

Road Safety Research Report 109

Collisions Involving Older Drivers: An In-depth Study

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EXECUTIVE SUMMARY

It is forecast (Department for Transport, 2007) that, by 2011, there will be approximately 12.2 million people in the UK over state pension age, many of whom will be continuing to drive for many years after retirement.

A sample of over 2,000 reported crashes involving drivers aged over 60 was considered, from three midland UK police forces for the years 1994–2005 inclusive. Each case was summarised on a database, including the main objective features (such as time and place), a summary narrative, a sketch plan and a list of explanatory factors. The summary narrative, in particular, included judgements by the researchers that emphasised the sequence of events leading up to the crash.

The main findings were as follows:

- Drivers aged under 70 years appeared to be no more likely to have caused any given crash than to have been the victim of another driver's carelessness. However, blameworthiness increased with driver age; drivers aged 85 years or more appeared to be over four times as likely to have caused a crash than they were to have been innocently involved.
- The most frequent class of crash caused by drivers aged over 60 years was right of way crashes; approximately 45% of the crashes where the older driver was to blame involved violation of another driver's right of way.
- The most frequent failures observed involved visual search errors when turning right onto a more major road.
- Older drivers also succumbed to illness and fatigue in a significant minority of cases. Cognitive failures also led them to be involved in a minority of cases of 'unintended acceleration'.

1 INTRODUCTION

According to the Department for Transport (2007), the number of people over state pension age is projected to increase by 11.9% from 10.9 million in 2002 to 12.2 million in 2011, and is expected to continue rising.

Previous UK research (Holland, 2001) has found that ‘. . . there is an increasing population of older people and a disproportionate increase in the numbers of older people who drive and expect to continue driving. Their mileage is also expected to increase over the next few decades, and importantly, the change is substantial enough to have a big impact on the age and sex base of the driving population in the UK. In addition, both the driving styles and the types of crashes older people have differ from those of younger and middle-aged people.’

The increase in older-driver numbers and increased driving exposure are an international issue, and have led to expectations of an increase in future road crash frequency. In a review by Langford and Koppel (2006) it was predicted that, by 2025, older-driver fatalities in the US (Hu *et al.*, 2000) and Australia (Fildes *et al.*, 2001) will broadly triple, relative to 1995 levels. However, a review of European research on older drivers by Hakamies-Blomqvist and Peters (2000) quoted Maycock (1997), who estimated that ‘half of the increased fatality risk of drivers aged 75 years or more, compared to drivers aged 30 years, might be due to the enhanced susceptibility of the older drivers to be killed in the crashes in which they are involved, rather than to their higher crash rates’. Tefft (2008) carried out research in the US on fatal crash data, using national survey data to derive various exposure measures. Older drivers were found to have a higher risk of being involved in, and responsible for, crashes in which they themselves die; they also posed more risk to other road users than middle-aged driver groups. However, the degree to which older drivers’ risk to other road users was elevated depended strongly upon whether risk was measured on a per driver, per trip, or per mile basis. Once exposure by mileage was accounted for, for example, a randomly-selected driver aged 85 or older was about 720% more likely than a randomly selected driver aged 30 to 39 to die in a crash, but only about 0.8% more likely to be responsible for a crash fatal to an occupant of another vehicle or a non-motorist, over the course of a year. Tefft concluded that ‘the public health impact of older drivers on other road users presently is relatively small’.

A study using Poisson regression models by Tay (2008) found that increasing the numbers of licensed older drivers had an insignificant effect on fatal crashes, but a strongly and positively correlated link with the number of **injury** crashes; Tay theorised that older drivers’ tendency to compensate for their reduced driving abilities by driving at a slower speed, minimising their exposure at night, wearing a seat belt, not drinking and driving, driving in familiar environment, etc., would reduce the severity of their crashes and explain this finding.

Langford *et al.* (2006) have argued that, when the crash rates of drivers of different ages are compared after being matched for yearly driving distance, most drivers aged 75 years and above are safer than all other drivers. This occurs because of the 'low mileage bias', whereby, independent of age, drivers travelling more kilometres will typically have lower crash rates per kilometre than those driving fewer kilometres. Only older drivers in their survey who drove less than 3,000 km per year (roughly 10% of the sample) showed evidence of increased crash risk. The 'low mileage bias' was also revealed in the work of Alvarez and Fierro (2008), who found that, 'as a group, older drivers are as safe as or safer than other age groups, and only low mileage older drivers have a high crash rate'. Alvarez and Fierro also found that those driving on a 'restricted' licence on medical grounds did not appear to have an elevated crash risk. Langford *et al.* (2006) believed that one explanation for these findings was that lower mileage drivers were more likely to be using local urban roads with more 'conflict points', such as intersections.

Older drivers, it was suggested by Hakamies-Blomqvist and Peters (2000), have specific problems with visual attention. Studies quoted in their review showed that a simulated driving task combined with a secondary task of visual analysis in experimental conditions found significant performance decrements in older drivers. Another study quoted in the review on 'merging decisions' at intersections found no age differences in accuracy, but the elderly needed about 50% more time to decide whether to merge in a given traffic situation. Rabbitt *et al.* (1996) compared driving instructors' observations of older-drivers' behaviour with the experiences of the older drivers in the study. The instructors found some skills to be intrinsically difficult for older people, such as vigilance, speed and distance judgements and co-ordination. The older drivers in question appeared to be unaware of these deficits, although Rabbitt *et al.* (1996) believed that this finding may have resulted from a lack of feedback relating to the task.

Brouwer *et al.* (1991) found that older drivers were over-represented in crashes when turning at intersections, usually by failing to yield the correct right of way. Brouwer *et al.* suggested that divided attention could be a problem for older drivers; they 'misperceive or do not adequately react to other traffic . . . particularly in complex acts such as turns at intersections'. Research by Clarke *et al.* (2007) found that older drivers had fewer fatal crashes than younger drivers overall, but that they tended to be involved in fatal crashes resulting from observational and misjudgement errors, in particular in collisions arising from right of way violations (cf. Brouwer *et al.*, 1991). Another study (Clarke *et al.*, 2004) examining motorcycle crashes concluded that 'Looked But Did Not See' (LBDNS) errors appeared to affect older 'at fault' drivers more than younger ones; these appeared to be the result of both cognitive expectation failures in the internal 'schema' of drivers and the more global visual failures that can occur with age.

Langford and Koppel (2006) studied the epidemiology of older-driver crashes in Australia. Older-drivers' crash patterns revealed in this research also showed their

difficulties with intersection negotiation. Langford and Koppel found that 50% of older-driver crashes occurred at intersections, compared with 21% of crashes involving middle-aged drivers. There was a strong over-representation in crashes resulting from older drivers attempting to turn across oncoming vehicles. Langford and Koppel concur with analysis of the intersection problem from the Organization for Economic Co-operation and Development (OECD, 2001). This argued that older drivers at intersections may be operating under time pressures, with additional undue demands for divided attention and multiple processing, both of which might 'exceed their capacities' for the task.

Oxley *et al.* (2006) carried out a strategic crash analysis of over 400 older-driver crashes at specified 'black-spot' sites in Australia. They found that intersection crashes occurred when traffic volumes and speeds were high, where there were nearby upstream signals, where conspicuity of signals was poor, and when drivers had to negotiate wide multi-lane carriageways. Oxley *et al.* highlighted the problems that older drivers have 'in determining safe gaps and turning across oncoming traffic when there is no control or only partial-control of the turning phase, and when the complexity of the intersection and presence of other (fast-moving) traffic interferes with judgement'. They also found that crashes going straight on across a crossroads junction – crossing a road where other drivers have priority – were far more common than making a cross-flow turn against other drivers who had priority. Oxley *et al.* proposed that converting crossroads junctions to roundabouts would prove beneficial, as 'negotiating a roundabout is a fundamentally simpler and safer task than choosing a coincident gap in two streams of traffic'. Furthermore, Oxley *et al.* advocated more fully-controlled turning phases at traffic-light controlled intersections, and measures to increase and optimise sight-lines from all junctions, such as the removal of vegetation and roadside furniture.

Much other work has shown that older drivers are particularly at risk at intersections, for example Langford and Koppel (2006); OECD (2001); Boufous *et al.* (2008); Moore, *et al.* (1982); Viano *et al.* (1990); Verhaegen (1995); Bédard *et al.* (2002); and Skyving *et al.* (2009). Boufous *et al.* (2008), for example, linked police crash records and hospitalisation data from Australia. They found that 'intersection configuration, rurality [and] road speed limit . . . were significant independent predictors of injury severity in older people'. They also found that complex intersections with multiple lanes and branches were more likely to result in severe injuries, and that crashes occurring in rural, rather than metropolitan, areas increased injury severity in older drivers. Boufous *et al.* suggested that this might be due to rural drivers continuing to drive for more years than their urban counterparts, due to low population density and relatively less public transport in rural areas.

Reasons for this increased risk at intersections centre on the fact that older drivers suffer various cognitive and perceptual declines that may compromise their ability to perform gap acceptance tasks at these locations. Specific areas of decline include the following:

1. Problems with divided attention – Hakamies *et al.* (2004), in a review for the Swedish National Road and Transport Research Institute, found that the intersection negotiation task requires the division of attention between many sub-tasks, and that older drivers have more difficulty in filtering out irrelevant stimuli under these conditions.
2. Visual search problems – Maltz and Shinar (1999), in a two-part eye movement study involving younger and older drivers, found that older drivers had longer search episodes than younger drivers, and that their visual search patterns were characterised by more fixations and shorter saccades. Older drivers also allocated a large percentage of their visual scan time to a small subset of areas in a test ‘driving image’; in contrast younger drivers were shown to scan these images more evenly. Additionally, Bao and Boyle (2009) found that, compared with younger and middle-aged groups, older drivers had a significantly smaller proportion of visual sampling to the left and right during rural intersection negotiation. Bao and Boyle also found that older drivers had significantly fewer glances toward the turning direction, i.e. they risked failing to see things that were directly in front of them at the intersection as they turned.
3. Narrowing of older drivers’ useful field of view and poor contrast sensitivity – Horswill *et al.* (2008) used a video-based hazard perception test and an assessment battery on a sample of drivers aged over 65 years. They found that hazard perception response times increased significantly with age, but that this age-related increase could be accounted for by measures of contrast sensitivity and useful field of view. Both these factors make traffic conflicts harder to detect, which in turn impacts on older drivers’ crash risk.
4. Poor judgement of vehicle approach speed – Hancock and Manser (1997) conducted two ‘time to contact’ experiments, and found that older drivers can be poor at judging the approach speed of a visually simulated target vehicle. Furthermore, Spek *et al.* (2006), using a statistical modelling approach, found that drivers who needed to cross a stream of traffic tended to accept smaller time gaps as the traffic approach speed increases. Spek *et al.* reported that this effect appeared to be stronger for older drivers than for younger drivers, suggesting that the older driver is more prone to collide with a speeding vehicle. Lobjois and Cavallo (2009) found that these difficulties in older adults also extend to their time judgements when crossing the road as pedestrians.
5. Slow post-turn decision manoeuvring – the review by Hakamies-Blomqvist *et al.* (2004) showed that, even when older drivers were assisted by collision warning systems designed for intersections (in a simulated driving task), they sometimes tended to take more time to accelerate and complete their manoeuvre, leading to more near misses. Another simulator study by Yan *et al.* (2007) found that older drivers tended to select larger gaps to make turns, turn the steering wheel more slowly, and keep a further clearance distance from the vehicle ahead after the turn.

Åberg and Rimmö (1998), in their update of work by Reason *et al.* (1990), found that inattention errors increased with age; they reported that increased scores on this factor possibly resulted from the ‘automatization of driver behaviour’ that occurs with increased driver age and experience. Parker *et al.* (2000), using a questionnaire approach, similarly found that crash involvement in drivers aged over 50 years was associated with higher levels of errors and lapses of attention; this was in contrast to young drivers who had shown higher levels of driving violations in previous work by the same author.

Fatalities involving older females in particular, using US data, were examined by Baker *et al.* (2003), who found that ‘senior women are primarily overrepresented in crashes that occur under the “safest” conditions, in daylight, when traffic is low (not at rush hour), when the weather is good, and when the roads are dry’. Although the authors point out that elderly drivers may perform most of their driving under such conditions, they point out that ‘interventions to encourage self-adjusting their exposure to unsafe conditions are not likely to be sufficient to protect this driver population’. They also noted that fatal crashes in this driver group are more likely at intersections in built-up areas. Similarly, older drivers have been shown to be overrepresented in junction crashes in many other studies over the last two decades (as outlined in the multiple studies described and summarised above). With an ageing population which has greater susceptibility from side impacts (e.g. Viano *et al.*, 1990), and reports of an increased risk of fatality from side impacts as opposed to frontal impacts (e.g. Bédard *et al.*, 2002), it seems likely that the human and financial cost of this type of crash will increase with time.

2 METHOD

Our method largely relies on the human interpretation of road crash case reports. Furthermore, the construction of interpretations, typologies and models has not been driven by theory in the main, but generated primarily from the data themselves, although theoretical models are acknowledged. The most attention is given to the full sequential nature of the crash story in each individual case, which is where the technique of qualitative human judgement methodology proves more useful than more traditional statistical methods applied to aggregated data.

The first step was to draw a heterogeneous sample of police road crash files involving drivers aged 60 years and over. The files were found to contain varying amounts of information depending on the circumstances of the crash and any subsequent legal proceedings, and were assigned 'A' or 'B' class according to the quality and depth of information contained within them. Each file contained a report sheet/card, which is a summary of information about the crash, such as date, time, location, weather conditions, junction type and many other items. The sheet also includes a brief crash story as interpreted by the attending police officer. This is constructed by the officer a short time after the crash by reference to his or her pocket book. It contains the actions and, in some cases, the reported intentions and behaviours of drivers and witnesses.

In addition to the report sheet/card, 'A' class case files contained a range of further items, which help to fill out the often complex circumstances of the crash. These may include maps, photographs, statements of vehicle examiners and, perhaps most importantly, interview and witness statements, which are rich in information. The interpretation consists of the reconstruction of an entire crash story from the information available in the police file.

2.1 The crash database

The data were entered into a FileMaker Pro database customised to handle the information and search parameters required for this project. Figure 2.1 shows the standard data entry layout.

Data are entered describing the relatively objective facts of each case: time of day, speed limit, class of road, etc. The database includes some fields configured as check boxes or 'radio buttons'; these provide quick access to selected cases during further analysis. Summary fields are also used to calculate things such as the mean age of involved drivers. Any combination of fields in the database can be used to search for cases matching a variety of criteria. A variety of layouts are also used to present and analyse the data, in addition to the data entry layout above.

Figure 2.1(a) and (b): A standard data entry sheet on the database

RECORD NUMBER	351306		Grade of info.	<input checked="" type="radio"/> A <input type="radio"/> B		Severity	Slight	
Driver 1 Age	62	<input checked="" type="radio"/> M <input type="radio"/> F	Driver 2 Age	22	<input type="radio"/> M <input checked="" type="radio"/> F	Driver 3 Age		<input type="radio"/> M <input type="radio"/> F
Injuries to driver?	none		Injuries to driver?	whiplash and bruising to left arm		Injuries to driver?		
Charges?	DWDC (driver)		Charges?			Charges?		
Council Ward Code	NG17 4LW		Council Ward Code	NG19 7EE		Council Ward Code		
Primary blame	Driver 1		Primary blame			Primary blame		
Date	22/12/05		Date			Date		
Day	Thursday		Day			Day		
Time 24hrs	18:30		Time 24hrs			Time 24hrs		
Road Type	A class		Road Type			Road Type		
Speed Limit	40		Speed Limit			Speed Limit		
Area	<input type="radio"/> Rural <input checked="" type="radio"/> Urban		Area			Area		
Road Features	<input type="checkbox"/> T Junction <input checked="" type="checkbox"/> Crossroads <input checked="" type="checkbox"/> Traffic Lights <input type="checkbox"/> L/H Bend <input type="checkbox"/> R/H Bend <input type="checkbox"/> Roundabout <input type="checkbox"/> Dual carriageway		Road Features	<input type="checkbox"/> Hillcrest <input type="checkbox"/> Dip <input type="checkbox"/> Sliproad <input type="checkbox"/> Other...		Road Features		
Lighting	Darkness, street lamps lit		Lighting			Lighting		
Weather	Fine		Weather			Weather		
Road Conditions	Dry		Road Conditions			Road Conditions		
Type of Vehicle	Private car		Type of Vehicle	Private car		Type of Vehicle		
Vehicle Owner	Own vehicle		Vehicle Owner	Own vehicle		Vehicle Owner		
Further details (make, model etc.)	Vauxhall Vectra		Further details (make, model etc.)	Peugeot 306		Further details (make, model etc.)		
Seatbelt(s) in use?	<input checked="" type="radio"/> yes <input type="radio"/> no <input type="radio"/> ulk <input type="radio"/> n/a		Seatbelt(s) in use?	<input checked="" type="radio"/> yes <input type="radio"/> no <input type="radio"/> ulk <input type="radio"/> n/a		Seatbelt(s) in use?	<input type="radio"/> yes <input type="radio"/> no <input type="radio"/> ulk <input type="radio"/> n/a	
Airbag(s) deployed	<input type="radio"/> yes <input type="radio"/> no <input checked="" type="radio"/> ulk <input type="radio"/> n/a		Airbag(s) deployed	<input type="radio"/> yes <input type="radio"/> no <input checked="" type="radio"/> ulk <input type="radio"/> n/a		Airbag(s) deployed	<input type="radio"/> yes <input type="radio"/> no <input type="radio"/> ulk <input type="radio"/> n/a	
Reg year number 1	2003		Reg year number 1	1995		Reg year number 1		
Reg year prefix 1			Reg year prefix 1			Reg year prefix 1		
Reg year suffix 1			Reg year suffix 1			Reg year suffix 1		
Test Pass Date	N/A		Test Pass Date	N/A		Test Pass Date	N/A	
Licence Type	Full		Licence Type	Full		Licence Type	Full	
Drivers Familiar?	no		Drivers Familiar?	yes		Drivers Familiar?		
Passengers?	Relative		Passengers?			Passengers?		
Passenger 1 age	u/k		Passenger 1 age			Passenger 1 age		
Passenger 1 sex	<input type="radio"/> M <input checked="" type="radio"/> F		Passenger 1 sex	<input type="radio"/> M <input type="radio"/> F		Passenger 1 sex	<input type="radio"/> M <input type="radio"/> F	
Passenger 2 age	u/k		Passenger 2 age			Passenger 2 age		
Passenger 2 sex	<input checked="" type="radio"/> M <input type="radio"/> F		Passenger 2 sex	<input type="radio"/> M <input type="radio"/> F		Passenger 2 sex	<input type="radio"/> M <input type="radio"/> F	
Passenger 3 age	u/k		Passenger 3 age			Passenger 3 age		
Passenger 3 sex	<input type="radio"/> M <input checked="" type="radio"/> F		Passenger 3 sex	<input type="radio"/> M <input type="radio"/> F		Passenger 3 sex	<input type="radio"/> M <input type="radio"/> F	
Passenger 4 age			Passenger 4 age			Passenger 4 age		
Passenger 4 sex	<input type="radio"/> M <input type="radio"/> F		Passenger 4 sex	<input type="radio"/> M <input type="radio"/> F		Passenger 4 sex	<input type="radio"/> M <input type="radio"/> F	
Passengers injuries?			Passengers injuries?			Passengers injuries?		

(a)

A ‘prose account’ is also entered for each case, giving a step-by-step description of the crash. The causal story is always written from the viewpoint of the older driver, who is labelled as ‘Driver 1’, though much consideration is also given to other road users’ actions, intentions and blameworthiness. The prose accounts give a detailed summary of the available facts, including information from witnesses that appears to be sufficiently reliable. Discrepancies can occur between the interviews of drivers and the statements of independent witnesses, but these can usually be resolved by considering all statements together with various other reported facts. These can

Prose Account	<p>It was late in the afternoon on a fine day in winter. It had already got dark and streetlamps were lit. The driver (M,62) of a Vauxhall Vectra (1) was waiting at a traffic light controlled crossroads on an urban A road with a 40 mph limit. When the lights changed to green, he pulled off and turned right, even though he was travelling in a lane marked straight ahead only (he was apparently unaware of a right turn filter lane at the lights). He turned right straight into the path of an oncoming Peugeot 306, driven by (F,22) that was travelling straight on across the junction from the opposite direction on a green light. The two cars collided in the centre of</p>	Junction problem type <input type="checkbox"/> Divided attention/irrelevant Stimuli <input type="checkbox"/> Visual Search Problems <input type="checkbox"/> Contrast Sensitivity <input type="checkbox"/> Poor judgement of approach speed <input type="checkbox"/> Slow post-turn manoeuvring <input type="checkbox"/> Other <input type="checkbox"/> Unknown/not possible to classify
Map		
Minimum Set of Explanations	<p>Driver 1: A1 Driver unaware of need to give way B1 Wrong positioning</p>	
PF	<p>2 <input type="checkbox"/> CF1 <input type="checkbox"/> 9A <input type="checkbox"/> CF2 <input type="checkbox"/> 16A <input type="checkbox"/> CF3 <input type="checkbox"/> CF4 <input type="checkbox"/></p>	
Alc. Level	<p>N/A <input type="checkbox"/></p>	
Avoiding Action Attempted	<p>none <input type="checkbox"/></p>	
Violation / Error type	Turns	Shunts
	<p>ROWY <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p>	<p>PIT <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p>
Comments / Quotes / Special Factors	<p>Driver 1: "I saw the lights go green so I thought I could go... it was my fault I was in the left lane, I didn't know there was a right turn filter lane."</p>	
Bend Errors	<input type="checkbox"/>	Shunt errors <input type="checkbox"/>

(b)

include the measurement of skid marks by the police, vehicle damage reports, etc. Figure 2.1(b), it should be noted, only shows part of a typical prose account because the text is held in an expandable field in the database.

Next, a sketch plan of each crash is made from sources in the file. The orientations of the sketch plan and the icons contained in it are standardised for speed of entry and to allow direct comparisons between example or prototype cases.

A minimum set of possible explanations for each crash is recorded from a standard checklist adapted and developed in a series of previous studies (Clarke *et al.*, 1998; 2002; 2004). The list has subsections for the road environment, vehicle and driver characteristics, and specific driver actions. The emphasis throughout is on giving the finest grain description possible of each crash, not for use as a formal coding scheme, but rather to provide search and selection aids to identify homogeneous groups of cases for further qualitative analysis. In addition, we entered data for a version of a national 'contributory factors in crashes' form originally developed at the Transport Research Laboratory (TRL) which involves the identification of one major precipitating factor (PF) from a possible list of 15, and a further coding of up to four contributory factors (CFs), together with a confidence rating in the CFs identified. Finally, entries are made in additional fields for comments and quotes from involved drivers and others.

The ultimate aim of entering facts and figures, prose accounts, standardised graphics and explanatory factors in the database was to build a library of analysed cases stored as a series of case studies. In this sense, the database is used to find groups and recurring patterns in cases, after each case has been analysed individually, rather than being considered as 'raw' data awaiting analysis. In this way it was possible to find patterns, sequences and processes within each group of crashes. Statistical examinations were not the primary focus of the study, but simple statistics were used to characterise the sample.

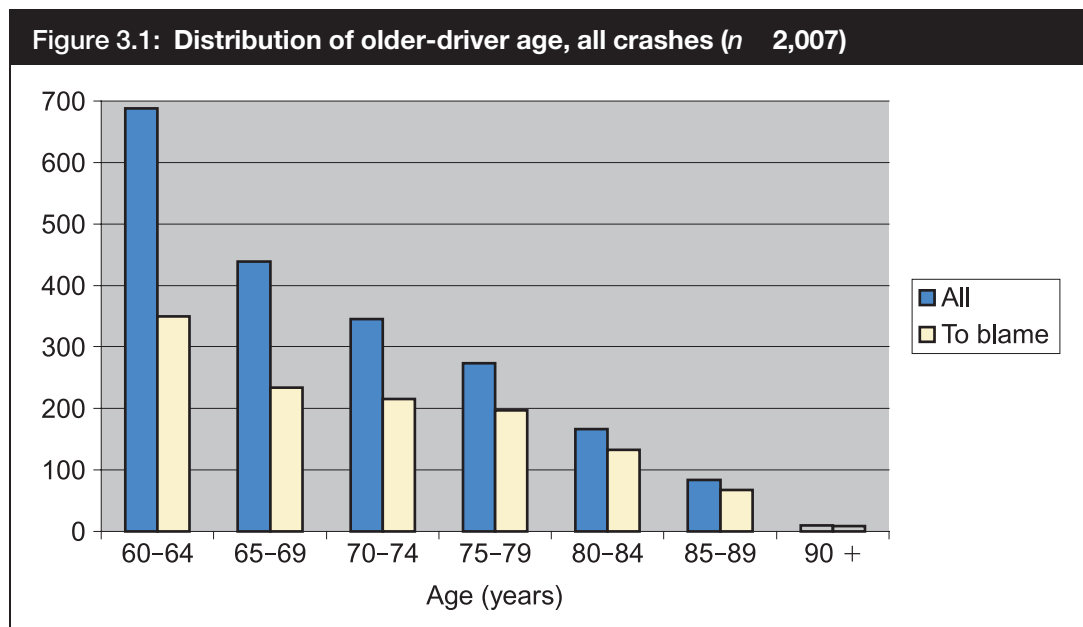
3 RESULTS

3.1 General overview/summary

In total, 2,007 cases involving a driver aged 60 or over were entered into the database. Of these, 1,206 (60%) involved an older driver who was at least partly to blame for the crash. Approximately two-thirds of the total cases were rated as ‘A’ class, i.e. containing sufficient evidence to build up a good picture of crash causation and processes. Older male drivers at fault in a crash outnumbered older female at-fault drivers by a ratio of over two to one.

3.2 Driver age

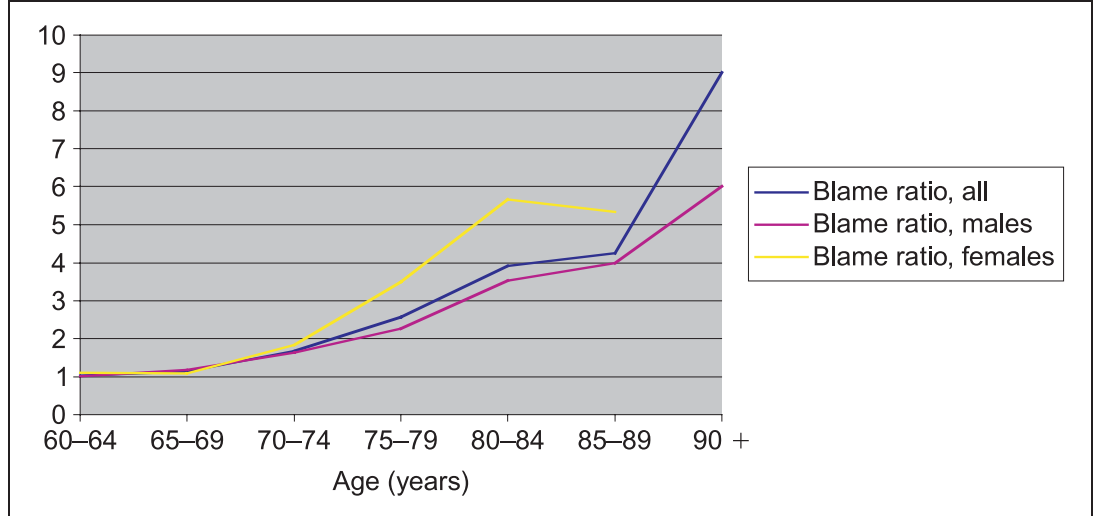
Figure 3.1 shows the distribution of driver ages, in five-year bands, for all drivers in the sample, and for only those drivers considered to have been blameworthy.



3.3 Blameworthiness ratios

All cases were assessed by coders as to the blameworthiness of any participants in the incident. Drivers could be rated as either ‘to blame’, ‘at least partly to blame’ or ‘not to blame’ in any given crash, and there were also codings for unforeseen mechanical failure and miscellaneous others. Comparisons using non-blameworthy drivers can be used as a quasi-induced exposure measure; such measures have been found to be effective in recent research, for example Chandraratna and Stamatiadis (2009). Figure 3.2 shows the pattern of blameworthiness ratios across drivers in each age band, i.e. the number of crashes where the driver was rated as at least partly or fully to blame, divided by the number of crashes caused by all other factors, most usually another road user/driver.

Figure 3.2: Pattern of blameworthiness ratios by driver age and gender



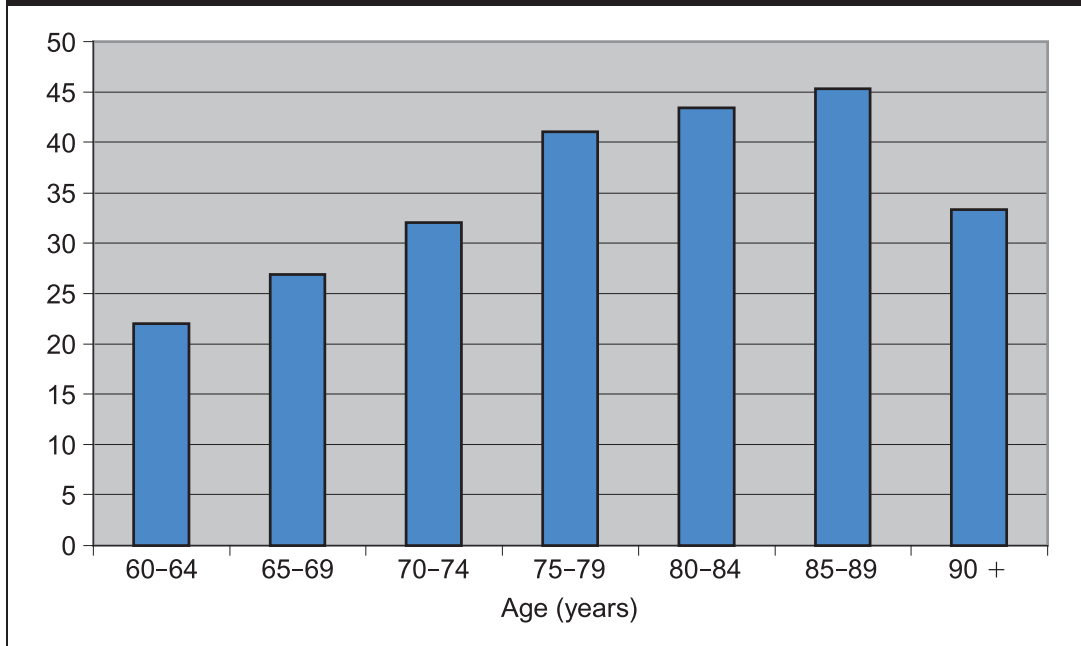
It can be seen that drivers in the first two age-bands (60–64 years and 65–69 years) appeared no more likely to have caused a crash than they were to have been innocently involved in such a crash. However, by the second to last age-band (85–89 years), older drivers as a whole appeared to be over four times as likely to have caused a crash than they were to have been innocently involved. In addition, female older drivers seemed to show an increased blameworthiness ratio somewhat in advance of older males, peaking at over five times more likely to have caused a crash, in the 80–84-year-old age band. It should be noted, however, that results in the last age-group (90+ years) should be treated with caution as there were only a very small number of drivers in this group, and no female drivers at all.

3.4 Severity of older-driver crashes

Figure 3.3 shows the proportion of blameworthy older-driver crashes that resulted in death or serious injury (killed or seriously injured (KSI) rates).

Figure 3.3 shows that the proportion of KSI outcomes rose with age, approximately doubling between the first age-band (60–64 years) and the penultimate age-band (85–89 years). Although the proportion dropped for drivers aged over 90 years, the small number of cases in this group made this finding unreliable. Nearly 16% of killed or seriously injured older drivers were not wearing seat belts. In comparison, Christmas *et al.* (2008) noted that wearing rates tended to be highest for drivers and passengers aged 60 or over, and estimated that only 2–5% of drivers and front-seat passengers (aged 60+ years) did not use seat belts in 2007.

Figure 3.3: Proportion of older-driver KSI crashes by age band

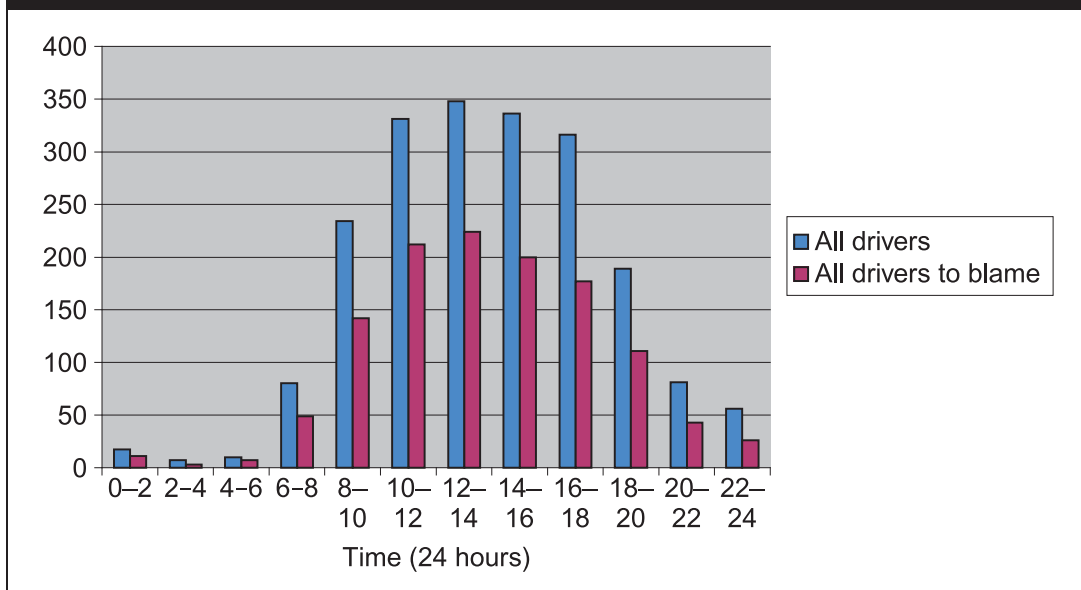


3.5 Time of day and older-driver crashes

Figure 3.4 shows the distribution of all crashes and blameworthy crashes in 12 two-hour time bands covering the 24-hour period.

Figure 3.4 shows that older-driver collisions as a whole appeared most common between midday and two in the afternoon, but were high throughout the six-hour period from ten o'clock in the morning to four o'clock in the afternoon. When blame ratios by time period were examined, older drivers were found to have caused

Figure 3.4: Older-driver crashes by time of day

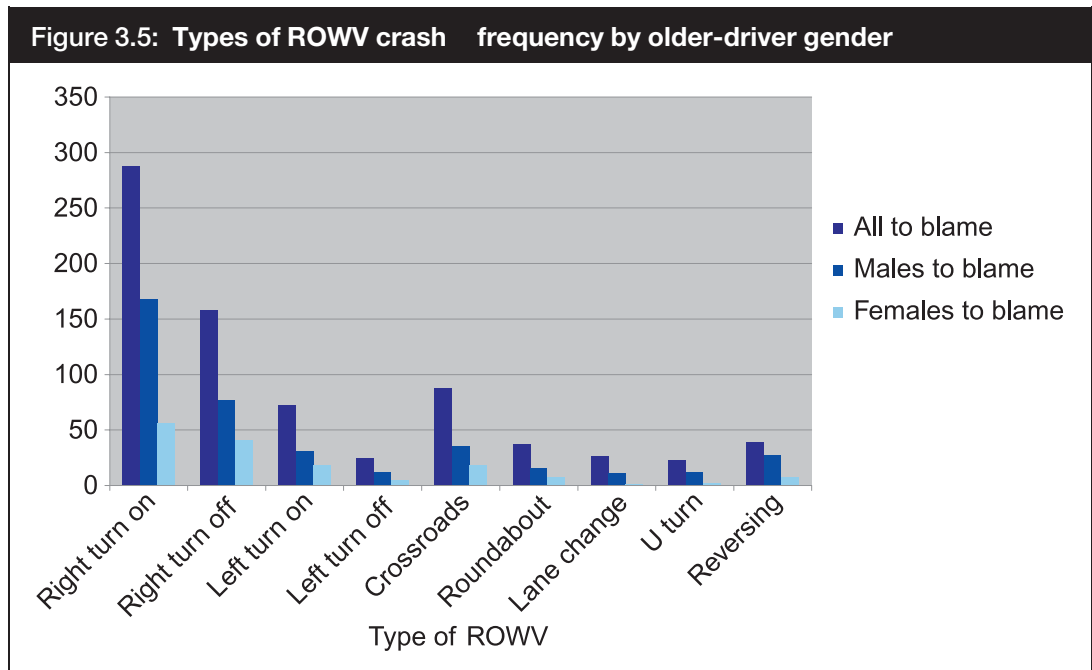


the highest proportion of crashes that they become involved in between the hours of ten o'clock in the morning and two in the afternoon.

When lighting conditions were considered separately from hour of day, it was found that over 80% of blameworthy older-driver crashes occurred in daylight. There was also no evidence that the proportion of blameworthy crashes that occurred during the hours of darkness increased with age.

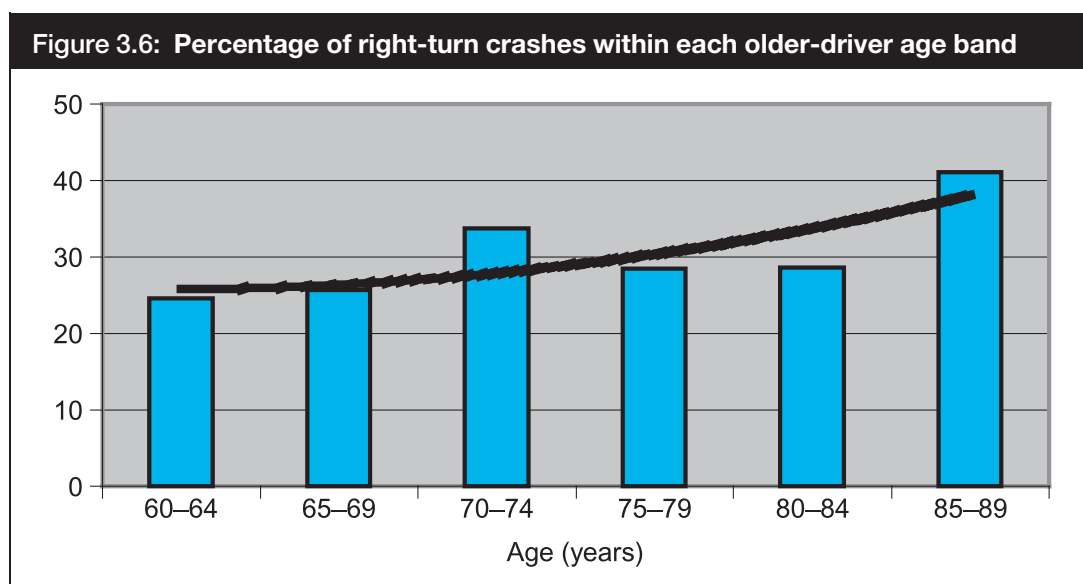
3.6 Right of way violation crashes

Older drivers seemed to have a large number of right of way violation (ROWV) crashes. Over 38% of the sample as a whole consisted of such crashes, and approximately 45% of all crashes where the older driver was considered at least partly to blame were ROWV collisions. Figure 3.5 shows the distribution of differing types of ROWV collision for all older drivers to blame, and male and female older drivers considered separately.



Taken as a whole, ROWV crashes showed a high level of older-driver blameworthiness; the average blameworthiness figure for all classes of ROWV in Figure 3.5 was 2.84. There was only one class of ROWV crash where the older driver appeared to be more likely to have been a victim of another driver’s mistake, and this was in lane-changing collisions. The highest blameworthiness ratio was found in reversing crashes, where the older driver appeared over eight and a half times more likely to have caused a reversing crash than to have become the innocent victim of one.

Figure 3.5 shows that the largest categories of ROWV crash occurred where an older driver was performing right turns on and right turns off a road, and violated another driver's right of way while doing so. These two types of manoeuvre accounted for approximately 64% of all ROWV crashes where the older driver was considered to blame. Overall, 65% of right-turn crashes involved vehicles turning onto a road and 35% involved vehicles turning off a road. This perhaps results from the fact that a driver turning onto a carriageway would typically have to check in two directions (left and right), whereas a driver turning off a carriageway would only have to check ahead. Figure 3.6 shows the percentage of these right-turning crashes within each age-band (the final age-band, 90+ years, has been excluded as there are very few cases in this band). A second order polynomial trend line has been overlaid to illustrate the slight rise in the proportion of this type of crash with increased driver age.



3.6.1 How do older drivers cause right-turn collisions?

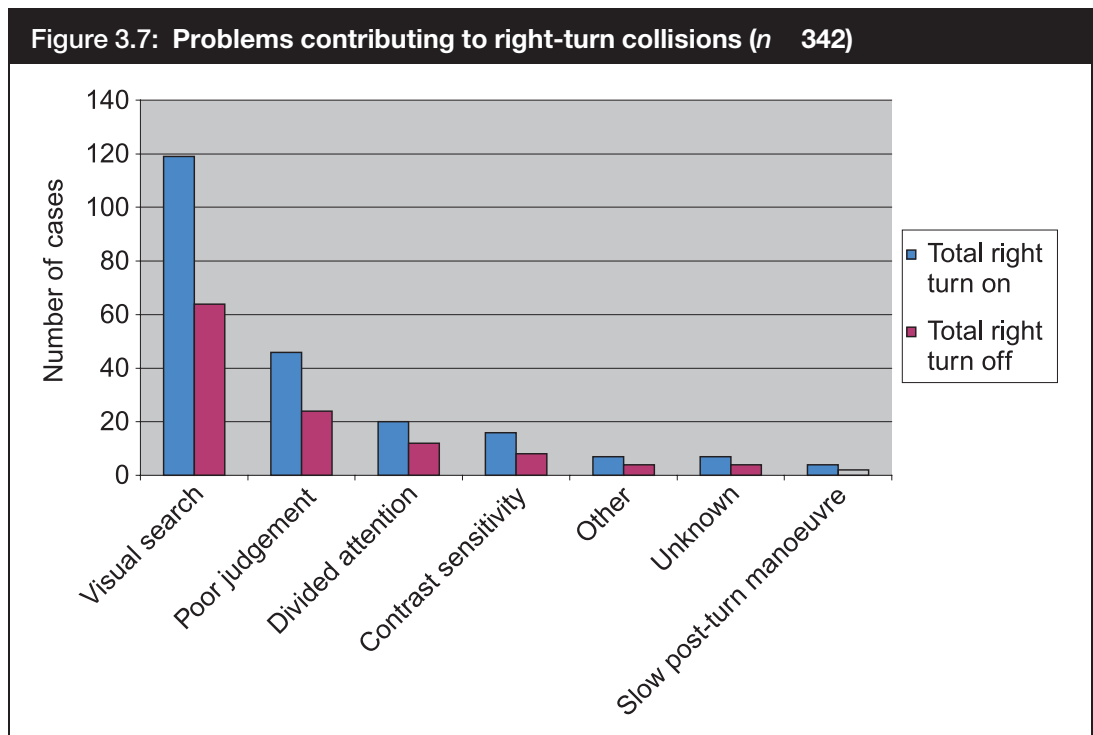
All right-turn crashes were assessed for evidence of the primary fault categories that would be predicted by prior research. In summary, these were as follows:

1. Problems with divided attention (after Hakamies-Blomqvist *et al.*, 2004) – evidence of difficulty in filtering out irrelevant stimuli; and distracted by the ‘wrong’ vehicle, pedestrians, etc.
2. Visual search problems (after Maltz and Shinar, 1999; Bao and Boyle, 2009) – evidence suggesting smaller proportion of visual sampling to the left and right during intersection negotiation; looking in wrong direction; failure to re-check in correct direction, etc.
3. Poor contrast sensitivity (after Horswill *et al.*, 2008) – evidence of traffic conflicts having been hard to detect; low light levels; low sun; mist, spray, or rain, etc.

4. Poor judgement of vehicle approach speed (after Hancock and Manser, 1997; Spek *et al.*, 2006) – evidence of poor approach speed judgement; acceptance of inadequate time gaps.
5. Slow post-turn decision manoeuvring (after Hakamies-Blomqvist *et al.*, 2004; Yan *et al.*, 2007) – evidence of more time taken to accelerate and complete the manoeuvre.

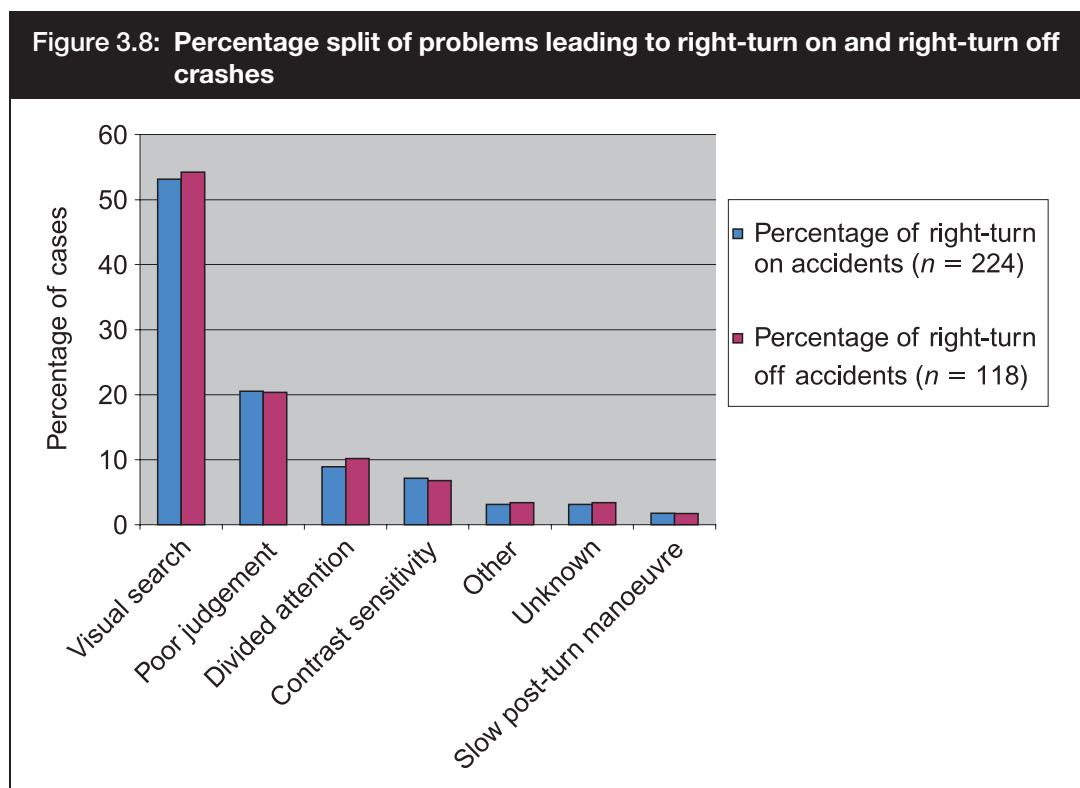
The assignment of right-turn cases into these fault categories was carried out by two separate researchers, using a training/pilot group of cases initially. The level of inter-rater agreement was found to be more than 95% over all cases where a rating could be made.

Just under three-quarters of all right-turn crashes were attributed to either visual search problems or poor judgement of approach speed (see Figure 3.7). Visual search problems were clearly the main cause of all right-turn collisions as these problems were a factor in over half (53.5%, $n = 342$) of these collisions. Visual search problems included failing to see a vehicle when the approaching vehicle was clearly in view and failing to allow for restricted views when, for example, emerging from a junction through a gap in stationary traffic. Poor judgement of approach speed accounted for a further 20.5% ($n = 342$) of collisions and accounted for drivers turning across the path of oncoming vehicles when they wrongly believed that they had time to make the turn before the approaching vehicle reached them.



Although there were almost twice as many right-turn on crashes as there were right-turn off crashes, a closer examination of the crashes failed to show any significant differences between the problems encountered by drivers that were the

main cause of the collisions, as Figure 3.8 shows. There was, in fact, hardly any difference in the proportion of crashes attributed to each problem between the two groups.



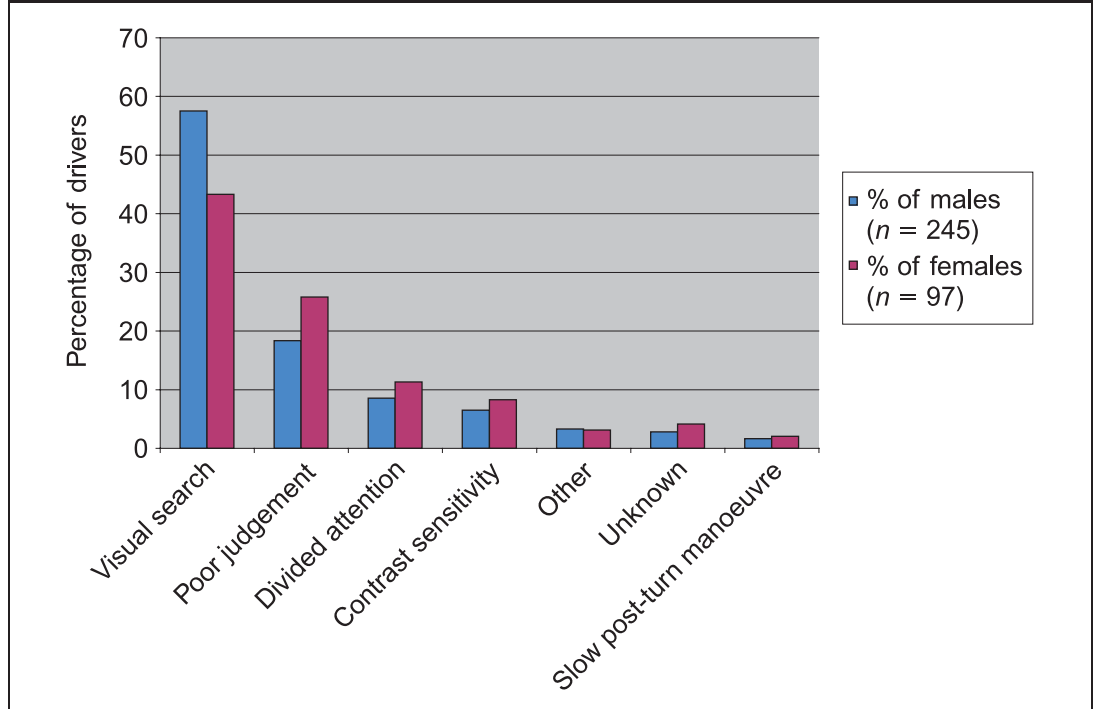
Splitting the drivers into age groups also failed to show any significant differences and it was concluded that a driver's age did not have a major influence on the type of problems that they are likely to experience in right-turn collisions.

In almost three-quarters (71.6%) of right-turn crashes a male older driver was to blame and 28% were female ($n = 342$). An examination of all crashes where Driver 1 was to blame failed to show any statistical significance between the genders in right-turn crashes.

Considering the problems experienced by male and female drivers separately did show that there was a greater proportion of male drivers (57.6%, $n = 245$) involved in right-turn crashes caused by visual search problems than female drivers (43.3%, $n = 97$), and a greater proportion of female drivers (25.8%, $n = 97$) involved in right-turn crashes caused by poor judgement of approach speed than male drivers (18.4%, $n = 245$). However, neither of these differences was found to be statistically significant. The differences are illustrated in Figure 3.9.

The vast majority of right-turn crashes also occurred during daylight hours (80.1%, $n = 342$). This is almost the same proportion of crashes that occurred in daylight across all crash types where Driver 1 was to blame (81.6%, $n = 1,206$), so it can be concluded that night-time visibility problems are not specific to right of way crashes.

Figure 3.9: Problems leading to right-turn collisions involving male and female drivers



3.6.2 Who hits right-turning older drivers?

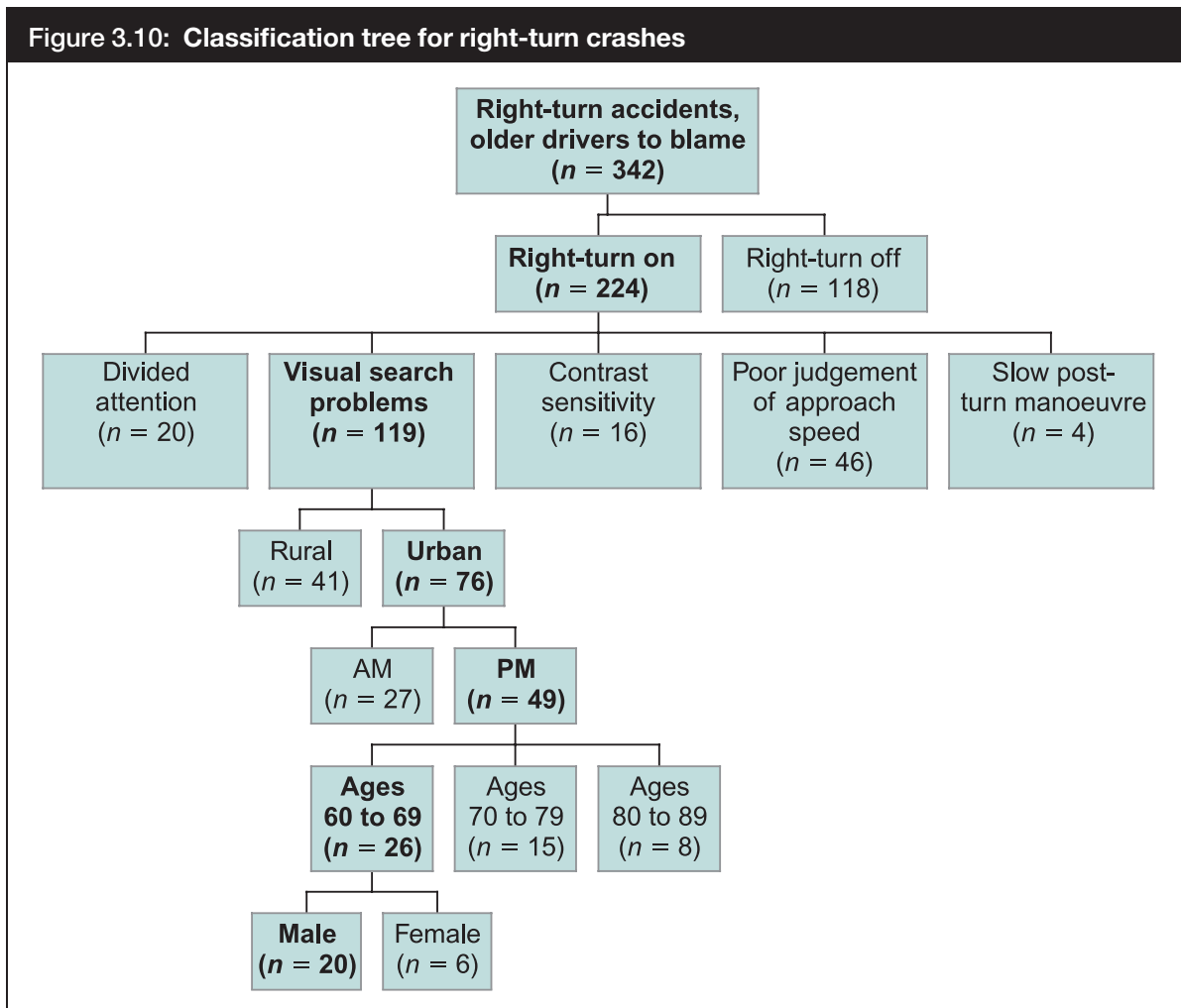
Although individual cases were assessed for purposes of primary blameworthiness (see Section 3.3), there remained the possibility that other drivers' behaviour in right-turning crashes had contributed in a secondary manner to older-driver ROWV crashes.

A measure of the difference in driver age was derived in each case, i.e. how much of an age difference there was, per case, between the older driver and the driver who had crashed into them. It was found that the mean age of the colliding driver was significantly **lower** in right-turning crashes than in all other types of older-driver crash contained in the sample (unpaired $t = 4.98$, $p < 0.0001$). There was, however, no significant difference observed in the numbers of male/female colliding drivers in older-driver right-turning crashes.

Motorcyclists were also significantly more likely to be the colliding party in older-driver right-turn crashes (relative to their numbers as colliders in all other crashes; $p < 0.0001$, Fisher's test). Colliding motorcyclists in right-turn crashes were also significantly younger than other colliding drivers in right-turn crashes ($p < 0.003$).

3.6.3 A classification tree and prototype right-turn crash

Figure 3.10 shows a classification tree of right-turn collisions, the most prototypical 'path' being shown in bold.



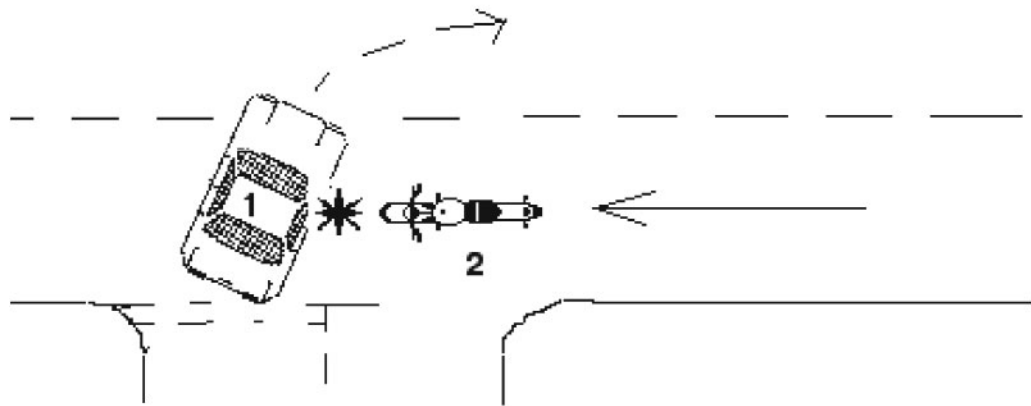
Using the tree in Figure 3.10, the example prototype in Figure 3.11 shows the most typical right-turn collision caused by an older driver.

Figure 3.11: Example prototype of the most typical right-turn collision caused by an older driver

Story:

It was the middle of the afternoon on a fine day in summer. The driver (M,60) of a Honda Jazz (1) was waiting at a give way line to turn right onto an urban A road with a 30 mph limit. He looked right and left, but failed to see an approaching Kawasaki motorcycle (2) ridden by (M,48) that was approaching from the right. The car pulled out in front of the motorcyclist, who braked, but was unable to avoid a collision with it. The motorcyclist received minor injuries, and driver 1 admitted that the crash must have been his fault. He completed an NDIS [National Driver Improvement Scheme¹] course as an alternative to prosecution for driving without due care.

Diagram:

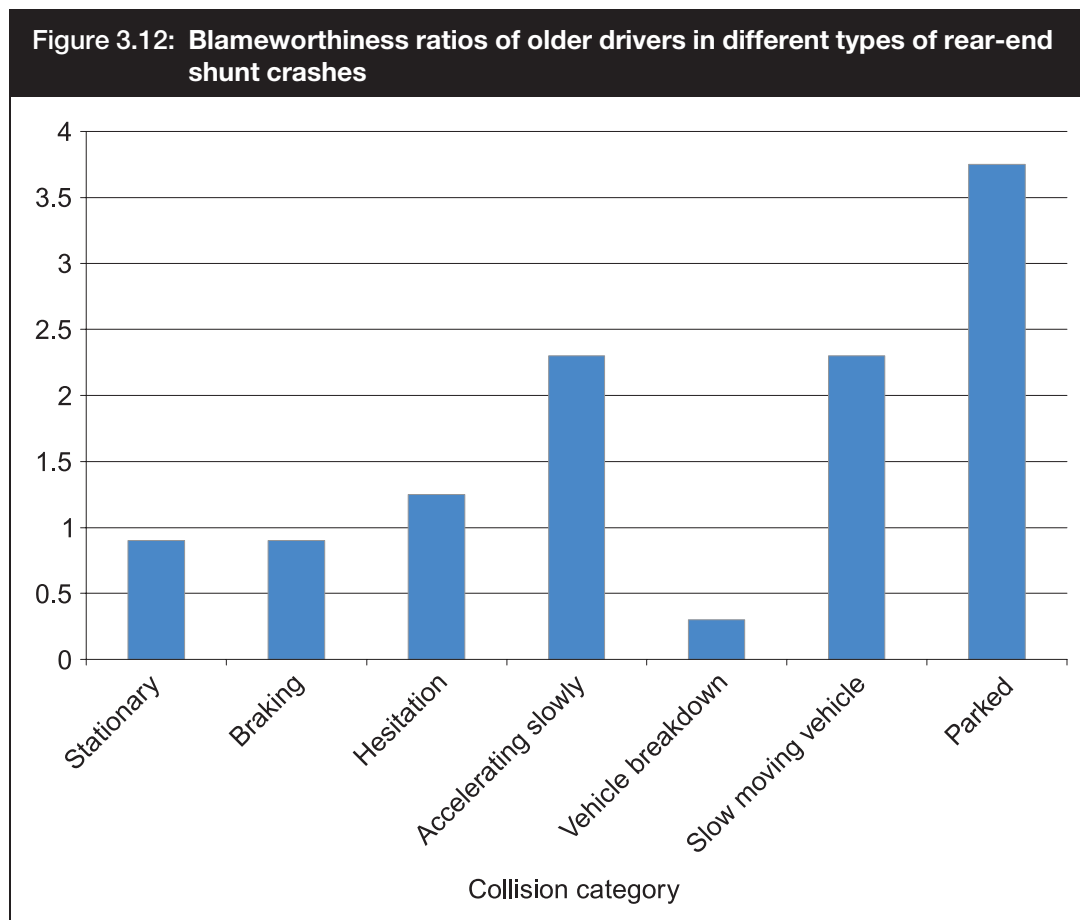


3.7 Rear-end shunt crashes

Rear-end shunt collisions were the second most common type of collision after ROWV in this sample; 18.7% of all crashes where the older driver was to blame were as a result of them running into another driver's vehicle ahead. The overall blame ratio, however, was very close to 1, i.e. older drivers seemed just as likely to have been hit from behind by another driver as they were to have run into the vehicle ahead. Blameworthy rear-end shunt crash older drivers were, on average, significantly **younger** than blameworthy older drivers in non-rear-end shunt crashes

¹ When a person is involved in a Road Traffic Incident and evidence is collated by the police which indicates that they have been 'Driving Without Due Care and Attention, or Driving Without Reasonable Consideration to Other Road Users' contrary to Section 3 of the Road Traffic Act 1988, then they may be given an option to attend a National Driver Improvement Course. This option is offered as an alternative to having the incident referred to the Crown Prosecution Service which will result in a Summons to attend court where they may receive a fine and penalty points on their driving licence.

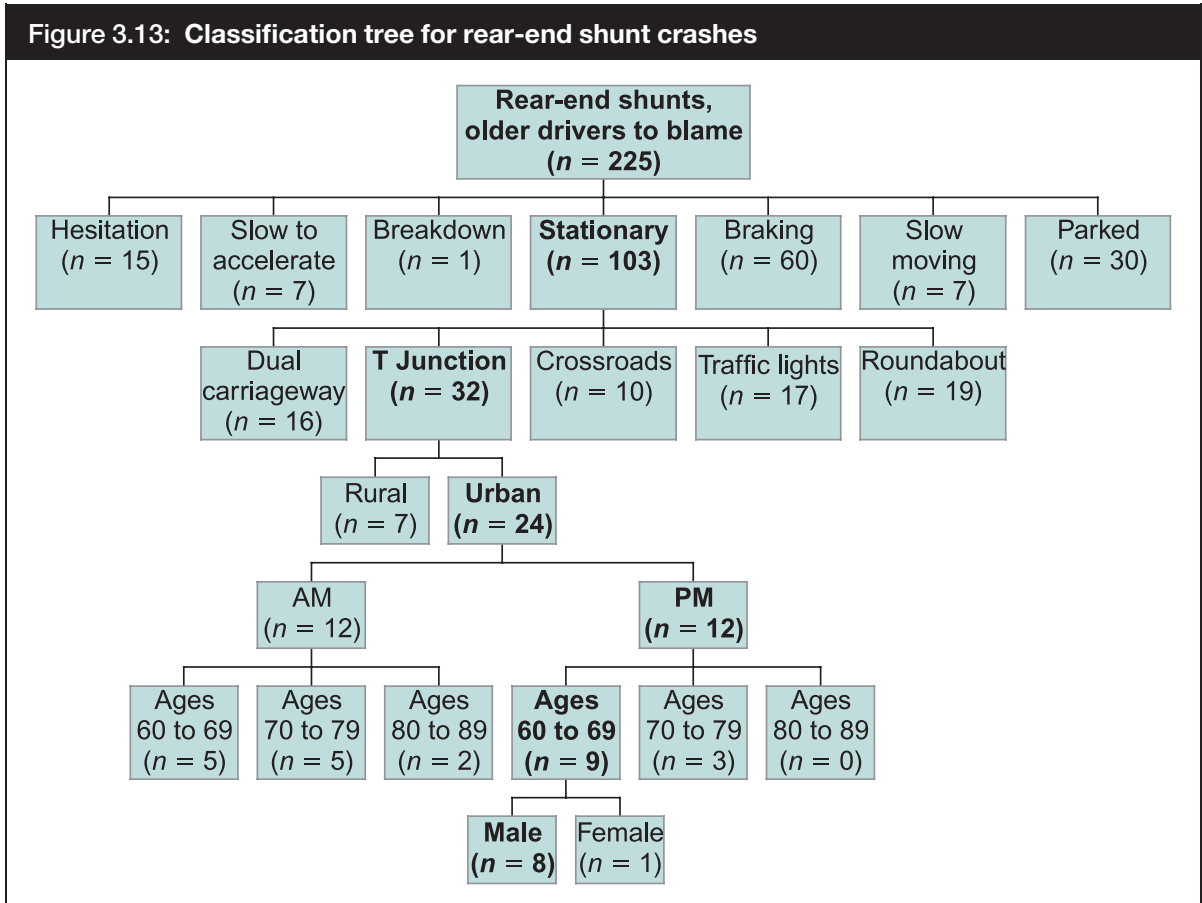
($p < 0.0001$). At-fault rear-end shunt drivers in the sample were also found to be significantly more likely to be male than female ($p < 0.04$; Fisher's test).



As can be seen in Figure 3.12, while the overall blame ratio in rear-end shunt crashes was close to 1 in many cases, there were some exceptions. The most obvious occurred where the older driver hit a **parked** and stationary vehicle (as opposed to a stationary element of queuing traffic, say), or other stationary obstruction in the road such as a delivery/road works van or construction skip. Blameworthy drivers in this group were, on average, significantly older than blameworthy drivers in non-parked shunt crashes ($p < 0.004$). The limited number of cases in the categories of 'accelerating slowly' and 'slow moving vehicle' meant it was difficult to draw any such conclusions about these two groups, however.

3.7.1 A classification tree and prototype rear-end shunt crash

Figure 3.13 shows a classification tree of rear-end shunt collisions, the most prototypical ‘path’ being shown in bold.



Using the tree in Figure 3.13, the example prototype in Figure 3.14 shows the most typical right-turn collision caused by an older driver.

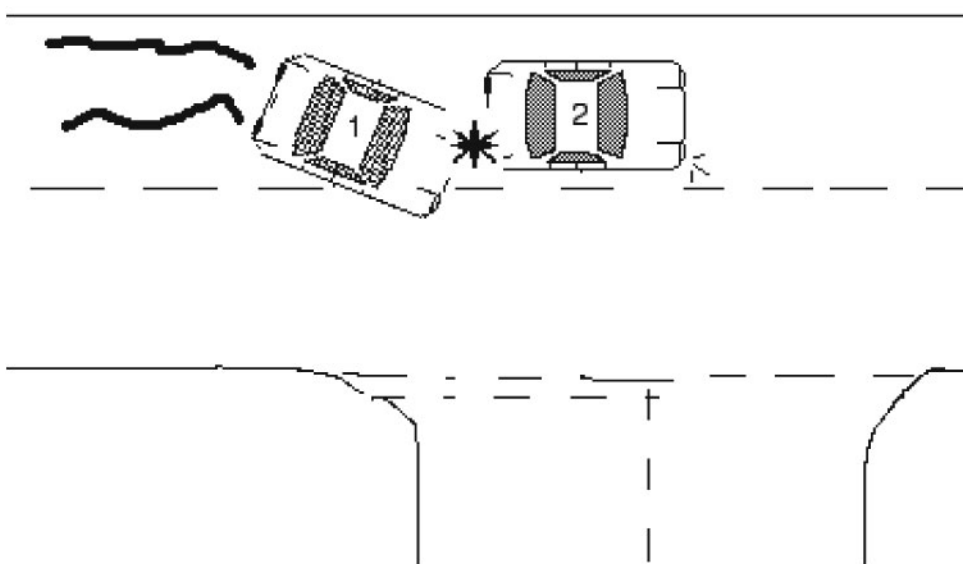
Figure 3.14: Example prototype of the most typical right-turn collision caused by an older driver

Story:

It was a dry and fine Friday afternoon in March. The driver (M,63) of a Toyota Yaris car (1) was travelling along a single carriageway road with a 30 mph limit when he failed to see that the driver (F,17) of a Ford Fiesta 1.4 car (2) was stationary ahead waiting for traffic to clear so she could turn right into a side road. When he did realise he slammed on his brakes but skidded into the rear of driver 2's car. Driver 1 was not hurt in the incident but driver 2 complained of headache and shock. Driver 2 was a learner driver and under instruction at the time of the incident. Her instructor (M,44) who was occupying the front passenger seat suffered whiplash as a result of the collision.

The crash was clearly the fault of driver 1 for failing to see that driver 2 was waiting to make the turn but police decided not to press charges

Diagram:



3.8 Crashes with driver illness as a contributory factor

Crashes attributable to an older driver's chronic or acute illness formed 9.3% of the sample. As might be expected, older drivers whose illness caused a crash were, on average, significantly older (unpaired $t = 2.88, p < 0.005$) than drivers in non-illness crashes. There was no significant difference observed in the numbers of male/female older drivers in illness versus non-illness crashes.

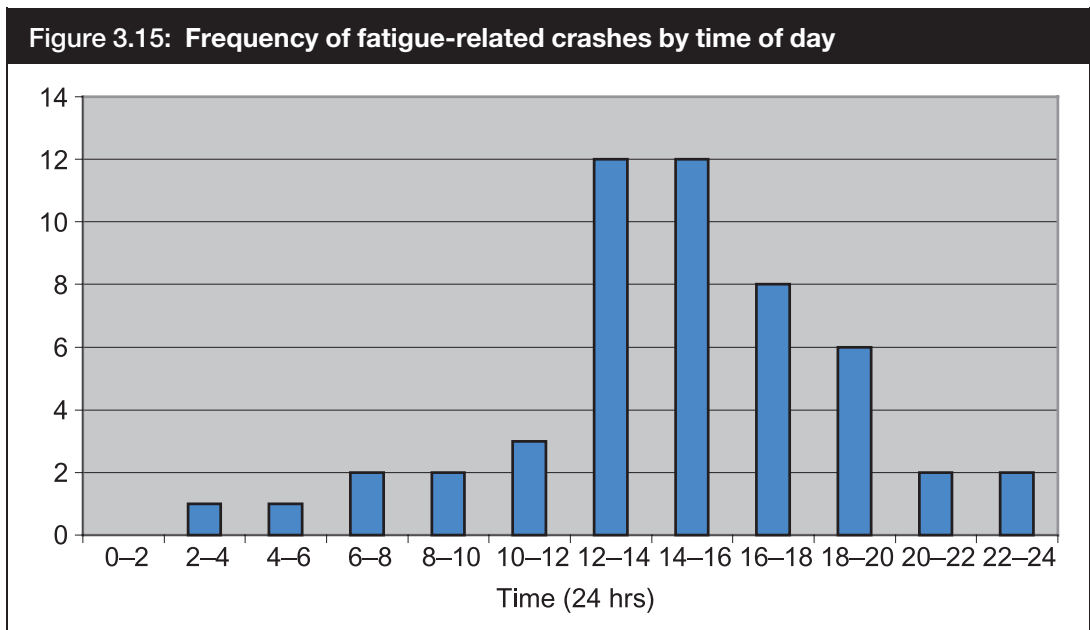
Table 3.1 shows the rank order of types of medical condition contributing to older-driver crashes. (It should also be noted, however, that approximately a third of these crashes had no details of the precise medical condition affecting the driver.)

Table 3.1: Medical conditions contributing to older-driver crashes	
Condition	Number of cases in sample
Myocardial infarction (heart attack)	26
Transient ischaemic attack (TIA) or stroke	25
Diabetes mellitus	6
Bronchitis, emphysema	5
Alzheimer's or dementia	4
Visual field defects, uncorrected poor eyesight	4
Parkinson's disease	1
Aneurysm	1
Bipolar disorder	1
Clinical depression	1

3.9 Crashes with driver fatigue as a contributory factor

Crashes attributable to older-driver fatigue formed approximately 4% of the sample. Fatigue-affected drivers, unlike those affected by illness, were not significantly older than older drivers in non-fatigue crashes. There was no significant difference observed in the numbers of male/female older-drivers in fatigue versus non-fatigue crashes. When blameworthiness was considered, older drivers in this sample appeared to be over five times more likely to have caused a fatigue-related crash than have become an innocent victim of one.

Figure 3.15 shows that older-driver fatigue-related crashes were concentrated in the afternoon, and that nearly half occurred in the four-hour period between midday and four o'clock in the afternoon.



3.10 Overtaking crashes

Overtaking crashes formed a relatively minor subset of this sample – 5% of crashes where the older driver was to blame involved overtaking. It should also be noted that a fairly wide definition of overtaking/passing another vehicle was used; it included, for example, passing parked cars. Older drivers seemed to be over one and a half times more likely to have caused an overtaking collision as to have been involved as an innocent party. As with rear-end shunt collisions, blameworthy overtaking older-drivers were, on average, significantly **younger** than blameworthy older-drivers in non-overtaking crashes ($p < 0.009$). There was, however, no significant difference observed in the numbers of male/female overtaking drivers in older-driver crashes.

Somewhat surprisingly, over 60% of blameworthy overtaking collisions did **not** involve coming into conflict with oncoming vehicles. A common error was hitting the vehicle that was being overtaken by misjudging the clearance distance from it, or cutting in too soon (34% of overtaking cases). Collisions with bicycles and parked cars were quite common in this subset. Other smaller sub-groups were:

- turning right into the path of a vehicle already committed to overtaking, without signalling (16% of overtaking cases); and
- hitting a vehicle by passing it, having failed to notice signals that it was about to turn (11% of overtaking cases).

3.11 Unintended acceleration/spontaneous acceleration syndrome crashes and the older driver

Freund *et al.* (2008) have defined unintended acceleration, or ‘UA’ (sometimes referred to by UK police as ‘spontaneous acceleration syndrome’), as ‘an inadvertent, unexpected, high-power acceleration from a stationary position or a very low initial speed that involves the unintentional pressing of the accelerator instead of, or in addition to, the brake pedal’. They further suggest that this definition be somewhat expanded to include those incidents where an older driver may be proceeding normally until an emergency arises ahead, at which point they hit the accelerator rather than the brake. Freund *et al.* state that UA events have a two-fold nature:

- inadvertent activation of the accelerator rather than the brake; and
- failure to either detect and/or correct this error.

It is the latter that can make the difference between a slight mistake and a near certain collision.

UA crashes, using the definition(s) above, formed only a small part of the database – 47 cases, or approximately 4% of total crashes where the older driver was to blame. Nevertheless, this seemed to be a class of crash that involved older drivers in particular, even within this sample of crash-involved drivers aged over 60. UA crash

drivers were, on average, significantly older than blameworthy older drivers in non-UA crashes (mean age 76 years versus mean age 70 years; $p < 0.0001$). There was no significant difference observed in the numbers of male/female older drivers in UA versus non-UA crashes.

The vast majority of UA crashes involved older drivers of automatic cars accelerating suddenly, either forward or reversing, and usually while carrying out low-speed manoeuvring such as parking and reversing.

3.12 Excess speed and loss of control crashes

Crashes that had any kind of excessive speed contributing to their causation (in terms of either limit or prevailing road conditions) were found in only 8% of cases where the older driver was considered to be to blame. In over half of these cases, the category of speeding was not assigned as a result of any deliberate risk-taking by the older driver; instead, collisions were more likely to result from the misjudgement of an appropriate speed for conditions.

There were also far more crashes in the sample caused as a result of another driver's speeding behaviour (of all types). It can be concluded, therefore, that drivers aged over 60 were more likely to have become the victim of a speed-related collision caused by another driver than to have caused the speed-related crash. There was some evidence that blameworthy **other** drivers in speed-related crashes were, on average, younger than at-fault **other** drivers in non-speed-related crashes (mean age 29 years versus mean age 33 years; $p < 0.04$).

There was a similar picture with loss of control crashes involving older drivers. Although these crashes seemed quite a large category (23% of total at-fault crashes), more than half of these cases (15% of total at-fault crashes) fell into the category of 'loss of control – other' (as opposed to going out of control on a left or right bend). The majority of these crashes, in particular, occurred as a result of the illness, fatigue or unintended accelerations described in Sections 3.8, 3.9 and 3.11 respectively – these factors also accounted for nearly a third of crashes where an older driver went out of control on a bend. Other very common factors in this latter group were wet and slippery roads, and driver distraction.

There was also evidence that at-fault **other** drivers had a similar proportion of loss of control crashes (20% of total) where they hit a blameless older driver. Over half of these crashes involved excess speed on behalf of the other driver.

3.13 Pedestrian crashes

Approximately 9% of crashes in the total sample involved a driver hitting a pedestrian, but the pedestrian was regarded as being primarily to blame more than twice as often as the older driver. Pedestrian crashes where the older driver was to blame formed only a small part of the sample (approximately 4% of total

blameworthy crashes). There was no evidence of any within-sample age or gender differences in older drivers who had hit pedestrians.

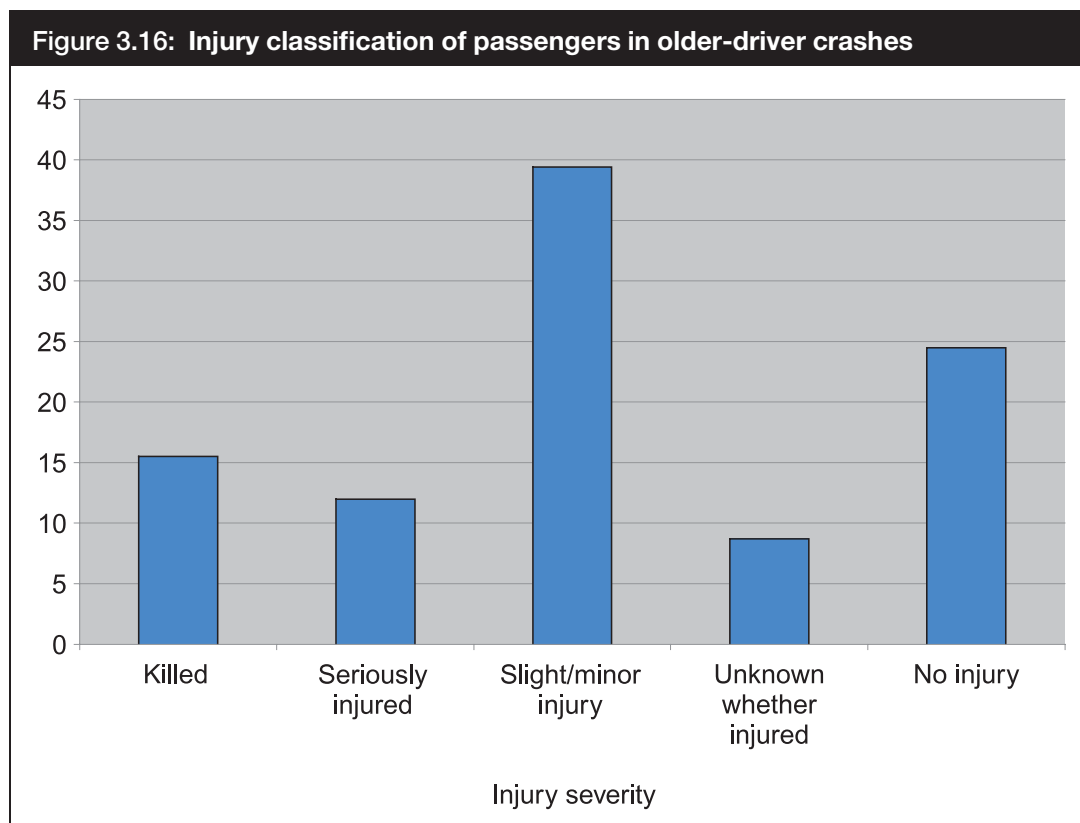
Twenty-four per cent of pedestrian crashes where the driver was to blame involved them reversing into a pedestrian whom they had not observed to have been behind their vehicle. Twenty per cent involved hitting a pedestrian who was crossing in the vicinity of a road junction, while 14% involved hitting a pedestrian in the vicinity of a pelican or zebra crossing. Failures of observation were the most common explanatory factors in all these pedestrian collision types.

3.14 Alcohol

As might be expected from the time of day results (see Section 3.5), older drivers were not highly involved in collisions where impairment by alcohol was a factor. Only 3.3% of crashes in the whole sample showed alcohol as a causative factor, and in less than half of these cases the older driver was the person who had consumed the excess alcohol. It seemed, therefore, that older drivers were more likely to have been hit by a driver over the alcohol limit than to have caused a crash by driving with excess alcohol.

3.15 Passengers in cars driven by older drivers

Passengers were present in nearly 30% of cases where the older driver was considered blameworthy. The three most common groups of passenger were: (1) partners of the driver (56% of total), (2) relatives of the driver (18% of total),



and (3) friends of the driver (18% of total). The average age of passengers was similar to the average driver age in the case of partners and friends, but the average age of relatives was (as might be expected) significantly younger. Figure 3.16 shows the percentage of passengers killed or seriously injured (KSI) in the total crashes where the older driver was considered to blame.

4 DISCUSSION

It is clear from the evidence presented here that, although older drivers are often considered a homogenous group, there are wide differences in the type of crash and blameworthiness of the driver in different age-groups of older driver. Drivers aged under 70, for instance, appeared to suffer just as much from other drivers (of any age) crashing into them as they did by causing crashes themselves. To judge from this sample at least, there would seem little point in concentrating road safety campaigns (for example) on a group of drivers who are as likely to be an innocent victim as they are to be a blameworthy driver. However, after 70 years, blameworthiness ratios appeared to rise with age; drivers aged 85 years or more appeared to be over four times as likely to have caused a crash than they were to have been innocently involved in one.

Some older drivers seemed to have clear difficulties in particular areas, the most obvious being right of way violation (ROWV) crashes. Right turns onto a road were the most frequent type of collision, and the most common failures of older drivers were in visual search at the junction. It will be remembered that Maltz and Shinar (1999) found that older drivers showed longer search episodes and visual search patterns characterised by more fixations and shorter saccades. They were also uneven in their allocation of visual scan time compared with younger drivers.

It is also possible that the high proportion of visual search difficulties found in older-driver right-turn crashes (turning right both 'on' and 'off' a road) occurred as a result of increased levels of 'change blindness' in older drivers. This is a phenomenon whereby a driver shows an inability to detect changes made to an object or a scene during an eye saccade or blink. Caird *et al.* (2005), for example, found that drivers aged 65 years or more made less 'correct' decisions than either young or middle-aged drivers in a change blindness experiment involving the manipulation of 36 intersection images. Caird *et al.* commented that 'older drivers appeared to rely heavily on the traffic control devices (e.g. lights) in the intersection to make decisions, often to the exclusion of other important objects, such as pedestrians and vehicles' (p. 246).

Another possible explanation for visual search failures at junctions lies in the 'useful field of view' (UFOV) identified by researchers such as Horswill *et al.* (2008) and Owsley *et al.* (1991). The UFOV refers to the visual field extent needed for a specific visual task, and the size of the UFOV is different from the visual field size as determined by clinical perimetry – it is smaller than the area of visual sensitivity. The UFOV is measured binocularly and can require detection, localisation or identification of suprathreshold targets in complex visual scenes. It is affected by variables such as the addition of a secondary central task, increased similarity between target and distractor, and decreased stimulus duration. Owsley *et al.* (1991) reported that the impact of these variables is generally much greater for

older adults; their UFOV test provided a measure of efficiency at the earliest stage of attention, at which visual stimuli quickly capture and direct attention to highly salient visual events. This ability is critical during driving and is particularly important when approaching an intersection, where visual attention must quickly direct attention to events in the periphery. In tests, 95% of the intersection crashes sampled were incurred by subjects who failed the UFOV test, and all individuals with multiple crashes in the sample failed the UFOV.

The finding that right-turning older drivers were significantly more likely to be hit by a younger driver than was the case in other types of collision is in accordance with the work of Keskinen *et al.* (1998). In a video observational study of driver behaviour at T-junctions, they found that older drivers had the shortest time/safety margins when they were turning and a younger driver was approaching on the main road. Keskinen *et al.* commented that: 'An older driver turning and a young driver approaching [could therefore] create a potentially dangerous combination with a low safety margin.' Time differences were also found to be particularly short when the opponent driver was riding a motorcycle; this finding might explain why motorcyclists (who were also younger on average than other colliding drivers) appeared to be over-represented in the older driver right-turn crashes examined in this study. Another possible explanation lies in the increased number of 'Looked But Did Not See' (LBDNS) errors observed in motorcycle crashes involving drivers aged over 65 years (e.g. Clarke *et al.*, 2004).

Proposed countermeasures for reducing the likelihood of right of way crashes involving older drivers have included engineering-based solutions such as intersection decision support (IDS) systems. Creaser *et al.* (2006) performed an analysis of the effectiveness of such systems on driver gap-acceptance behaviour at rural intersections in the US. They found that signage providing detailed gap information (i.e. time-to-arrival values, warning levels for gaps) resulted in the best performance among older drivers, as opposed to signage that did not provide specific gap-related information (i.e. only detected vehicles approaching, but not the safety of the gap). Boufous *et al.* (2008) recommended other engineering-based measures for reducing intersection crashes, such as the installation of traffic control devices or four-way stop signs at complex intersections; increased sign luminance; increased reflectivity of road markings; larger sign symbols; and better positioning of traffic signs. Others, such as Skyving *et al.* (2009) and Lord *et al.* (2007), have recommended the safety benefits of roundabout style intersections when used to replace conventional crossroads or T-junctions.

Other proposed solutions for the right of way problems of older drivers have included retraining initiatives – Kua *et al.* (2006) reviewed several studies that focused on older-driver retraining. They found some limited evidence that physical retraining and visual perception retraining could improve driving-related skills in older drivers; there was also moderate evidence that educational interventions improved driving behaviour, but did not reduce crashes in older drivers.

With regard to eyesight testing, Owsley *et al.* (1991) have reported that, although good visual status is related to UFOV, good visual status **alone** is not a sufficient condition for a normal UFOV. Approximately 50% of their test subjects had good visual function yet failed a UFOV test, and the UFOV test was a better predictor of crashes than visual status alone. Taken as a whole, this suggests that a standard eyesight test may fail to identify drivers with UFOV problems that could lead to intersection collisions.

Rear-end shunt crashes were the second most common type of crash (after ROWV). There was some evidence that the younger age-groups of driver (under 70 years) were more likely to have crashes of this type.

Rear-end shunts are among the most frequent type of crash on the road, and there have been attempts to evaluate technological countermeasures such as forward collision warning (FCW) systems, for example by Jamson *et al.* (2008). Jamson *et al.* found that all drivers may benefit from such systems, with low sensation-seeking, non-aggressive drivers showing acceptance of both non-adaptive and adaptive forms of FCW.

It is possible that, with this sample, we are seeing a type of ‘middle-aged spread’ of crash causation – it will be recalled that the youngest age groups in this sample showed a greater propensity for causing rear-end shunt (and overtaking) crashes. It could be that, as a driver cohort ages past 70, they tend to ‘specialise’ in different types of crash, becoming less like the ‘average’ blameworthy driver (with a propensity for causing rear-end shunts, for example) and more like the elderly groups identified by prior research, and detailed here, in having more of a propensity for causing right of way crashes. This remains speculation, however, as we did not examine a comparable group of drivers aged under 60 years.

There is evidence from this sample that nearly 10% of older-driver crashes were caused by chronic or acute illness. It is perhaps not surprising to find quite high levels of illness in a sample drawn from drivers aged over 60 years. There have been a number of research studies recommending test procedures that could be adopted by medical professionals when deciding whether an older at-risk driver should continue to drive. Molner *et al.* (2007), for example, reviewed some clinical measures that might be used by physicians to identify at-risk older drivers, having pointed out that such physicians often lacked evidence-based tools to do so. They found that high scores in components of three ‘toolkits’ were associated with motor-vehicle crashes in their subjects. These toolkits were as follows:

1. Mini-mental State Examination (MMSE), which contained such components as orientation to time, spelling ‘WORLD’ backwards, etc. (after Folstein *et al.*, 1975). Freund and Colgrove (2008) have also found the MMSE useful in distinguishing between safe and unsafe drivers in a simulated driving experiment.

2. Driving Habits Questionnaire, including questions on how often drivers committed lapses and misread signs, took the wrong turn off a roundabout, or got into the wrong lane approaching a roundabout or junction (after Parker *et al.*, 2000).
3. Ottawa Driving and Dementia Toolkit, which included questions such as ‘Do you think at present you are a safe driver?’ and ‘Have you had any car crashes in the last year?’ (after Byszewski *et al.*, 2003).

In addition, Molner *et al.* (2007) found that two other responses/tests were associated with past or current crashes. These were the response that participants were ‘bothered a great deal by Diabetes mellitus’ and the Timed Toe Tap Test (in which, with heel resting on ground, the time to tap the left toes on the ground 15 times is measured). Molner *et al.* also reported that ‘almost all measures employed were acceptable to enrolled patients’.

The identification and assessment of drivers with medical problems that affect their ability to drive is, of course, a potentially controversial area. Nevertheless, researchers such as Meuser *et al.* (2009) in the US have reported the effectiveness of ‘voluntary’ procedures, whereby various professionals and family members may report medical fitness concerns to licensing authorities; such authorities may then evaluate the driver and revoke their licence if necessary. In the UK, Brayne *et al.* (2000), in a study of drivers aged 84 and over, reported that doctors were very rarely involved in the decision to stop driving, but that health status was cited, along with a reduction in confidence, as the reason for elderly drivers taking the decision to stop driving. Brayne *et al.* believed that any call to screen for dementia or health status in the older population might not reduce the rise in crashes seen with age, as those with cognitive impairment or failing health in the oldest age-groups have already chosen to stop driving. Therefore the majority of crashes seen in older age-groups involve fit older people, with relatively intact health and cognition.

There are also crashes that, although relatively few in terms of proportion in the sample, seem to affect the oldest of elderly drivers to a disproportionate extent: unintended acceleration (UA) crashes and fatigue-related crashes. The majority of UA crashes involve automatic cars accelerating suddenly, either forward or reversing, and usually while carrying out low-speed manoeuvring such as parking and reversing. This is not a category of crash that has been found in significant numbers in any of the other samples drawn by this research group in various studies over the years (e.g. Clarke *et al.*, 2002), so it seems reasonable to suggest that this particular failure is more or less exclusive to drivers aged over 60 – there are no cases in the sample where an older driver becomes the victim of another driver’s unintended acceleration under the definition used (that of Freund *et al.*, 2008). Similarly, fatigue-related crashes are relatively few in proportional terms, but older drivers do appear to be more than five times as likely to cause a fatigue-related crash as become the victim of another driver’s fatigue.

5 CONCLUSIONS

To judge from this sample at least, older drivers do not seem to have an increased level of blameworthy crashes until around 70 years of age; thereafter, their level of blameworthiness rises. Older drivers would appear to have significant problems with visual processing at junctions, which leads to an increased level of blameworthiness in right of way violation (ROWV) crashes, in particular right turns onto a more major road. Further perceptual research that investigated turn decisions at junctions might throw more light on the precise nature of these visual processing failures.

Older drivers also suffer many crashes as a result of the increased incidence of acute and chronic disease that age brings. They also appear more likely to cause fatigue-related crashes than other driver groups, at least when examined in an 'induced exposure' fashion. Cognitive failures in aging also seem to be linked to a minority of crashes where elderly drivers perform an 'unintended acceleration' in an automatic vehicle.

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