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Work-related road safety in South Australia

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ABSTRACT

This report presents a broad investigation of work-related road safety in South Australia in three distinct parts. In the first part, a review of national and international literature on work-related road safety is conducted. The second part presents an analysis on the burden of work-related light vehicle crashes in South Australia for the years 2006 to 2010. Three separate methods of identifying work vehicles that were involved in South Australia crashes were utilised. Each of the methods identified a particular set of work vehicles which were then analysed separately. Despite this, the results from each method were reasonably consistent. Compared to non-work vehicles, the crash involved work vehicles were more likely to be newer, travel during daytime hours on weekdays, and be driven by males of working age. A large proportion of the work vehicles were found to consist of commercial-type vehicles such as utilities, vans, and station wagons, which are less likely to be fitted with safety features that are common on other light vehicles. Another finding was that work vehicles that crashed in the greater Adelaide metropolitan area between 6am and 7pm on a weekday while being driven by a person younger than 65, had a higher crash risk than non-work vehicles. No definitive reason for the increased crash risk could be identified. In the third part of the report, an analysis of the crash and injury experience of a large government light vehicle fleet in South Australia is presented. Information on the safety features of each vehicle that entered the government fleet between 1 January 1998 and 31 December 2010 were obtained, along with details on crash involvement and total travel distance. Within the government fleet, the uptake of safety features over time was similar to that of the general vehicle fleet and even greater for some features such as electronic stability control and traction control. Analysis of the crash data (while controlling for total travel distance) revealed that the crash rate of the government fleet had reduced over time. With respect to the different safety features installed on each vehicle, it was found that those vehicles that were equipped with ESC or had a 5-star ANCAP safety rating had a statistically significantly lower crash rate compared to those that were not.

KEYWORDS

Employment, Traffic accident, Fleet safety, OHS, Vehicle safety technologies

Summary

Work-related road crashes account for the greatest proportion of worker serious injuries and fatalities in Australia. Furthermore, work-related crashes represent the most costly type of workplace incident, both in terms of property damage and workers' compensation payments, and also account for a sizable proportion of total road fatalities.

This report presents a broad investigation of work-related road safety in South Australia in three distinct parts. In the first part, a review of national and international literature on work-related road safety is conducted. Various aspects of work-related road safety are reviewed and discussed including the availability of relevant data, the definition of a work vehicle crash, the amount of work-related driving, the financial cost of work-related crashes, the trends in the number of Australian work-related road fatalities, the characteristics of work-related crashes, and the potential for countermeasures to reduce the number and severity of work-related crashes.

The second part of the report presents an analysis of the burden of work-related light vehicle crashes in South Australia for the years 2006 to 2010. Three separate methods of identifying work vehicles that were involved in South Australia crashes were utilised. The first method used Polk data to identify vehicles that had been involved in a fatal or serious injury crash within three years of being purchased by a fleet buyer. The second method used WorkCover data to identify vehicles of which an injury claimant was an occupant. Lastly, registration data was used to identify vehicles that were listed as entitled to an input tax credit for business use.

Each of the methods identified a particular set of work vehicles which were then analysed separately. Despite this, the results from each method were reasonably consistent. Compared to non-work vehicles, the crash involved work vehicles were more likely to be newer, travel during daytime hours on weekdays, and be driven by males of working age. A large proportion of the work vehicles were found to consist of commercial-type vehicles such as utilities, vans, and station wagons, which are less likely to be fitted with safety features that are common on other light vehicles.

Another finding was that work vehicles that crashed in the greater Adelaide metropolitan area between 6am and 7pm on a weekday while being driven by a person younger than 65, had a higher crash risk than non-work vehicles (20 per cent for WorkCover identified and 8 per cent for those identified through registration data). The largest increases in risk were for right angle and side swipe crashes. The possibility that this effect was due to either a reporting bias or differences in the occupancy of work vehicles were both discounted and no definitive reason for the increased crash risk could be identified.

In the third part of the report, an analysis of the crash and injury experience of a large government light vehicle fleet in South Australia is presented. Information on the safety features of each vehicle that entered the government fleet between 1 January 1998 and 31 December 2010 were obtained, along with details on crash involvement and total travel distance.

Within the government fleet the uptake of safety features over time was similar to that of the general vehicle fleet and even greater for some features such as electronic stability control and traction control. Analysis of the crash data (while controlling for total travel distance) revealed that the crash rate of the government fleet had reduced over time. With respect to the different safety features installed on each vehicle, it was found that those vehicles that were equipped with ESC or had a 5-star ANCAP safety rating had a statistically significantly lower crash rate compared to those that were not.

Contents

1 Introduction

Safety in the workplace is governed by an occupational health and safety (OHS) framework where legislation is supported and enforced by OHS agencies. Within this framework all employers have an obligation to identify any dangerous activities and enact safety procedures to prevent or minimise the risk of worker or public injury. OHS agencies support this process by advising employers and prosecuting breaches. Any incidents where a worker or member of the public are seriously injured or killed are investigated and, where necessary, prosecutions can be made. In a similar manner to the OHS framework, the safety of public road users is governed by a road safety framework where legislation is supported and enforced by the police who also investigate serious crashes (i.e. safety failures) and make prosecutions.

Despite their similarities there are important differences in the OHS and road safety frameworks. Road safety laws are applied in a general fashion to all drivers, vehicles, and roadways. A limited number of additional laws target sub-groups of drivers, vehicles, or road environments that are known to have a higher crash risk. For example, restrictions for learner/provisional drivers, maximum speed limits for heavy vehicles, and lower speed limits on busy roads. However, these laws are still broadly applied and, apart from rare cases, there is no specific targeting of individual drivers, vehicles, or roadways. While the road safety framework provides plenty of guidance, it is still largely up to the individual driver to decide how they will behave, what kind of vehicle they will purchase, and how they will respond to the road environment.

Conversely, the OHS framework can be quite prescriptive and sets out in great detail how a worker or piece of machinery should be managed. Examples of this include defining appropriate working hours or how machine guarding should be set up. Moreover, the OHS framework requires that employers continuously monitor their workers and workplace environments for dangerous behaviours and hazards. Elimination or active management of any identified issues should then be undertaken as soon as is practically possible.

Work-related driving on public roads is a task undertaken by many employees and represents an overlapping of OHS and road safety frameworks. This overlapping has resulted in ambiguities of jurisdiction and obligation such as whether a vehicle that is considered road-worthy under the Australia Design Rules (ADRs) can also be considered a 'safe' workplace, or whether a valid driver's licence can be considered sufficient training to operate a vehicle.

Encompassing work-related driving within the OHS framework presents several challenges. Under the OHS framework work-related driving represents a unique situation where there are opportunities for workers to injure themselves, injure the public, or be injured by the public at a location away from the workplace where employers have limited control over the 'work' environment. Additionally, workers who leave the workplace and begin driving move from an OHS framework to a road safety framework in which they may already have established behaviours and attitudes from their own private driving. These personal responses to the road safety framework may be different, and inconsistent, with the responses expected by the OHS framework.

Dykes et al. (2001) as well as Lancaster and Ward (2002) describe a situation in England, Wales, and Scotland where road safety law is given precedence over OHS law during work-related road crashes. That is, the police take the lead in investigating to determine cause, allocate responsibility, and identify any illegal behaviour under road safety law. As a consequence, employers have little motivation to improve work-related road safety and incidents where an employer contributed to a crash (e.g. through inappropriate scheduling) may go undetected.

Other problems also arise from the overlapping safety frameworks. The accurate reporting of work-related crash costs is impeded as compensation is shared between agencies within the two frameworks. This makes it difficult to calculate the full cost to society. Additionally, data collection relevant to work-related road safety is also impeded. Under the road safety framework data on road crashes is collected routinely by the roads authorities but not in the context of worker safety. This means that crashes involving work vehicles are not identified as such and information relevant to OHS, such as how long a worker had been driving before their crash or how long they had been working before undertaking their journey, is not collected. As a result there is a lack of longitudinal data directly relevant to work-related road safety research.

Despite this, research on work-related road safety has still been possible through various data matching methods. For example, by matching police reported crash data to OHS injury data. From this research it has been revealed that work-related driving represents one of the leading causes of work-related injuries and fatalities as well as one of the most costly in terms of property damage and workers compensation payments. The most recent Australian reports suggest that work-related road fatalities account for 14 per cent of all road fatalities and 58 per cent of all work-related fatalities. It is thus in the interest of OHS agencies and any companies that regularly use vehicles to pursue methods of reducing the crash and injury risk of work-related driving.

In light of this, the overlapping of the OHS and road safety frameworks also present a number of opportunities. OHS legislation has the potential to have significantly more control over what vehicles may be provided to workers and can influence their driving attitude and performance through guidance and sanctions. Furthermore, due to the significant amount of work-related driving on public roads, any improvements from changes in the OHS framework will ultimately improve road safety overall. It may also be possible for corporate fleet buyers to use their collective purchasing power to influence vehicle manufacturers to equip some safety features as standard equipment.

It is suggested that new vehicle safety technology, which is currently in the midst of a revolution, represents one of the best methods of improving work-related road safety. For the past 25 years, major advances have been made in the area of vehicle crashworthiness with high levels of secondary safety expected in new vehicles. But much more recently, technologies have been developed that tackle primary safety by focusing on crash prevention using arrays of sensors in systems that actively intervene to prevent a crash from occurring. In the next few years several new systems will be used to further enhance the ability of vehicles to assist drivers in avoiding a crash. These may provide an opportunity for workplaces to reduce the incidence of crashes in vehicles that they manage.

The purpose of this report is to estimate the burden of work-related road crashes in South Australia and to investigate the potential for new vehicle technologies to reduce this burden through the analysis of a large South Australian based fleet.

The report is presented in five chapters. Chapter two is a review of relevant literature on work-related vehicle safety. Within the literature review the data sources and specific definitions used for the analysis of work-related road crashes are presented and discussed. The driving exposure and crash cost of work vehicles is then described. Following that, the characteristics of both work-related fatal crashes and all crashes are reported along with a review of various methods of improving work driver safety.

Chapter three presents an analysis of work-related crashes in South Australia with the aim of estimating the burden of injury. Three methods of identifying vehicles that were being used for work when involved in a crash are presented. The methods identify separate categories of work vehicles (with some small overlap) and the characteristics of each category are investigated. The overall burden of work-related light vehicle crashes in South Australia is discussed through consideration of all the categories together.

Chapter four describes the analysis of a large vehicle fleet based in South Australia. The characteristics of the fleet is examined over time including factors such as the yearly crash rate, the average age of the vehicles, and the prevalence of various vehicle safety features within the fleet. The effect that the safety features have upon the yearly crash rate is then examined in further detail.

Chapter five presents a discussion on the findings of the report and how they are relevant to the problems and opportunities associated with work-related road safety in South Australia.

2 Literature review

This review is presented in nine sections and an overview of the contents of each section is given below. It should be noted that the review will concentrate on work-related safety of light vehicles but general mention of other vehicle types is also made. Further information on work-related truck crashes can be found in Quinlan, 2001 or Charbotel et al., 2003, and information on work-related bicycle crashes can be found in Dennerlein & Meeker, 2002.

In most instances, Australian crash databases do not allow a particular crash to be identified as work-related. This means that many previous studies have linked crash data with other work-related data sources or have used surveys to conduct research on work-related road safety. Section 2.1 describes the data situation and describes some of the other data sources that have been used for work-related road safety research.

There are many differences in how work-related crashes, vehicles, and workers are defined. Section 2.2 discusses some of these differences and some of the considerations that are required when comparing results between studies.

Around half of all new vehicles sold each year are bought by organisations for work purposes or for use by employees. Around a third of all travel in Australia is for work purposes and if commuting is included this percentage increases to around a half. The use and safety of work vehicles will thus have a significant impact on national road safety. Section 2.3 investigates the crash exposure of work vehicles and makes comparisons to the exposure of the general vehicle fleet.

The full cost of a work-related road crash is difficult to determine. However, estimates have shown the cost to be significant for both the Australian economy as a whole and for individual organisations. Reducing or eliminating these costs is obviously good economic practice and can serve as an incentive to improve work-related road safety. Section 2.4 reviews the literature on the cost of work-related road crashes in Australia.

Work-related road crashes are the leading cause of worker death and represent a significant proportion of the total number of road fatalities in Australia each year. Because of this, they have been relatively well recorded over time. Section 2.5 presents an analysis of fatal work-related crashes in Australia over time.

Non-fatal work-related road crashes have been tracked less well than fatalities, but the last decade has seen increased interest on the size of the resulting burden of, the reasons for, and the characteristics of such incidents. Section 2.6 describes the characteristics of and the risk factors for work-related crashes, and the role of worker attitudes to risk.

One significant finding by researchers in the United Kingdom, who were investigating the characteristics of work-related crashes, is the 'work driver effect'. That is, that company drivers with a high annual mileage have a higher crash rate compared to ordinary drivers with comparable annual mileage. Section 2.7 describes the discovery and further research of the work driver effect documented in the literature.

Finally, the desire to prevent or reduce the severity of work-related road crashes has led to an increasing amount of literature detailing the effectiveness of various interventions measures. Both driver-based and vehicle-based interventions are reviewed in Section 2.8 along with developments in improving driver behaviour through the promotion of a positive company safety culture and safety climate.

The findings of the literature review are summarised and discussed in Section 2.9.

2.1 Data

Work-related road safety has been studied for many decades, and Australian-based research has featured prominently. Two reviews of international the literature (European Road Safety Observatory, 2006; Murray, 2007) feature numerous citations to Australian research and underscore Australia as a world leader in several areas of work-related road safety.

Two parliamentary road safety committees from Australian states have produced reports which focus entirely on work-related road safety. The Staysafe 36 Report published by the NSW parliament in 1997 presented the research of many stakeholders involved in the areas of road safety, OHS, insurance, fleet management, driver training, and law enforcement (Staysafe 36, 1997). The report offers some of the earliest Australian research on the reasons, challenges, and opportunities for improving work-related road safety. A similar convening of stakeholders resulted in the Travelsafe 34 report from the Queensland parliament in 2002 (Travelsafe 34, 2002).

Staysafe 36, Travelsafe 34, and other reviews (Haworth et al.,2000; Murray et al., 2002) discuss the problems that arise because data directly useful to the analysis of work-related road safety were lacking. The primary issue was that the work-relatedness of crashes is not recorded in Australian mass crash databases. This issue is not unique to Australia and has been noted in the United Kingdom (Dykes et al., 2001), New Zealand (McNoe et al., 2005), and the United States (Pratt, 2003).

There was some indication that this data deficiency might be addressed to some degree in the future: Murray et al. (2002) reported that as a result of Travelsafe 34, 'purpose of journey' has become a routinely collected crash variable in Queensland. It was noted however, that during the first years of collection there were issues of missing and inaccurate data. In the United Kingdom, the police crash report form, STATS19, was likewise reported to have been amended to begin collecting 'purpose of journey' information (Murray, 2007).

In addition to mass crash data there are several alternative sources of data that can be used for the analysis of work-related road safety. While each source has potential limitations they can be suited to particular types of analysis and produce valuable results. The main alternative data sources are described below.

Workers compensation data

In most jurisdictions workers compensation agencies maintain records of all serious injuries or fatalities sustained by workers. These records often contain enough detail to establish whether a motor vehicle was involved in the injury incident. By themselves these records enable comparisons of injuries sustained due to road crashes with all work-related injuries. Linking with crash data, either through registration number or through probabilistic matching of common variables such as driver sex and age, may allow the comparison of casualty crashes involving people at work and those not involving workers. Of course, such data will only cover crashes in which a worker was injured and crashes that involve only property damage or a third party injury will not be documented.

A further limitation of workers compensation data is that in most Australia states workers who are injured in a crash while commuting are not entitled to claim and are thus not recorded. Personal communication with Safe Work Australia revealed that only NSW and Queensland have workers compensation schemes that cover commuting workers but that such coverage may be removed in future amendments to state legislation. Charbotel et al. (2001) describes a similar situation in some

European countries as well as the United States and Canada where commuting crashes are not indemnified under workers compensation schemes.

Registration data

Vehicle registration databases are another source of potentially useful data. In some states, vehicles that will be used for work are required to be identified as such when registered. This provides an estimate on the size of the work vehicle fleet and by linking crash data with registration data it is possible to identify those crashes that involve vehicles which were registered for work-related purposes.

There are two potential issues to keep in mind however. The first is that while a vehicle may be registered for work there is no way to tell if it was being used for work or non-work purposes at the time of a crash. Secondly, a number of privately registered vehicles may also be used for work, such as for pizza delivery or commuting, while conversely some work registered vehicles may be provided to a worker as a component of their remuneration and only be used for private purposes.

Data provided by companies or fleet managers

Surveys of large companies that employ regular drivers or data from fleet vehicle managers may also serve as potential sources of data. Large companies often keep details regarding crashes that enable the linkage of several data sources such as workers compensation, compulsory third party claims, police reports, etc. Furthermore, information that the company itself collects about their employees and their work history and patterns may also be useful.

However, the data contained in these sources are usually from business systems and are not always suited to the requirements of data extraction for research purposes. Additionally, collecting a suitably representative sample from such sources is difficult and costly. The results from the analysis of a single company or fleet may provide some insight but are unlikely to fully represent work-related road trauma overall (Symmons and Haworth, 2005).

Coroners files

Incidents that result in fatal injuries are usually investigated thoroughly by various agencies and thus the work-relatedness of fatal incidents may be established. Coroners' files, in particular, would be expected to assist in ascertaining the work-relatedness of a fatal road crash. Unfortunately, work-relatedness is not directly indicated within coroners' findings and so coroners' files must be reviewed individually to ascertain a determination which can be time consuming and in some cases may not be possible. Analysis of digital copies (e.g. by searching for keywords like work or business) may reduce the amount of time required.

2.2 Definitions

Throughout the literature concerning work-related road crashes there is little consensus on the definition of a work vehicle or work-related crash, which can make meta-analysis and comparisons between studies problematic. In some studies the definitions are guided by the availability of data (as described in the previous Section) while others choose to focus on a particular subgroup of interest. This section discusses some of the differences in definitions that are important to keep in mind when reading through the literature.

Vehicle type

A work vehicle may refer to a diverse group that can contain light vehicles (cars, station wagons, etc) commercial vehicles (utilities and vans), heavy vehicles (trucks, buses, and semi tailers), mobile plants (construction vehicles like graders), and even bicycles. Some sources group all these vehicle types together for analysis, some are only interested in motor vehicles, some focus on a particular subgroup, and some additionally consider non-road vehicle types including sea, air, and rail.

Vehicle usage

Complicating matters further is that work vehicles are used for many different purposes in different circumstances. For example, a work vehicle may be used simply for travel within a metropolitan area, for carrying passengers between cities, or for transporting heavy goods in a rural setting. It is likely that, correspondingly, the crash characteristics of vehicles will be different too. For this reason some studies attempt to isolate groups of vehicles with similar usage for analysis. Lynn and Lockwood (1998), for example, chose to analyse the drivers of light vehicles who drove at least once per week for work-related purposes.

There are also conflicting opinions within the literature over what constitutes a work-related road crash. Some studies only consider crashes on a public road while a worker was on duty. Many also consider crashes where a worker was commuting between work and home. A less common consideration is crashes where a worker was struck by a vehicle while on foot or cycling.

Vehicle origin

Vehicles come to be used for work purposes for several reasons. They may be purchased by a company to form part of a pool of vehicles for general use by workers when required. These pools of vehicles are usually referred to as fleet vehicles and fleets can range from as small as two vehicles up to thousands for large companies. Some company owned vehicles are provided to individual workers for sole use as part of a remuneration package or lease agreement. These sole use vehicles may be required by the worker for their daily work or equally may be primarily for private use. Finally, many privately owned vehicles will also be used for work purposes or for commuting between work and home.

There are examples within the literature of studies that encompass work vehicles of all origins and other studies that focus on certain subgroups. For example, the report by Haworth (2000) was primarily concerned with how company policy could affect work-related road safety and so defined a work vehicle as any vehicle over which an organisation has some degree of influence in their selection and operation.

2.3 Exposure

To understand how work-related driving interacts with the general road safety framework an estimation of exposure is required. This estimation will also elucidate the potential that improvements in work-related road safety have to affect overall road safety.

Wheatley (1997) estimated that of the 10 million registered vehicles in Australia, three million were used for work purposes and that 60 per cent of new vehicles were initially sold for commercial purposes. Based on financial review data from 2001, Murray et al. (2002) estimated that 54 per cent of new vehicles in Australia were bought by either a business, the government, or for rental purposes. A similar situation exists in the United Kingdom where Downs et al. (1999) reported that over 2.25 million cars are company owned and over half of all new cars sold each year are registered in a company's name.

Wheatley (1997) further estimated that 33 per cent of all Australian travel was work-related; increasing to 50 per cent if commuting was included. This correlates well with the findings of the Australian Bureau of Statistics who conducted a survey of vehicle use over the 12 month period of November 2009 to October 2010 and reported that 34.8 per cent of vehicle travel was for business, 23.7 per cent was travelling between work and home, and 41.5 per cent was for private of other purposes (ABS, 2011a). The survey of vehicle use also investigated the average annual kilometres travelled per vehicle for a particular purpose. Vehicles were reported to have travelled an average annual distance of 13,700 km for business, 7,000 km between work and home, and 7,600 km for personal and other purposes. A survey of drivers in the United Kingdom who drove light vehicles for work purposes was conducted by Lynn and Lockwood (1998) who found that such drivers travelled, on average, 20,000 miles per year for work purposes compared to 7,000 miles per year for private purposes. It was unclear however, whether commuting was considered as work or private driving.

The indication is that work-related driving makes up around half of driving within Australia. Further to this, it suggested that work vehicles are driven greater distances (compared with private and other vehicles) and thus they, and their drivers, have a greater exposure to crash risk. This exposure imbalance for work vehicle drivers, with respect to crash involvement, is explored further in Section 2.7.

2.4 Crash cost

The cost of crashes is often highlighted as a reason for addressing work-related road safety. Additionally, promoting the economic benefits of reducing crashes is thought to be a good motivator for companies to reduce unnecessary costs.

Because work-related road crashes exist within both the OHS and road safety frameworks it is difficult to fully account for their total cost. Direct costs are spread between several different agencies (property insurance, CTP, workers compensation, etc.) but there are also many indirectly associated costs that are not immediately obvious. Examples of these costs are the extra administration required to deal with a crash and the loss of productivity due to a damaged vehicle or injured worker. Murray et al. (2002, Table 8) presented a list of individual costs (direct and indirect) that may arise as a result of a vehicle crash under the four headings of vehicle costs, driver costs, third party costs, and other costs. A reproduction of that list is shown in Table 2.1.

In the NSW parliamentary report Staysafe 36, Wheatley (1997) estimated that work-related crashes in Australia account for more than half a billion dollars in injury costs and an additional one billion dollars in property damage. Dykes et al. (2001) estimated that the overall cost in the United Kingdom was between 14.5 billion and 18.1 billion pounds. The cost in the United States was estimated by Minahan (1997) to be 54.7 billion dollars.

These direct costs are imposing but it was remarked that indirect costs may be several times larger. Easton (1997) suggested that indirect costs may be 4 to 10 times the amount of direct costs. Similarly, Collingwood (1997) stated that, based on data from the NSW general insurance industry, average direct repair costs range between $1,700 and $2,000 and indirect costs can be 4 or 5 times that amount.

More recently, Davey and Banks (2005) investigated the direct costs of work vehicle incidents (mainly crashes but also includes some non-crash incidents such as theft and storm damage) in a large Australian fleet over the five year period 1999 to 2003. The costs associated with 10,170 incidents were obtained. These costs consisted of mostly property damage claims but some were also further matched to workers compensation and CTP claims where possible; that is, where there was also an injury. For the incidents overall, a mean total cost of $2,281 was found. For the subset where a person was injured the mean total cost was $28,122.

In a separate study, using the same data, Banks and Davey (2005) investigated how the characteristics of injury incidents affected the cost. Male drivers displayed a mean total cost that was double that of female drivers. There was no significant difference in the mean total cost when disaggregated by driver age. There was some suggestion, however, of an imbalance between the property damage costs and injury costs. Younger drivers had a higher mean property damage cost but lower injury cost while the opposite was true for older drivers. The higher injury cost for older drivers may have been due to more severe injuries or more costly loss of time associated with a higher average salary. There were large differences in the mean total cost for incidents involving different vehicle types but these were not statistically significant. Finally, multiple vehicle incidents, such as at roundabouts and failures to give way, were found to have higher mean total costs compared with single vehicle incidents.

Table 2.1
Potential costs associated with work-related road crashes
[reproduced from Murray et al. (2002, Table 8)]

Vehicle costs	**Driver costs**
Recovery and storage	Personal injury compensation
Repair of vehicle	Medical and welfare
Vehicle downtime and replacement vehicle	Counselling
Reduced resale value	Loss of expertise
New vehicle if written off	Lost productivity due to absence
Leased vehicle life costs if written off	Replacement driver/overtime/temporary driver
Increase insurance premiums	Reassessment and training
Third party costs	**Other costs**
Vehicle damage	Redelivery
Vehicle downtime and loss of earnings	Missed/late delivery penalties
Property damage	Customer service/good will/missed sales
Personal injury compensation and rehabilitation	Damaged/lost stock
Hospital fees	Own property damage
Inconvenience	Investigation time
Disbursements including expert witnesses, police reports, post-mortem (if fatal), and GP notes or reports	Management and administration time
	Image/reputation/PR
Legal, court issue setting down and specialist fees	Increased congestion
Fines	Extra tax to cover road safety improvements

2.5 Overview of work-related road fatalities in Australia

Fatal crashes are easily definable and are, in most cases, investigated thoroughly. They are thus useful in presenting a measure of the total crash problem that is consistent and accurate over time.

To investigate work-related fatalities in Australia, Harrison et al. (1989) examined coroners' files from the years 1982 to 1984. Of the 15,462 coroners' files that were the result of traumatic fatalities during the three year period, 1,738 fatalities were classified as being work-related. Over a third of the work-related fatalities were attributed to road trauma. However, it was noted that a large number of road trauma fatalities could not be classified in respect of their work-relatedness due to a lack of information, particularly for cases where a person may have been driving between work and home.

Using the data from the earlier report, and noting the limitations in identification, Harrison et al. (1993) investigated specifically work-related road fatalities in Australia. A total of 600 work-related fatalities that were the result of injuries sustained in road vehicle accidents on public roads were identified. Sixty one per cent occurred in the course of work and the remaining 39 per cent occurred while commuting between home and work.

Using the same methodology of reviewing coroners' files, Driscoll et al. (2001) identified work-related fatalities in Australia for the years 1989 to 1992. Mitchell et al. (2004) then investigated the subset of cases identified by Driscoll et al. (2001) that were work-related road fatalities. In addition to identifying road fatalities as occurring in the course of work and while commuting between home and work, fatalities that occurred to bystanders to work were also identified. A bystander to work was defined as a person who was fatally injured in a vehicle crash as a result of the actions of a person who was working, where the driver of the 'working vehicle' was deemed primarily 'at fault'. 1,680 work-related road fatalities were identified, of which 32 per cent occurred in the course of work, 36 per cent occurred while commuting between home and work, and the remaining 32 per cent occurred to bystanders to work.

Both Harrison et al. (1993) and Mitchell et al. (2004) identified several risk factors relating to work-related road fatalities that occurred in the course of work. The greatest of these were:

- Being male
- Being aged between 25 and 59
- Driving a truck (especially long haul)
- Working in the transport and storage industry

Mitchell et al. (2004) noted that those persons involved in a crash when a bystander was fatally injured were most commonly professional drivers (mainly truck and bus drivers). Mitchell et al. (2004) also highlighted the following features of fatally injured commuters:

- Commonly employed in the wholesale and retail, manufacturing, and community service industries
- Commonly employed within the labourers and related workers or tradespersons occupational groups
- Of those with a known BAC, over 15 per cent had a BAC of 0.05 g/100 mL or greater
- Commonly crashed in the morning between 7 am and 8 am, or in the afternoon between 5 pm and 6 pm

Neither Harrison et al. (1993) nor Mitchell et al. (2004) disaggregated the frequency of working road fatalities by year. However, both Harrison et al. (1989) and Driscoll (2001) identified workplace traffic fatalities and commuting fatalities and disaggregated these by year. Compared with the follow up studies there is a small (< 6%) mismatch between the totals that is likely due to further refinement of the data over time and the exclusion of commuting fatalities that did not involve a vehicle.

Table 2.2 shows the frequency of work-related fatalities in Australia per year based on the Harrison et al. (1989) and Driscoll et al. (2001) studies. Also shown is the breakdown between fatalities that occurred in the course of work and while commuting between work and home as well as the frequency of fatalities as a percentage of all work-related fatalities and as a percentage of all road fatalities. A discussion of the results shown in Table 2.2 is presented in subsection 2.5.3 below.

Driscoll et al. (2005) compared the results from Mitchell et al. (2004) to similar studies from New Zealand and the United States. It was found that Australia may have a higher incidence of work-related road fatalities than New Zealand (e.g. McNoe et al., 2005) and the United States (e.g. Stout et al., 1996; Loomis et al., 1997) but the characteristics of such fatalities were similar in all three countries.

In more recent times work-related road crashes are more likely to be recorded and identified by OHS and workers compensation agencies – although still not by state-wide crash databases other than Queensland which records purpose of journey. Registration data is also more likely to prove useful as vehicles being used for work are required, in some jurisdictions, to be identified as such for tax purposes.

From the financial year 2003/04 onwards (currently up to 2009/10), Safe Work Australia has reported on the number of fatalities that were the result of vehicle incidents (Safe Work Australia, 2012a). Work-related vehicle fatalities were divided into those that occurred in the course of work, those that occurred while commuting between home and work, and those that occurred to bystanders to work. It should be noted that while the majority of fatalities arising from vehicle use are road based the category may also include a small number of air or sea based vehicle incidents. Furthermore, the number of commuting fatalities aggregates all transport types including non-road vehicle transport as well as cycling and walking. However, Safe Work Australia (2012a) reported that over the seven years of data presented all but 20 of the commuting fatalities involved a road vehicle. In addition, of the 45 commuters killed while walking, at least 40 involved being struck by a road vehicle.

Safe Work Australia (2012a) used several data sources to identify work-related vehicle fatalities, including OHS records, the National Data Set for Compensation-based Statistics (NDS), the Notified Fatalities Collection (NFC), and the National Coroners Information System (NCIS). The use of multiple data sources resulted in a more comprehensive list of work-related fatalities. However, due to difficulties in establishing the work-relatedness of road fatalities, Safe Work Australia (2012a) advised that the numbers of identified commuting and bystander fatalities should be regarded as an undercount.

The frequency of work-related vehicle fatalities per financial year (and as an average for all years) is shown in Table 2.3 with a breakdown according to whether the death occurred in the course of work, while commuting between home and work, or whether the death occurred to a bystander to work. The frequency of work-related vehicle fatalities is also shown as a percentage of all work-related fatalities and as a percentage of all road fatalities. A discussion of the results shown in Table 2.3 is presented in subsection 2.5.3 below.

Table 2.2
Work-related road fatalities in Australia per year (1982 – 1984 & 1989 – 1992)

Study	Year	Work-related vehicle fatalities	Breakdown		% of all work-related fatalities	% of all road fatalities[a]
			Working	Commuting		
Harrison et al. (1989)	1982	242	57.4%	42.6%	50.5%	7.4%
	1983	206	59.2%	40.8%	50.6%	7.5%
	1984	186	57.5%	42.5%	47.4%	6.6%
Driscoll et al. (2001)	1989	366	48.4%	51.6%	71.8%	13.1%
	1990	298	47.7%	52.3%	64.6%	12.8%
	1991	264	43.2%	56.8%	62.4%	12.5%
	1992	241	45.6%	54.4%	61.3%	12.2%

[a] number of road fatalities from BITRE (2011)

Table 2.3
Work-related road fatalities in Australia per financial year (2003/04 – 2009/10)

Year	Work-related vehicle fatalities	Breakdown			% of all work-related fatalities	% of all road fatalities[a]
		Working	Commuting	Bystander		
2003/04	213	37%	46%	16%	50.5%	13.3%
2004/05	242	38%	45%	17%	57.9%	15.1%
2005/06	253	36%	50%	14%	54.5%	15.7%
2006/07	255	42%	42%	16%	54.7%	15.9%
2007/08	235	42%	43%	16%	52.6%	15.5%
2008/09	247	39%	51%	10%	53.8%	16.9%
2009/10	195	39%	41%	20%	57.9%	13.7%
Average	235	39%	45%	16%	54.6%	15.2%

[a] number of road fatalities from BITRE (2011)

The work-relatedness of road crashes in France is directly identified in routine crash data. Charbotel et al. (2010) reported on the number of work-related road fatalities in France split by working and commuting for the years 1997 to 2006. Those results are presented in Table 2.4 below for comparison. While it is acknowledged that there may be differences in the French and Australian OHS and road safety frameworks, these results likely provide an indication of what the true situation in Australia may be. That is, commuting fatalities (which are known to be undercounted) more likely represent up to 75 per cent of all work-related road fatalities which in turn represent around 25 per cent of all road fatalities.

Table 2.4
Number of road fatalities (aged 14 – 64) in France by category of journey
[adapted from Charbotel et al. (2010)]

Year	Work-related vehicle fatalities	Breakdown		% of all road fatalities
		Working	Commuting	
1997	1,181	29%	71%	25%
1998	1,280	26%	74%	25%
1999	1,312	27%	73%	27%
2000	1,161	30%	70%	25%
2001	1,182	31%	69%	25%
2002	1,081	28%	72%	24%
2003	864	31%	69%	24%
2004	779	25%	75%	23%
2005	793	25%	75%	25%
2006	672	23%	77%	24%

2.5.1 South Australia

Through personal correspondence with Safe Work Australia, the authors of the present report were able to obtain the number of work-related vehicle fatalities that occurred in South Australia per financial year. This data is shown in Table 2.5.

When comparing the South Australia statistics to those of the whole of Australia there is an obvious discrepancy. The number of work-related road fatalities as a percentage of all work-related fatalities and all road fatalities is significantly lower in South Australia. Safe Work Australia advises that this is likely caused by the difficulty in identifying commuting fatalities in South Australia which are not covered by workers compensation. In contrast, commuting fatalities in NSW and QLD are formally reported to compensation agencies resulting in overall higher national statistics.

With this in mind, there is an average of at least eight work-related road fatalities in South Australia each year, representing 35.3 per cent of all work-related fatalities and 6.2 per cent of all road fatalities.

Table 2.5
Work-related road fatalities in South Australia per financial year reported by Safe Work Australia

Year	Work-related vehicle fatalities	% of all work-related fatalities	% of all road fatalities[a]
2003/04	3	13.6%	2.0%
2004/05	8	38.1%	5.5%
2005/06	8	30.8%	5.5%
2006/07	6	37.5%	5.7%
2007/08	10	47.6%	9.3%
2008/09	6	20.7%	4.7%
2009/10	13	59.1%	11.0%
Average	8	35.3%	6.2%

[a] number of road fatalities from BITRE (2011)

2.5.2 New South Wales

Stuckey et al. (2010) used NSW crash and registration data to identify those fatal crashes occurring in "occupational light vehicles" during 2004 (in NSW it is mandatory to identify work-use in registration records). Organisationally registered vehicles had a fatality rate of 4.5 deaths per 100,000 vehicles, and sole-trader registered vehicles had a fatality rate of 7.2 deaths per 100,000 vehicles. It should be noted that the majority of the fatalities appeared to occur while the worker was commuting. The average fatality rate for vehicles "while at work" was estimated to be 1.12 deaths per 100,000 vehicles, although this was only estimated indirectly. While death rates on occupational light vehicles "while at work" were small compared with those experienced outside of work, an implication of this finding was that fleet-buying decisions affect the safety of workers where employees use fleet managed vehicles for non-work-related (i.e. commuting) travel.

2.5.3 Analysis of the changes in work-related road fatalities over time

Figure 2.1 shows the number of work-related fatalities over time based on the data from the three studies summarised in Tables 2.1 and 2.2. Bystander fatalities for the period 1989 – 1992 were calculated by averaging the total number of bystander fatalities reported by Mitchell et al. (2004). Over the almost 30-year timeframe shown, there are likely to be significant changes in Australian demographics as well as the frameworks governing OHS and road safety. As such, for each yearly period the following rates are also shown (where "working fatality" refers to being killed while driving for work as opposed to commuting to work or as a bystander to work):

- Working fatalities per 5,000 road fatalities – based on BITRE (2011)
- Working fatalities per 10,000 worker fatalities
- Working fatalities per 10 million population – based on ABS (2011b)
- Working fatalities per 1 million workers – based on ABS (2011c)

In the following analysis, period 1 (P1) will refer to 1982 – 1984 investigated by Harrison et al. (1989, 1993), period 2 (P2) will refer to 1989 – 1992 investigated by Driscoll et al. (2001) and Mitchell et al. (2004), and period 3 (P3) will refer to 2003/04 – 2009/10 investigated by Safe Work Australia (2012a). For readability the following definitions will be used:

- The road fatality rate = working fatalities per 5,000 road fatalities
- The worker fatality rate = working fatalities per 10,000 worker fatalities
- The population rate = working fatalities per 10 million population
- The worker rate = working fatalities per 1 million workers

Both P1 and P2 show a decline in the frequency of working and commuting road crashes over time and there is relatively little difference in their worker fatality rate, population rate, or worker rate. There is a marked increase, however, in the road fatality rate (an average of 416 during P1 to an average of 585 during P2). The reason for this increase is likely caused by road fatalities where the work-relatedness could not be established. The prevalence of fatalities with indeterminate work-relatedness for P1 and P2 was 31 per cent and 7 per cent respectively. Driscoll et al., 2002, who conducted a comprehensive comparison of the results from P1 and P2, concluded that this resulted in a substantial underestimation of work-related road deaths during P1.

In light of this, it is suggested that the true road fatality rate during P1 is likely to be similar to that found during P2, with a corresponding increase in the worker fatality rate, the population rate, and the worker rate. These adjustments would align the trends in rates with trends in the general road fatality rate.

Driscoll et al. (2002) also concluded that the reduction in the number of work-related fatalities over P1 and P2 was the result of both a real reduction in risk and changes in industry type distribution (e.g. a reduction in the relative proportion of driving by more risky industries such as agriculture and transport). The reasons for the reduction in work-related fatalities due to road crashes were less clearly related to work factors, but were probably the result of a general decline in overall road fatality risk over the periods.

Compared to P1 and P2, the frequency of work-related road fatalities during P3 was relatively constant over time. The population rate and worker rate were lower, however, and this appears to indicate that there has been a reduction in the relative frequency of working fatalities.

The worker fatality rate during P3 was slightly higher than it was during P2. Given that working road fatalities actually decreased, the increase in the worker fatality rate may have been due to the success of the OHS framework in reducing the number of workplace fatalities in settings other than driving.

During both P2 and P3 the road fatality rate was similar. This suggests that the observed improvements in worker road safety are closely associated with improvements in road safety more generally.

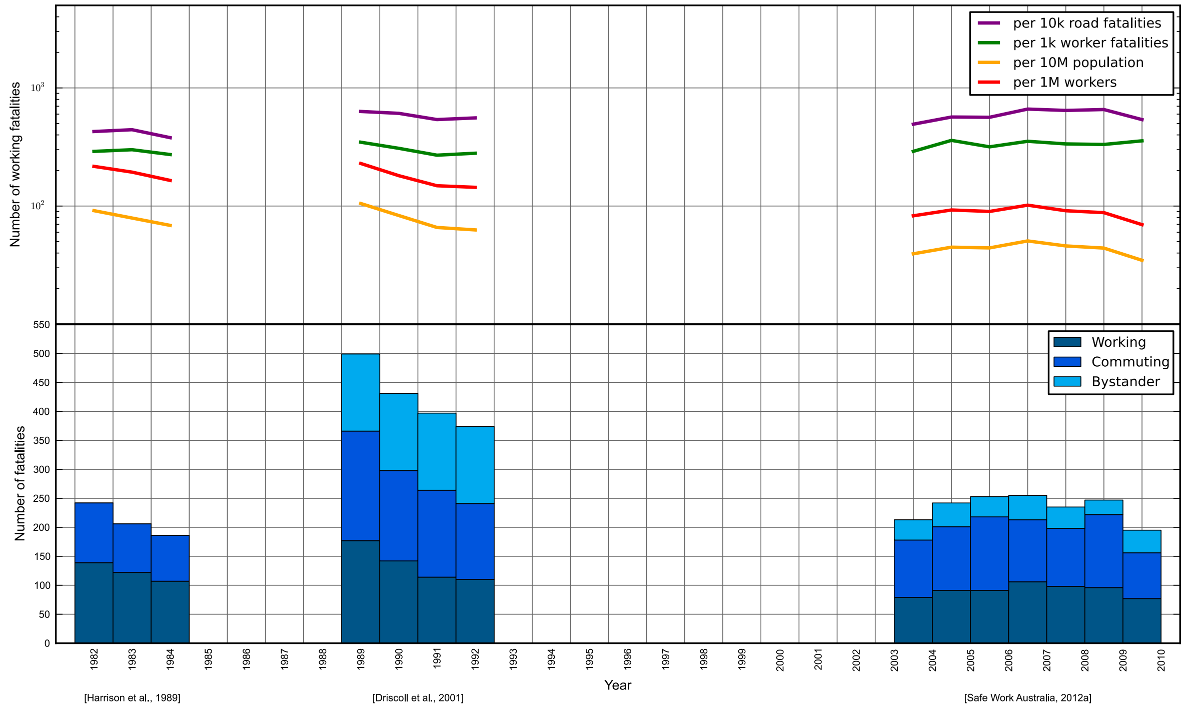

Figure 2.1
Work-related road fatalities in Australia

2.6 The characteristics of work-related road crashes

There has been much research on work-related road crashes in general (rather than only on fatalities) and the characteristics of such crashes. This type of analysis has mainly made use of workers compensation or registration data linked to routine crash data.

An Australian overview of the frequency and characteristics of workers compensation claims arising from vehicle incidents has been previously provided by Safe Work Australia. From the financial year 2003/04 to 2009/10 Safe Work Australia has reported annually on the number of serious claims that were the result of vehicle incidents (Safe Work Australia, 2011, 2012b). A serious claim is defined as an accepted claim involving a death, a permanent incapacity, or a temporary incapacity involving an absence from work of one working week or more but excludes claims which results from journeys to and from work. It should be noted that while the majority of claims arising from vehicle use are road based the category also includes a small number of air or sea based vehicle incidents. In addition to the number of serious claims, the median working time lost and the median compensation payment was also reported.

Table 2.6 shows the characteristics of serious claims resulting from a vehicle incident reported by Safe Work Australia (2011, 2012b). Further road-related incidents are likely listed under the category of being hit by moving objects but it was not possible to determine how many there were. The median working time lost for serious claims resulting from a vehicle incident was consistently longer, by about 1.2 weeks, than the median time lost for all serious claims. Similarly, the median compensation payment for serious claims resulting from a vehicle incident was higher, by about $1,800, than the median payment for all serious claims.

The increase over time in the median compensation payment for serious claims resulting from a vehicle incident is noteworthy, but is probably being affected by external economic factors such as increases in treatment costs.

Table 2.6
Characteristics of serious claims resulting from a vehicle incident reported by Safe Work Australia (2011, 2012b) per financial year

Year	Serious incidents	Percentage of all serious incidents	Median working time lost (weeks)	Median compensation payment ($)
2003/04	2995	2.1%	4.9	6,900
2004/05	3310	2.3%	4.6	6,800
2005/06	3045	2.2%	5.0	7,800
2006/07	3135	2.3%	5.2	9,200
2007/08	3320	2.5%	5.1	9,100
2008/09	3255	2.4%	5.8	10,000
2009/10	2900	2.3%	-	-

The characteristics of work-related road crashes that resulted in a worker's compensation claim were described by Boufous & Williamson (2006). Police casualty crash records were linked with workers compensation data from NSW. There were 13,124 drivers identified who had been injured or killed due to a work-related road crash during the five year period from 1998 to 2002. Univariate analyses were then conducted to explore the characteristics of these drivers and the crashes they were involved in. Almost three quarters of the drivers were commuting at the time of their crash with the remaining crashes occurring while the driver was working (consistent with other reports described above). Commuting crashes resulted in more severe injuries on average compared to crashes that occurred while working. Seventy two per cent of crashes that occurred while working and 56 per cent of commuting crashes involved male drivers. In both journey types males were also over-represented in crashes resulting in more severe injuries.

Drivers aged 25 to 34 had the highest crash involvement regardless of gender or journey type. The prevalence of older male drivers was higher in working crashes compared to commuting crashes, but this was not the case for females who showed a more constant age involvement across journey type. Truck drivers were highlighted as a particular at risk group that represented almost half of all fatalities that occurred due to working crashes.

Boufous and Williamson (2009) also conducted a multivariate analysis of these data to identify those driver/crash factors that contributed to the severity of work-related injury crashes. Logistic regression analyses were carried out for work-related crashes overall and separately for crashes that occurred while commuting and crashes that occurred while working. An increased risk of a high severity injury (permanent disability or death) was found for older drivers (particularly while working), taxi drivers, and drivers who were commuting.

A large study on how crashes involving work vehicles compared to crashes of non-work vehicles was conducted by Symmons and Haworth (2005) using police and registration data that were linked by the NSW Roads and Traffic Authority. Crash details of 396,899 vehicles that crashed between 31 December 1995 and 30 June 2000 were matched to registration data such that they could be classified as either fleet (25%) or non-fleet (75%). When cars were considered alone the crash rate (per 10,000 registered vehicles) was found to be higher for fleet (136.3) than for non-fleet (116.6), although there was no compensation for driving exposure. Univarate analysis revealed statistically significant differences in crash severity, location, speed limit, time of day, day of week, and crash type according to the fleet status of vehicles. However, these differences were found to be relatively small.

Only small differences were found in respect of the demographics of the drivers. Fleet car drivers had a slightly older mean age (42 vs 40 for non-fleet), and were more likely to be male (66% vs 59% for non-fleet).

The crash rate for taxis was found to be around 10 times higher than fleet and non-fleet cars and such crashes mostly occurred within the Sydney metropolitan area, at night, and on weekends. Taxi drivers were also found to be less likely to be wearing a seatbelt at the time of a crash but it was noted that under NSW law taxi drivers are exempted from the mandatory seatbelt wearing requirement.

The higher risk for males, older drivers, truck drivers, taxi drivers, and commuters has also been found overseas, in countries such as France (Charbotel et al., 2010; Hours et al., 2011), Finland (Salminen, 2000), the United Kingdom (Clarke et al., 2005, 2009), and the United States (Pratt, 2003; Chen, 2009).

Risk factors

It has been speculated that the reason work driving has a higher crash rate compared to private driving is because of the time pressures and distractions due to thinking about work. These factors or possibly a disregard for vehicles employees don't own may, in turn, cause reckless driving behaviour such as speeding, using a mobile phone, driving when tired, and poor gap selection. A survey of sales and marketing and construction workers from Finland who drove regularly was conducted by Salminen and Lahdeniemi (2002). Drivers were asked to select the three most important factors (from a list) relevant to both their work and leisure driving. Statistical testing revealed that time pressures, tiredness, thinking about work while driving, and use of mobiles phones were all more common during work driving.

Crashes that involved drivers with an illegal alcohol level, who were speeding, or who were fatigued were studied by Boufous and Williamson (2006) in respect of the work-relatedness of the crash. Symmons and Haworth (2005) also studied such crashes and additionally identified crashes where a driver was not wearing a seatbelt. In general, speeding was the most prevalent crash factor followed by fatigue, driving with an illegal alcohol level, and not wearing a seatbelt. The prevalence of fleet car drivers was lower than that of non-fleet drivers for all four of the identified factors. However, disaggregation by age revealed little difference in the prevalence between fleet and non-fleet drivers in respect of any of these factors, suggesting differences in driver ages in fleet and non-fleet crashes are explanatory. Driving with an illegal alcohol level was more common during commuting, while speeding, and to a lesser extent fatigue, was more common while driving for work. All three of these factors were more prevalent for male drivers.

More detailed analysis of speeding during work driving was provided by Stradling (2001) who conducted a survey of 791 English motorists. It was found that 12 per cent of the sample had been penalised for speeding and that this was strongly correlated with crash involvement. Those who were penalised for speeding were more likely to be:

- Male drivers
- Young drivers
- Drivers of a higher social class or better off
- Drivers who live out of town
- Drivers who drive high mileage
- Drivers of newer and higher powered cars
- Drivers of employer owned cars

- Drivers who only sometimes drive for work

Fatigue and its role in work-related crashes were studied by Carter et al. (2003). It was observed that, for male drivers, as sleep debt increases, so does crash frequency. This was true for working, commuting, or private driving. In Australia, Williamson & Boufous (2007) used a similar data set and methodology to their earlier studies to conclude that fatigue-related crashes occur in similar ways regardless of work status.

While this seems to indicate that fatigue is not a risk factor peculiar to work-related driving, there has been some research focused on the medical industry where workers commonly drive home at late hours or after working long shifts. Barger et al. (2005) conducted a web-based survey of 2,737 residents in their first postgraduate year (interns) in the United States. The survey consisted of questions regarding the number of shifts worked and their duration as well as details of any crashes, near-misses, or incidents of involuntary sleeping. It was found that the odds ratio of having a crash after an extended work shift compared to a non-extended work shift was 2.3.

Similarly, Scott et al. (2007) conducted a daily survey of 895 full-time hospital staff nurses in the United States over the course of four weeks. Survey questions collected information on work hours, sleep duration, drowsy/sleep episodes at work, and drowsy/sleep episodes while driving. Two thirds of the nurses reported at least one episode of drowsy driving. Factors that increased the chances of an episode of drowsy driving were shorter sleep durations, working at night, and incidents of drowsy/sleep episodes at work.

It is possible that other occupations that deal with emergency situations, like police or paramedics, will also experience unexpected extended work shifts. Indeed, even comparatively ordinary occupations may experience extended work shifts from time to time. If not managed correctly such extended work shifts can expose workers to the risks of driving while fatigued.

Driver attitudes

Work drivers are a heterogeneous group who perform many different tasks, in a wide range of industries and have a variety of personalities, attitudes, and performance with regards to safety. Many drivers learn to drive privately and thus form attitudes and behaviours before entering the work force. These attitudes and behaviours are likely to be sustained within work-related driving. Even drivers for companies that have a strong safety culture may regress to less safe personal habits because driving is conducted away from the workplace and is often unsupervised.

It has been noted already that work drivers may experience time pressures, fatigue, or have a disregard for vehicles they do not own. If these factors are combined with an incompatible driving attitude the result may be an increase in crash frequency.

Several Australian studies by Newnam have shed some light on how work driver's attitudes to road safety are formed and influenced. Initially, Newnam et al. (2002) conducted a survey of 204 people who drive for work from four different organisations to compare the factors influencing the safety of work drivers in work and personal vehicles. It was discovered that drivers had a higher crash involvement per kilometre travelled when driving a work vehicle but at the same time were less likely to speed or engage in dangerous driving. Note though that the number of survey participants was small and so the findings should not be regarded as conclusive.

The finding that work drivers are less likely to speed was explored further by Newnam et al. (2004). Reanalysis of the earlier survey data revealed that the "subjective norm" and "anticipation of regret" were both factors that reduced the desire to speed when driving for work. It was suggested that these factors could be encouraged by workplace management to reduce work driver speeding. The results, however, were based on the survey responses of mainly older males with 20 years driving experience and may not be applicable to the broader work driver population.

Newnam et al. (2005a) conducted focus groups of both managers and drivers from eight government agencies in Queensland to obtain qualitative data on the awareness, or attention given to, work-related driving safety as a safety issue; the importance attached to workplace driving in general and some of the meanings attached to workplace driving; and the ways in which managers and drivers talk about workplace driving. The results from the driver focus groups revealed that work-related driving was not readily managed under the OHS framework and that this was known to adversely affect safety while driving. From the manager focus groups there was a similar disconnect between work-related driving safety and OHS. Managers believed that it was not their responsibility to be accountable for unsafe workplace driving and tended to concentrate more on budgetary issues. This had the unfortunate side effect of promoting productivity and tight time constraints over safe driving practices. The overall perception from the study was that there was an inadequate culture of safety within the agencies that were examined but it was unknown if this was indicative of organisations in general.

A complimentary, and more quantitative, study by Newnam et al. (2005b) investigated how the culture of safety within several Queensland government organisations interacts with drivers personal driving attitudes. The concept of a ‘safety climate’ was introduced and defined to consist of two elements; nurturing a safety motivation and raising safety knowledge in employees. The relationship between this safety motivation, safety knowledge, and crash involvement, while compensating for the personal attributes of self-efficacy and attitudes towards traffic safety was then explored. A survey of 385 government drivers was conducted and it was found that motivation to drive safely but not safety knowledge influenced crash involvement. It was also found that safety motivation mediated the link between self-efficacy and attitudes towards traffic safety and crash involvement. These findings suggest that encouraging the intrinsic value of safety (such as by discussing safety and providing feedback on driving performance) over extrinsic motivators (like rewards or punishments) will be more effective in reducing crash involvement. However, once again, this study was only able to consider a small number of participants from only one type of organisation.

In their most recent work, Newnam et al. (2008) build upon the previous study by surveying not only work drivers but also workplace supervisors and fleet managers. Data was collected from 380 drivers and 88 supervisors from Queensland government agencies along with 47 fleet managers from a vehicle leasing agency that is a government provider. When the factors related to the drivers alone were considered, the findings of the previous study were confirmed in terms of the relationship between a driver’s individual safety motivation and their crash involvement. When additional data from the supervisors and fleet managers were incorporated into the analysis it was found that driver’s perceptions of their fleet manager’s safety attitude (but not their supervisor’s), their own attitude, and their own efficacy beliefs predicted motivation to drive safely. A motivation to drive safely was increased further when both the fleet manager and supervisor were perceived to value safety. These findings suggest that attitudes to work-related driving safety are passed down from managers and supervisors who thus have an important role to play in nurturing a culture of safety. The interactions between fleet managers, supervisors, and drivers are not the same in all organisations however. Indeed, some smaller organisations are unlikely to have dedicated fleet managers and it is important to consider this when considering the broader implications of this research.

In the United Kingdom, Darby et al. (2009) examined data collected from a large telecommunications organisation with an online fleet driver assessment program. The online assessment consisted of a series of multiple choice questions designed to measure a driver’s exposure to risk, attitude to safe driving, behavioural responses, knowledge of the road rules, and hazard perception along with details of any recent crash involvement. Over a four year period the assessment was completed by 16,004 registered drivers of cars and light commercial vehicles. The majority of the drivers were male (~93%) and had a mean age of 44. Analysis of the data, using a Poisson regression model, revealed that attitude and behaviour both exhibit a statistically significant association with collision involvement.

It was also found that aggressive personalities were positively associated with crash involvement and it would seem appropriate to limit people with such a personality from driving. However, it was noted by Downs et al. (1999) as well as Lancaster and Ward (2002) that there can be a trade-off between a personality that is likely to be a safe driver and a personality that is likely to perform well at a specific job. For example, somebody who is extroverted and aggressive may make a good salesman but also have an elevated crash risk.

2.7 The work driver effect

It has been shown (in Section 2.3) that work vehicles have a greater driving exposure compared to private vehicles. Moreover, studies described above tend to suggest that work driving is more likely to involve a segment of the population who are at increased risk of crashing due to age and sex factors. However, a series of reports from the Traffic Research Laboratory (TRL) in London (UK) has identified the existence of an increased crash involvement by company car drivers which they have called the "work driver effect".

A survey of a representative sample of car drivers was conducted by Maycock et al. (1991). Drivers were asked questions regarding their demographics, annual distance travelled, and crash history. Based on the returned answers, the average number of crashes per year (as a function of distance travelled) for these ordinary drivers was established. Lynn and Lockwood (1998) conducted a similar survey of company car drivers who drove as a necessary part of their job under the hypothesis that work drivers may have a higher number of crashes per year than ordinary drivers because they usually drive very high annual distances and are often required to drive under the time pressures imposed by tight business schedules. In addition, because the cars they drive are not their own, it is possible that they are less concerned about their cars than drivers of privately owned vehicles.

Australian reports from the Staysafe 36 seminar lend support to this theory. Fatigue and stress from driving was highlighted by Easton (1997) as a common hazard faced by work drivers while Skews (1997) remarked that there was an attitude of “it’s just a company car” among many drivers within Australian companies which resulted in aggressive and careless driving.

When Lynn and Lockwood (1998) compared the results of their survey to those of Maycock et al. (1991) it was found that the company car drivers had about 50 per cent more crashes per year when differences in demographic and exposure variables had been allowed for. This finding suggested the existence of a work driver effect but no specific reasons for the effect could be identified through analysis of any of the collected survey data. However, one possibility that should be considered is a difference in the propensity of drivers to report work crashes and private crashes. Work crashes may be more likely to be reported since work-vehicle damage will be obvious to others and will likely be documented in company records. In comparison, the reporting of a private crash relies completely upon the driver’s memory/honesty. Additionally, since the cost of repairing work-vehicle damage is covered by the company, rather minor crashes that would be ignored by private drivers are more likely to be reported.

Figure 2.2 which is adapted from Lynn and Lockwood (1998, fig 2) shows the number of crashes per year as a function of annual distance travelled for both male ordinary car drivers and male company car drivers. The work driver effect can clearly be seen as a higher crash rate for the company drivers.

The company car drivers were confirmed to drive a greater distance annually. Disaggregation revealed that company car drivers' travel, on average, consisted of around 75 per cent work driving and 25 per cent private driving. The yearly crash rate while driving for work was found to be similar to that while driving for private purposes and the crash rate for both increased with distance travelled although less than linearly. The lower annual distance travelled for private driving but similar crash rate suggests that company car drivers are more at risk during private driving compared to work driving.

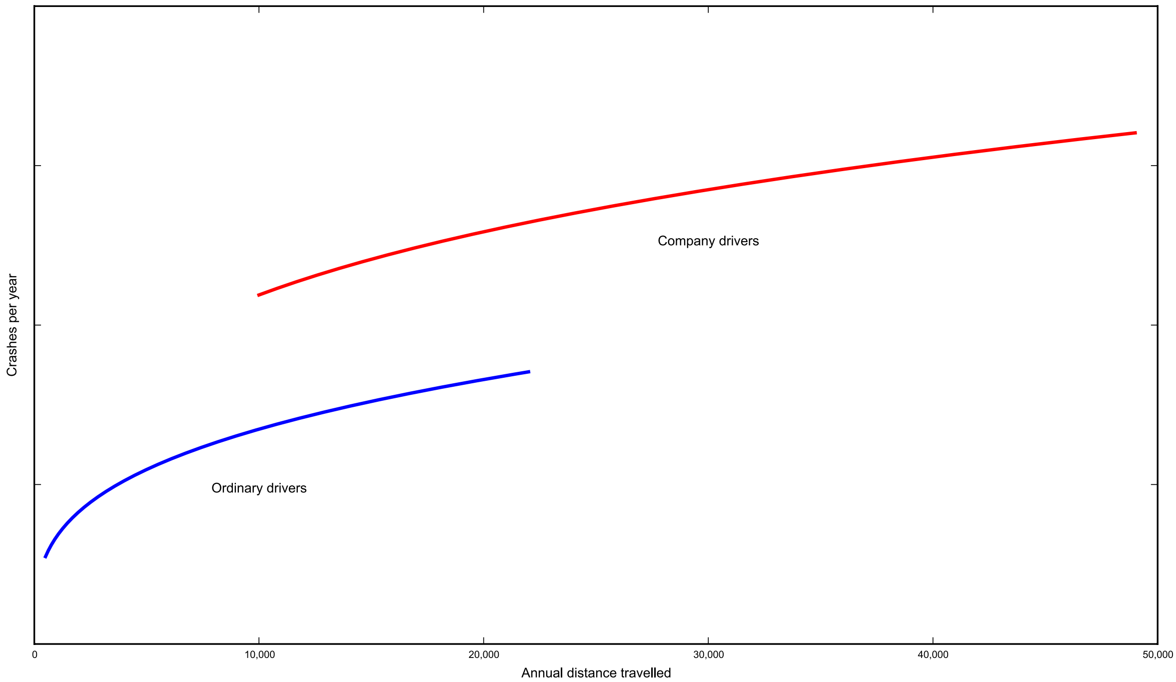

Figure 2.2
Number of crashes per year as a function of annual distance travelled for male ordinary car drivers and male company car drivers [adapted from Lynn and Lockwood (1998)]

The work driver effect was explored further in a follow up study by Downs et al., (1999). Reanalysis of the data revealed that the size of the effect depended on how a work driver was defined. Using a broad definition of 'any driver of a company owned vehicle' produced an effect of 29 per cent. For 'drivers who drove for work regularly' the effect was 40 - 50 per cent.

Of particular interest to Downs et al. (1999) was the non-linear increase in the crash rate and higher than normal crash risk during private driving associated with company car drivers. It was noted that as distance travelled increases the amount of driving on highways increases. The lower crash risk associated with highway driving is likely to be one of the reasons for the non-linear increase in crash rate. It was commented that as distance travelled increases there is also likely to be a change in the distribution of trip frequency, trip duration, road type travelled, and so on. Differences in this distribution for private driving may be the cause of the increased crash risk. Furthermore, it was speculated that workers who spend a large amount of their time driving for work may be more inclined to perform non-work ancillary tasks such as eating, driving, or calling family/friends on a mobile while driving.

Differences in crash rate and distance travelled were also investigated within those classified as work drivers by conducting a survey of drivers from a large company in the United Kingdom (Chapman et al., 2001). The drivers were divided into five groups based on the ownership and type of vehicle most commonly driven, the reasons that the vehicle is supplied to the individual, and the likely journey purpose when the vehicle is used. The groups consisted of one group of drivers who drive their own vehicles, three groups of company car drivers that range from senior managers (who receive a vehicle as part of a remuneration package) to sales staff who drive a pool vehicle, and one group of drivers who drive a liveried company vehicle.

When the results of all the groups combined were analysed, the crash rate was found to be similar to that of the company car drivers in Lynn and Lockwood (1998). However, the yearly crash rate and annual distance travelled of each group varied considerably. Both senior managers and own vehicle drivers had low annual mileages and a higher proportion of driving for private purposes. Despite this similarity, senior managers experienced the highest impact of the work driver effect while drivers of their own vehicles experienced the least. Potential reasons for the different impact of the work driver effect experienced by each different group were suggested, such as time pressures and disregard for company owned vehicles, but none could be directly concluded. One potential consideration that was not mentioned was that the vehicles driven by senior managers are likely to be more expensive and this may, as a consequence, lead to a higher crash reporting rate.

Broughton et al. (2003) noted that the work driver effect identified by Lynn and Lockwood (1998) was likely to be dominated by property damage only crashes and the effect may be different (or disappear) if only injury crashes are considered. To investigate this, another survey was conducted and the characteristics of drivers recently involved in injury crashes (identified using police crash records) were statistically compared to the characteristics of company and ordinary drivers. The aim was to determine which driver type characteristics were over-represented among the injury crash involved drivers.

It was discovered that drivers with high proportions of work-related travel had a much greater risk of being involved in an injury crash than other drivers of the same sex, annual travel, and percentage of distance travelled on highways. Drivers who travelled more than 80 per cent of their annual distance for work-related purposes (23 per cent of the sample) had around 53 per cent more injury crashes. Drivers who travelled 1 – 80 per cent of their annual distance on work-related journeys had around 13 per cent more injury crashes.

Broughton et al. (2003) sought to identify specific causes for the work driver effect by collecting data on the attitudes and behaviours of drivers. However, no direct evidence of drivers' attitudes and behaviours affecting the likelihood of an injury crash could be found. Despite the lack of direct evidence, there were still some indications of an increased crash risk for drivers who drove more than 50 miles after a full day of work, drove under time pressure to reach a destination, or drove while eating, drinking, or talking on a mobile.

The work driver effect has been identified in data several times by multiple studies based in the United Kingdom. Depending on the definition of a work driver, the severity of the crashes considered, and the annual distance travelled, the work driver effect appears to increase crash risk by 13 to 50 per cent. However, caution is required: no conclusive mechanism for this effect has been shown. The effect is likely to be due to the heterogeneous mix of work drivers, types of vehicle, different driving attitudes, and types of journey. Downs et al. (1999) conducted interviews with several feet managers, fleet trainers, fleet drivers, and fleet insurers to gain some insight into what may be cause of the work driver effect and what could be done to reduce it. The responses fell into two main areas of driver attitude/behaviour and company policy. Both these areas have been the subject of research and are discussed in the following Sections.

While no studies of the work driver effect have been conducted in Australia, it may exist to some degree. It is important to remember however, that differences between Australia and the United Kingdom may mean that the size or importance of the work driver effect may also be different.

2.8 Company policy

It has been suggested in the preceding section that work drivers may have a higher than average crash risk. The cause of this potential increased risk is unknown, although several studies have ruled out the possibility that an increased prevalence of risky behaviours like speeding or driving while fatigued are responsible and the absence of known risk factors may be a reason for caution – it is possible that biases in reporting, or confounding may be playing a role in these results. This suggests that the characteristics of work-related crashes are similar to those of non-work crashes but it is possible that work drivers may crash more often for reasons that are too subtle to detect statistically through the methodologies that have been employed to date (although qualitative studies highlight factors such as time pressures, stress, and distraction).

Companies that employ drivers have an obligation under OHS laws to take all reasonable measures to reduce the frequency and severity of work-related crashes as much as possible though their internal operating policies. Such policies should, in theory, be more effective than general road safety policy since they are able to directly engage with the relevant people (the drivers) and present an opportunity to not only reduce work-related crashes but also crashes overall throughout the community.

Examples of, and the spruiking of, company policy solutions (both driver based and vehicle based) appeared as far back as the Staysafe 36 seminar in 1997. Since then, there have also been numerous specific examples of individual company policy reported in literature (Haworth et al., 2000; Tapsas and Harris, 2005; Mooren et al., 2011). However, there is little scientific evaluation of these company policy outcomes. The primary reason for this appears to be that the policies are simply not designed for scientific evaluation. That is, reported successes are lacking in that they do not make use of control groups and do not compensate for factors such as changes in the economy, weather, general road safety, or effects like regression to the mean. Many companies implement a policy and evaluate the short-term effect based only on the change in crash costs. If a decrease in cost is found then that is seen as proof that the policy is working and no further evaluation is made.

Fortunately, some scientific evaluations of specific interventions and policies have been conducted, providing a more evidence based approach to measuring effectiveness. Literature on driver based and vehicle based interventions to improve work-related road safety is presented below followed by some discussion of company safety climate.

2.8.1 Driver based

A driver based intervention is designed to affect the behaviour or attitude of a targeted group of drivers such that their crash risk is reduced. There are many specific types of driver intervention but they usually fall into one of four categories; driver training, driver incentives, group discussions, or monitoring and feedback.

A well-cited study of driver based interventions was conducted by Gregersen et al. (1996). Four groups of approximately 900 professional drivers from a telephone company in Sweden were each assigned a different type of remedial measure. The measures were driver training, group discussions, safe driving campaigns, and bonuses for crash-free driving. A fifth group was assigned no remedial measure to act as a control group. The effectiveness of each measure was calculated by comparing the crash frequency of the associated group before and after the measure was applied. The change in crash cost was also calculated for each measure. Gregersen et al. (1996) found that group discussions, driver training, and bonuses for crash free driving reduced crash frequency, while all the measures reduced crash cost. It was noted however, that the results for these specific remedial measures applied to large groups of professional drivers may not apply for remedial measures in general or for work drivers in general.

In a similar type of study, Salminen (2008) investigated the effectiveness of two types of interventions on groups of drivers from electric companies in Finland. The first intervention was a set of small group discussions applied to a company with 172 drivers. The drivers participated in three meetings in groups of seven to fourteen where they discussed the issues with work-related driving in their company, the potential remedies for those issues, and then made commitments to change their driving behaviour. The second intervention consisted of a one day course in anticipatory driving and was applied to a company of 179 drivers. The interventions were evaluated by comparing the crash frequency during the three years before the intervention to the crash frequency during the three years after while using the number of other occupational incidents as a measure of control. For the company that used group discussions there was a significant decrease in crash frequency while the company that used driving training displayed a non-significant increase in crash frequency.

The effect of installing in-vehicle data recorders and providing workers with feedback based on their driving behaviour was investigated by Wouters & Bos (2000). In-vehicle data recorders were fitted to seven fleets that varied in terms of transport sector type, vehicle type, and traffic circumstances usually encountered. The operators of these fleets were asked to provide feedback to their drivers based on the recorded data. The method of providing feedback and the type of feedback was not directed and left to the fleet operator's discretion. A matched control fleet with similar characteristics was also identified for each of the experimental fleets. This resulted in a total sample of 840 vehicles of which 270 were fitted with data recorders. The observation period represented a total of around 3,100 vehicle years during which there were 1,836 crashes reported. Analysis consisted of comparing crash frequency before and after the intervention. The results showed an average reduction in crash frequency of 20 per cent but this varied considerably across vehicle type and transport sector. Not all of the variance could be accounted for and as such the authors suggested that the results should be viewed with caution.

As part of their investigation of the work driver effect Downs et al. (1999) investigated how several driver based interventions interacted with crash frequency. It was concluded that there was no evidence to show that driver training, incentives, driver monitoring, or reviews/feedback were able to significantly reduce the crash frequency of fleet car drivers.

Based on the review of many specific company policy implementations Haworth et al., 2000 concluded that incentives (not rewards) were the most effective type of intervention. However, this was based on evaluations from 1988 and normative attitudes and behaviours may have evolved since then.

Ludwig and Geller (2000) conducted an analysis of seven driver intervention studies which they published from 1991 to 1999. Each of the studies applied a different type of intervention to pizza delivery drivers in the United States. The drivers were employees of eight pizza stores that were franchisees of three national chains located in four different towns. During each study, trained researchers unobtrusively observed the following three behaviours of the drivers from one or more stores as they entered and exited the store car park:

- Seatbelt use
- Turn signal use
- The propensity to come to a complete stop at an intersection (i.e. exiting onto the main road)

Each study used an intervention to target a specific behaviour (though all three were usually observed) at one or more stores with additional stores used as control sites. The observation of stores as experimental or control sites over the course of the seven studies resulted in 10 years worth of data that enabled a longer term analysis of the intervention effects and their interactions.

The effectiveness of the interventions in each of the studies is shown in Table 2.7 where the mean change in baseline behaviour for each participating store (or group) is presented. The mean change is presented both for while the intervention was in effect and also during a follow up period a few weeks later.

The majority of the interventions produced a positive effect on the targeted behaviour. The size of the effect varied greatly depending on the type of intervention however, as did the effect on non-targeted behaviours. Ludwig and Geller (2000) discussed the implications of each study individually and several factors were noted.

In study 1 the response of individual drivers to the intervention was analysed and the results were rather diverse. Most drivers exhibited various levels of improvement, in line with the overall group, but other drivers became worse or showed no change in behaviour at all. Further to this, in study 2 it was discovered that those drivers with good baseline behaviour had a greater improvement in response to a mandated policy of turn signal use than those drivers with poor baseline behaviour. The opposite was true in study 4 where drivers with poor baseline behaviour had a greater improvement in response to a group discussion about the value of turn signal use that resulted in goal setting with regular feedback on the group's collective performance. However, when the feedback was suddenly changed to also publicly show individual performance, the drivers with good baseline improved dramatically while there was little further improvement from those with a poor baseline.

In study 1 non-targeted behaviour was found to improve but in study 2 it worsened. This was thought to be an effect of 'countercontrol' where drivers who felt that their managers were attempting to control their behaviour opposed the measures in other ways. In addition, study 3 found that goal setting following a group discussion resulted in greater behaviour improvement and better spread of improvements to non-targeted behaviours compared with goal setting following a lecture. When goals were being set, it was shown in study 6 that it was more effective to set incrementally increasing targets to reach a final goal over time rather than simply setting a high initial goal. Even greater effectiveness was shown when both the final goal and incremental targets were set.

When analysing the results from all the studies collectively it was found that drivers from stores which experienced multiple successive interventions showed a stacking effect that improved, or maintained, behaviour levels during each subsequent intervention. In spite of this, maintaining long term improvements in behaviour after the withdrawal of an intervention was considered unlikely. Observation of one site 5 years and 9 months after the last intervention showed that all behaviours had fallen to levels equivalent to, or below, the initial baseline level. It was noted however, that the pizza delivery drivers from a single store turn over almost completely every 4 to 6 months. Thus, after such a long time frame none of the drivers who had experienced an intervention would be expected to still be employed.

Table 2.7
Effectiveness of intervention studies summarised in Ludwig and Geller (2000) [adapted from Table 6]

Study	Explanation of intervention	Store or group	Mean seatbelt use			Mean turn signal use			Mean complete stops at intersection		
			B	I	F	B	I	F	B	I	F
1	Group discussion on the value of seatbelts culminating in a commitment to increase use and the signing of promise cards	A	**41%**	**68%**	**69%**	58%	74%	65%	-	-	-
		B	**14%**	**69%**	**41%**	40%	49%	45%	-	-	-
2	Use of turn signals was mandated as a company policy and reminders were attached to pay-checks	A	78%	65%	79%	**70%**	**78%**	**84%**	-	-	-
		B	74%	59%	70%	**46%**	**51%**	**59%**	-	-	-
3	Group discussion on value of stopping at intersection then selection of specific group goal with weekly feedback provided	A	75%	85%	88%	68%	76%	72%	**54%**	**66%**	**53%**
	Presentation on value of stopping at intersection then assignment of group goal with weekly feedback provided	B	57%	56%	61%	66%	62%	51%	**45%**	**69%**	**42%**
4	Group discussion on the value of turn signal use with agreed group goal set and group feedback provided every 4 days	A	-	-	-	**6%**	**21%**	↓	12%	16%	↓
		B	-	-	-	**33%**	**53%**	↓	30%	35%	↓
	Public individual feedback added	A	-	-	-	**21%**	**32%**	**21%**	16%	18%	21%
		B	-	-	-	**53%**	**59%**	**36%**	35%	48%	36%
5	Best performing individual each week given rewards that were previously chosen by the group	A	64%	57%	52%	**35%**	**58%**	**53%**	35%	29%	49%
		B	59%	73%	86%	25%	29%	12%	**14%**	**31%**	**21%**
6	Private feedback on driver turn signal use provided weekly along with a goal that was either static (A), incremental (B) or both (C)	A	82%	85%	78%	**47%**	**49%**	**57%**	38%	39%	42%
		B	66%	64%	68%	**42%**	**58%**	**53%**	45%	34%	38%
		C	76%	78%	74%	**42%**	**70%**	**44%**	39%	47%	39%
7	Drivers participated in a community seatbelt safety campaign by providing reminder cards to customers when delivering	A	**57%**	**75%**	**74%**	54%	76%	73%	-	-	-

B – Baseline, I – Intervention, F – Follow up, ↓ - Secondary intervention applied immediately following the initial intervention
The targeted behaviour of each study intervention is indicated in bold

2.8.2 Vehicle based

In the past, vehicle based interventions were typically aimed at limiting the severity of a crash by purchasing the most crashworthy vehicles. This usually consisted of purchasing a vehicle as new which would then be sold after two or three years before its capital value dropped significantly and then purchasing a new vehicle. In this way, most work vehicles are no more than a few years old. This has had the effect of ensuring that fleet vehicles have usually had better than average crashworthiness; Newstead et al. (e.g. 2011) have shown consistent improvement in crashworthiness with year.

More recently however, primary safety technologies have been developed that focus on crash prevention using arrays of sensors in systems that actively intervene to prevent a crash from occurring. Because many of these technologies have only recently become available on a narrow range of vehicles, the effect of purchasing work vehicles equipped with such features has seen limited exploration in the literature. There is some evidence for their effectiveness within the context of the general vehicle fleet however. Electronic Stability Control (ESC) is one primary safety technology that has been present for a number of years and has a well-established effectiveness of over 30 per cent in single vehicle crash prevention (Scully and Newstead, 2010). The benefits of ESC were seen to be so critical that the Australian Design Rules (ADRs) were amended such that from November 2013 all new passenger vehicles sold in Australia must be equipped with the technology.

Another technology is Intelligent Speed Adaptation (ISA) which aims to reduce speeding by alerting the driver when they exceed the speed limit or actively preventing the vehicle from doing so. ISA has been shown to have a benefit cost ratio of greater than one and is one of the few safety technologies that are retrofitable (Doecke et al., 2010).

The most recent primary safety technologies are Advanced Driver Assistance Systems (ADAS) that make use of cameras and/or radar to detect the environment around the vehicle. This spatial environment data can then be used to assist the driver in a number of ways including collision avoidance. One example is Autonomous Emergency Braking (AEB) that detects objects in front of the vehicle (i.e. another vehicle or a pedestrian) and applies the brakes at the last moment to avoid a crash. Preliminary research of AEB (also known as frontal collision avoidance technology) has shown promising effectiveness in preventing frontal collisions (Anderson et al., 2012).

Purchasing vehicles that are equipped with primary safety technologies not only improves worker safety but also benefits the general vehicle fleet once the vehicles are sold. Anderson et al. (2010) found that aggressive uptake of new safety technologies by government and private fleets can be effective in increasing the prevalence of those technologies in the overall fleet in the period during which rate of uptake is high.

Even in light of the above Haworth (2004) noted that there are multiple considerations, some of which are conflicting, when developing a vehicle purchasing policy. Two examples of this were given. The first was the consideration of vehicle mass. It has been shown that vehicles with a high mass have a better crashworthiness but also a greater aggressivity (Cameron et al., 1998). Thus there is an ethical paradox of protecting the employees within the vehicle versus protecting the public who may be struck by the vehicle.

The second example consideration was that of mobile phone hands free kits. A recent update in company policy stated that using mobile phones while driving was prohibited and so previously installed hands free kits were to be removed. The drivers were concerned however, that this would also remove the included mobile phone charger. This was considered a safety issue because being able to charge a phone was important on long drives into rural locations where there was the potential to become stranded. Additionally, if an employee was to disobey the mobile phone use policy and make a call while driving then it would be safer to do so with the hands free kit rather than without.

One vehicle purchasing policy that was evaluated was that of the South Australia Department for Transport, Energy and Infrastructure. Leyson (2010) analysed the effect of implementing a policy of mandatory safety features for all new vehicles. From 1 April 2008 all new vehicles were to be equipped with the following safety features:

- Electronic Stability Control
- Anti-lock brakes

- Daytime running lights
- At least a 4-star ANCAP safety rating
- Driver and front passenger airbags
- Cargo barriers for station wagons and hatchbacks

In January 2010, the purchasing policy was updated to include the following safety features as mandatory equipment:

- Traction control
- Non-fitment of hands free kits (accompanied by a policy of not using mobile phones while driving)
- At least a 5-star ANCAP safety rating
- Front side airbags
- Curtain airbags
- Head rests for all positions with front seats fully adjustable

The percentage of crashes involving new vehicles purchased one and two years after the initial policy was implemented was compared to the percentage of crashes by new vehicles purchased one year prior. Leyson (2010) found that for both one and two years after the policy was implemented there was a 20 per cent reduction in the number of crashes involving new vehicles. The total number of crashes was small however, and, in the absence of a control group, a regression to the mean effect cannot be ruled out.

The concept of regular vehicle maintenance and checking was mentioned by some studies but given the low proportion of crashes that are attributed to mechanical failure it is unlikely this would have a significant direct effect on crash frequency. The contribution of such practices to a safety climate may result in significant benefits however, as discussed below.

2.8.3 Safety Climate and Safety Culture

Wishart and Davey (2004) found that there has been a move from single interventions like driver training to the promotion of safety climate as the preferred tool for influencing driver behaviour. This was in agreement with Downs et al. (1999) who suggested that a combination of measures encouraged under a strong culture of safety was most likely to produce an improvement in fleet driver safety.

A description of, and the difference between, an organisation's safety climate and safety culture in the context of work-related road safety was provided by Wills et al. (2004). Safety culture was described as a broad concept that includes organisational behaviours, accidents, injuries, attitudes, beliefs, practices, rules, and actions. It is complex and difficult to quantify as it is neither entirely psychological nor behavioural.

An organisation's safety climate was described as the workers perceptions about safety practices and is psychological in nature. For example, workers' perceptions about how committed managers and supervisors are to driver safety, how well fleet safety policies are communicated to employees, and their workload. In other words, safety climate can be thought of as the psychological manifestation of the safety culture and is far easier to quantify using surveys such as the driver based questionnaire (DBQ) developed by Reason et al. (1990).

The concept of a safety climate was introduced in an earlier section on driver attitudes. It was noted that there was a link between work drivers' attitudes to safety and their manager's attitudes. The concept of a safety culture was demonstrated by Fort et al. (2010) who compared the characteristics of French employees who were involved in a work-related road crash to a control group identified from electoral files through telephone interviews. The details of potential work-related risk factors were compared such as education level, company size, type of work contract, seniority, and working conditions. It was found that, after adjustment for road risk exposure, there were several factors that increased crash risk. These included scheduling issues (i.e. inflexible schedule organisation, lack of consecutive rest-days, and lack of flexibility in performing the work), difficulties of communication with superiors, a low seniority in the activity, low educational level, and physical constraints at work. Beyond these factors an organisation's safety culture also encompasses the implementation of the driver based and vehicle based interventions described earlier.

The implication then is that improvements in safety culture will improve safety climate and lead to safer driving behaviours and less crashes. Some characteristics of the link between safety culture, safety climate, and driver behaviour were revealed by Ludwig and Geller (2000). It was shown that an intervention that was based on group discussions was more effective in improving behaviour than the same intervention if it was mandated. Analysis found that during the discussion the drivers felt like they helped create the intervention and thus were more invested in its success. This desire for the intervention to be successful can be seen as an improvement in the organisations safety climate. The improvement in safety climate (from a discussion based intervention) also caused a more effective spread of improvements to driver behaviours that were not the intended target of the intervention.

Evidence of the link between safety climate and driver behaviour has been shown by Wills et al. (2004) who conducted a questionnaire of 323 drivers from three Queensland based fleets. Questions relating to safety climate, driving behaviour, and crash experience were asked and a significant positive link between safety climate and behaviour was found. A further link showing a relationship with crash experience was not found, but was later shown to exist by Darby et al. (2009) using a larger data set from drivers in the United Kingdom.

Further evidence of the link between safety culture, driver attitudes, and crash frequency was provided by Bomel (2004) through the analysis of questionnaire responses and crash data from seven haulage companies in the United Kingdom. Some link between safety culture and driver attitudes was apparent but varied by company and it was noted that a strong safety culture did not necessarily guarantee positive driver attitudes. Only three companies were able to supply practical crash data for analysis but a modest relationship between driver attitudes and crash frequency was found; the companies with the best driver attitude scores had the lowest crash rate and vice versa. However, as this study had a small sample size, its findings should not be thought of as conclusive.

Despite the evidence that improving safety climate is more effective than single driver or vehicle based interventions, many organisations are wary of doing so. Improving safety climate can be seen as a rather abstract idea that lacks specifics on how it should be implemented, what results can be expected, how results are measured, and the theory on how it achieves these results. This is in contrast to traditional interventions such as driver training where drivers are sent on a course to improve their skills and the theory that better skills equates to less crashes is intuitive (although flawed). Because of this, organisations need guidance to best practice in implementing a safety culture and improving their driver safety climate.

One policy guideline that exists in Australia is ISO39001:2012 - Road Traffic Safety (RTS) Management Systems (ISO, 2012). The International Organization for Standardization (ISO) develop voluntary international standards for products, services and good practice. Crackel and Small (2010), who were part of the development group from over 30 countries, reviewed the standard in draft form prior to its final 2012 release. They remarked that the standard provides guidance to organisations about implementing good road safety practice in the ISO format that they should already be familiar with from implementing other standards. The standard has safe systems at its core and considers all activity areas that play a role in road safety. One of the key actions for the standard is the periodic review and evaluation of performance. This iterative process aims for continuous improvement and the identification of deficiencies.

Another potential policy guide in development is the National Transport Commission's (NTC) national road safety partnership program (National Transport Commission, 2012). The program recognises that corporate Australia has a significant part to play in the road safety framework. As a consequence, the program aims to bring corporate Australia together with the traditional stakeholders of researchers and governments to cooperate on furthering road safety. The intention is that corporate Australia will benefit from a greater transfer of knowledge (for example about what interventions do or do not work) and be involved, to a greater degree, in the process of reducing work-related crashes. While the program is likely to engage with larger corporations initially the dissemination of knowledge should filter down over time to smaller organisations.

Although not strictly a policy guide, a recent publication by Newnam and Watson (2011) presents the development of an intervention framework. In contrast to other approaches that simply promote the improvement of organisational safety climate though any means, their framework focuses on targeted behavioural change through the use of behavioural psychology theories. That is, it considers the theory behind why a particular intervention does or does not work, and how effective it is.

Another aspect of the safety culture framework is that of leveraging corporate social responsibility as a means for promoting safer driving among workers and the community. This concept is often promoted by non-government road safety organisations such as Roadsafe (www.roadsafe.org.au) or Brake (www.brake.org.au) as well as appearing within the National Road Safety Strategy (Australian Transport Council, 2011).

The United Kingdom appears to have one of the more advanced corporate social responsibility frameworks encouraged by the Royal Society for the Prevention of Accidents (RoSPA) and mentioned by Dykes et al. (2001) and Bomel (2004) as a positive influence to work-related road safety that should be encouraged.

2.9 Summary

The topic of work-related road safety is broad and this chapter has covered a lot of ground. Issues with obtaining data on work-related road crashes mean that meaningful research is sometimes difficult but successful linkage of mass data on crashes with non-crash data sets such as workers compensation, registration, coroners' files, and private organisations have enabled progress to be made. Within this research, diverse definitions for what constituted a worker or a work vehicle were used. Definitions varied based on vehicle type, vehicle usage, and vehicle origin.

The high exposure of work-related driving and the costs associated with crashes were highlighted. Work-related driving was found to make up a third of all travel in Australia and up to a half if commuting to and from work is included. Crashes involving work vehicles in Australia collectively account for over a billion dollars in property damage and injury costs. Furthermore, it was noted that there were likely to be many (often undocumented) indirect costs that represented even more significant financial losses.

The numbers of work-related road fatalities over time in Australia were presented. Data as far back as 1982 was available and fatalities were broken down into those that occurred in the course of work, while commuting between home and work, and to bystanders to work. Analysis of the changes over time showed that the number of working driver fatalities has decreased relative to both population and workforce. However, relative to overall road fatalities and overall work-related fatalities the number has remained reasonably constant. This seems to indicate that the burden of work-related road fatalities has changed little over time other than to decrease in line with general road fatalities.

Literature on work-related crashes in general has only been published in relatively recent times. This may be in part due to the lack of relevant data as a consequence of road safety not being a high priority for OHS until recently; this was suggested by Murray et al. (2002) and Lancaster and Ward (2002). A review of the research that has appeared over the last decade showed that the numbers of work-related crashes in general have not changed considerably and that the identified risk factors were similar to those found for fatal work-related crashes, namely:

- Being male
- Being an older driver
- Being a professional driver
- Driving taxis, trucks, or emergency vehicles
- Commuting, especially late night or early morning

Further risk factors that are in common with risks for road crashes in general were also investigated. Speeding, driving while fatigued, driving with an illegal blood alcohol concentration (BAC), and non-seatbelt wearing were all found to have low prevalence among work-related crashes (even less than for crashes in general). This finding, and the fact that the previously mentioned risk factors are all likely to be the result of increased exposure (e.g. work drivers are more likely to be male and older), indicates that work-related crashes are probably characteristically similar to crashes in general.

However, there do appear to be some occupations that carry greater risks for drivers. Interns and nurses were shown to commute late at night or early in the morning after long shifts which increased their risk of fatigue related crashes. Emergency workers who are required to speed and disobey red lights are at a higher risk of crashing. It is also important to note that driving is a dangerous activity and any occupation that requires excessive driving exposes workers to a higher risk of being involved in a crash.

Another cause for concern is the discovery of a so-called work driver effect by researchers in the United Kingdom. They found that company drivers have a crash frequency that is 13 to 50 per cent greater than ordinary drivers with the same annual mileage. Despite several investigations, the reason for the increased crash frequency for company drivers remained unclear. Although it was noted that as company driver annual mileage increased the crash frequency while driving for private purposes increased at a faster rate than while driving for work purposes. Thus, it may be that driving all day for work increases the chances of crashing while driving home. Whether such an effect exists in Australia is unclear.

The literature on interventions aimed at reducing the number and severity of work-related road crashes was then reviewed. There were many examples of company policies implemented but very few had been evaluated in a scientific way. Driver based interventions included group discussions, driver training, incentives for crash free driving, and monitoring driving performance. Group discussions showed good promise while the other types of intervention produced results that were unconvincing. The evidence for vehicle based interventions is strong and there was great potential for crash avoidance demonstrated by new technologies that have recently begun being installed on new vehicles. The concepts of organisational safety culture and safety climate were introduced. Using these concepts to improve driver behaviour is currently viewed as best practice and multiple guides for their use are available or in development.

South Australia

For South Australia specifically there is sparse information on work-related road crashes. Information supplied by Safe Work Australia, which suffers from known undercounting of commuting crashes, showed an average of eight work-related road fatalities per year. This average annual number of work related road crash fatalities accounted for 35 per cent of all work-related fatalities and 6 per cent of all road fatalities. For work-related crashes in general in South Australia, there is no published information.

3 The burden of work-related light vehicle crashes in South Australia

3.1 Introduction

While there has been some estimate of the number of work-related road fatalities in South Australia by Safe Work Australia (see Section 2.5.1), there are several limitations that result in undercounting. Furthermore, there has been no information published on the number of non-fatal work-related crashes within Australia. This chapter aims to address this lack of data covering work-related crashes in South Australia by estimating the burden of light vehicle crashes during the years 2006 to 2010 through several work vehicle identification methods. The characteristics of the identified work vehicles will then be explored.

A work vehicle is defined, in this chapter, as any vehicle that is being used for work purposes. This includes driving for work as well as commuting between work and home (when this can be identified). Additionally, this report considers only light vehicles: cars, station wagons, utilities, 4WDs, and vans. While it is acknowledged that heavy vehicles represent a significant part of the work-related road injury problem, they are assumed to be involved in crashes that are characteristically different to light vehicles. The interventions and countermeasures used to combat heavy work-vehicle crashes are also likely to be different to those used for light work-vehicles. Thus, it is appropriate that light and heavy work-related crashes be considered separately.

3.2 Data

The data sets used in this chapter for the identification of work vehicles and their crash characteristics is described below.

3.2.1 TARS

The Traffic Accident Reporting System (TARS) database is a state-wide database maintained by the South Australian Department of Planning, Transport and Infrastructure (DPTI). The database includes all crashes reported to police subject to the requirements that the vehicle was towed from the scene, that there was more than $3,000 of property damage, or that someone was injured in the crash. For each crash, the TARS database contains details of the crash itself, the units involved, and any resulting casualties. Each crash record also includes a brief description of the crash.

No data is recorded in the TARS database regarding a vehicle’s origin, destination, or trip reason. Whether or not a vehicle was being used for work purposes at the time of being involved in a crash is therefore unknown.

There are several limitations to using police reported crash data, like that found in the TARS database, as discussed in Hutchinson (1987, Chapter 4). However, none of these limitations are likely to affect the analysis presented below in any appreciable way.

3.2.2 Polk

RL Polk Australia (Polk) maintains a historical database of vehicle sales, price, and specifications data. Within this database is a record for each new vehicle sold in Australia. Relevant to this project was that the records contained information on the buyer type and sale date of the vehicles as well as details of any safety features the vehicle was equipped with. Buyer type was listed as one of four general categories; government, fleet, private, and other.

The record for a specific vehicle can be retrieved by supplying that vehicle's unique vehicle identification number (VIN) to Polk. A small fee was charged by Polk for retrieving the data associated with each VIN.

3.2.3 WorkCover

De-identified WorkCover injury claims data for the period 2002 to 2011 were supplied by SafeWork SA. Each claim specified the date and time of the injury and contained detailed information on the worker's injuries such as the agency of injury, the nature of injury, the mechanism of injury, and the primary bodily location affected. Also contained in the claim data was the age and gender of the worker and general details about the worker's employer. However, the claims data contained no information on the geographic location of the injury incident; likely due to an assumption that all work-related injuries occur at the work place.

3.2.4 Registration

The South Australian Department for Planning, Transport, and Infrastructure (DPTI) keep records of all South Australian vehicle registrations. A vehicle that is used for business purposes (including government and non-profit) is entitled to an Input Tax Credit (ITC). The status of a vehicle's ITC entitlement is recorded at the time of registration with DPTI. The ITC entitlement status for a specific vehicle on a given date can be retrieved by supplying that vehicle's unique vehicle identification number (VIN) and registration number.

3.3 Light vehicle crashes in South Australia

Analysis of the TARS database revealed that there were 29,172 crashes involving 48,884 light vehicles during the five year period of 2006 to 2010. As mentioned, whether or not these light vehicles were operating as a work vehicle at the time of their crash is not a variable that is recorded in the TARS database.

Consequently, three separate methods were used to identify those light vehicles that were operating as a work vehicle when involved in a crash. Each of the methods made use of one of the additional data sets described above. The first used Polk records to identify vehicles that were bought by fleet operators three years or less prior to being involved in a serious or fatal crash. The second used WorkCover injury claims data to identify the vehicles of which an injured worker was an occupant when involved in a crash. The third method used registration data to identify vehicles that were registered as a work vehicle for tax purposes when involved in a crash.

Each of the methods is explained in the subsections below and an analysis of the vehicles identified by each method, and the crashes they were involved in, is conducted. A consideration of all the analyses together in terms of the burden of work-related crash in South Australia is then presented in a final discussion subsection.

3.4 Fleet vehicles identified using Polk data

3.4.1 Method

A VIN was available for 41,581 of the light vehicles that were involved in crashes during the period 2006 to 2010. Due to the cost involved in obtaining Polk data however, only those vehicles involved in crashes that resulted in fatal injuries or injuries requiring admission to hospital (referred to henceforth as fatal and serious crashes) were sought. There were 4,952 such vehicles and their VINs were sent to Polk for matching. Over 85 per cent of the VINs were successfully matched and the Polk data associated with 4,227 vehicles was obtained. Unsuccessful matches were made primarily when the year of the manufacture of vehicle in question predated 1993, as Polk do not have records for vehicles prior to this date.

Based on the Polk data, the buyer type and date of sale for each of the 4,227 vehicles was known. From the investigation of a large fleet (see Chapter 4) it was noted that fleet vehicles were usually sold on to the public three years after purchase. Thus, for the current analysis, a vehicle was defined as operating as part of a fleet if it was bought by a government or fleet buyer and involved in a crash within three years of being purchased.

It should be noted that some fleet vehicles may be sold earlier or later than three years after purchase. Vehicles that were sold to a private buyer earlier that three years and subsequently were involved in a fatal or serious crash within the three years would thus be incorrectly identified, and some work vehicles still in service after three years would similarly have been missed. It was assumed that error in the analysis of the crash numbers is acceptably low.

3.4.2 Results

Using the method described, 295 light vehicles were identified as operating as part of a fleet when involved in a fatal or serious crash. The remaining 3,932 vehicles were classified as non-fleet. To aid in comparison with the fleet vehicles, the subset of the non-fleet vehicles that were three years old or newer were also identified; there were 421 such vehicles.

Vehicle characteristics

The frequency of the vehicle types involved in serious or fatal crashes is shown in Table 3.1. Utility and taxi type vehicles were more prominent within the fleet vehicles compared to either of the non-fleet groups. Car type vehicles were the most common type across all the groups, regardless of fleet status.

Table 3.2 shows the prevalence of various safety features fitted to the vehicles. The prevalence is split into the proportion of vehicles that are fitted (FIT) and not fitted (NF) with each safety feature, as well as those that had fitment as an optional extra (OPT). Note that uptake of optional safety features is often generally low. The prevalence of ANCAP rated 3-star, 4-star, and 5-star vehicles in each group is also shown. Note that the star rating was not known for every vehicle in each group and the percentages presented are based on the 182 fleet vehicles, 1,051 non-fleet vehicles, and 278 non-fleet vehicles three years old or newer with a known star rating.

The majority of fleet vehicles were fitted with ABS and a driver airbag but few were fitted with ESC and front curtain airbags. The prevalence of all the safety features was higher in fleet vehicles compared to the non-fleet vehicles, but approximately equivalent to the non-fleet vehicles that were three years old or newer. One exception was a slightly higher prevalence of front curtain airbags fitted to non-fleet vehicles three years old or newer. This is likely to be because of the higher prevalence of car type vehicles in the non-fleet group which, compared to utilities and vans, are more likely to be fitted with front curtain airbags. Indeed, further investigation found that none of the seven vans or 71 utilities were fitted with front curtain airbags.

Given the differences in the ANCAP star ratings and the prevalence of safety features it is clear that the fleet vehicles as a group were safer than the non-fleet vehicles but approximately equivalent to the non-fleet vehicles three years old or newer.

Table 3.1
Frequency of light vehicles types involved in a serious or fatal crash, disaggregated by fleet status

Vehicle type	Fleet		Non-fleet		Non-fleet (3 years or newer)	
	Number	Percentage	Number	Percentage	Number	Percentage
Car	137	46.4%	2,815	71.6%	309	73.4%
Station wagon	55	18.6%	684	17.4%	78	18.5%
Van	7	2.4%	41	1.0%	4	1.0%
Utility	71	24.1%	349	8.9%	27	6.4%
Taxi	25	8.5%	43	1.1%	3	0.7%
Total	295	100.0%	3,932	100.0%	421	100.0%

Table 3.2
Prevalence of safety features fitted to light vehicles involved in a serious or fatal crash, disaggregated by fleet status

Safety feature	Fleet			Non-fleet			Non-fleet (3 years or newer)		
	NF	OPT	FIT	NF	OPT	FIT	NF	OPT	FIT
ESC	73%	4%	23%	94%	1%	4%	66%	11%	23%
ABS	7%	15%	78%	34%	29%	37%	6%	19%	75%
Traction control	55%	11%	34%	83%	6%	12%	58%	11%	32%
Driver airbag	1%	4%	95%	20%	19%	61%	1%	1%	98%
Front side airbags	37%	31%	32%	79%	11%	11%	39%	28%	33%
Front curtain airbags	75%	11%	14%	93%	3%	4%	59%	18%	22%
	3-star	4-star	5-star	3-star	4-star	5-star	3-star	4-star	5-star
Star rating	10%	71%	15%	33%	55%	6%	14%	68%	16%

Descriptive statistics

The characteristics of the serious and fatal crashes involving light vehicles were analysed. Table 3.3 shows the frequency of various crash characteristics for the fleet and non-fleet vehicle groups. There were large differences in the relative prevalence of the various crash types between each vehicle group. For example, the most common crash type within the fleet vehicle group was right angle but within the non-fleet groups the most common type was hit fixed object crashes. Hit fixed object type crashes were less common within the fleet vehicle group than within the newer non-fleet group; conversely right angle type crashes were more common within the fleet group, although both proportions were non-significant (2-tailed probability for a difference in the proportion). Further comparison between these two vehicle groups found that the fleet vehicles were:

- More likely to be involved in crashes on 50 – 60 km/h roads (NS)
- More likely to be involved in crashes during work hours on a week day (NS)
- Less likely to be driven by an old driver (S)
- Less likely to be driven by a young driver (NS)
- More likely to be driven by a male (S)

In addition, compared with non-fleet vehicles of all ages the fleet vehicles were less likely to be involved in fatal (NS) and single vehicle (S) crashes.

Table 3.3
Frequency of crash characteristics for light vehicles involved in a serious or fatal crash, disaggregated by fleet status

Crash characteristic	Fleet		Non-fleet		Non-fleet (3 years or newer)	
	N	%	N	%	N	%
Type						
Head on	30	10.2	287	7.3	37	8.8
Hit animal	-	-	16	0.4	1	0.2
Hit fixed object	41	13.9	895	22.8	80	19.0
Hit object on road	-	-	3	0.1	-	-
Hit parked vehicle	3	1.0	80	2.0	3	0.7
Hit pedestrian	31	10.5	320	8.1	41	9.7
Left road – out of ctrl	4	1.4	29	0.7	5	1.2
Rear end	56	19.0	576	14.6	77	18.3
Right angle	69	23.4	813	20.7	75	17.8
Right turn	29	9.8	415	10.6	51	12.1
Roll over	14	4.7	268	6.8	22	5.2
Side swipe	14	4.7	214	5.4	28	6.7
Other	4	1.4	16	0.4	1	0.2
Severity						
Hospital admission	276	93.6	3,580	91.0	394	93.6
Fatal	19	6.4	352	9.0	27	6.4
No. of vehicles						
Two or more	187	63.4	2,245	57.1	258	61.3
One	108	36.6	1,690	42.9	163	38.7
Location						
City	189	64.1	2,412	61.3	279	66.3
Rural	106	35.9	1,520	38.7	142	33.7
Speed limit (km/h)						
50 - 60	190	64.8	2,285	58.7	252	60.7
70 - 110	103	35.2	1,605	41.3	163	39.3
Time of day						
8am – 5pm	164	55.6	1,744	44.4	209	49.6
6 – 8am or 5 – 7pm	75	25.4	1,168	29.7	128	30.4
7pm – 6am	56	19.0	1,020	25.9	84	20.0
Day of week						
Weekday	227	76.9	2,775	70.6	307	72.9
Weekend	68	23.1	1,157	29.4	114	27.1
Driver age						
25 – 65	239	82.1	2,438	62.8	290	69.4
< 25	41	14.1	1,026	26.4	73	17.5
> 65	11	3.8	418	10.8	55	13.2
Driver sex						
Male	205	69.5	2,264	57.9	196	46.8
Female	90	30.5	1,644	42.1	223	53.2

Analysis of injury severity and responsibility in multiple vehicle crashes is shown in Table 3.4. The number of crashes that involved multiple vehicles is shown for each crash type. Two characteristics of multiple vehicles crashes are then presented. The first is the number and percentage of multiple vehicle crashes in which an occupant of a fleet vehicle was one of the most severely injured casualties. The second characteristic is the number and percentage of multiple vehicle crashes in which a fleet vehicle driver was deemed to be responsible for the crash. In each column of the table the number of fatal crashes for each crash type is shown in parenthesis.

Fleet vehicles were involved in 187 multiple vehicle fatal and serious crashes. This represents 63 per cent of the total number of fleet vehicle crashes identified in TARS.

In only 32 per cent of the multiple vehicle crashes was an occupant of a fleet vehicle one of the most severely injured casualties. This is probably due to the fact that, on average, fleet vehicles would be newer than the cars that they hit. Differences in vehicle age have been shown previously to be predictive of differences in injury severity in two vehicle crashes (Anderson and Hutchinson, 2010).

In 40 per cent of the multiple vehicle crashes a fleet vehicle driver was deemed to be responsible for the crash. The asymmetry in responsibility tends to indicate that drivers of fleet vehicles are less risky than the average driver.

Table 3.4
Injury propensity for fleet vehicle occupants and responsibility of fleet vehicle drivers during multiple vehicle crashes

Crash type	No. of multiple vehicle crashes [fatal]	Fleet vehicle occupant was one of the most injured casualties [fatal]		Fleet vehicle driver was deemed to be responsible party [fatal]	
Rear end	52	16	30.8%	20	38.5%
Right turn	26 [3]	7	26.9%	10 [1]	38.5%
Right angle	59 [4]	19 [1]	32.2%	28 [2]	47.5%
Side swipe	13	5	38.5%	7	53.8%
Head on	29 [1]	11	37.9%	7 [1]	24.1%
Hit pedestrian	4 [1]	-	0.0%	1	25.0%
Hit fixed object	3	2	66.7%	2	66.7%
Roll over	1	-	0.0%	-	0.0%
Hit parked vehicle	-	-	-	-	-
Hit animal	-	-	-	-	-
Hit object on road	-	-	-	-	-
Left road - out of ctrl	-	-	-	-	-
Other	-	-	-	-	-
Total	187 [9]	60 [1]	32.1%	75 [4]	40.1%

Regression analysis

In order to determine the individual effect that each crash characteristic has upon the likelihood of a fleet vehicle crash, a logistic regression was applied to the data for all crashes involving vehicles three years old or newer. Table 3.5 shows the results of this analysis where the dependant variable was fleet status.

Examination of the logistic regression analysis results revealed that crashes involving fleet vehicles were more likely to:

- Occur in 50 – 60 km/h speed zones compared with 70 – 110 km/h speed zones
- Involve drivers of a working age compared with older drivers
- Involve male drivers compared with female drivers
- Occur during working hours compared with commuting hours

Table 3.5
Coefficients of variables predicting fleet vehicle involvement in fatal and serious crashes, based on data for all light vehicles 3 years old or newer

	B	SE B	Exp (B)	Exp (B) 95% CI
No. of vehicles				
Two or more	-			
One	-0.077	0.174	0.926	0.659 – 1.302
Location				
City	-			
Rural	0.340	0.208	1.406	0.936 – 2.111
Speed limit (km/h)				
50 - 60	-			
70 - 110	-0.446*	0.205	0.640	0.428 – 0.958
Driver age				
25 – 65	-			
< 25	-0.304	0.230	0.738	0.470 – 1.157
> 65	-1.490**	0.315	0.225	0.121 – 0.418
Driver sex				
Male	-			
Female	-1.122**	0.169	0.325	0.234 – 0.453
Time of day				
9am – 4pm	-			
6 – 8am or 5 – 7pm	-0.379*	0.191	0.684	0.471 – 0.995
8pm – 5am	-0.255	0.229	0.775	0.495 – 1.214
Day of week				
Weekday	-			
Weekend	-0.313	0.191	0.731	0.503 – 1.063
Severity				
Hospital admission	-			
Fatal	0.018	0.332	1.018	0.531 – 1.952
Constant	0.600*	0.173	1.821	

* $p < 0.05$, ** $p < 0.001$

Crash rate analysis

Since there was no direct measure of driving exposure for any of the vehicles an induced exposure method was used to compare the crash rate of the identified fleet vehicles with that of the non-fleet vehicles three years old or newer. A full explanation of the method is given by Evans (1986, 1998), but for use in the current circumstances involves finding a crash type that is unaffected by vehicle safety features or driver behaviour to act as a measure of exposure. The measure of exposure used here was being stuck from behind in a rear end crash which is, in most cases, independent of vehicle safety features or driver characteristics.

In order to investigate further, the ratio of fleet to non-fleet vehicles within the registered South Australian fleet was sought. A study by Anderson (2012) identified all light vehicles registered in the South Australian fleet in mid-April 2010. Polk purchasing data was obtained for a representative sample of those vehicles. Within that sample, 149 fleet and 232 non-fleet (three years or newer) vehicles were identified using the same criteria as earlier.

Table 3.6 shows that the ratio of exposure crashes (struck from behind in a rear end crash) to registrations within the representative sample for each vehicle group is approximately equal. This indicates that, compared with fleet vehicles, non-fleet vehicles were driven an approximately equivalent amount and that there is probably, therefore, little difference in the distance travelled by the vehicles in each group.

The measure of exposure is not perfect however, as there may be differences in the way that the fleet and non-fleet vehicles are driven which could affect their chance of being struck from behind in a rear end crash. For example, if one group of vehicles was driven more at night when there is less traffic then their chance of being struck from behind in a rear end crash would be reduced. To overcome such possible confounding effects, the vehicle groups were restricted to those that crashed between 6am and 7pm on a weekday and were being driven by a person below the age of 65. These restrictions were considered to produce a sample that was most relevant to work vehicle driving while also being sensitive to the chosen measure of exposure.

Table 3.7 shows the results of the induced exposure analysis. A further potential confounding effect could arise if one group of vehicles was driven more in rural locations so the crash count and exposure count for each vehicle group is shown both for South Australia overall and for the Adelaide metropolitan area. The fleet vehicle group crash rate ratio compared to non-fleet vehicle (3 years or newer) group is also shown.

Neither of the observed differences in crash rate was significant but there was some small indication that fleet vehicles had a higher crash rate compared to non-fleet vehicles three years old or newer.

Table 3.6
Ratio of number of exposure crashes to the number of registrations within a representative sample

Group	Exposure crashes	Registrations	Ratio
Non-fleet (3 yrs or newer)	55	232	0.24
Fleet	36	149	0.24

Table 3.7
Crash rate comparison of the identified fleet and non-fleet (3 years old or newer) vehicles that were involved in fatal or serious crashes (between 6am and 7pm on a weekday, and being driven by a person below the age of 65) using induced exposure with rear end struck as the measure of exposure

Group	All crashes	Exposure crashes	Crash rate	Crash rate ratio (CRR)
South Australia				
Non-fleet (3 yrs or newer)	206	39	5.28	
Fleet	174	31	5.61	1.06
Adelaide				
Non-fleet (3 yrs or newer)	151	37	4.08	
Fleet	107	26	4.12	1.01

3.5 Work vehicles identified using WorkCover injury claims data

3.5.1 Method

All active claims (i.e. those that had been accepted as legitimate) with a mechanism of injury listed as 'vehicle accident' during the years 2006 - 2010 were extracted from the supplied WorkCover data. This resulted in a sample of 2,637 claims, from which those that were the result of a crash on a public road involving a light vehicle driven by a worker were identified.

In order to achieve this, the corresponding TARS crash record for each WorkCover injury claim was sought by attempting to match data common to both the claim and the crash record. Four common variables were used (see Table 3.8). Additionally, each claim contained the worker's description of the injury incident and the crash records contained a police reported crash description. These descriptions often included information that could be useful in matching such as details of a specific location or a particular series of events.

Table 3.8
Data common to WorkCover injury claims and TARS crash records

Variable	WorkCover	TARS
Date	Date of incident	Date of crash
Time	Time of incident	Time of crash
Gender	Worker gender	Driver or casualty gender
Age	Worker age	Driver or casualty age

It was assumed that for a legitimate match between a WorkCover injury claim and TARS crash record, the date and gender variables would correspond exactly. The time and age variables however might not be consistent, but should still be similar – within a few hours or years respectively.

For each injury claim, all crashes occurring on the corresponding date involving a light vehicle with a driver or casualty of the corresponding gender were extracted from the TARS database. The extracted crash records were then individually reviewed by hand to identify a valid match to the injury claim (if possible). The review process consisted of looking for crashes with a consistent or similar time and age and examination of the injury incident description and crash description for commonalities.

Many of the claims were unable to be matched to a crash record. Sometimes this was because the injury claim was for an incident that was not on a public road; that was not severe enough for the police to record; or the worker was not an occupant of a light vehicle. Other times it was because there was not enough information in the injury claim to distinguish between several possible crashes.

3.5.2 Results

There were 806 light vehicles identified as operating as a work vehicle at the time of their crash using the method described above. Despite each vehicle being identified as the result of a WorkCover injury claim, there were 315 vehicles that did not have any casualty listed on their corresponding TARS record. This is probably the result of workers who did not realise that they were injured until some time after the crash.

Vehicle characteristics

Table 3.9 shows the number of each type of work vehicle identified. For comparison purposes, the subgroup of 491 work vehicles that did have a casualty listed in their corresponding TARS record and all non-work light vehicles (involved in casualty crashes over the same period) were used. Just over half of the work vehicles were cars but significant numbers of utilities, station wagons, and vans were also present. The non-work vehicles contained a greater proportion of cars and lower proportions of utilities, station wagons and vans.

In Figure 3.1 the proportion of ages for each of the vehicle groups is shown. The work vehicles contained a large proportion of vehicles aged 0 to 4 years. Within that range the work vehicles with listed casualties appeared to contain vehicles that were slightly older. Beyond four years the proportion of work vehicles reduced steadily with increasing age. In contrast, the non-work vehicles had a low proportion of vehicles aged 0 to 4, a relatively even spread of vehicles aged 5 to 13, and a gradual decline in proportion thereafter. The average age of the vehicles was 4.9 years for both the work vehicle groups and 11.3 for the non-work vehicle group.

A valid VIN was available for 784 of the work vehicles and 474 of those work vehicles with a listed casualty. The associated Polk data for each VIN was obtained and the prevalence of safety features fitted to the work vehicles was examined as shown in Table 3.10. Also shown is the prevalence of 3-star, 4-star, and 5-star ratings for the 386 work vehicles and 244 work vehicles with a listed casualty that had an ANCAP star rating. Apart from a driver airbag, the fitment of safety features was generally poor throughout the identified work vehicles. The majority of the vehicles with a known rating were 4-star with only 7 per cent achieving the maximum 5-star rating. It was interesting to note that those work vehicles with a listed casualty were less likely to be fitted with safety features and had a lower ANCAP star rating.

Table 3.9
Frequency of light vehicle types

Vehicle type	Work vehicles		Work vehicles with casualties		Non-work vehicles with casualties	
	Number	Percentage	Number	Percentage	Number	Percentage
Car	432	53.6%	251	51.1%	20,263	77.8%
Station wagon	130	16.1%	85	17.3%	3,764	14.5%
Van	94	11.7%	56	11.4%	460	1.8%
Utility	144	17.9%	94	19.1%	1,358	5.2%
Taxi	6	0.7%	5	1.0%	191	0.7%
Total	806	100.0%	491	100.0%	26,036	100.0%

Table 3.10
Prevalence of safety features

Safety feature	Work vehicles			Work vehicles with casualties		
	Not fitted	Optional	Fitted	Not fitted	Optional	Fitted
ESC	82%	3%	15%	84%	2%	14%
ABS	21%	29%	50%	21%	31%	48%
Traction control	70%	9%	21%	74%	7%	19%
Driver airbag	13%	13%	74%	14%	12%	73%
Front side airbags	60%	25%	15%	63%	24%	13%
Front curtain airbags	83%	11%	6%	83%	11%	6%
	3-star	4-star	5-star	3-star	4-star	5-star
Star rating	18%	74%	7%	19%	68%	5%

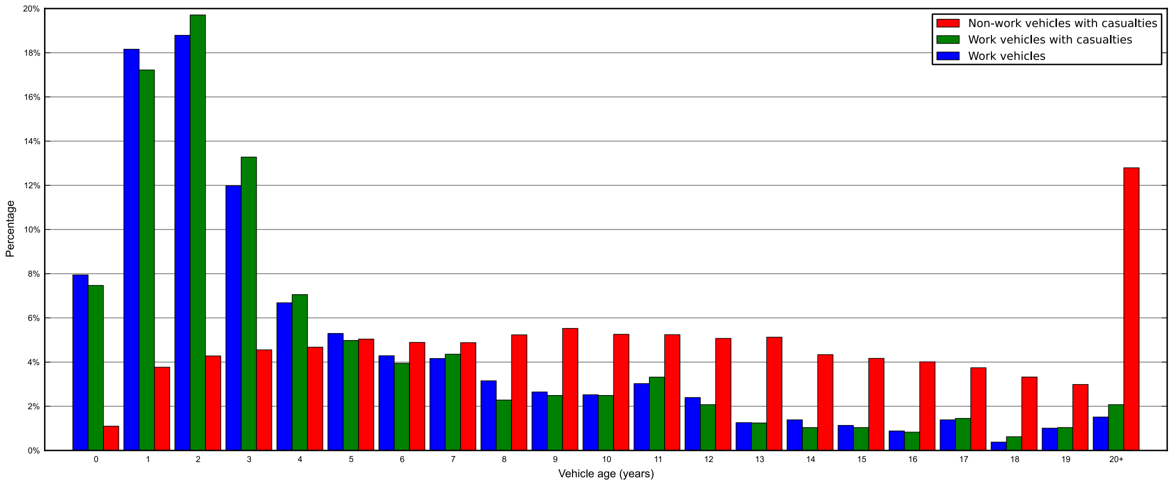

Figure 3.1
Proportions of vehicle ages

Descriptive statistics

Analysis of the crash characteristics for the work and non-work vehicles is shown in Table 3.11. The most common crash types involving the work vehicles were rear end, right angle, hit fixed object, and right turn. The same was true for the non-work vehicles, although in slightly different proportions.

The crash characteristics of the work vehicle with listed casualties were compared to both all identified work vehicles and non-work vehicles with listed casualties. Compared to the work vehicles overall, those work vehicles with a listed casualty were:

- More likely to be involved in single vehicle crashes (NS)
- More likely to be involved in crashes in a rural location (NS)
- More likely to be involved in crashes in a 70 – 110 km/h speed zone (NS)
- More likely to be involved in head on, hit fixed object, or roll over type crashes (NS)

Comparisons between the crash characteristics of the work vehicles with a listed casualty and the non-work vehicles with casualties were then made. Compared to the non-work vehicles with casualties those work vehicles with a listed casualty were:

- More likely to be involved in multiple vehicle crashes (S)
- More likely to be involved in crashes in a rural location (S)
- More likely to be involved in crashes in a 70 – 110 km/h speed zone (S)
- More likely to be involved in crashes during the day time hours (S)
- More likely to be involved in crashes during the working hours (S)
- More likely to be involved in crashes on a week day (S)
- More likely to be driven by people aged 25 – 65 (S)
- More likely to be driven by males (S)

It has been suggested that minor crashes by work vehicles may be over-reported. To investigate this suggestion, the difference in the crash severity of the work and non-work vehicles with listed casualties was investigated further. Crashes were separated into minor (doctor or hospital treatment) and major (hospital admission or fatal) severities and the ratio between the two was calculated. Non-work vehicles were found to have been involved in 5.5 minor severity crashes per major severity crash while work vehicles were involved in 4.4 minor crashes per major crash. This result implies that the work vehicles with a listed casualty were, in fact, less likely to have reported a minor severity crash compared with the non-work vehicles. Noting that the two vehicle groups may be driven in different ways the analysis was repeated with the vehicle sample restricted in the same way as in the crash rate analysis of the previous section (i.e. vehicles involved in crashes between 6am and 7pm on a weekday while being driven by a person younger than 65). After this restriction the results showed that non-work vehicles were involved in 8.5 minor crashes per major crash and the work vehicles were involved in 4.9 minor crashes per major crash. The implied propensity for non-work vehicles to report a minor crash is thus even greater.

The work vehicles were involved in 663 multiple vehicle crashes. In Table 3.12, the injury outcome for work vehicle occupants and the crash responsibility of work vehicle drivers during these multiple vehicle crashes is explored. In 90 per cent of the multiple vehicle crashes an occupant of a work vehicle was one of the most injured casualties. It should be kept in mind that only crashes that resulted in a worker submitting a WorkCover injury claim were identified and crashes involving work vehicles where a worker was uninjured have not been identified, and hence there is an obvious selection bias affecting this result. It has been reported in Table 3.12 only for the sake of completeness. In 29 per cent of multiple vehicle crashes the driver of a work vehicle was deemed to be responsible for the crash. The crash responsibility of work vehicle drivers was highest in head on, right turn, and right angle crashes (although still less than 50%) and lowest in rear end crashes.

Table 3.11
Frequency of crash characteristics for work identified light vehicles and all light vehicles (2006-2010)

Crash characteristic	Work vehicles		Work vehicles with casualties		Non-work vehicles with casualties	
	N	%	N	%	N	%
Type						
Head on	37	4.6%	30	6.2%	918	3.5%
Hit animal	3	0.4%	1	0.2%	106	0.4%
Hit fixed object	70	8.7%	45	9.2%	4,600	17.7%
Hit object on road	3	0.4%	1	0.2%	55	0.2%
Hit parked vehicle	14	1.7%	6	1.2%	648	2.5%
Hit pedestrian	-	-	-	-	36	0.1%
Left road – out of ctrl	4	0.5%	2	0.4%	181	0.7%
Rear end	343	42.6%	182	37.1%	9,209	35.4%
Right angle	157	19.5%	103	21.0%	4,860	18.7%
Right turn	67	8.3%	40	8.1%	2,857	11.0%
Roll over	52	6.5%	43	8.8%	1,233	4.7%
Side swipe	55	6.8%	37	7.5%	1,256	4.8%
Other	1	0.1%	1	0.2%	77	0.3%
Severity						
Property damage only*	257	31.9%	-	-	-	-
Private doctor	178	22.1%	166	33.8%	8,280	31.8%
Hospital treatment	270	33.5%	234	47.7%	13,752	52.8%
Hospital admission	97	12.0%	87	17.7%	3,586	13.8%
Fatal	4	0.5%	4	0.8%	418	1.6%
No. of vehicles						
Two or more	663	82.3%	394	80.2%	19,252	73.9%
One	143	17.7%	97	19.8%	6,784	26.1%
Location						
City	604	74.9%	353	71.9%	20,198	77.6%
Rural	202	25.1%	138	28.1%	5,838	22.4%
Speed limit (km/h)						
50 - 60	533	67.0%	304	62.8%	18,031	70.0%
70 - 110	262	33.0%	180	37.2%	7,716	30.0%
Time of day						
8am – 5pm	591	73.3%	356	72.5%	12,879	49.5%
6 – 8am or 5 – 7pm	179	22.2%	111	22.6%	8,689	33.4%
7pm – 6am	36	4.5%	24	4.9%	4,468	17.2%
Day of week						
Weekday	762	94.5%	462	94.1%	19,753	75.9%
Weekend	44	5.5%	29	5.9%	6,283	24.1%
Driver age						
25 – 65	674	83.8%	405	82.8%	16,331	63.2%
< 25	124	15.4%	79	16.2%	7,196	27.9%
> 65	6	0.7%	5	1.0%	2,294	8.9%
Driver sex						
Male	475	58.9%	288	58.7%	12,616	48.5%
Female	331	41.1%	203	41.3%	13,374	51.5%

* No casualty recorded in the TARS database but crash resulted in a WorkCover injury claim

Table 3.12
Injury propensity for work vehicle occupants and responsibility of work vehicle drivers during multiple vehicle crashes

Crash type	No. of multiple vehicle crashes	Work vehicle occupant was one of the most injured casualties in multiple vehicle crash		Work vehicle driver was deemed to be responsible party in multiple vehicle crash	
Rear end	342	310	90.6%	75	21.9%
Right turn	67	58	86.6%	25	37.3%
Right angle	157	144	91.7%	56	35.7%
Side swipe	55	51	92.7%	17	30.9%
Head on	37	32	86.5%	18	48.6%
Hit pedestrian	-	-	-	-	-
Hit fixed object	3	3	100.0%	1	33.3%
Roll over	2	1	50.0%	1	50.0%
Hit parked vehicle	-	-	-	-	-
Hit animal	-	-	-	-	-
Hit object on road	-	-	-	-	-
Left road - out of ctrl	-	-	-	-	-
Other	-	-	-	-	-
Total	663	599	90.3%	193	29.1%

Regression analysis

A logistic regression was applied to the data for all crashes involving light vehicles with a listed casualty as shown in Table 3.13 where the dependant variable was work status. Through examination of the results it was found that crashes involving work vehicles were more likely to:

- Involve multiple vehicles compared with only a single vehicle
- Occur in a rural location compared with a city location
- Occur in 70 – 110 km/h speed zones compared with 50 – 60 km/h speed zones
- Involve drivers of a working age compared with older or younger drivers
- Involve male drivers compared with female drivers
- Occur during working hours compared with commuting or night time hours
- Occur on week days compared with the weekend
- Result in low severity injuries compared with high severity injuries

Table 3.13
Coefficients of variables predicting work vehicle involvement in crashes, based on data for all light vehicles that have a listed casualty

	B	SE B	Exp (B)	Exp (B) 95% CI
No. of vehicles				
Two or more	-			
One	-0.267*	0.132	0.765	0.591 – 0.992
Location				
City	-			
Rural	0.325*	0.130	1.384	1.074 – 1.784
Speed limit (km/h)				
50 - 60	-			
70 - 110	0.273*	0.114	1.314	1.051 – 1.643
Driver age				
25 – 65	-			
< 25	-0.624**	0.126	0.536	0.419 – 0.686
> 65	-2.524**	0.383	0.080	0.038 – 0.170
Driver sex				
Male	-			
Female	-0.597**	0.094	0.550	0.457 – 0.662
Time of day				
9am – 4pm	-			
6 – 8am or 5 – 7pm	-0.913**	0.110	0.401	0.323 – 0.498
8pm – 5am	-1.615**	0.218	0.199	0.130 – 0.305
Day of week				
Weekday	-			
Weekend	-1.648**	0.193	0.192	0.132 – 0.281
Severity				
Low	-			
High	0.332*	0.128	1.393	1.084 – 1.790
Constant	-2.970**	0.083	0.051	

* $p < 0.05$, ** $p < 0.001$

Crash rate analysis

As in the previous section, an induced exposure method (with rear end stuck as the measure of exposure) was used to compare the crash rate of the identified work vehicles to the crash rate of the non-work vehicle fleet. The analysis was again restricted to crashes between 6am and 7pm on weekdays involving a driver younger than 65 and applied to both all crashes in South Australia as well as only those that occurred in the greater Adelaide metropolitan area.

To enable a more appropriate evaluation, the work vehicles with listed casualties were compared to the non-work vehicles with listed casualties. However, there was a significant difference in the vehicle age profiles for each group that would likely have an effect on crash rate for reasons such as the introduction of more effective safety features over time. We wished to identify non-vehicle related differences in rates and so an adjustment was made: this difference in vehicle ages was taken into account by weighting the non-work vehicle crashes by the age profile of the work vehicles with a listed casualty (see Figure 3.1). That is, crashes by non-work vehicles of an age that is more common within the work vehicles are given more weight and vice versa. Table 3.14 shows the results of the induced exposure analysis.

The results are statistically significant and show that the crash involvement of work vehicles is greater than that of non-work vehicles. For the whole of South Australia, the crash risk for work vehicles was found to be greater by 30 per cent. When restricted to crashes within the Adelaide metropolitan area the crash risk was found to be greater by 20 per cent.

To investigate further, the crash rate comparison within Adelaide was disaggregated by crash type as shown in Table 3.15. For each crash type, the number of work crashes was compared to the expected number of work crashes to determine the crash rate ratio and chi-squared result (X^2). The expected number of work crashes was calculated as shown in the equation below, where N_{nw} is the number of non-work vehicle crashes, E_w is the number of work vehicle exposure crashes, and E_{nw} is the number of non-work exposure crashes. The disaggregated results revealed a statistically significant overrepresentation of work vehicles in right angle and side swipe crashes.

$$Expected\ work\ crashes = N_{nw} \cdot \frac{E_w}{E_{nw}}$$

The crash characteristics of the 70 right angle and 30 side swipe crashes involving work vehicles were reanalysed but no common indication for their overrepresentation was identified.

It was noted that a possible explanation for the overrepresentation of work vehicles may be a difference in levels of occupancy. If work vehicles have, on average, a greater number of occupants than non-work vehicles then the opportunity for injuries is likewise greater. However, investigation of this possibility revealed that the average occupancy (occupants per vehicle) of work vehicles was in fact lower than that of non-work vehicles (1.30 vs 1.44).

Another possible explanation was the over-reporting of work vehicle crashes but such an effect was shown to be unlikely in the analysis of the descriptive statistics above.

Given the lack of other possible explanations, it therefore appears that work vehicles are associated with a genuine increase in crash risk. Some caution is still advised, however, due to the previously mentioned uncertainties about the appropriateness of the induced exposure method. Indeed, the fact that rear end crashes, which would be the most sensitive to the induced exposure method, were not found to have a higher work vehicle crash risk may be evidence of this.

Table 3.14
Crash rate comparison of the identified work and non-work vehicles that had a listed casualty (between 6am and 7pm on a weekday, and being driven by a person below the age of 65) using induced exposure with rear end struck as the measure of exposure

Group	Crash count	Exposure count	Crash rate	Crash rate ratio (CRR)
South Australia				
Non-work (weighted)	654.98	273.89	2.39	
Work	428	138	3.10	1.30**
Adelaide				
Non-work (weighted)	553.37	263.56	2.10	
Work	313	124	2.52	1.20*

* p < 0.05, ** p < 0.001

Table 3.15
Crash rate comparison of the identified work and non-work vehicles with a listed casualty that crashed in the greater Adelaide metropolitan area, disaggregated by crash type

Crash type	Number	Expected	CRR	X^2
Rear end	155	148.01	1.05	0.33
Right turn	32	27.91	1.15	0.60
Right angle	70	45.43	1.54	13.28**
Side swipe	30	14.41	2.08	16.86**
Head on	9	5.18	1.74	2.82
Hit pedestrian	-	0.37	-	^
Hit fixed object	13	14.44	0.90	0.14
Roll over	1	0.90	1.11	^
Hit parked vehicle	2	2.81	0.71	^
Hit animal	1	0.01	70.85	^
Hit object on road	-	0.13	-	^
Left road - out of ctrl	-	0.15	-	^
Other	-	0.59	-	^
Total	313	260.35	1.20	10.65*

* $p < 0.05$, ** $p < 0.001$, ^ expected value too small to calculate X^2

3.6 Work vehicles identified using registration data

3.6.1 Method

VIN and registration data was available for 41,533 of the light vehicles involved in casualty crashes during the period 2006 to 2010. The details for those vehicles were sent to DPTI and the ITC entitlement status of 37,366 light vehicles was obtained; for 3,580 of the vehicles no match for the VIN and registration number could be found and the remaining 587 were not registered on the crash date.

It was assumed that any ITC entitled vehicle was being used for work at the time of the crash. However, this definition is limited in that many ITC entitled vehicles are owned by private buyers who drive them for both work purposes and private purposes. It was not possible to determine whether a crash involved ITC entitled vehicle was driving for work or private purposes. As such, vehicles identified with this method will be defined simply as 'ITC entitled' vehicles.

3.6.2 Results

Of the 37,366 vehicles with known ITC entitlement data, 5,900 had an entitlement and were defined as ITC entitled vehicles. The remaining 31,466 vehicles without an ITC entitlement were defined as ITC non-entitled vehicles and used for comparison.

Vehicle characteristics

The proportion of each light vehicle type in the two groups is shown in Table 3.16. Cars were the most prevalent type for the ITC entitled vehicles, followed by a significant proportion of utilities, station wagons, and vans. For the ITC non-entitled vehicles the prevalence of cars was greater with a corresponding reduction in the proportion of other vehicle types. Figure 3.2 shows the proportion of vehicle ages (at time of crash) for the ITC entitled vehicles and for the ITC non-entitled vehicles. Vehicles aged 1 to 2 years old were the most prevalent in the ITC entitled vehicles group. Beyond that age the proportion of vehicles declined steadily. For the ITC non-entitled vehicles, the prevalence of vehicles initially increased with age to a maximum at around nine years old and then declined thereafter. The average age of the ITC entitled and ITC non-entitled vehicles was 5.8 years and 10.0 years respectively.

Table 3.16
Frequency of light vehicles types, disaggregated by ITC entitlement status

Vehicle type	ITC entitled vehicles		ITC non-entitled vehicles	
	Number	Percentage	Number	Percentage
Car	2,553	43.3%	25,160	80.0%
Station wagon	1,230	25.1%	4,880	15.5%
Van	756	12.8%	246	0.8%
Utility	1,360	23.1%	1,180	3.8%
Taxi	1	0.0%	-	-
Total	5,900	100.0%	31,466	100.0%

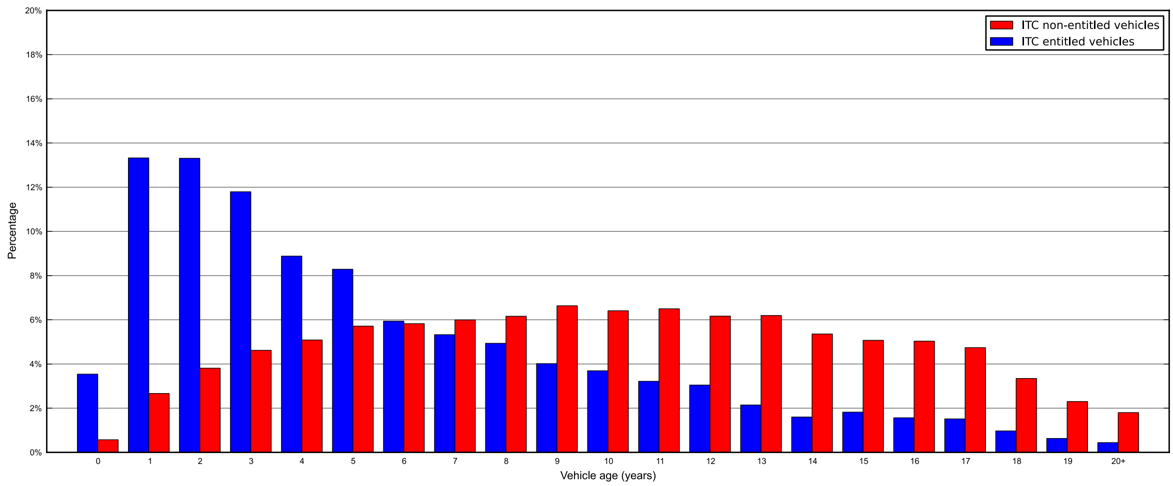

Figure 3.2
Breakdown of vehicle age for the ITC entitled and ITC non-entitled vehicles

Descriptive statistics

Table 3.17 shows the crash characteristics of the vehicles with a known ITC entitlement status. For both groups the most common crash type was rear end followed by right angle, and right turn. The vehicles with an ITC entitlement showed a higher prevalence of right turn and hit fixed object crashes, and a lower prevalence of rear end and side swipe type crashes compared to the vehicles without an ITC entitlement. Further comparison of the two vehicle groups found that those vehicles with a ITC entitlement were:

- More likely to be involved in lower severity crashes (NS)
- More likely to be involved in crashes in a rural location (S)
- Less likely to be involved in crashes during night time hours (S)
- More likely to be involved in crashes on weekdays (S)
- Less likely to be driven by younger or older drivers (S)
- More likely to be driven by a male (S)

As in the previous section, the ratio of minor to major severity crashes for the ITC entitled and ITC non-entitled vehicles was compared. When all vehicles with a known entitlement were considered there was little difference in the number of minor crashes per major crash (7.5 for ITC entitled and 7.4 for ITC non-entitled). When the vehicles were restricted to those that crashed between 6am and 7pm on a weekday while being driven by a person younger than 65, the ITC entitled vehicles were involved in 9.4 minor crashes per major crashes while the ITC non-entitled vehicles had a slightly higher rate of 10.6. This result further refutes the theory that there is an over-reporting of minor crashes by work vehicles.

Table 3.17
Frequency of crash characteristics for light vehicles with known ITC entitlement status

Crash characteristic	ITC entitled vehicles		ITC non-entitled vehicles	
	N	%	N	%
Type				
Head on	209	3.5%	920	2.9%
Hit animal	12	0.2%	73	0.2%
Hit fixed object	394	6.7%	2,990	9.5%
Hit object on road	6	0.1%	36	0.1%
Hit parked vehicle	62	1.1%	502	1.6%
Hit pedestrian	228	3.9%	965	3.1%
Left road – out of ctrl	20	0.3%	116	0.4%
Rear end	2,658	45.1%	13,199	41.9%
Right angle	1,144	19.4%	6,430	20.4%
Right turn	573	9.7%	3,630	11.6%
Roll over	164	2.8%	724	2.3%
Side swipe	415	7.0%	1,803	5.7%
Other	15	0.3%	65	0.2%
Severity				
Private doctor	2,383	40.4%	11,706	37.2%
Hospital treatment	2,821	47.8%	16,029	50.9%
Hospital admission	633	10.7%	3,396	15.8%
Fatal	63	1.1%	335	1.1%
No. of vehicles				
Two or more	4,780	81.0%	25,118	79.8%
One	1,120	19.0%	6,348	20.2%
Location				
City	4,836	82.0%	26,754	85.0%
Rural	1,064	18.0%	4,712	15.0%
Speed limit (km/h)				
50 - 60	4,372	75.1%	23,907	77.0%
70 - 110	1,448	24.9%	7,144	23.0%
Time of day				
8am – 5pm	3,293	55.8%	15,915	50.6%
6 – 8am or 5 – 7pm	2,107	35.7%	11,462	36.4%
7pm – 6am	500	8.5%	4,089	13.0%
Day of week				
Weekday	4,954	84.0%	24,594	78.2%
Weekend	946	16.0%	6,872	21.8%
Driver age				
25 – 65	4,550	80.2%	19,603	63.9%
< 25	884	15.6%	8,306	27.1%
> 65	242	4.3%	2,774	9.0%
Driver sex				
Male	4,067	69.2%	15,389	49.1%
Female	1,808	30.8%	15,979	50.9%

The ITC entitled vehicles were involved in 4,780 multiple vehicle crashes. Table 3.18 explores the injury outcome for occupants and the crash responsibility of drivers during these multiple vehicle crashes. In 46 per cent an occupant of an ITC entitled vehicle was one of the most injured casualties and in 51 per cent a driver of an ITC entitled vehicle was deemed to be responsible for the crash. The probability that an occupant of the ITC entitled vehicle was one of the most injured casualties was greater than 50 per cent in multiple vehicle head on and right angle crashes. Multiple vehicle right angle and side swipe crashes had a higher than 50 per cent chance of being caused by an ITC entitled vehicle driver.

Table 3.18
Injury propensity for ITC entitled vehicle occupants and responsibility of ITC entitled vehicle drivers during multiple vehicle crashes

Crash type	No. of multiple vehicle crashes	An ITC entitled work vehicle occupant was one of the most injured casualties in multiple vehicle crash		An ITC entitled work vehicle driver was deemed to be responsible party in multiple vehicle crash	
Rear end	2,635	1,202	45.6%	1,312	49.8%
Right turn	529	221	41.8%	235	44.4%
Right angle	1,014	506	49.9%	572	56.4%
Side swipe	356	155	43.5%	186	52.2%
Head on	208	116	55.8%	104	50.0%
Hit pedestrian	7	-	0.0%	2	28.6%
Hit fixed object	23	13	56.5%	9	39.1%
Roll over	4	1	25.0%	2	50.0%
Hit parked vehicle	-	-	-	-	-
Hit animal	1	-	0.0%	-	0.0%
Hit object on road	-	-	-	-	-
Left road - out of ctrl	-	-	-	-	-
Other	3	-	0.0%	1	33.3%
Total	4,780	2,214	46.3%	2,423	50.7%

Regression analysis

A logistic regression was applied to all the vehicles with a known ITC entitlement status with the dependent variable being ITC status. Analysis of the results, shown in Table 3.19, revealed that crashes involving ITC entitled vehicles were more likely to:

- Occur in a rural location compared with a city location
- Involve drivers of a working age compared with older or younger drivers
- Involve male drivers compared with female drivers
- Occur during working hours compared with commuting or night time hours
- Occur on week days compared with the weekend

Table 3.19
Coefficients of variables predicting ITC entitled vehicle involvement in crashes, based on data for all light vehicles that have a known ITC entitlement

	B	SE B	Exp (B)	Exp (B) 95% CI
No. of vehicles				
Two or more	-			
One	-0.040	0.040	0.961	0.888 – 1.038
Location				
City	-			
Rural	0.337**	0.044	1.401	1.284 – 1.528
Speed limit (km/h)				
50 - 60	-			
70 - 110	0.016	0.038	1.016	0.944 – 1.094
Driver age				
25 – 65	-			
< 25	-0.746**	0.040	0.474	0.439 – 0.513
> 65	-0.756**	0.053	0.471	0.424 – 0.522
Driver sex				
Male	-			
Female	-0.931**	0.031	0.394	0.371 – 0.419
Time of day				
9am – 4pm	-			
6 – 8am or 5 – 7pm	-0.161**	0.032	0.852	0.801 – 0.906
8pm – 5am	-0.527**	0.054	0.590	0.531 – 0.656
Day of week				
Weekday	-			
Weekend	-0.408**	0.039	0.665	0.616 – 0.719
Severity				
Low	-			
High	-0.042	0.047	0.958	0.873 – 1.052
Constant	-0.929**	0.027	0.395	

* $p < 0.05$, ** $p < 0.001$

Crash rate analysis

As in Sections 3.4 and 3.5, an induced exposure method (with rear end struck as the measure of exposure) was used to compare the crash rate of the ITC entitled and ITC non-entitled vehicles (that crashed between 6am and 7pm on a weekday while being driven by a person below 65) within both the whole of South Australia and just the greater Adelaide metropolitan area. As in the previous section, the age profiles of the two vehicle groups were significantly different and so crashes involving the ITC non-entitled vehicles were weighted by the ITC entitled vehicles age profile (see Figure 3.2). The results of the induced exposure analysis are show in Table 3.20.

A statistically significant overrepresentation of ITC entitled vehicles was found for both the whole of South Australia and also for just the greater Adelaide metropolitan area. Compared to ITC non-entitled vehicles, the crash risk for ITC entitled vehicles was 11 per cent greater within the whole of South Australia and 8 per cent greater within Adelaide.

Further analysis of the difference in crash rate for crashes within Adelaide was conducted by disaggregating by crash type as shown in Table 3.21. A statistically significant higher crash risk for ITC entitled vehicles was found for rear end, side swipe, hit pedestrian, and hit parked vehicle crashes while a lower risk was found for hit fixed object crashes.

The legitimacy of these results was tested, as in the previous section, though investigation of the differences in the average occupancy for the ITC entitled and ITC non-entitled vehicles. The ITC entitled vehicles were found to have an average occupancy of 1.29 compared with 1.27 for the ITC non-entitled vehicles. While this difference could result in an increased injury risk for ITC entitled vehicles, it is unlikely to fully explain the findings presented here.

In the absence of other possible explanations these results suggest an increased crash risk for ITC entitled vehicles. Although, once again, it is important to keep in mind the potential shortcomings of the induced exposure method.

Table 3.20
Crash rate comparison of the ITC entitled and non-entitled vehicles (between 6am and 7pm on a weekday, and being driven by a person below the age of 65) using induced exposure with rear end struck as the measure of exposure

Group	Crash count	Exposure count	Crash rate	Crash rate ratio (CRR)
South Australia				
Non-ITC entitled (weighted)	890.61	297.99	2.99	
ITC entitled	4,091	1,230	3.33	1.11**
Adelaide				
Non-ITC entitled (weighted)	793.85	287.55	2.76	
ITC entitled	3,441	1,154	2.98	1.08**

* $p < 0.05$, ** $p < 0.001$

Table 3.21
Crash rate comparison of the ITC entitled and non-entitled vehicles that crashed in the greater Adelaide metropolitan area, disaggregated by crash type

Crash type	Number	Expected	CRR	X^2
Rear end	1,909	1,752.61	1.09	13.95**
Right turn	365	353.93	1.03	0.35
Right angle	590	600.02	0.98	0.17
Side swipe	269	197.29	1.36	26.07**
Head on	57	51.85	1.10	0.51
Hit pedestrian	129	91.54	1.41	15.33**
Hit fixed object	70	99.25	0.71	8.62*
Roll over	8	7.34	1.09	0.06
Hit parked vehicle	34	23.00	1.48	5.27*
Hit animal	1	0.44	2.27	^
Hit object on road	2	1.28	1.56	^
Left road - out of ctrl	1	1.44	0.69	^
Other	6	5.90	1.02	0.00
Total	3,441	3,185.89	1.08	20.43**

* $p < 0.05$, ** $p < 0.001$, ^ expected value too small to calculate X^2

3.7 Summary of results

Three methods have been presented for identifying light vehicles that were being used for work when involved in a crash on a public road. Using Polk data, 295 fleet vehicles that were involved in fatal or serious crashes were identified. WorkCover injury claims data was used to identify 806 vehicles of which a claimant was an occupant when involved in a crash. Another 5,900 possible work vehicles that were involved in crashes were identified based on a positive ITC entitlement contained within registration data.

Each of the methods has distinct advantages and disadvantages when compared to the other two. Using the Polk data, fleet vehicles were specifically identified but only when involved in fatal or serious crashes. The Polk identified vehicles were compared to all other passenger vehicles that were involved in fatal and serious crashes.

The WorkCover injury claims data identified all light vehicles where a working occupant was injured as a result of a crash. However, crashes involving work vehicles where a worker was uninjured or not entitled to submit a claim were not identified. Additionally, there were a significant number of claims that did not have a listed injury within the TARS database. The WorkCover identified vehicles that had a listed casualty in their TARS record were compared with all other light vehicles with a TARS listed casualty.

A large number of possible work vehicles were identified as having an ITC entitlement recorded in registration data. It was unknown however, whether these vehicles were being used for work or private purposes at the time of their crash. The positive ITC vehicles were compared to the ITC non-entitled vehicles.

There was some overlap between the vehicles which were identified by the three methods. This overlap is displayed in the Venn diagram shown in Figure 3.3 below. Given that all three of the methods were attempting to identify vehicles being used for work, the small amount of overlap is surprising. It further highlights however, that each method identified a slightly different set of vehicles that would have otherwise been missed by the other methods. Thus, despite their individual deficiencies, when the results of the three methods are considered together they combine to present a more comprehensive overall picture of the burden of work-related light vehicle crashes in South Australia.

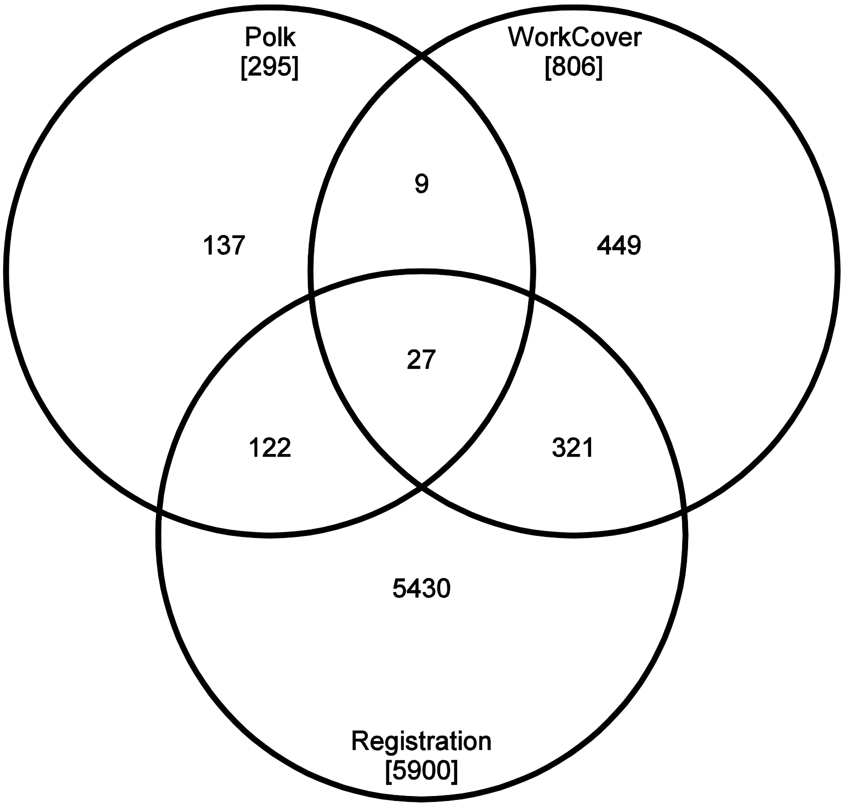

Figure 3.3
Venn diagram showing the overlap of the vehicles identified by each of the three methods

3.8 Discussion

Despite the differences in the identification methods there were some characteristics common to all three identified work vehicle groups. Commercial vehicles, like vans, utilities, and station wagons were more prevalent among the work vehicles. The work vehicles were also more likely to be newer and equipped with better safety features. It was discovered however, that vans and utilities are an exception to this as they are less likely to be fitted with safety features such as curtain airbags presumably due somewhat to their chassis design.

Descriptive statistics showed that work vehicles were more likely to be involved in crashes between the hours of 8am and 5pm, on weekdays, in rural locations, while being driven by males, and while being driven by people aged between 25 and 65. Crash severity was investigated further and the suggestion that work vehicles are over-reported in minor crashes was shown to be incorrect.

Through specific analysis of multiple vehicle crashes it was discovered that head on type crashes were the most likely to result in injuries for work vehicle occupants and right angle crashes were the most likely to be caused by work vehicle drivers.

The characteristics of crashes involving the work identified vehicles were described and investigated through logistic regression. In contrast with their comparison groups, the identified work vehicles crashed more often during working hours, crashed more often on weekdays, were more likely to be driven by people aged 25 – 65, and were more likely to be driven by males.

Other regression results varied by work vehicle identification method. The Polk identified vehicles had a greater crash propensity in low speed zones while the WorkCover identified vehicle crashes were more common in high speed zones. The WorkCover and registration identified vehicles had a statistically significant greater propensity to be involved in rural crashes but this was not true for the Polk identified vehicles. Only the WorkCover identified vehicles were found to have a lower prevalence in minor severity crashes that was statistically significant. These differences suggested that, compared to the other work vehicle groups, the WorkCover identified vehicles spent more time travelling on high speed, rural roads and consequently were involved in a high proportion of major severity crashes. It is important to keep in mind that for each identified vehicle group the regression analysis was conducted with comparison groups that had their own unique differences. Both the differences in the comparison groups and the differences in the identified work vehicle groups may be responsible for the variation in the regression results.

Through the use of an induced exposure method the crash rate of the work vehicle groups and their comparison groups was calculated. This analysis was restricted to crashes that occurred between 6am and 7pm on weekdays with drivers younger than 65 and results were presented for the whole of South Australia as well as just the greater Adelaide metropolitan area. In all cases the work vehicle groups had a crash rate that was higher than their comparison groups. However, this finding was only significant for the WorkCover and registration identified work vehicles. In the Adelaide metropolitan area, where the induced exposure method is most likely to be valid, the crash risk was found to be 20 per cent higher for the WorkCover identified work vehicles and 8 per cent higher for the registration identified work vehicles. The crash rates for both these work vehicle groups were disaggregated by crash type and analysed further. The WorkCover identified work vehicles were found to be overrepresented in right angle and side swipe crashes. The registration identified work vehicles were overrepresented in rear end, side swipe, hit pedestrian, and hit parked vehicle crashes and underrepresented in hit fixed object crashes.

A suggested explanation for the greater work vehicle crash risk was a difference in average vehicle occupancy. However, it was shown that differences in the average occupancy of work and non-work vehicles were unable to account for the differences in crash risk. The indication then is that there may be a legitimate increase in crash risk for South Australian work vehicles which warrants further research and attention from both OHS and road safety agencies.

4 The crash and injury experience of a large fleet in South Australia

4.1 Introduction

In this section, data obtained from a large managed vehicle fleet are analysed. The data were obtained from Fleet SA, who manage the fleet of government vehicles in South Australia. Fleet SA maintain detailed records of each vehicle in the fleet, and the crashes that occur (of all severities).

This data allowed an examination of a controlled fleet of work vehicles over a ten year period. The crash data were analysed over time, and with respect to the different safety features installed on each vehicle. Additionally, vehicle exposure could be controlled for using odometer readings that were taken whenever the vehicles were refuelled.

The objectives of this part of the study were to:

- Provide a general description of the crash experience of the vehicles in the fleet, and any changes over time.
- Examine the extent to which vehicle safety technologies were installed on new vehicles, and how that compares to the general fleet.
- Perform a statistical analysis to determine if any safety technologies had a significant effect on crash rate.

4.2 Data

Fleet SA maintain records of every vehicle that is part of the fleet and of any crashes they are involved in. Vehicle and crash data were obtained from Fleet SA for analysis. Vehicle records were used to look up vehicle specifications based on the vehicles' vehicle identification number (VIN). Relevant details of the data are described below.

4.2.1 Fleet SA

The Fleet SA vehicle data consisted of 42,899 vehicle records, which were all of the vehicles that entered the managed fleet between 1 January 1998 and 31 December 2010. While Fleet SA purchase vehicles for SA Police, the SA Ambulance Service, the Country Fire Service, and the State Emergency Service, these were excluded from analysis, as those vehicles would be involved in specific, potentially riskier types of driving. Their inclusion might have limited the generalisability of the results of the analysis. Each vehicle record held by Fleet SA includes the make and model, registration, VIN, model year, and the dates of entering and exiting the fleet.

The corresponding crash data consisted of all the crashes involving Fleet SA vehicles between 2000 and 2010. There were a total of 18,671 crashes recorded during this time period. The crash records were matched to the vehicle records via the vehicle registration numbers. Of the crashes recorded, 18,527 were matched to vehicles from the data set; the remainder involved vehicles that were most likely purchased prior to 1998.

There were a total of 647 crashes in the data set that resulted in an injury to any person involved. The remainder of the crashes (around 97%) did not result in any injury.

The odometer reading of each vehicle had been recorded every time the vehicle had been refuelled. The latest odometer reading for each vehicle was taken as of June 2012. For vehicles that had left the fleet, this would have been very close to the total number of kilometres driven by that vehicle. For vehicles that were still active in the fleet in June 2012, it would have been the reading at the most recent refuelling. The odometer readings allowed us an opportunity to control for exposure when examining crash rates, and this was the main advantage of using the detailed Fleet SA data.

4.2.2 Polk

The Vehicle Identification Numbers (VINs) of the Fleet SA vehicles were used to look up vehicle specification data from the Polk database described earlier in Section 3.2.2.

4.3 Method

The analysis was conducted in three components.

- Descriptive statistics were compiled on the vehicle and crash data.
- The vehicle and crash data were linked to compare the crash rates of vehicles by their year of purchase. Of interest were any trends in the crash rates.
- Finally, the VFACTs data were linked to the vehicle records. The rate of introduction of different technologies was established, and this was used to determine statistically whether particular technologies were affecting the likelihood of a particular vehicle being involved in a crash.

4.3.1 Adjustment of odometer readings

A key advantage to the Fleet SA data was that exposure could be measured through two means: the time that a particular vehicle spent in the managed fleet, and the odometer reading for each vehicle.

As described above, the latest odometer reading for each vehicle was supplied as of June 2012. Since the analysis was limited to crashes occurring between 2000 and 2010, some of these odometer readings had to be interpolated to reflect the exposure to crash risk during this period, and ignoring the period between the end of 2010 and June 2012.

In some cases, the date that a vehicle left the fleet was recorded as after the end of 2010. The latest that a vehicle was recorded leaving the fleet was 29 December 2011. In these cases, the odometer reading was linearly interpolated back to 31 December 2010. The interpolation was performed as follows:

$$Odometer^{new} = \frac{Odometer^{recorded} \times Number\ of\ days\ between\ purchase\ date\ and\ 31^{st}\ Dec\ 2010}{Actual\ number\ of\ days\ spent\ in\ fleet}$$

In some other cases, the date that a vehicle left the fleet was not recorded, and so it presumably left the fleet sometime after the end of 2011. In these cases, the time spent in the fleet for that vehicle was assumed to be three years, or the time between its purchase date and 27 June 2012, whichever was smaller. This number was then used in the above formula for the “Actual number of days spent in the fleet”. Thus, a vehicle purchased close to the end of 2010 would be estimated at spending about a year and a half before its odometer reading was recorded. However, a vehicle purchased at the start of 2009 would be assumed to have been in the fleet for three years and sold around the start of 2012.

Using this interpolation gives an estimate of the kilometres driven by these vehicles during the period 2000-2010. Another option was to exclude these vehicles from any analysis, but when this was done only a minority of the remaining vehicles in the sample were found to be equipped with technologies of interest and thus any effects of these technologies would have been unlikely to be apparent in the resulting analysis. Electronic stability control, for example, only became common on vehicles from around 2007 onwards.

4.3.2 Linking Fleet SA vehicles with Polk data

Vehicles in the Fleet SA database were linked with Polk records by make, model, year and variant. As Fleet SA manage many vehicles of the same make/model variant, it was only necessary to match vehicles via a sample of VINs that sufficiently described the range of makes and models in the dataset.

The Polk data also contained a record for the vehicle market class. The total sample of vehicles contained 30,810 passenger vehicles (71.8%), 11,607 'light trucks' (27.1%), and 83 'heavy trucks' (0.2%) with the remainder unknown. Those classified as 'light trucks' were utilities, vans and 4WDs (e.g. Toyota Hilux, Ford Transit, Subaru Forester), and those classified as 'heavy trucks' were larger utilities and vans (e.g. Ford F-250, Mercedes Sprinter).

4.4 Results

4.4.1 Descriptive crash statistics

Note that Fleet SA collect data on all incidents that cause vehicle damage or loss. These incidents are mainly crashes, but they also include other incidents that have cause damaged or loss. For the purposes of this chapter, the focus is on those crashes causing injury and/or significant vehicle damage.

Figure 4.1 splits the crash data by the presence of injury, location, crash cost and cause. Here the percentages given are taken as a percentage of the total with a known value. We can see firstly that the majority of crashes in the data set did not result in an injury to the fleet driver or any other people involved. The division of crashes between rural and metropolitan roads is the same for injury and non-injury crashes (roughly 18% rural and 82% metropolitan). The rural crashes in this figure contain crashes classified with a location as 'country', and the metropolitan crashes were those classified by Fleet SA as 'CBD', 'Metro' or 'Town'.

The final column classifies each crash by vehicle repair cost. Those classified as 'major' had a repair cost in excess of $5000, those classified 'moderate' had a cost between $1000 and $5000, and those classified as 'minor' had a cost under $1000.

On average the injury crashes were costlier than non-injury crashes, and rural crashes were more costly than metro crashes. For rural injury crashes, 84 per cent of crashes were categorised as 'major', whereas for metro non-injury crashes, just 3.4 per cent were 'major', and 62.4 per cent were 'minor'. However, because many more crashes were metro rather than rural, and because the majority of crashes were non-injury, the majority of 'major' crashes were classified as metro and non-injury.

Because the cost classification ends at $5000, any further analysis regarding severity was not possible. But, it would seem reasonable to suggest that the average 'major' injury crash might have incurred costs much higher than a 'major' non-injury crash, due to the added expense of medical bills and time off work.

Because the Fleet SA data also contains many minor incidents, the crash data were further limited to a smaller set of 1,391 'critical' crashes. These crashes fell into three categories:

- Major crashes with an injury
- Major crashes without any injury
- Moderate and minor crashes with an injury

In Figure 4.2, the critical crash data are split into these categories, and then by location and crash cause. Of the three categories, the biggest was major crashes without injury, which consisted of about half of the critical crashes. The other two categories (which both involve injury) comprised roughly a quarter of the critical crashes each.

For the first two of the above categories (those with a major repair cost), about a third of crashes were on rural roads, and the remaining two thirds were on metropolitan roads. In contrast, of the third category (those with an injury, but with a low repair cost), the vast majority occurred on metropolitan roads (95%).

Across all categories, the most common causes of crash were loss of control and inattention. Give way errors and animal strikes also accounted for a small proportion of crashes. In metropolitan crashes, the most common crash causes were give way errors and inattention. In the first two categories, loss of control accounted for just under 10 per cent of metropolitan crashes. Reversing crashes were more common for the final category in metropolitan areas (low crash cost, but with an injury).

Table 4.1 lists the crashes by whether the fault was with the driver of the Fleet SA vehicle or with a third party. The majority of the overall crashes (78.9%) were the fault of the fleet driver – note that this does not imply whether or not the fleet drivers are more likely to be at fault than the general population, as many crashes would have been single vehicle and thus fault could only be attributed to the fleet driver. For the critical crashes, the fleet drivers were slightly less likely to be at fault. Interestingly, in the third category (moderate/minor crashes with injury), the fleet drivers were less likely to be at fault than a third party.

Table 4.1
Fleet SA crash data by fault assignment

Fault	Overall	Critical crashes	Major crashes with injury	Major crashes without injury	Moderate/minor crashes with injury
Third party	3,933 (21.1%)	509 (36.6%)	107 (34.7%)	160 (21.5%)	242 (71.4%)
Fleet driver	14,738 (78.9%)	882 (63.4%)	201 (65.3%)	584 (78.5%)	97 (28.6%)
Total	18,671	1,391	308	744	339

For the remainder of this section, the focus is on the critical crashes that fit into each of the three categories described above.

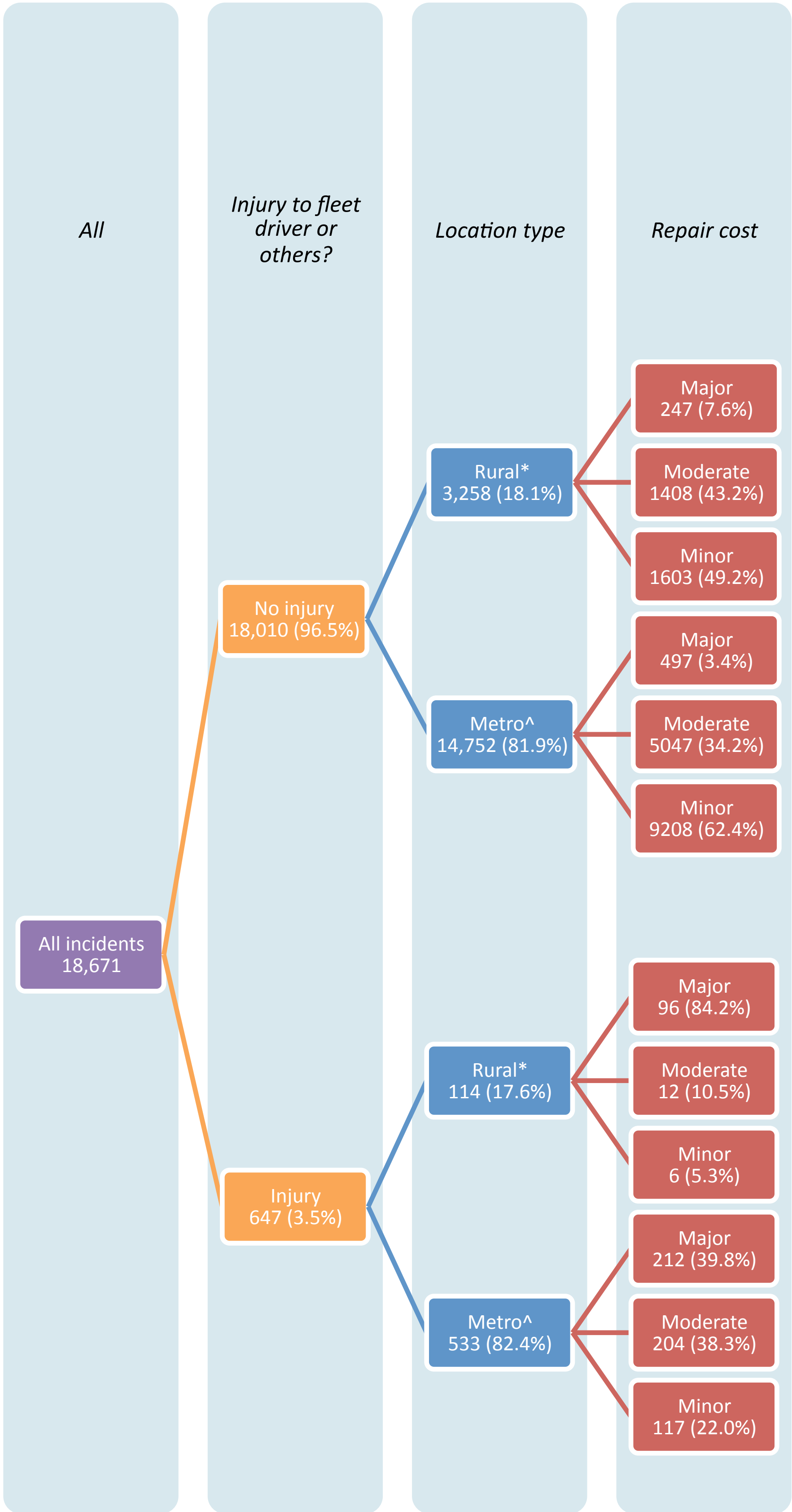

Figure 4.1
Crash data split by injury, location, and crash cost.
* Location type rural are those crashes classified as county by Fleet SA
^ Location type metro includes those classified as CBD, Metro and Town by Fleet SA

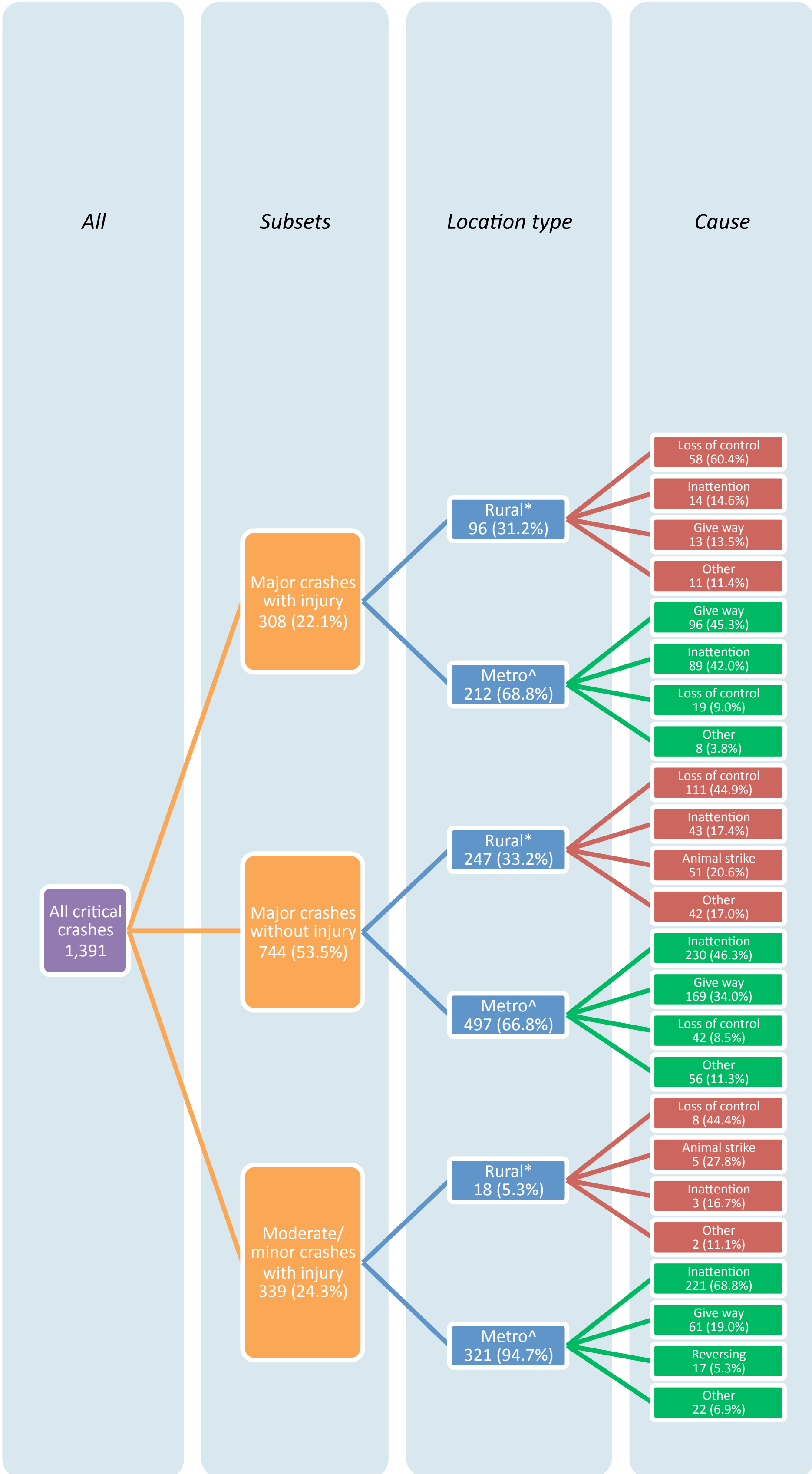

Figure 4.2
Critical crash data split by subset, location, and crash cause.
* Location type rural are those crashes classified as county by Fleet SA
^ Location type metro includes those classified as CBD, Metro and Town by Fleet SA

Crash rate by year

The crash rate history of Fleet SA vehicles was analysed by examining the number of (critical) crashes in each year from 2000 to 2010 and comparing with the number of active vehicles in each year. The number of active vehicles in each year was defined as the number of vehicles that were part of the fleet at any time during that year.

While there were also records available for vehicles purchased during 1998 and 1999, these years were excluded from the analysis. The reason for this is that the vehicle data only included vehicles purchased after 1 January 1998. Any vehicles purchased prior to this date that were still active in the fleet from 1998 onwards were not included in the data set and as such would not be counted as ‘active’. Since each vehicle typically spent about two years in the fleet at this time, the first two years (1998 and 1999) were excluded to allow for an accurate estimate of the number of active vehicles in the fleet during each year. Figure 4.3 shows the number of active vehicles in the fleet for each year – there was a slight increase with time but in general the number of active vehicles was between 10,000 and 12,000.

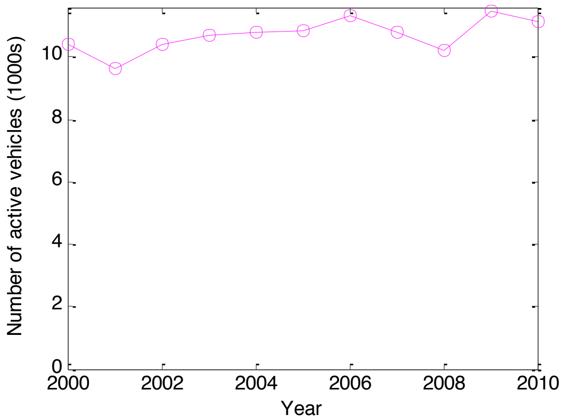

Figure 4.3
Number of active Fleet SA vehicles per calendar year

Figure 4.4 shows the number of crashes involving Fleet SA vehicles each year from 2000 to 2010. This is split into all critical crashes, and then by the three subsets of the critical crashes. The number of crashes was highest in 2004 (159 total critical crashes), and then reached a high point again in 2008, but this number dropped steadily from then onwards, to a low in 2010 of 92 critical crashes. The individual plots for each subset of critical crashes also exhibit similar trends, although the drop in 2009 appears to be mainly driven by a drop in the number of ‘Major no injury’ crashes.

Figure 4.5 shows the number of crashes for each 1000 active vehicles. The general trend is consistent with the trend in total crashes, with peaks in 2004 and again in 2008, followed by a decline in 2009 and 2010. Both of these figures indicate a noticeable decrease in the number of crashes in 2010. The subsets of critical crashes exhibit similar trends as they do in Figure 4.4. It is not clear at this stage whether the drop in 2010 represents a true drop in crashes, or is possibly due to some change in the recording of crashes, and we would recommend exercising some caution when interpreting these results.

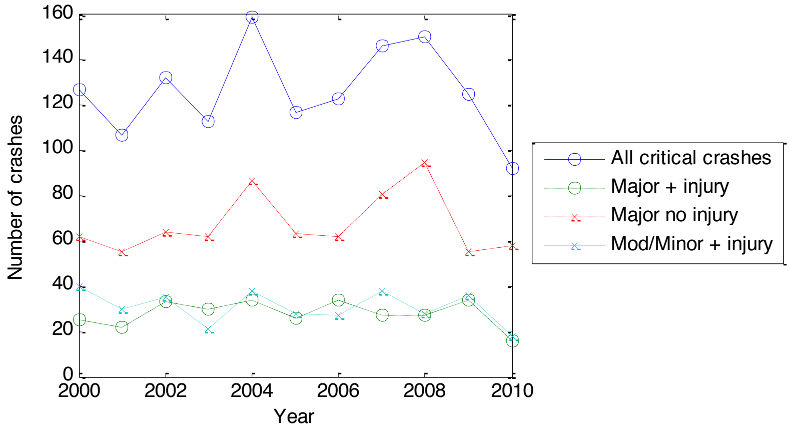

Figure 4.4
Total number of crashes by Fleet SA vehicles per calendar year

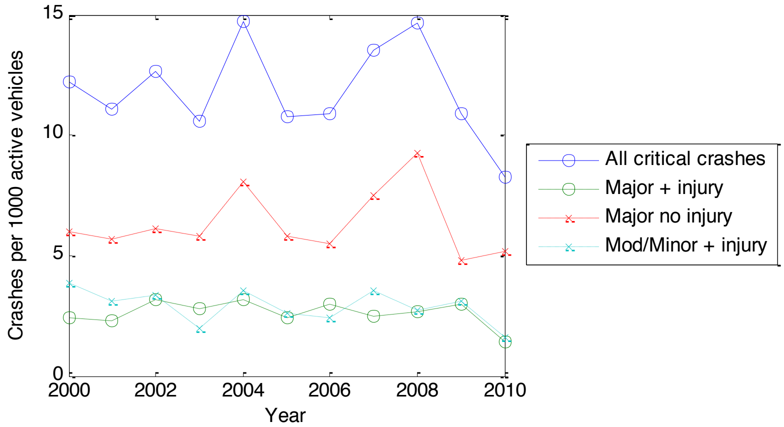

Figure 4.5
Number of crashes per 1000 active Fleet SA vehicles per year

Crash rate by year of purchase

The crash rate was also examined based on the year that each vehicle was purchased and the time that those vehicles spent active in the fleet. Figure 4.6 shows the number of vehicles that were purchased for each year between 2000 and 2010 (total of 36,251). Figure 4.7 shows the average time spent in the fleet for vehicles purchased in each of those years, with an end date of 31 December 2010. That is, the time in fleet only accounts for time spent in the fleet up until the end of 2010 at the latest, which is where the crash records cease. The average time spent in the fleet appears to decrease from around 2008 onwards – many vehicles purchased during those years were not sold prior to the end of 2010, and so while their actual lifespan was longer, the relevant time in fleet is only calculated to the end of 2010.

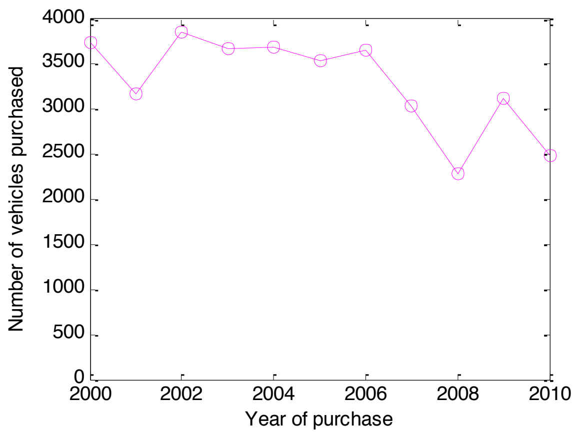

Figure 4.6
Number of vehicles purchased each year

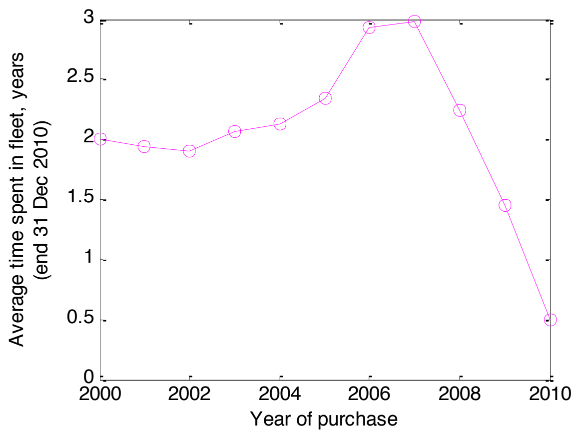

Figure 4.7
Average years spent in fleet by year of purchase, maximum end date 31 Dec 2010

The critical crash data were linked to the vehicles purchased in each of these years. There were a total of 1,260 critical crashes recorded by these vehicles.

Figure 4.8 shows the number of crashes recorded between 2000 and 2010, for vehicles purchased in a given year. For example, this shows that for the vehicles purchased in 2000, approximately 30 critical crashes were recorded for every 1000 vehicles purchased. This graph reaches a high in 2006 and then steadily drops; as might be expected, this mimics the trend shown for the average time spent in the fleet. Because the crash records are limited to the end of 2010, the number of crashes is lowest for those vehicles purchased during 2010.

Figure 4.9 is the number of crashes experienced by 1000 vehicles per year spent in the fleet, for vehicles that were purchased in a given year. This resolves the dependency of the number of crashes on the time spent in the fleet. For example, for every 1000 vehicles purchased in 2008, around 16 crashes were recorded for each year that they spent in the fleet. The results in Figure 4.9 show an overall downward trend in yearly crash rates, with a strong downward trend for vehicles purchased after 2008.

Figure 4.10 shows the number of crashes per 100,000 km driven. This figure was generated using the adjusted odometer readings as described in the methods section above. Up until 2008, there was an average of around 0.08 to 0.1 critical crashes per 100,000 km driven. As exhibited in other plots, there was a strong decline in crash rate in the years 2009 and 2010.

In all cases, the general trends shown for all critical crashes were the same as the trends shown by the three critical crash subsets.

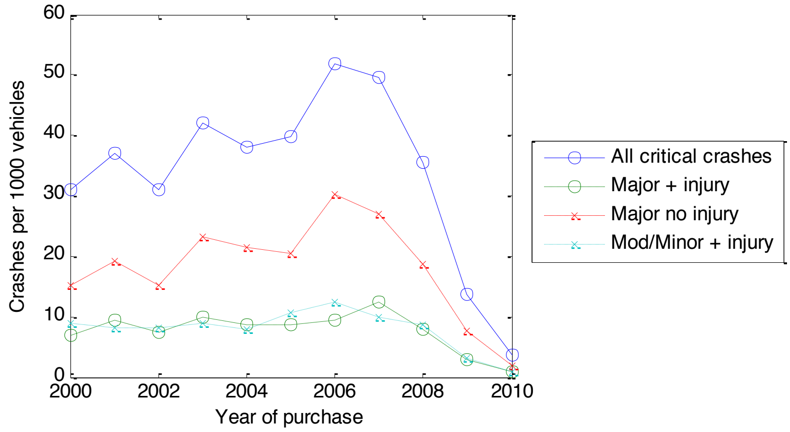

Figure 4.8
Number of crashes per vehicle (during 2000-2010) by year of purchase

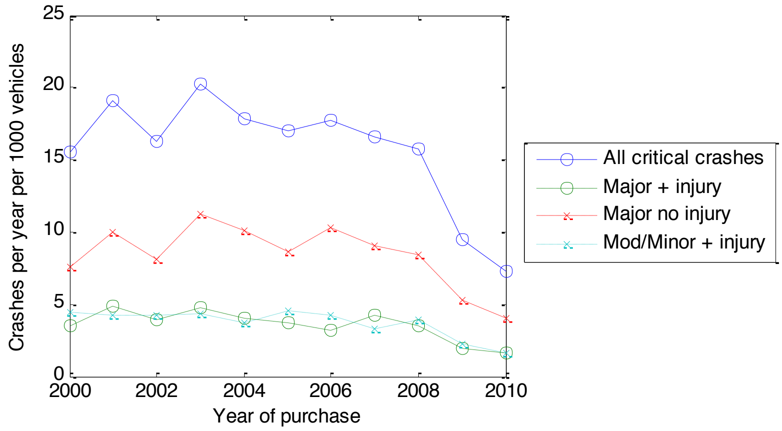

Figure 4.9
Number of crashes per year spent in the fleet, by year of purchase

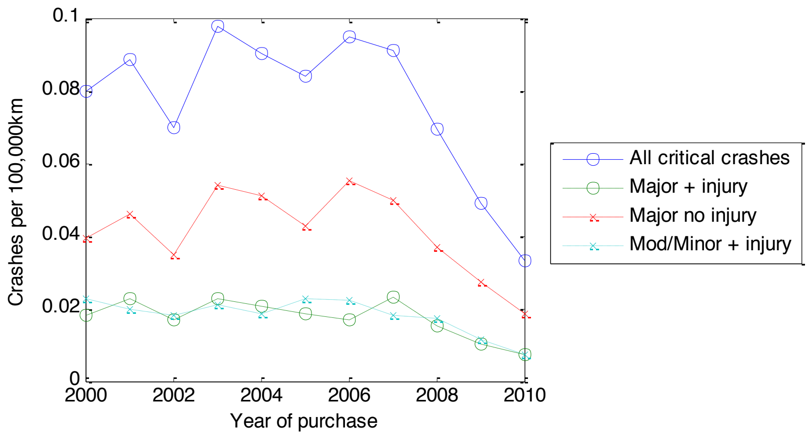

Figure 4.10
Number of crashes per 100,000km travelled, by year of purchase

4.4.2 Descriptive statistics on ANCAP ratings

Data from Polk were used to describe the evolving nature of the vehicles that Fleet SA manage. Each vehicle was matched to its safety specifications via the VIN sample that was matched with Polk. Disaggregation of this data allowed the features of vehicles to be described as a function of the year of manufacture.

The Australasian New Car Assessment Program (ANCAP) rate vehicles according to their crash test performance and according to a range of other safety related features. Five star ratings indicate top-of-the range safety performance and represents expected levels of safety for most volume selling vehicles in today's market.

Figure 4.11 shows the number of vehicles in the dataset by year of manufacture, split according to star rating. Note that for this plot the coloured areas are indicative of the number of vehicles in each classification – for example, in 2000 there were approximately 350 three star vehicles recorded as purchased (green segment), and about 80 four star vehicles (orange segment). The total number of vehicles purchased in each year is indicated by the dashed line. In 2000, there were about 3700 vehicle purchased. The space between the coloured areas and the dashed line is indicative of how many vehicles had an unknown star rating, noting that Polk apply strict application of star ratings to those variants of models that are explicitly rated by ANCAP.

This plot indicates that the number of four star vehicles increased greatly from 2002 onwards, and in 2008 the number of five star vehicles began to increase. In 2010, there were roughly an equal number of four and five star vehicles, and only a minority of vehicles were three star or less. It can be seen that since 2008, the proportion of vehicles acquired with 5 stars has greatly increased. It should be noted that this was in part affected by the closure of Mitsubishi in Adelaide, as cars they produced up until their closure were four stars, and the graduation of the Holden Commodore to a five star rating in 2009.

Figure 4.12 is a similar plot for the pedestrian star ratings. In general the pedestrian star ratings were much lower for the purchased vehicles. In fact, for 2002-2007, there were a sizeable portion of zero star vehicles in the fleet. By 2010, the majority of vehicles with a known star rating were rated one star, followed by two and three star.

The lack of four star pedestrian vehicles can be explained by a lack of availability (during that time period only one vehicle scored four stars on the ANCAP pedestrian assessment – the 2007 Subaru Impreza).

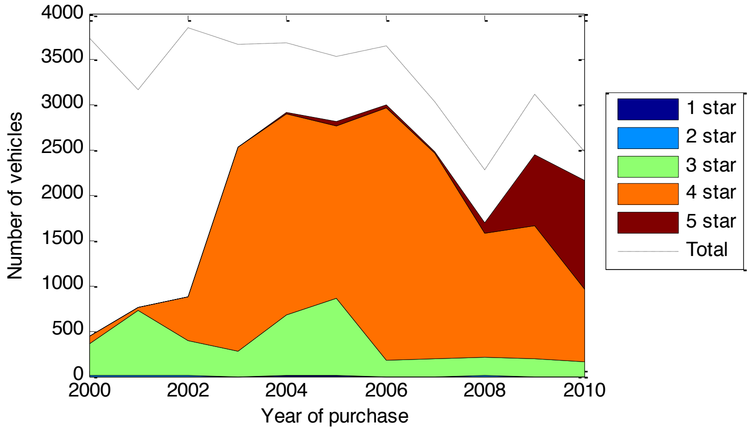

Figure 4.11
Occupant ANCAP star rating by year of purchase

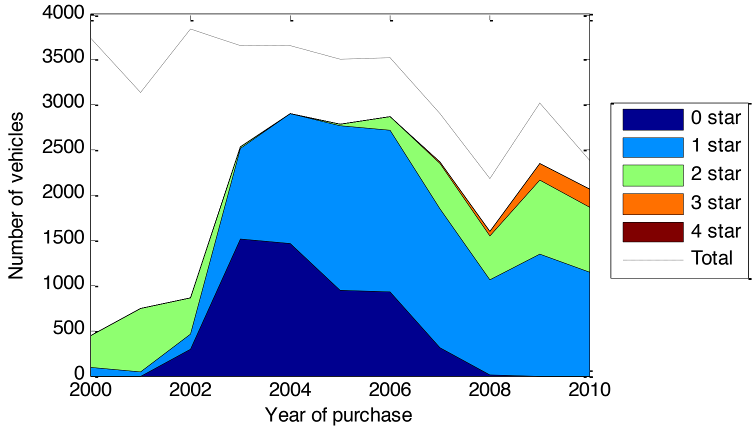

Figure 4.12
Pedestrian ANCAP star rating by year of purchase

4.4.3 Descriptive statistics on the introduction of safety technologies

Polk data were used to examine the rate of introduction of different vehicle technologies into the managed fleet. Each relevant field in the Polk record was recoded into one of three possible values:

- Standard: The feature was always included on this vehicle model
- Optional: The feature was available as an option for this vehicle model
- Not installed: The feature was not available for this vehicle model

The plots below show the percentage of vehicles purchased in a given year with particular safety features, based on whether that feature was standard, optional or not installed. The percentages were calculated including any vehicles that had an unknown status for that feature. Thus, the plotted points do not necessarily sum to 100 per cent for each year of purchase. (However, the number of vehicles with an unknown status for each technology was very low, so the sum is very close to 100 per cent in most cases.)

In general the safety features tended to be either ‘standard’ or ‘not installed’, and features were rarely just ‘optional’. The exceptions to this are airbags and ABS installations on vehicles purchased in the early 2000s.

Primary safety technologies

Five primary safety technologies were considered (primary safety technologies are designed to help prevent a crash from occurring):

- Antilock Braking System (ABS): modulates brake pressure to prevent wheels from skidding under heavy braking
- Traction Control System (TCS): prevents wheels from slipping under acceleration
- Electronic Brake Distribution (EBD): a subsystem of ABS that modulates brake pressure between the front and rear wheels
- Electronic Stability Control (ESC): controls the level of braking to each wheel to prevent loss of control
- Brake Assist (BAS): applies full braking pressure if it detects emergency braking, based on the speed of applying the brake pedal

Note that the installation of these technologies is cumulative and complimentary. ABS is required for EBD, ESC and BAS technologies to work. Similarly, while EBD may be installed on some vehicles that don’t have ESC, any vehicle that has ESC would typically have EBD as well.

More recent technologies were considered (e.g. lane keeping system, active cruise control, automatic emergency braking), but the number of installations was very small.

Installation rates were compared to data presented by Anderson (2012) for new vehicles sold into the general South Australian vehicle fleet between 1991 and 2009.

Figure 4.13 shows the prevalence of ABS on vehicles purchased between 2000 and 2010. ABS was either standard or optional on most vehicles in 2000 but in the years following became standard on the majority of vehicles purchased. By 2006, ABS was found in over 80 per cent of all the vehicles purchased. This result was very similar to that found by Anderson (2012).

Figure 4.14 shows the prevalence of TCS on vehicles purchased between 2000 and 2010. TCS was relatively uncommon on 2000 vehicles, and was in around 70 per cent of vehicles purchased in 2010, with the main rise in installations occurring from around 2006 onwards. The prevalence of TCS in the general new vehicle fleet was lower (around 50%) in 2009 (Anderson, 2012).

Figure 4.15 shows the prevalence of EBD on vehicles purchased between 2000 and 2010. This technology was relatively uncommon in 2000 (standard or optional on less than 10% of vehicles), but during the following 10 years became much more common, being found in 80 per cent of the new vehicles purchased in 2010. This was very similar to the EBD installation rates in the general fleet (Anderson, 2012).

Figure 4.16 shows the prevalence of ESC. Up until 2003, ESC was not found in any vehicles purchased, however since then the rate of installation rose to around 70 per cent in 2009 and 2010. This was slightly higher than the installation rate for ESC in the general new vehicle fleet, which was around 50 per cent in 2009 (Anderson, 2012).

Figure 4.17 shows the rate of BAS installations, which mimics the trend shown for ESC. The results for BAS installation in the general new vehicle fleet (Anderson, 2012) were similar.

In general, all technologies have been taken up at an increasing rate. These trends mirror trends seen for the fleet in general (Anderson, 2012).

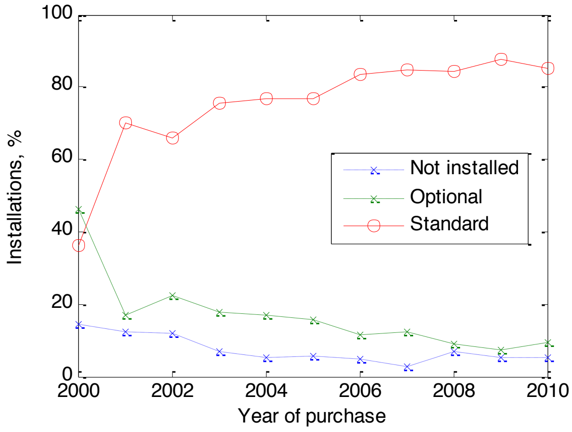

Figure 4.13
Installations of Antilock Braking Systems (ABS) by year of purchase

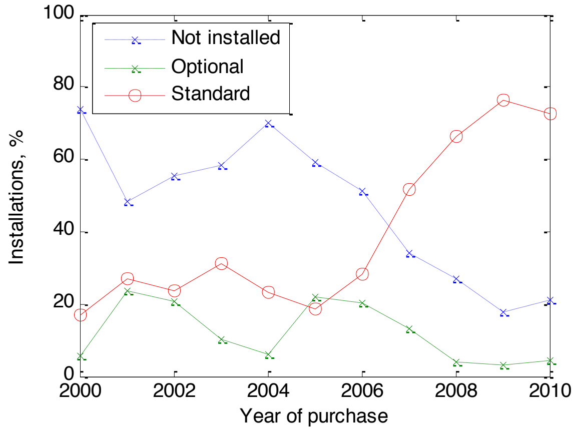

Figure 4.14
Installations of Traction Control Systems (TCS) by year of purchase

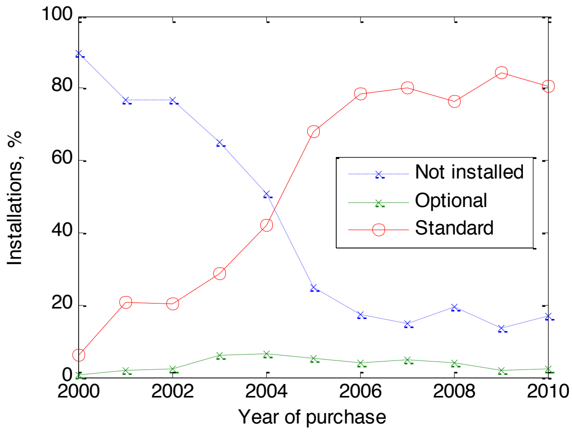

Figure 4.15
Installations of Electronic Brake Distribution (EBD) by year of purchase

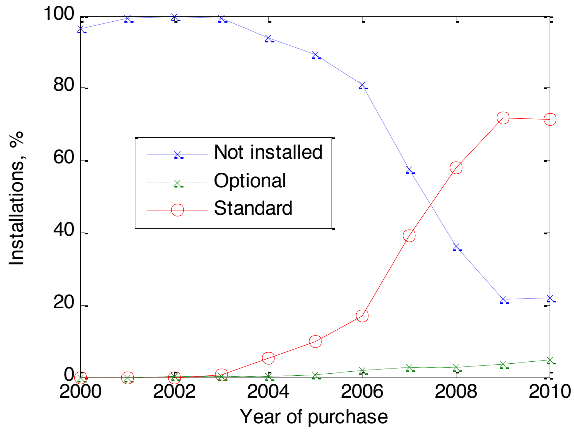

Figure 4.16
Installations of Electronic Stability Control (ESC) by year of purchase

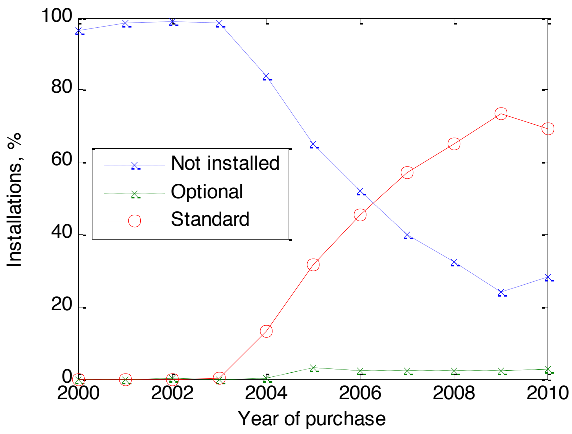

Figure 4.17
Installations of Brake Assist Systems (BAS) by year of purchase

Secondary safety technologies

Three secondary safety technologies were also examined (secondary safety technologies aim to reduce the risk and severity of injury in the event of a crash):

- Airbags
- Seat belt pretensioners: reduces seat belt slack by actively tightening seat belts when a collision occurs.
- Seat belt force limiters: limit the maximum force on the vehicle occupant by using mechanisms that reduce the effective stiffness of the belt at high load levels.

Again, results have been compared to those presented by Anderson (2012) for the general new vehicle fleet in South Australia.

Figure 4.18 and Figure 4.19 show the prevalence of driver airbags and front passenger airbags. Driver airbags were installed in over 90 per cent of vehicles purchased from 2004 onwards, and in over 95 per cent of vehicles from 2006 onwards. Installation of front passenger airbags lagged the driver installations, but were found in over 95 per cent of vehicles purchased in 2009 and 2010. This is a similar result to that found in the general new vehicle fleet (Anderson, 2012).

Figure 4.20 shows the prevalence of seat belt pretensioners. Note that this is for the driver's seat belt, but the same numbers were observed for the front passenger also. Pretensioners were found on about half of the vehicles purchased in 2000, rising to about 90 per cent in 2010. This is a similar result to that presented by Anderson (2012).

Figure 4.21 shows the prevalence of seat belt force limiters. Again, this plot is for the driver's seat belt, but the same numbers were observed for the front passenger also. Force limiters were virtually non-existent on vehicles purchased in 2000, but were found in about 80 per cent of vehicles purchased from 2006 onwards. This is also similar to the results presented by Anderson (2012).

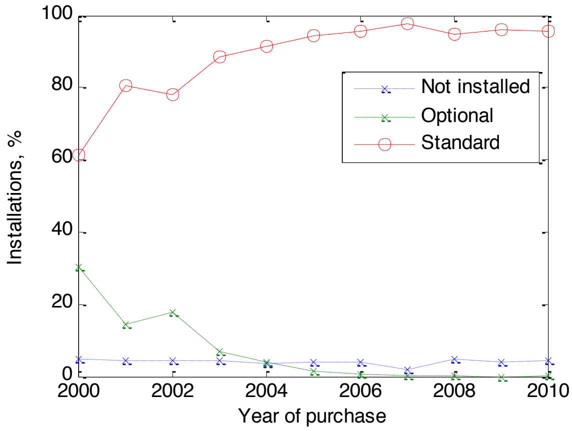

Figure 4.18
Installations of driver side airbags by year of purchase

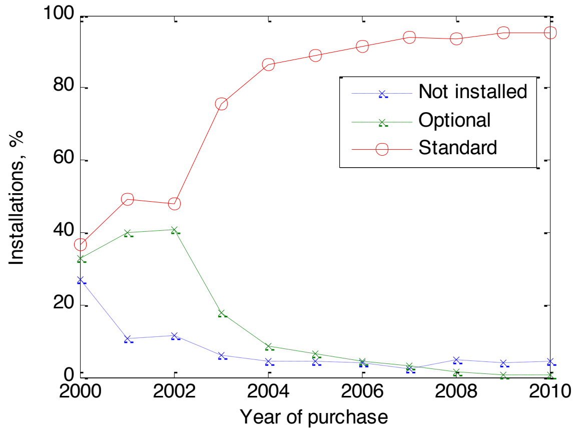

Figure 4.19
Installations of front passenger airbags by year of purchase

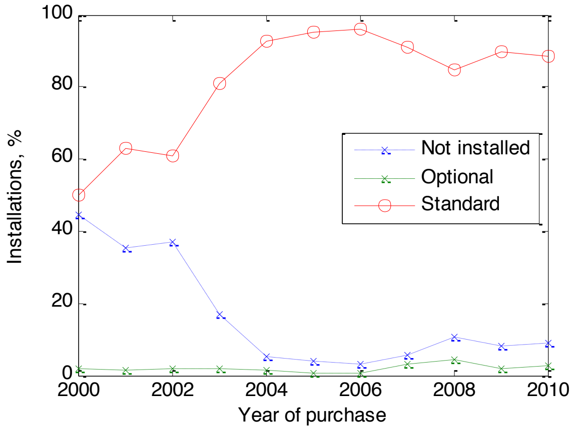

Figure 4.20
Installations of driver seat belt pretensioners
by year of purchase (same for front passenger)

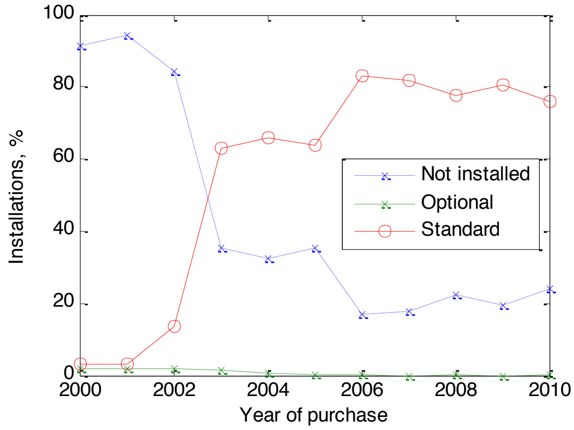

Figure 4.21
Installations of driver seat belt force limiters
by year of purchase (same for front passenger)

4.5 Statistical analysis

Two methods of regression were attempted: multiple linear regression and binary logistic regression. In both regressions, the data source was the vehicle entries, with the presence or absence of safety features used as predictor variables. The number of crashes that each vehicle was involved in was used as the response variable in the linear regression, and for the binary logistic regression the response variable was whether or not the vehicle had been involved in a crash.

Neither of these regression models were deemed appropriate for the data at hand, based on the measures of model fit (e.g. R^2). Many permutations of the response and predictor variables were considered in the regression models, including limiting the crashes to those of a particular type, and considering the different vehicle technologies by themselves and in conjunction with one another. The adjusted odometer values were used to control for exposure.

Thus, instead of attempting to develop a regression model that accounted for every possible input, each vehicle technology was considered on its own. The vehicle and crash data were limited accordingly, and contingency tables were used to determine whether each vehicle technology had a statistically significant effect on crash rates.

A contingency table is a 2x2 table that compares the number of cases with and without a particular feature, to the number of cases with a particular response. For our purposes, each case was a vehicle, the feature was a particular safety feature, and the response was whether or not the vehicle was involved in a critical crash (with the definition of 'critical' being used as per earlier in this section). Statistical significance was measured via the chi-squared test (χ^2). For the result to be significant ($p \le 0.05$), χ^2 must be greater than or equal to 3.84.

For the primary safety features, the contingency tables were constructed independently of other vehicle technology features. Thus, the tables were limited to vehicles that were the same apart from the presence of the safety feature in question.

For each technology being considered, the contingency tables (and the associated measure of statistical significance) were generated for all vehicles purchased between 2000 and 2010, in both rural and metro areas, and including all vehicles. The analysis was then repeated with different limitations placed on the data. These limitations included:

- Rural crashes only
- Metropolitan crashes only
- Passenger vehicles only (and then split again by rural and metropolitan)
- Light trucks (utilities and vans) only (and then split again by rural and metropolitan)
- Vehicles purchased between 2000 and 2005 only
- Vehicles purchased between 2006 and 2010 only

The reason for considering these different permutations was to examine the stability of the results with respect to crash location, vehicle type and vehicle year. Following is a summary of the results for each vehicle technology.

In each table of results the crash rates (crashes per vehicle) are given for the vehicles with and without the technology installed. The ratio of these crash rate values is also given – a number higher than one indicates that the vehicle technology was associated with a higher rate of crashes, and a number lower than one indicates that the vehicle technology was associated with a lower rate of crashes. These ratios were then adjusted using the average distance driven by the vehicles with and without the technology (effectively giving a ratio of crash rates per kilometre driven).

4.5.1 ABS

The first technology to be considered was ABS. Vehicles were only included in the contingency table that did not have TCS, EBD, BAS or ESC installed. This was done to isolate the effect of ABS alone.

Table 4.2 shows the results for all vehicles purchased between 2000 and 2010, including crashes that occurred in all areas. Although these results were not statistically significant, note that the crash rate ratio indicates that ABS was associated with a lower rate of crashes, however when corrected for distance travelled, ABS is associated with a higher rate of crashing. The analysis was repeated with the limitations described above, and in general, ABS was associated with an increased crash rate (when adjusted for distance travelled).

This result was statistically significant ($p < 0.05$) when crashes were limited to those that occurred in metropolitan areas and these results are given by Table 4.3. The crash rate ratio in this case was close to 3, and higher than this when adjusted for distance travelled. Note that for this result, the 'ABS-no' category mainly consisted of light trucks (utilities and vans), as there were very few passenger vehicles that did not have ABS. Of the 2735 vehicles without ABS, 2719 were light trucks. This result may be unexpected, but has been found in other studies as well (Burton et al., 2004).

Table 4.2
Contingency table for crashing based on ABS installation

	Crash-no	Crash-yes	Per cent crashed	Average km driven	Crash rate ratio	Adjusted crash rate ratio
ABS-yes	3,027	101	3.23%	44,629	0.92	1.13
ABS-no	2,639	96	3.51%	54,793		
		$p = 0.551$, $X^2 = 0.355$				

Crashes included: All critical crashes
Vehicles included: All purchased 2000-2010
Not installed: EBD, TCS, BAS or ESC

Table 4.3
Contingency table for crashing based on ABS installation, for metropolitan crashes only

	Crash-no	Crash-yes	Per cent crashed	Average km driven	Crash rate ratio	Adjusted crash rate ratio
ABS-yes	3,057	71	2.27%	44,629	2.96	3.63
ABS-no	2,714	21	0.77%	54,793		
		p = 0.000, X^2 = 21.31				

Crashes included: Metropolitan crashes
Vehicles included: All purchased 2000-2010
Not installed: EBD, TCS, BAS or ESC

4.5.2 EBD

For considering the effect of EBD, vehicles were only included if they had ABS installed, and did not have TCS, BAS or ESC. This was to consider the effect of EBD on crash rates in isolation.

In general, the presence of EBD was associated with lower crash rates (with and without adjusting for distance travelled), but this result was not statistically significant for all vehicles and crashes, or in any of the variations of analysis listed earlier.

The contingency table and results for EBD across all vehicles and crashes is given in Table 4.4.

Table 4.4
Contingency table for crashing based on EBD installation

	Crash-no	Crash-yes	Per cent crashed	Average km driven	Crash rate ratio	Adjusted crash rate ratio
EBD-yes	2,994	85	2.76%	41,214	0.86	0.93
EBD-no	3,027	101	3.23%	44,629		
		p = 0.279, X^2 = 1.17				

Crashes included: All critical crashes
Vehicles included: All purchased 2000-2010
Not installed: TCS, BAS or ESC
Installed: ABS

4.5.3 TCS

In the analysis for TCS, vehicles were included that had ABS installed, but did not have EBD, BAS or ESC. Thus, the effect of TCS was considered in isolation.

In general, the presence of TCS was associated with a slightly higher crash rate (with and without adjusting for distance travelled), but this result was not statistically significant for all vehicles and crashes, or in any of the variations of analysis listed earlier.

Table 4.5 gives the contingency table for TCS installation across vehicles and crashes.

Table 4.5
Contingency table for crashing based on TCS installation

	Crash-no	Crash-yes	Per cent crashed	Average km driven	Crash rate ratio	Adjusted crash rate ratio
TCS-yes	3,791	143	3.63%	43,846	1.13	1.15
TCS-no	3,027	101	3.23%	44,629		
		$p = 0.353$, $X^2 = 0.861$				

Crashes included: All critical crashes
Vehicles included: All purchased 2000-2010
Not installed: EBD, BAS or ESC
Installed: ABS

4.5.4 BAS

For the analysis of BAS, vehicles were limited to those without ESC, but with ABS, TCS and EBD installed. Thus, the effect of BAS was considered in isolation of ESC.

Across the different variations of data considered, the presence of BAS was generally associated with a lower crash rate (with and without the adjustment for distance travelled). The results were driven mainly by passenger vehicles, with only 30 light trucks meeting the inclusion criteria, of which six had BAS. Table 4.6 shows the contingency table for BAS installation across all vehicles, years and crash locations.

When the analysis was limited to 2000-2005 vehicles, the negative association between BAS and crashes was statistically significant and these results are given in Table 4.7. In contrast, the results for 2006-2010 suggested a positive association between BAS and crashing; this result was not statistically significant but was close to being significant with a p-value of 0.08 (Table 4.8). It is not clear why this shift occurs between the earlier data and later data.

Table 4.6
Contingency table for crashing based on BAS installation

	Crash-no	Crash-yes	Per cent crashed	Average km driven	Crash rate ratio	Adjusted crash rate ratio
BAS-yes	818	37	4.33%	44,468	0.879	0.935
BAS-no	734	38	4.92%	47,284		
		$p = 0.567$, $X^2 = 0.326$				

Crashes included: All critical crashes
Vehicles included: All purchased 2000-2010
Not installed: ESC
Installed: ABS, TCS, EBD

Table 4.7
Contingency table for crashing based on BAS installation, for vehicles purchased 2000-2005

	Crash-no	Crash-yes	Per cent crashed	Average km driven	Crash rate ratio	Adjusted crash rate ratio
BAS-yes	294	6	2.00%	50,962	0.255	0.240
BAS-no	247	21	7.84%	48,016		
		$\mathbf{p = 0.001}$, $X^2 = 10.65$				

Crashes included: All critical crashes
Vehicles included: All purchased 2000-2005
Not installed: ESC
Installed: ABS, TCS, EBD

Table 4.8
Contingency table for crashing based on BAS installation, for vehicles purchased 2006-2010

	Crash-no	Crash-yes	Per cent crashed	Average km driven	Crash rate ratio	Adjusted crash rate ratio
BAS-yes	524	31	5.59%	40,957	1.656	1.896
BAS-no	487	17	3.37%	46,894		
		p = 0.084, X^2 = 2.99				

Crashes included: All critical crashes
Vehicles included: All purchased 2006-2010
Not installed: ESC
Installed: ABS, TCS, EBD

4.5.5 ESC

Finally, the analysis was conducted for ESC. To consider ESC in isolation, the vehicles were limited to those that had every other technology installed – i.e. they had ABS, TCS, EBD and BAS.

The presence of ESC was associated with lower crash rates, with and without the adjustment for distance travelled. This effect was statistically significant when all crashes were included, across all types of vehicle and location (Table 4.9). The results were also statistically significant for rural and metropolitan crashes considered separately, for passenger vehicles only and for the years 2006-2010 on their own.

The result lost statistical significance for light trucks only and if only 2000-2005 was considered. This appears to be due to the reduced sample size that met the inclusion criteria for the analysis (particularly since BAS installation was one of these criteria, and was relatively uncommon on light trucks and up until 2005).

Table 4.9
Contingency table for crashing based on ESC installation

	Crash-no	Crash-yes	Per cent crashed	Average km driven	Crash rate ratio	Adjusted crash rate ratio
ESC-yes	6,561	158	2.35%	31,886	0.543	0.758
ESC-no	818	37	4.33%	44,468		
		p = 0.001, X^2 = 11.81				

Crashes included: All critical crashes
Vehicles included: All purchased 2000-2010
Installed: ABS, TCS, EBD, BAS

4.5.6 Five-Star ANCAP rating

Finally, a contingency table analysis was conducted for vehicles with and without a five-star ANCAP rating. Only vehicles with a known ANCAP rating were included. There was generally an association between a five-star ANCAP rating and a reduced risk of crashing. The exception for this was for light trucks where a five-star ANCAP rating was associated with an increased risk of crashing (after adjusting for distance travelled) but this result was not statistically significant.

The association with a reduced risk of crashing was statistically significant for all vehicles and critical crashes, and the results are given in Table 4.10. The adjusted crash rate ratio implies a crash risk reduction of 25 per cent for vehicles with a five-star ANCAP rating. This is consistent with the adjusted crash rate ratio for ESC given in Table 4.9.

The results were statistically significant when passenger vehicles were considered on their own, for rural crashes only, for metropolitan crashes only, and for the years 2006-2010. For the earlier years (2000-2005), the result was not significant due to the reduced sample size of ESC equipped vehicles. The adjusted crash rate ratio was lowest (implying the greatest benefit) for passenger vehicles only, and implied a 56 per cent reduction in crashes for five-star vehicles. These results are given in Table 4.11.

Table 4.10
Contingency table for crashing based on five-star ANCAP rating

	Crash-no	Crash-yes	Per cent crashed	Average km driven	Crash rate ratio	Adjusted crash rate ratio
Five-star-yes	2,220	25	1.11%	18,282	0.316	0.746
Five-star-no	19,230	703	3.53%	43,209		
		p = 0.000, $X^2 = 37.01$				

Crashes included: All critical crashes
Vehicles included: All purchased 2000-2010 (with known ANCAP rating)

Table 4.11
Contingency table for crashing based on five-star ANCAP rating, for passenger vehicles only

	Crash-no	Crash-yes	Per cent crashed	Average km driven	Crash rate ratio	Adjusted crash rate ratio
Five-star-yes	1,749	10	0.57%	15,291	0.162	0.441
Five-star-no	15,226	552	3.50%	41,507		
		p = 0.000, $X^2 = 43.80$				

Crashes included: All critical crashes
Vehicles included: Passenger vehicles purchased 2000-2010 (with known ANCAP rating)

4.6 Summary of results

Fleet SA vehicle and crash data were used to analyse crash rates over time and by year of vehicle purchase. The data were also linked to Polk records that described the technologies that each vehicle came equipped with.

The crash data showed that, overall, most of the recorded crashes did not result in an injury (96.5%), and that most crashes resulted in under $5,000 of damage. The divide between metropolitan and rural crashes was split roughly 80 per cent to 20 per cent for both injury and non-injury crashes. In general, rural crashes and injury crashes were more likely to cost more. Of the costliest (>$5,000) injury crashes in rural areas, the majority were caused by loss of control. In metro areas, the costliest injury crashes were most likely to be caused by inattention or give way errors.

Since many of the crashes included in the database were relatively minor incidents (both in terms of repair cost and injury), the crash data were limited to a ‘critical’ set of crashes. These were the crashes that caused an injury (to the fleet driver or a third party), or had a repair cost over $5,000, or both. Amongst these crashes, rural crashes were slightly more common. The main causes of rural crashes were loss of control or inattention, and the main causes of metropolitan crashes were inattention or give way errors.

The results of the time based analysis suggest an overall downward trend in crashes over the period 2000 to 2010, with a strong decrease occurring in 2010. Furthermore, vehicles purchased in 2009 and 2010 appear to have a lower risk of crashing during their lifetime than vehicles purchased between 2000 and 2008, and on a time-in-fleet and per-kilometre basis. The drop in crashes for 2009 and 2010 may be due to some factor in the vehicles themselves, but may also be an indication that the data is not complete for those years, or the rules for its collection had been changed in such a way that certain crashes were not included in the dataset.

Based on ANCAP ratings of occupant and pedestrian safety, the fleet appears to be moving towards higher safety ratings. The proportion of five-star occupant rated vehicles in the fleet increased strongly after 2008, and only a small proportion of vehicles were under four stars. For pedestrian safety, the proportion of 2-star and 3-star vehicles has increased since 2006. However, around half of vehicles were still rated 1-star in 2010 and only a very small proportion were rated 3-star.

The uptake of vehicle safety technologies was strong over the 10 year period in question. ABS was found almost universally on purchased vehicles by 2010. Other primary safety technologies such as TCS, EBD, BAS and ESC increased from zero (or close to zero) installations, to being found in the majority of purchased vehicles by the end of 2010. In terms of secondary safety, driver airbags were almost universal by 2010, as were passenger airbags. Seatbelt pretensioners and force limiters were taken up and were in the majority of vehicles by 2010. The installation rates of these technologies were generally similar to those in the general new vehicle fleet (Anderson, 2012), however Fleet SA vehicles had slightly higher installation rates for ESC and TCS.

The statistical analysis showed that the presence of ABS may in fact be associated with a higher rate of crashing, with this result being heavily influenced by light trucks (due to almost all passenger vehicles being equipped with ABS). The results for TCS and EBD were not statistically significant but were associated with slightly higher and slightly lower crash rates, respectively. For vehicles purchased between 2006 and 2010, there was a statistically significant association between BAS and reduced crashes.

The results for ESC were more definitive: there was a statistically significant association between ESC and a reduction in crashes, and this held true for rural and metropolitan crashes separately and for passenger vehicles on their own. The results for a five-star ANCAP rating were also more definitive, with a five-star rating having a statistically significant association with a reduction in crashes.

4.7 Discussion

The results presented in this section demonstrate a relatively in-depth look at a managed fleet of work vehicles, with a measure of exposure and comprehensive information on the features of each vehicle. Such a large set of data makes it possible to perform many different analyses, and without a doubt there are further possibilities for analysis that are yet to be explored.

Despite the large number of crash records in the Fleet SA database, only a small proportion was used in most of this analysis. This is due to the database containing every minor incident that occurred as well as more serious crashes – this is in contrast to police-recorded data which only exists for the more serious incidents (in terms of injury or property damage).

Of the critical crashes, those with a repair cost in excess of $5,000 had similar properties regardless of whether injury occurred: the split between rural and metropolitan was roughly one third to two thirds, and the crash causes were similar. Crashes with a repair cost under $5,000 that resulted in injury were different: they were far more likely to occur in metropolitan areas (95%) and were more likely to be caused by inattention. More details on this particular subset of crashes may reveal a common story.

The Fleet SA data has shown that, generally, the managed vehicle fleet is being involved in less crashes with time, and this is true when controlling for the time spent in the fleet per vehicle, and when controlling for the distance driven by each vehicle. There was a large apparent drop in crash rates in 2010, but our advice is that this result should be interpreted with caution until any other explanations can be explored. This may have been the result of a change in recording or some other side effect of how the data was processed. If the measured drop in crashes is in fact a true indication, then this is a promising result.

The results of the statistical analysis for ABS are perhaps unexpected, but similar effects have also been demonstrated in a previous study (Burton et al., 2004). As noted in the results section, the ABS data was primarily driven by light truck crash involvement, and there may be some confounding factor that is not accounted for in the results as presented. At present ABS is nearly ubiquitous on new passenger vehicles and almost so on light trucks – thus any effect of ABS is unlikely to be measurable in future data.

The results for ESC are promising and confirm results found by other studies (Scully and Newstead, 2010; Mackenzie and Anderson, 2009). If any technology is to be made mandatory on new fleet purchases, then ESC would be the first candidate. An alternative would be to make five-star ANCAP vehicle purchases mandatory, as the five-star rating requires ESC and was shown to have a similar (if not stronger) association with a reduction in crashes. In fact, the results for five-star ANCAP vehicles are likely to be a proxy for the effect of ESC, along with other more subtle aspects of vehicle design that are more likely to be found on five-star vehicles.

It is worth noting that the calculations of statistical significance in Section 4.4 did not account for driving exposure. The use of contingency tables meant that the value of chi-squared was based purely on the counts of vehicles in each category, without account for distance travelled. However, we have shown the adjusted crash rate ratios based on driving exposure, and in the majority of cases the adjusted ratio indicated a similar (positive or negative) effect as the non-adjusted version.

In the future, it would be of interest to examine the influence of new technologies such as Automatic Emergency Braking (AEB) on crash rates within the managed vehicle fleet. Managed fleets have a great potential to introduce such technologies in large numbers and to collect detailed data on the resulting crash experience of these vehicles. This will be important for evaluating the effect of new technologies, as well as the more established technologies considered in this study.

5 Discussion

In Chapter one, the concepts of an OHS framework and a road safety framework were introduced. Work-related driving on public roads was observed to be an activity where these two safety frameworks overlapped. This overlapping presents both problems and opportunities for work-related road safety.

Problems may arise in the event of a work-related crash because of the way resources are distributed between the two frameworks. Two examples of this are the determination of total crash costs and obtaining relevant data. Total crash costs are made difficult to determine because various components of compensation are paid by multiple agencies within both safety frameworks. Analysis of work-related crashes from an OHS perspective is difficult due to a lack of relevant data because investigation of crashes is usually only conducted by the police from a perspective which is mainly concerned with compliance with the road rules, and the routine collection of other variables. Such data does not necessarily allow remedial actions to be identified in the way a full workplace investigation might.

Nevertheless, research has shown that work-related road crashes account for the greatest proportion of worker serious injuries and fatalities. Consequently, work-related crashes also represent the most costly type of workplace incident, both in terms of property damage and workers compensation payments, and account for a sizable proportion of total road fatalities.

Cooperation between the two safety frameworks presents a number of opportunities for improving work-related road safety and resolving the problems mentioned above. While the road safety framework sets out regulations that apply to all drivers, there is much potential under the OHS framework to support these regulations by influencing individual driver behaviour through guidance and sanctions. The OHS framework also has greater opportunity to promote the benefits of vehicle safety features to individual companies and fleet buyers. This promotion will also have positive flow on effects to general road safety through the on-selling of company or fleet vehicles to the general public and would encourage manufacturers to equip safety technologies as standard features in popular models of vehicle.

The previous three chapters have presented analysis on various aspects of work-related road safety. Chapter two reviewed the literature on a broad range of subjects relevant to work-related driving and safety. Chapter three investigated the burden of work-related light vehicle crashes in South Australia and Chapter four investigated the crash and injury experience of a large fleet in South Australia. This Chapter seeks to discuss how the findings of these studies are relevant to the problems and opportunities associated with work-related road safety, particularly for South Australia.

Three sections are presented below. The first discusses the findings of the two investigation chapters, with reference to the findings of other research covered in the literature review. The second highlights some of the deficiencies in data relevant to work-related road safety and suggests some potential remedies. The third outlines the potential for improvement in work-related road safety and how this may be achieved.

5.1 Work-related road safety in South Australia

The findings of Chapter three and Chapter four were generally consistent with the findings of other research discussed in Chapter two. That is, that work vehicles involved in crashes are more likely to be newer, travel during daytime hours on weekdays, and be driven by males of working age.

In the present study it was not possible to separately identify crashes that occurred while at work and those that occurred while commuting. While this prevented the comparison of findings with some other Australian studies such as Boufous and Williamson (2006, 2009), there were still several interesting findings relevant to South Australian work-related road safety.

A statistically significant increase in crash risk was found for work vehicles (20 per cent for WorkCover identified and 8 per cent for those identified through registration data) that crashed in the greater Adelaide metropolitan area between 6am and 7pm on a weekday while being driven by a person younger than 65. A similar increase in crash risk for work vehicles was found by Symmons and Haworth (2005). However, unlike the analysis presented here, they did not control for driving exposure (instead using number of crashes per 10,000 registrations).

The suggestion that crashes involving work vehicles can experience a reporting bias was shown to be false. In fact, the number of minor injury crashes per major injury crash was lower for work vehicles compared to non-work vehicles. Similarly, it was also shown that the occupancy of crash involved work vehicles was lower than that of non-work vehicles.

Much like the “work driver effect”, described in Section 2.7, no reason for the increased crash risk for work vehicles could be identified. Some of the qualitative research that was reviewed suggested that work drivers may experience time pressures or be distracted thinking about work or other ancillary tasks (Salminen and Lahdeniemi, 2002). Another possible suggestion is that work vehicle drivers may commonly travel to locations or drive vehicles that they are unfamiliar with. Driving while searching for a specific address or in a vehicle with unfamiliar controls may lead to an increase in crashes due to inattention. The largest increases were in right angle and side swipe crashes and it is open to speculation as to whether these types of crash might be more common when drivers are in unfamiliar vehicles or locations, or are more distracted than the average driver.

Another finding was that work vehicles are more likely to consist of commercial-type vehicles such as utilities, vans, and station wagons. These vehicle types are less likely to be fitted with safety features that are common on other light vehicles. Despite this, the findings from Chapter four analyses found that the uptake of safety features for a large group of fleet vehicles was similar to that of the general vehicle fleet. Moreover, ESC uptake was found to be greater for the fleet vehicle group which may have been a result of safety policy changes like those outlined in Leyson (2010). In support of such safety policies, it was found that those fleet vehicles that were equipped with ESC had a statically significantly lower crash rate compared to those that were not.

5.2 Data collection relevant to work-related road safety

One topic that arose in all three of the previous chapters was the difficulty in obtaining data that was relevant to the research being conducted. Both Chapter three and Chapter four required the linking of two sets of data in order to enable the required analysis, and similar deficiencies have been noted by others (see Section 2.1). The linking of data sets assists but is time consuming, potentially costly, and will inevitably result in some number of mismatched records. Given the significant burden of workplace injury that is the result of driving, it would seem appropriate to consider ways in which directly relevant data can be more easily recorded for future monitoring of road related workplace safety.

Many studies link OHS data (which contains details on workers and their injuries) with police reported crash data (which contains details on the crash). The same method was used in this report (see Section 3.5.1) and it is suggested that an automatic linkage might be possible. That is, when a work-related crash is reported to WorkCover the associated police vehicle collision report number should be recorded along with the rest of the incident data like worker demographics and injury specifics. This would then allow for the easy recovery of relevant TARS data for every work-related crash and eliminate the need for complex linkage methods.

It might also be worth considering more in-depth investigation of work-related crashes within the OHS framework. While the analysis of mass data is effective in identifying overall trends, it is limited to investigating only those variables that are collected. Beyond these collected variables there are often important features of individual crashes which are not necessarily obtainable from routine police records. The suggestion then is that an annual set of worker injuries, that were the result of a crash on a public road, should be investigated in a similar way that a workplace incident would be.

Finally, it would be advantageous if work-related crashes that occur while a driver is commuting between home and work were identified in some way.

5.3 Improving work-related road safety

There was no evidence within any of the literature presented in Chapter two that work-related crashes are associated with an overrepresentation in any type of risky behaviour. In fact, the prevalence of crashes associated with speeding, driving while fatigued, driving with an illegal BAC, or non-seatbelt wearing was observed to be lower for work vehicles than for non-work vehicles (Symmons and Haworth, 2005; Boufous and Williamson, 2006). Additionally, crashes associated with fatigue that did involve a work vehicle were found to be characteristically similar to those involving non-work vehicles (Williamson and Boufous, 2007).

Overall, the indication from the literature was that work-related crashes occurred in similar ways to other crashes. The findings presented in Chapter three suggest that work-related crashes occur more often than other crashes but, in agreement with the literature, there was little difference in their characteristics.

Work-related road safety is therefore expected to benefit from most programs aimed at improving road safety in general. These programs are often divided into those that address vehicles, drivers, and the road environment. There may be little extra that can be done in terms of the road environment for work-related road safety (except in some cases such as roads leading to specific locations like remote mining sites) but there is potential for improvement through addressing vehicles and drivers.

The findings of Chapter four provide some insight into the possible improvements that might be brought about though the purchasing of work vehicles with modern safety features. Within the fleet that was analysed, those vehicles equipped with ESC or which had a 5-star ANCAP rating were found to have lower crash rates. It is also important to note the influence that the purchasing power of company and fleet operators can have upon vehicle manufacturers. This power may be used to encourage the fitment of modern safety features to the types of vehicles that are known to lack them, such as utilities and vans.

Beyond the requirement of a driver’s licence and the enforcement of the road rules by police, there were several actions suggested in the literature that could be directed at work drivers to improve their road safety. Examples of this include the setting of realistic driving goals so that drivers are not under time pressure and reducing commission based driving work that can lead to fatigue based crashes. Group discussions have also proven to be beneficial to safety in some workplaces (Gregerson et al., 1996). The greatest potential for improving work-related road safety appears to be in encouraging a safety climate within the workplace, and to include driving as a work activity subject to safety considerations (Downs et al., 1999). It is also suggested that cooperation between OHS and road safety agencies on activates that are relevant to work-related driving may be beneficial. One example of this would be to run concurrent and complementary media campaigns.

Guidelines for improving work-related road safety using the types of programs mentioned here were presented in Section 2.8.3. These guidelines, which are aimed at employers, advocate a holistic approach to crash prevention and are based on a safe systems approach. The key concept is the periodic review and evaluation of performance to enable the identification of deficiencies which should result in continuous improvement of work-related road safety.

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