 years or more account for just 14.1 million km or 4.3%. The distance driven by males is substantially greater than the distance driven by females in every age group except drivers aged 16-17 years. The relative difference between males and females is especially large for drivers aged 60 years or more.

[3] It can be shown that this method yields a valid estimate of total travel in the LGA that is not dependent on assumptions about the distance travelled by each vehicle sampled.

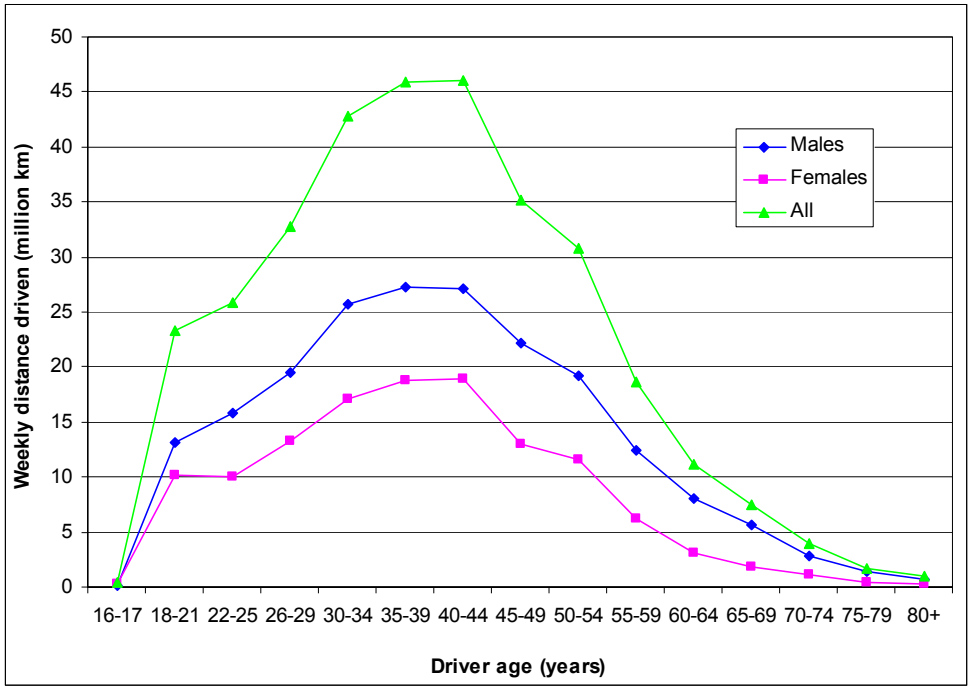

Figure 1. Total distance driven on arterial roads in Melbourne each week during non-holiday periods by driver age and sex.

Generalising the exposure findings

The exposure information reported by Steer Davies Gleave (2002) has previously been used by Drummond (2003) to calculate the rate of accident involvement per distance driven for various age groups. However, the rates calculated by Drummond applied only to accidents and exposure on arterial roads in the Melbourne Statistical Division during non-holiday weeks.

Using information about drivers of light passenger vehicles involved in casualty accidents in Victoria from 1998 to 2004, the project team investigated whether the exposure data from the 2001 Melbourne On-Road Exposure Survey could be used to calculate accident involvement rates for the whole of the Victorian road network and for all times of year.

Region of Victoria

Analysis of data on drivers involved in casualty accidents revealed noticeable differences between the driver age profiles for the Melbourne Statistical Division and the rest of Victoria. In particular, drivers aged 65 years or more comprised only 6.7% of drivers in casualty accidents in the Melbourne Statistical Division but 11.0% in the rest of Victoria. This suggests EITHER that drivers aged 65 years or more account for a lower proportion of all driving exposure in Melbourne than in the rest of Victoria OR that the relative accident rate per distance driven of drivers aged 65 or more (relative to younger age groups) is lower in Melbourne than in the rest of Victoria. No matter which of these explanations is true, it is clear that exposure data collected only in Melbourne cannot be used to calculate accident rates that apply to the whole of Victoria.

Road class

Some differences were found between the age profiles of drivers involved in accidents on different road classes in Melbourne. Drivers aged 65 or more comprised a relatively small proportion of drivers involved in accidents on freeways (3.8%), a higher proportion of drivers involved in accidents on arterial roads (6.1%) and a higher proportion again on local roads (7.7%). However, the under-representation of older drivers in freeway accidents (relative to arterial road accidents) partly compensates for their over-representation in local road accidents, so that the overall representation of drivers aged 65 or more in accidents across all road classes (6.7%) does not differ greatly from their representation on arterial roads (6.1%).

The similarity of the age profiles of accident-involved drivers on arterial roads and all road classes is illustrated in Figure 2. While it seems likely that the relative exposure of various age groups does vary between road functional classes, it appears probable that exposure patterns on arterial roads are reasonably representative of total exposure across all road classes. Consequently, the results of the on-road exposure survey can be used to estimate relative rates of accident involvement for each age group on all Melbourne roads.

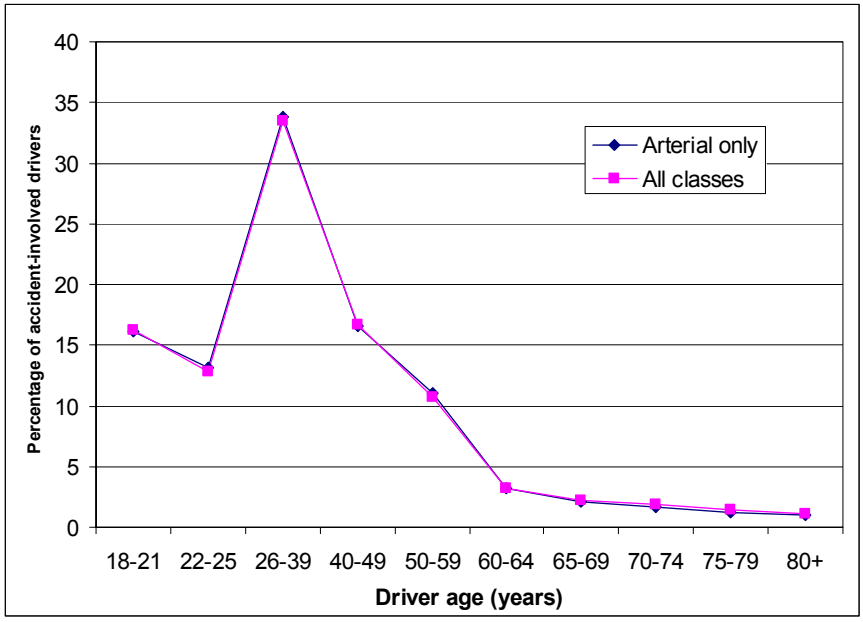

Figure 2. Percentage of accident-involved drivers by age group for accidents on arterial roads and accidents on all Melbourne roads.

Time of year

As shown in Figure 3 (on the next page), the age profile of drivers involved in accidents in Melbourne is very similar for holiday and non-holiday periods. Drivers aged 65 years or more comprise 7.0% of drivers involved in accidents in Melbourne on school and public holidays and 6.6% at other times. Whilst there are, no doubt, differences in exposure patterns between holiday and non-holiday periods, there is nothing in this chart to indicate that the proportion of overall exposure accounted for by drivers in each age group differs greatly between holiday and non-holiday periods. Thus it seems reasonable to assume that the relative exposure of various age groups during non-holiday periods is fairly representative of relative exposure across the whole year. The results of the on-road exposure survey can therefore be used to estimate relative rates of accident involvement for each age group for the whole year.

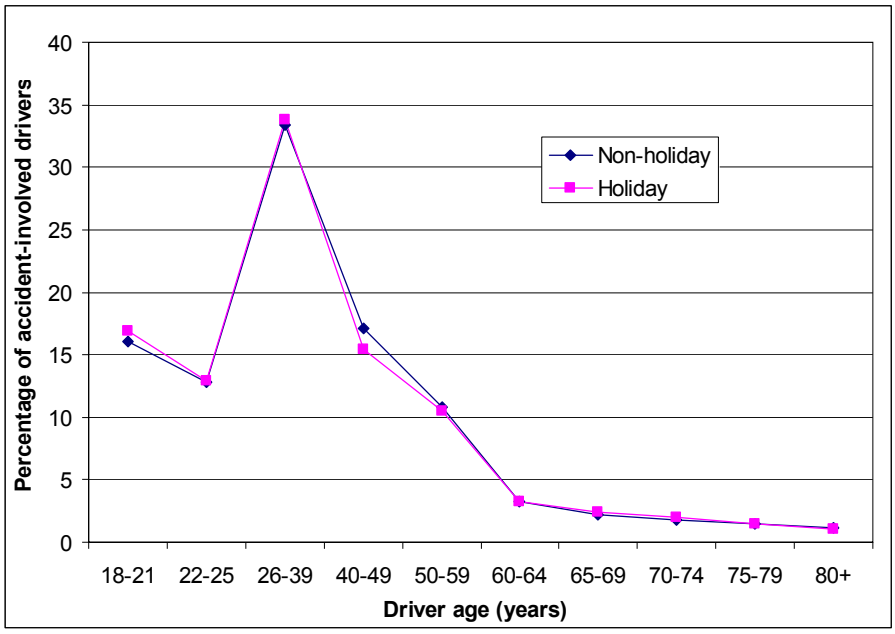

Figure 3. Percentage of accident-involved drivers by age group for accidents in Melbourne during holiday and non-holiday periods.

Relative rate of casualty accident involvement per distance driven

The calculation of relative rates of accident involvement was based on counts of drivers aged 18 years or more driving light passenger vehicles[4] involved in casualty accidents on all roads in the Melbourne Statistical Division from 1998 to 2004 (inclusive). Steer Davies Gleave (2002) provided estimates of exposure only for a single, non-holiday week and only for arterial roads. Thus it was not possible to calculate absolute rates of accident involvement per distance driven. Instead, relative rates were calculated, with the rates for each age group being expressed relative to the rate for drivers aged 40-49 years, the group with the lowest rate of accident involvement.

Using counts of drivers involved in casualty accidents on all roads in the Melbourne Statistical Division from 1998 to 2004 and estimates of exposure on arterial roads in the Melbourne Statistical Division from the Melbourne On-Road Exposure Survey of 2001, four relative rates were calculated:

- the rate of involvement in casualty accidents per distance driven
- the rate of involvement in serious casualty (serious injury or fatal) accidents per distance driven
- the rate of injury per distance driven
- the rate of serious or fatal injury per distance driven.

The four relative rates are shown for all age groups in Figure 4. All rates are relative to a rate of 1.0 for serious or fatal injury among 40-49 year old drivers. For all age groups, the rate of driver injury is lower than the rate of driver involvement in casualty accidents because not all casualty accidents result in an injury to the driver (it may be a pedestrian or a passenger or an occupant of the other vehicle who is injured). The rate of involvement in serious casualty accidents is lower than the rate of involvement in casualty accidents and the rate of serious or fatal injury is lower than the rate of injury because serious and fatal injuries comprise a subset of all injuries. All four rates rise steeply for drivers aged 70 years or more (and for drivers aged 25 or less).

[4] Light passenger vehicles comprise cars, station wagons, utilities, panel vans and 9-13 seat mini-buses.

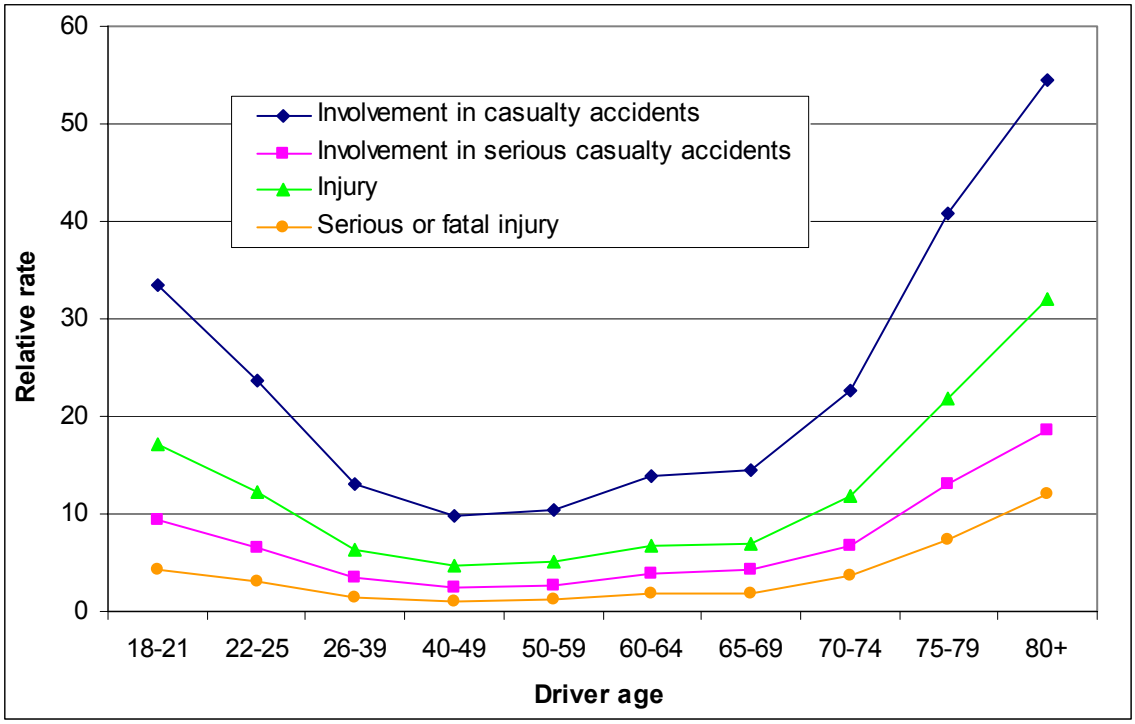

Figure 4. Relative rate of accident involvement and injury per distance driven by driver age group for accidents in the Melbourne Statistical Division

Relative standard errors and 99% confidence intervals were calculated for the relative rates of involvement in casualty accidents. Tests based on relative standard errors revealed that all age groups other than 50-59 year olds have a rate of involvement in casualty accidents per distance driven that is significantly higher than the rate for 40-49 year olds.

The relative rate of involvement in casualty accidents per distance driven is shown for males and females in Figure 5. All rates are relative to 40-49 year old males. For 18-21 year old drivers, the rate for males is higher than the rate for females, but the reverse is true for all remaining age groups. All groups except males aged 50-59 years and females aged 75 years or more have a significantly higher rate of involvement in casualty accidents per distance driven than males aged 40-49 years. For males aged 50-59, the rate is only 8% higher than for males aged 40-49 and the difference is not significant. The elevated rate for females aged 75 years or more is not significant because of the very small sample size for this group in the exposure survey.

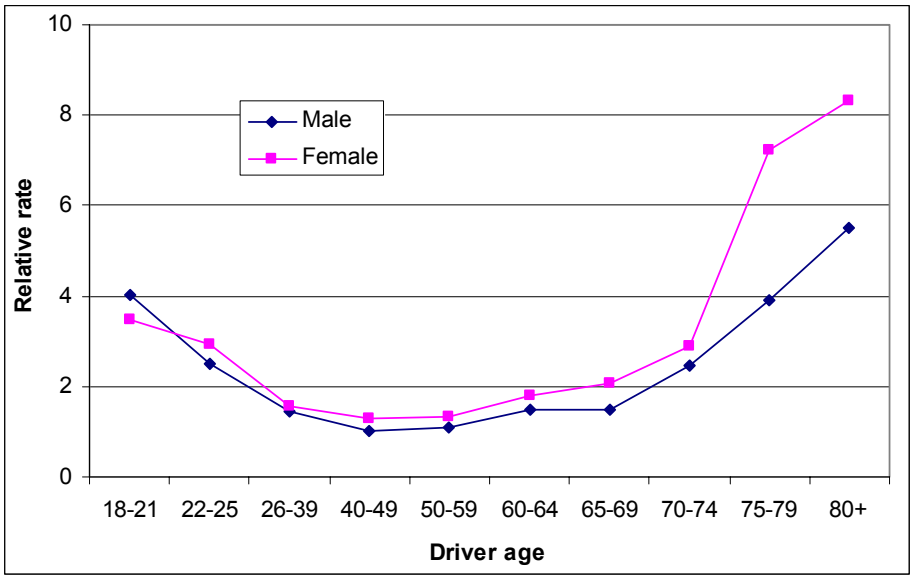

Figure 5. Relative rate of involvement in casualty accidents per distance driven by driver gender and age group for accidents in the Melbourne Statistical Division

Characteristics of older driver casualty accidents

In order to get an indication of the factors that contribute to the elevated casualty accident rates of older drivers, data on drivers of light passenger vehicles involved in casualty accidents on all Victorian roads from 1998 to 2004 (inclusive) were examined in greater depth to identify differences between the accidents in which older drivers are involved and those involving young and middle-aged drivers. In view of the very large sample size for this analysis (169,745 drivers of all ages involved in casualty accidents), tests of statistical significance were not required and the differences identified by the analysis can be assumed to be statistically reliable. The differences identified include the following:

(1) By comparison with young and middle-aged drivers, older drivers are over-represented in accidents at intersections. The proportion of accidents at intersections is 64.3% for drivers aged 65 or more, compared with 58.6% for drivers aged 40-49 and 57.4% for all drivers aged 18-64 years.

(2) Older drivers are over-represented in accidents at Stop and Give Way signs. The proportion of accidents at Stop and Give Way signs is 18.4% for drivers aged 65 or more, compared with 8.3% for drivers aged 40-49 and 7.8% for all drivers aged 18-64 years. Older drivers are also slightly over-represented in accidents at pedestrian signals.

(3) Older drivers are over-represented in accidents in 50 km/h and 60 km/h zones. The proportion of accidents in 50 km/h zones is 9.3% for drivers aged 70 or more, compared with 6.7% for drivers aged 40-49 years. The proportion of accidents in 60 km/h zones is 56.1% for drivers aged 75 or more compared with 52.9% for drivers aged 40-49.

(4) Examination of the vehicle movements being performed at the time of the accident revealed that older drivers are over-represented performing a variety of low-speed manoeuvres. Drivers aged 60 or more are over-represented in accidents that occur while performing U-turns and entering or leaving parking spaces. Drivers aged 65 or more are over-represented making right turns. Drivers aged 70 or more are over-represented in accidents that occur while reversing or leaving a driveway.

(5) Older drivers are over-represented in a variety of accident types that are suggestive of the driver having insufficient control of the vehicle, including collisions with fixed objects, temporary road

works, stationary vehicles and parked vehicles. However, failure to detect the object struck cannot be ruled out as an alternative explanation for some of these collisions, especially those that involve reversing into a parked vehicle or fixed object.

(6) Older drivers are over-represented in a variety of roles that apparently involve failing to give way (including, among others, driving a right-turning vehicle that is struck by an oncoming vehicle or a vehicle approaching from the right) or encroaching on another vehicle's space (including unsafe lane changes and side swipes).

(7) For all multi-vehicle accidents[5], VicRoads assigns the labels 'Vehicle 1' and 'Vehicle 2' to the two vehicles involved in the initial collision on the basis of the movement being undertaken by each vehicle at the time of the collision. Examining the movements being performed by Vehicles 1 and 2 in the various multi-vehicle accident types shows that the driver of Vehicle 1 is more likely to be at fault than the driver of Vehicle 2 in most multi-vehicle accidents (other than cross-traffic accidents). In multi-vehicle accidents, older drivers are over-represented as the driver of Vehicle 1. The proportion of drivers in multi-vehicle accidents recorded as driving Vehicle 1 is 53.5% for drivers aged 60 or more, compared with 39.9% for drivers aged 40-49 and 41.5% for drivers aged 26-59.

(8) Older drivers are under-represented as the driver of the front vehicle in a rear-end accident and as the driver of a vehicle not involved in the initial collision. Drivers in these roles are typically the innocent parties in accidents caused by errors of other drivers.

(9) Despite their apparent difficulties with vehicle control and encroaching on the space of other vehicles, older drivers were found NOT to be over-represented in run-off-road accidents, loss of control while overtaking or head on collisions while overtaking. All of these accident types, typically involving high speeds, were found to be much more characteristic of young drivers.

Factors contributing to high accident rates

A recent New Zealand study (Keall and Frith, 2004) found that older drivers undertake shorter trips, on average, than young and middle-aged drivers. It is reasonable to suppose that a similar pattern would apply in Victoria. This implies that the low speed manoeuvres associated with the start or finish of almost every trip, such as parking or leaving parking, entering or leaving a driveway, driving on local streets and entering the arterial road network, would comprise a greater proportion of the total risk associated with each trip for older drivers than for young and middle-aged drivers. Consistent with this hypothesis, older drivers were found to be over-represented in most of the manoeuvres mentioned and also in accidents in 50 km/h and 60 km/h zones. Thus it appears that many of the characteristics typically associated with older driver accidents may be partly or even largely the result of older drivers typically making shorter trips than young and middle-aged drivers.

The risk of being involved in an accident varies greatly between different road environments and road types. For example, accident rates per distance travelled are typically far lower on freeways than on arterial roads and local streets. The over-representation of older drivers in accidents on local roads and their under-representation on freeways suggests that older drivers do a high proportion of their driving (relative to young and middle-aged drivers) on local streets, where accident rates are highest, and a low proportion on freeways, which are comparatively safe. Differences in risk associated with different road types and road environments are likely to contribute substantially to the elevated accidents rates of older drivers.

All four of the accident involvement rates plotted in Figure 4 rise steeply with increasing age. However, the rate of involvement in serious casualty accidents rises more steeply than the rate of involvement in casualty accidents and the rate of serious or fatal injury rises more steeply than the rate of injury. This is seen more clearly in Figure 6, where the rates have been recalculated so that each

[5] For the purposes of this analysis, a multi-vehicle accident is one in which the first harmful event is a collision between two vehicles, neither of which is parked.

rate separately is relative to the rate for the 40-49 age group, meaning that the four curves meet at 1.0 for the reference age group.

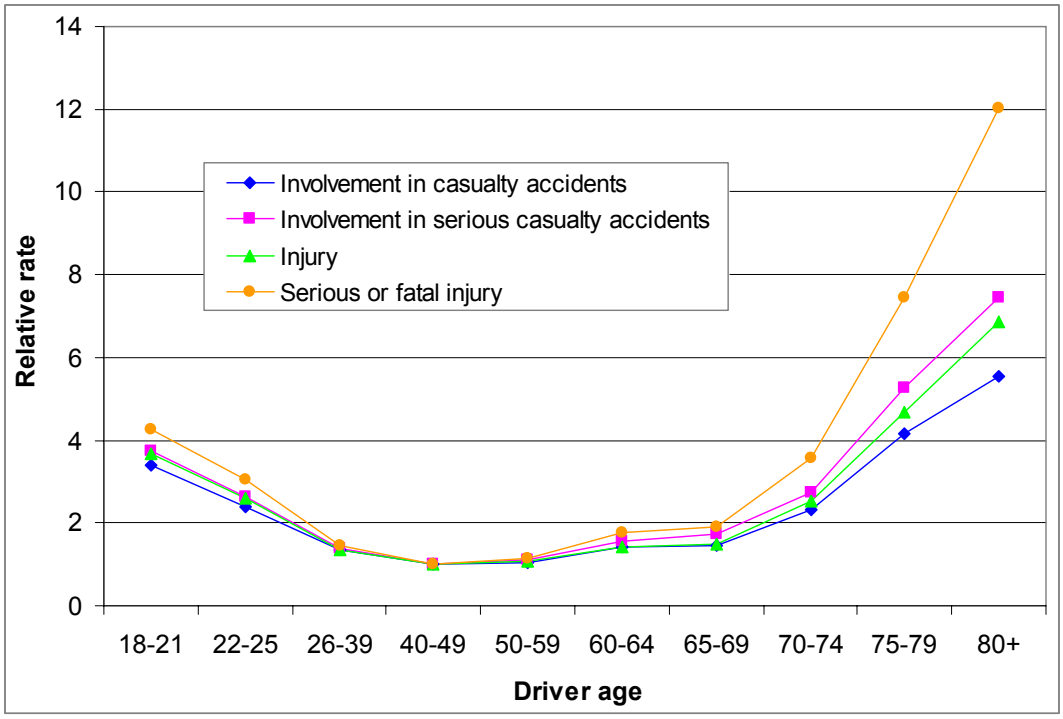

Figure 6. Relative rate of accident involvement and injury per distance driven by driver age group for accidents in the Melbourne Statistical Division

The steeper increases for the more severe accidents and injuries largely reflect the lesser physical robustness of older drivers when compared with young and middle-aged drivers (although other factors such as older, less protective vehicles may also contribute). Of two drivers involved in similar crashes, the older driver is the more likely to be injured; of two drivers injured in similar crashes, the older driver is the more likely to be seriously or fatally injured. Thus an accident involving an older driver is more likely to be counted in official records of casualty accidents than is a similar accident involving a young or middle-aged driver. In other words, the physical frailty of older drivers directly contributes to their elevated rate of involvement and injury in casualty accidents. What is more, the passengers of older drivers are likely to be of comparable age to the driver, so the frailty of their passengers also contributes to their high rate of involvement in casualty accidents.

It has been seen that the elevated casualty accident rates of older drivers are partly due to the types of situation in which their driving typically occurs (exposure) and partly due to their greater likelihood of being injured in the event that an accident occurs (frailty). Other factors such as vehicle crashworthiness may also make a contribution. However, some characteristics of the accidents in which older drivers are involved strongly suggest that a gradual deterioration in driving competence also contributes to their high accident rates. Relevant findings from the analysis of involvement in Victorian casualty accidents in the present study include the following:

- Older drivers are under-represented in the roles where they are most likely to be the innocent parties in accidents caused by errors of other drivers.
- In multi-vehicle accidents, older drivers are over-represented as the driver of Vehicle 1, the driver more likely to be at fault.
- Older drivers are over-represented in roles that involve failing to give way to another vehicle or encroaching on another vehicle's space.
- Older drivers are over-represented in roles that are likely to involve having insufficient control of the vehicle.

- Older drivers are over-represented in collisions with parked vehicles.

These patterns of accident involvement lead to some speculations about the nature of the functional impairments that may become more common with increasing age. The over-involvement of older drivers in accidents involving low speed manoeuvres such as U-turns and entering or leaving a parking space, if it is not entirely attributable to a higher proportion of exposure in these situations, suggests that some older drivers may find it difficult to perform large steering movements at low speed. On the other hand, these same accident characteristics, plus the over-representation of older drivers in accidents while reversing, might indicate that some older drivers have difficulty turning their heads far enough to monitor stationary objects and approaching vehicles in all directions. Consistent with this speculation, U-turners of all ages were much more likely to be hit by a vehicle approaching from behind (i.e. from the same direction as the U-turner's initial direction of travel) than by a vehicle approaching from the opposite direction, suggesting that the difficulty of monitoring for traffic approaching from behind may contribute to U-turn accidents (in which older drivers are over-represented). In extreme cases, difficulty in turning one's head might even make it difficult to monitor traffic approaching from the right or left when facing a Stop or Give Way sign, another accident scenario in which older drivers are over-represented.

Older drivers were found to be over-represented in collisions with parked vehicles, buildings and fences. In view of the size and conspicuity of such objects, this is unlikely to indicate difficulties with detection and seems much more likely to indicate difficulties either with judgement of distance or with vehicle control. In some circumstances, failure to realise that the vehicle is parked rather than in motion might also contribute to collisions with parked vehicles.

Other aspects of ageing that might contribute to high accident rates for older drivers include gradually deteriorating vision and slower processing of incoming information in high demand situations such as when negotiating busy intersections. It is also possible that the much lower distance driven each week by many older drivers, especially females, means that some skills are not practised often enough to be performed optimally. However, the present study was not able to investigate these factors.

CONCLUSIONS

The Melbourne On-Road Exposure Survey of 2001 collected information about the distance driven by light passenger vehicle drivers of all ages in a typical non-holiday week on arterial roads in the Melbourne Statistical Division. Investigation of variations in accident involvement with age suggested it would be reasonable to use the exposure data to calculate relative rates of accident involvement for drivers of all ages on all classes of road at all times of year. However, the results cannot be generalised from Melbourne to the whole of Victoria because exposure patterns and/or relative accident rates differ between Melbourne and the rest of the state.

For both males and females, accident rates follow a U-shaped curve, being lowest for drivers aged 40-49 years and rising steeply with increasing age, especially beyond age 70. Factors contributing to the elevated accident rates of older drivers include:

- changing exposure patterns, with older drivers typically undertaking shorter trips and doing more of their driving in relatively high risk road environments
- increasing frailty, which increases the likelihood that any accident that does occur will result in an injury and will therefore be counted in official statistics
- a gradual deterioration in driving competence, which may involve difficulty in performing large steering movements at low speed, difficulty in turning the head far enough to monitor stationary objects and approaching vehicles in all directions, difficulty in judging distance and/or difficulty with vehicle control.

REFERENCES

Catchpole J, Styles, T, Pyta V and Imberger K (2005). *Exposure and accident risk among older drivers.* Research Report ARR 366. (ARRB Group: Vermont South, Victoria).

Drummond A (2003). *The risks of crashing while driving around Melbourne.* Report RD 828. (VicRoads: Kew, Victoria).

Keall MD and Frith WJ (2004). Older drivers crash rates in relation to type and quantity of travel. *Traffic Injury Prevention, 5*, 26-36.

Steer Davies Gleave (2002). *Melbourne On-Road Exposure Survey 2001: MORES-01: Report 6– Project summary report.* (VicRoads: Kew, Victoria).