



**The relationship between vehicle performance and novice
driver crash involvement
RR 12-001**

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Abstract

The aims of this project were (i) to provide contemporary evidence of the relationship between vehicle performance factors and the risk of serious injury crash involvement among young novice drivers in Western Australia, and (ii) to review the current Australian vehicle restriction programs. Data for analysis were n=11,321 vehicles driven by those aged 17+ years involved in serious injury crashes during the period 2001-2008. High performance vehicles driven by those aged 17-19 years accounted for less than 1% of the serious injury crashes investigated, while 7.6% of serious injury crashes involving drivers aged 17-19 years involved a high performance vehicle. The findings of a number analyses provided some evidence, albeit definitive, to suggest that drivers aged 17-19 years have a higher relative rate of crash involvement when driving a high performance vehicle and that six and eight-cylinder vehicles and high performance four-cylinder vehicles have a higher representation in single vehicle crashes compared with two-vehicle crashes. Comparable vehicle restriction schemes for novice drivers currently operate in four Australian jurisdictions (Victoria, New South Wales, Queensland and South Australia). A review of the schemes noted an absence of published empirical evidence to support their introduction and no evaluations to date to determine their impact on the novice driver problem. All jurisdictions expressed the view that the schemes were somewhat difficult to administer and enforce. On the basis of the above findings and others, a number of recommendations were provided to the Road Safety, including the rejection of a vehicle restriction scheme for Western Australian novice drivers.

Keywords

Road safety; vehicle performance; young novice drivers; crash risk

Disclaimer

This report is disseminated in the interest of information exchange. The views expressed here are those of the authors and not necessarily those of Curtin University, Monash University, or The University of Adelaide.

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Technical Supplement

Hutchinson, T.P. & Anderson, R.W.G. (2012)

Vehicle performance and crash risk amongst novice drivers in Western Australia.

Adelaide: Centre for Automotive Safety Research, The University of Adelaide.

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EXECUTIVE SUMMARY

Introduction

Drivers aged 17-25 years in Australia and across all other highly motorised Western countries are substantially over-represented among drivers killed and seriously injured. In 2010, this age group accounted for 26.2% of all driver deaths in Australia while representing only 15.4% of the population. While this age group is nearly twice as likely as all age drivers to be killed, the risk is greater still for those drivers in the initial period of licensure. Graduated Driver Licensing systems have been implemented across countries such as the USA, New Zealand, the United Kingdom and Australia to control the exposure of novices to factors associated with an increased risk of crashing. Unlike their overseas counterparts however, a number of Australian jurisdictions (e.g., Victoria, New South Wales, Queensland, South Australia) have placed restrictions on the vehicles young novices can drive based on the performance of the vehicle.

Western Australia has for some years debated the need to introduce similar restrictions but has not done so to date because of an absence of strong empirical evidence to support a statistically increased risk of crashing among novices who drive high performance vehicles. A review of the limited number of available studies of the relationship between vehicle performance and driver behaviour and driving outcomes, including a much earlier investigation of the issue in Western Australia published in 2005 by Palamara & Gavin, failed to identify strong and valid findings regarding a consistent, quantifiable influence of vehicle performance on driving outcomes. At best, the published research shows a reasonably consistent theme of drivers of high performance vehicles, including young drivers and males, as being more likely to engage in anti social and risk taking behaviour on the road and of having a higher risk of involvement in a crash. The most recent Australasian research by Keall & Newstead (2012) provides the strongest evidence of this, though it also notes that young drivers in high performance vehicles involved in a crash represent a relatively small proportion of crashes among this age group – a finding similarly noted by Palamara & Gavin (2005). None of the previous investigations have however, addressed the relationship between driver characteristics and vehicle selection and the interaction between these in relation to driving outcomes. Thus, it is not entirely clear whether driving outcomes are directly influenced by vehicle performance per se or whether drivers with certain dispositions or personality traits that dispose them to risk taking seek out certain types of vehicles to express their behavioural style. If so, would restricting high sensation seeking drivers to lower

performance vehicles significantly alter their likelihood of engaging in risky behaviours and becoming involved in a crash?

The aim of this study, commissioned by the Road Safety Council of Western Australia in 2009, was to provide more definitive contemporary Western Australian evidence of the relationship between vehicle performance factors, age of driver, and risk of involvement in a serious injury crash to reconsider the need for a restricted vehicles scheme for novice drivers.

The specific objectives of the research were as follows:

Objective One

To investigate the relationship between vehicle performance and serious injury crash involvement among Western Australian drivers (i) aged 17-19 years holding a provisional, restricted 'C' class motor car drivers' licence and (ii) drivers older than 19 years holding a full, unrestricted 'C' class motor car drivers' licence

Objective Two

To compare the finding from Objective 1 with the findings of the previous investigation undertaken by Palamara & Gavin (2005).

Objective Three

To consider the recent experiences of other Australian jurisdictions with respect to vehicle performance restrictions for novice drivers

Objective Four

To provide recommendations to the Road Safety Council of Western Australia regarding the need for vehicle performance restrictions for novice drivers and the form of those restrictions.

Method

The research was undertaken by the Curtin-Monash Accident Research Centre (C-MARC) (Curtin University, Western Australia and Monash University, Victoria) in collaboration with the Centre for Automotive Safety Research (CASR). C-MARC was primarily responsible for the management of the project and Objectives Two and Three, while CASR was primarily responsible for Objective One and the production of the technical supplement. Both institutions contributed to Objective Four.

Data for the investigation of the statistical relationship between vehicle performance and crash risk were selected from all police reported serious injury (death or hospitalisation)

crashes occurring during the period 2001-2008, provided by Main Roads Western Australia.. To enable the calculation of the rates of crash involvement for drivers by age and vehicle performance, and to investigate the safety and performance characteristics of the fleet of Western Australian vehicles, a sample of 3,750 registered private passenger vehicles was randomly selected from each year of the period 2001 to 2008 (totalling 30,000 vehicles). Vehicle Identification Numbers (VIN) and driver licensing and vehicle ownership information was obtained from the Department of Transport for each crash involved vehicle and driver and each vehicle in the sample of the vehicle fleet. VINs were subsequently forwarded to RL Polk Australia for the retrieval of manufacturer's information on the performance of the vehicle and its safety features.

After applying the criteria for the inclusion of relevant vehicles and drivers, the final crash dataset consisted of n=11,321 vehicles (post-1990) and actively licensed drivers aged 17+ years (categories into those aged 17-19 years, 20-24 years and 25+ years). The performance of vehicles was based on both the number of cylinders and the power to weight ratio (kilowatt output/kerbside weight x 100kgs) of the vehicle, resulting in the following categories of performance:

- four-cylinder vehicles: PWR ≤ 59 ; PWR 60-74; PWR 75-89; PWR ≥ 90
- six-cylinder vehicles: PWR ≤ 99 ; PWR 100-109; PWR ≥ 110
- eight-cylinder vehicles: PWR ≤ 109 ; PWR 110-139; PWR ≥ 140

Relative rates of crash involvement were calculated for *owner-drivers only* for the various driver/vehicle groups using the average crash rate for those aged 17-19 years in all four-cylinder vehicles. In addition to this analysis, the proportion of high performance vehicles in single and two car crashes was calculated and followed up with univariate and multivariate modelling of the effect of various driver, vehicle, and crash location factors on the ratio of single vehicle crashes to two car crashes. Finally, a set of time series analyses were undertaken on the 2008 sub-set of the sample of the WA. vehicle fleet to document the history and introduction of various vehicle safety technologies and vehicle performance characteristics and the relationship between the two.

Summary of Findings

Objective One

The complete findings from the analysis of serious injury crashes 2001-2008 are reported in the attached technical supplement prepared by Hutchinson & Anderson (2012). The main findings were as follows:

- Vehicle performance was categorised using both the number of cylinders of the crashing vehicle and the power to weight ratio of the vehicle. Vehicles considered to be of 'higher performance' were those in the following groups:
 - four-cylinder vehicles with a PWR ≥ 90 kw/tonne;
 - six-cylinder vehicles with a PWR ≥ 110 kw/tonne; and,
 - all eight-cylinder vehicles
- These high performance vehicles accounted for 7.6% of the n=1,285 vehicles crashed by owner and non owner-drivers aged 17-19 years and less than 1% of the n=11,321 owner and non owner-driver vehicles (all ages) involved in a serious injury crash.
- Calculation of the crash rates for owner drivers only showed that in comparison with the crash rate for those aged 17-19 years in all four-cylinder vehicles, a relative higher rate of crashing for 17-19 year olds was observed for those driving:
 - four-cylinder vehicles with a PWR ≥ 90 kw/tonne;
 - six-cylinder vehicles with a PWR ≤ 99 kw/tonne and PWR 100-109 kw/tonne; and,
 - all eight-cylinder vehicles
- Overall, the trend was for the relative rate of crashing to decrease with the age of the owner-driver and to increase with the performance of the vehicle.
- The interpretation and confidence of the observed relative crash rates are constrained by the necessary exclusion for methods reasons of some two-thirds of serious injury crashes involving drivers aged 17-19 years.
- Calculation of the relative numbers of high performance vehicles in single and two car crashes where the driver (of any age) was hospitalised or killed showed an increasing proportion of high performance vehicles in single vehicle crashes, ranging from a low of 24% for four-cylinder vehicles with a PWR 60-74 to a high of 57% for eight-cylinder vehicles with a PWR ≥ 140 kw/tonne. Overall, the trend was for a higher representation of six and eight-cylinder vehicles and high performance four-cylinder vehicles in single vehicle crashes.

- Multivariate analysis of the ratio of involvement in single and two car crashes showed statistically significant effects for performance of the vehicle, year of car, age of driver, day of week and hour of day, and location of crash based on speed limit and distance in relation to the Perth metropolitan area. Hutchinson & Anderson (2012) advised that caution must be exercised in the interpretation of these individual findings.
- Analysis of the safety features and crash worthiness of vehicles by performance category for a sample of the Western Australian registered fleet, 2008, showed that safety and performance are strongly associated- Electronic Stability Control, side curtain airbags, and a 4 or 5 star ANCAP rating were more common among higher performance vehicles.

Objective Two

The methods employed by Palamara & Gavin (2005) differed somewhat to those employed in this study, particularly in relation to the selection and analysis of crash data; the retrieval of vehicle manufacturers' information to determine the performance characteristics of crashed vehicles, and the classification of the performance of vehicles. Notwithstanding these methodological differences, both studies noted that serious injury crashes involving young novice drivers in high performance vehicles account for a very small proportion of the road crash problem among this age group and more generally. The studies differed however, in relation to the observed statistical relationship between high performance vehicles and the risk of crashing. Palamara & Gavin (2005) found no evidence to support such a relationship, while this study found some evidence and trend of an increased crash risk based on the calculation of relative rates of serious injury crash involvement and the ratio of involvement of high performance vehicles in single vehicle versus two vehicle crashes. Both studies expressed similar concern that restricting young novices from certain high performance vehicles might inadvertently limit their access to vehicles with outstanding or superior technologies to reduce their risk of crash involvement and risk of injury. This study supported the conclusion through an analysis of a sample of Western Australian vehicles registered in 2008, where it was found that higher performance vehicles were also more likely to feature Electronic Stability Control, superior airbag systems, and to have 5-star ANCAP ratings (particularly among four-cylinder vehicles).

Objective Three

Four Australian jurisdictions - Victoria, New South Wales, Queensland, South Australia - currently operate a restricted vehicles scheme for novice drivers that restrict the driving of:

- all eight-cylinder vehicles;
- some normally aspirated high performance six-cylinder vehicles (at times based on a power to weight ratio limit or kilowatt output that varies across jurisdictions), and,
- turbo charged vehicles unless they are ‘low powered’ or diesel fuelled.

It seemed that the existing Australian vehicle performance restriction schemes were primarily introduced in response to political and community pressure rather than strong existing evidence in support of higher performance vehicles being a significant contributor to the crash problem of young novice drivers. Consequently, the operational definitions of a high performance vehicle across the schemes did not necessarily align with a known increased risk of crashing for this driver group. Although there was some consistency across jurisdictions in the broad definition of a ‘high performance’ vehicle, the definition of a high performance normally aspirated six-cylinder vehicle was found to vary somewhat across the jurisdictions and perhaps for this reason there is strong interest, promoted by vehicle manufacturers, in the development of a national standard based on a simplified power to weight ratio of 130kw/tonne tare weight. The administrative efficiency of this definition is seemingly tied to the redevelopment of and access to the National Exchange of Vehicle and Driver Information System (NEVDIS) to enable the ready retrieval by jurisdictions of the required manufacturer’s information on vehicle characteristics (e.g., kilowatt output, tare weight). However, this may not be possible for another two to three years. At present, WA.’s TRELIS systems provides no useful information to assist with the administration and enforcement of a restricted vehicles program since it *does not* contain *all required information* to apply any of the criteria of the existing schemes or the proposed national definition based on a power to weight ratio.

From the discussions with representatives from jurisdictions that operate a restricted vehicle scheme there was reason to conclude:

- the schemes can be difficult to support, defend and promote given the absence of empirical evidence in support of a relationship between vehicle performance and crash risk;

- some schemes have difficulty in informing and advise the motoring public (and police) on permissible and restricted vehicles; for example, lists of vehicles are not readily updated, leaving the onus on the motorist and police to determine if the vehicle is unrestricted or restricted;
- the exemption process can be onerous, resource intensive, and open to abuse, which ultimately undermines the intent and possible effectiveness of the scheme, and,
- that to date, there has been little if any commitment to an evaluation of the effectiveness of the schemes.

Recommendations

The following recommendations were provided to the Roads Safety Council for consideration based on the findings of the various project Objectives.

1. Reject the introduction of a vehicle performance restriction scheme for Western Australian novice drivers

This study has failed to provide compelling evidence to support the introduction of a vehicle performance restriction scheme; such a scheme is therefore not recommended at this point in time. Notwithstanding the identified methodological problems for the study, there are a number of reasons to reject the introduction of a vehicle restriction scheme:

- crashing high performance vehicles driven by novice drivers do not represent a sizable road safety problem;
- a statistical association between vehicle performance and crash risk for young novice drivers was observed but it was not overwhelming strong or unequivocal;
- no evaluations of the existing Australian vehicle performance restriction schemes have been undertaken; therefore, it is not known whether such schemes effectively reduce novice driver crashes and injury or whether they are cost-effective;
- Western Australia does not presently have, nor is likely to have in the near future, ready access to the vehicle performance information required to administer and enforce a vehicle restriction scheme; and that,

- restricting access to some high performance vehicles may inadvertently restrict the access of young novices to vehicles which feature a high level of vehicle safety technology.

2. Progress the introduction of outstanding and empirically supported graduated driver training and licensing initiatives in Western Australia

Compared with some other Australian and overseas jurisdictions, Western Australia's existing graduated training and licensing system could be strengthened by the adoption of other initiatives related to increased driving experience as a learner and reduced exposure to crash risk factors as a provisional driver. In relation to these issues, the State should:

- expedite a thorough reexamination, particularly in relation to access and equity issues, of the current requirement for supervised driving during the learner phase to consider an increase in both the number of required hours and the conditions under which those hours are obtained (e.g., daytime versus nighttime; types of roads); and,
- move to introduce other licensing initiatives such as peer passenger restrictions and restrictions on the use of mobile phones during the provisional period. Both initiatives are likely to reduce the occurrence of distracted driving and possible risk taking when driving in the company of peers.

3. Further investigation and development of a broad platform of initiatives to more broadly target the problem of speeding and reckless driving by young novice drivers

Whilst it is acknowledged that high performance vehicles have an increased ability to accelerate and maintain higher speeds, speeding and other reckless behaviour among young novice drivers is not confined to those driving high performance vehicles. For this reason then, it is recommended that the State investigate and develop initiatives that target the behaviour of the young novice driver, rather than the vehicle per se, in an effort to reduce speeding and other reckless behaviour across this target population. For example, consideration should be given to:

- the introduction of differential speeding penalties for novice drivers that would effectively result in the suspension of a provisional driver in the first 12 months for a single speeding offence (or at the very least a subsequent offence). Such a

system operates in New South Wales and could be applied here as Western Australia similarly suspends provisional drivers in the first 12 months of licensure upon the loss of four demerit points.

- the imposition of vehicle restrictions on provisional drivers who are caught speeding or engaging in reckless or dangerous driving, including BAC offences, while driving a high performance vehicle;
 - the introduction of ‘offence free’ periods as a prerequisite for novice drivers progressing from P1 to P2 stages and from a P2 stage to full licensure; and,
 - the development and implementation of a trial education program targeting novice drivers committing any speeding offence, utilising a monitored Intelligent Speed Adaptation (ISA) device fitted to their vehicle.
4. Encourage the purchase of safer vehicles by all young drivers by providing information about safe first car choices and the provision of financial incentives to purchase safer vehicles

Young novice drivers have a higher risk of crash involvement compared with older and more experienced drivers. For this reason it is important that young drivers have access to vehicles with emerging technologies that will reduce their likelihood of crashing and also provide them with superior protection in the event of a crash. The secondary analysis in this study of a 2008 sample of vehicles registered in Western Australia showed that vehicles with superior safety features such as Electronic Stability Control, side curtain airbags, and even in some cases driver airbags, were far more common in vehicles that might otherwise be classified as high performance from a power to weight ratio point of view, especially among four and six-cylinder vehicles. Indeed, this finding suggests that any possible restriction on the access of novices to higher performance vehicles might, in the shorter term, also inadvertently restrict their access to vehicles with high safety ratings, at least until these technologies filter down over time to be more common among cheaper and lower performance vehicles. In the meantime the State government should:

- strongly encourage the purchase of safer vehicles by young novice drivers through an educational campaign on ‘safe first car choice’, along the lines of campaigns undertaken in New South Wales and Victoria; and,

- consider vehicle registration rebates or discounts to young novice drivers who purchase vehicles meeting the 'safe first car' criteria.

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1. BACKGROUND

Drivers aged 17-25 years in Australia and across all other highly motorised Western countries are substantially over-represented among drivers killed and seriously injured. In 2010, this age group accounted for 26.2% of all driver deaths in Australia (Bureau of Infrastructure, Transport and Regional Economics, 2011) despite representing only 15.4% of the population (Australian Bureau of Statistics, 2010). Furthermore, drivers aged 17-25 years were nearly twice as likely as all age drivers to be killed: 6.3 deaths per 100,000 population *versus* 3.3 for all age drivers (Bureau of Infrastructure, Transport and Regional Economics, 2011). The over-representation of this driver age group is similarly noted in Western Australia. Western Australian police-recorded crash data linked with death and hospitalisation records for the period 2002-2007 shows that drivers aged 16-25 years accounted for 30% of all fatally injured drivers of light passenger vehicles and 31% of all drivers admitted to hospital, despite representing only 14% of licensed drivers in Western Australia (Oxley, Langford, Palamara, Muir, Koppel, Bohensky & Williamson, 2009).

Over the years a wealth of information has been amassed on the many and varied risk factors for the crash involvement of young and novice drivers (typically those in the provisional licensing period). The most consistent and strongest evidence has related to the risk associated with driver inexperience and age. Research has identified that the combination of inexperience and age associated immaturity increases the risk of crash involvement but that reductions in crash risk over time have higher associations with increasing experience - particularly for the youngest novice drivers - than increases in driver age (i.e., maturation) *per se* (Forsyth, Maycock & Sexton, 1995). Other longitudinal investigations of the crash involvement of novices have clearly demonstrated that their risk of crashing is highest in the initial months of solo driving and decreases rapidly thereafter (McCartt, Shabanova & Leaf, 2003; Palamara, 2005). In Western Australia for example, a five-year follow-up study of the crash rates of the population of drivers first licensed at 17 years of age in 1998 (see Figure 1.1) found that novices were 60% more likely to be involved in a police reported crash in the first six month of licensing compared with the second six months and 2.4 times more likely to crash in the first year compared with the fifth year (Palamara, 2005).

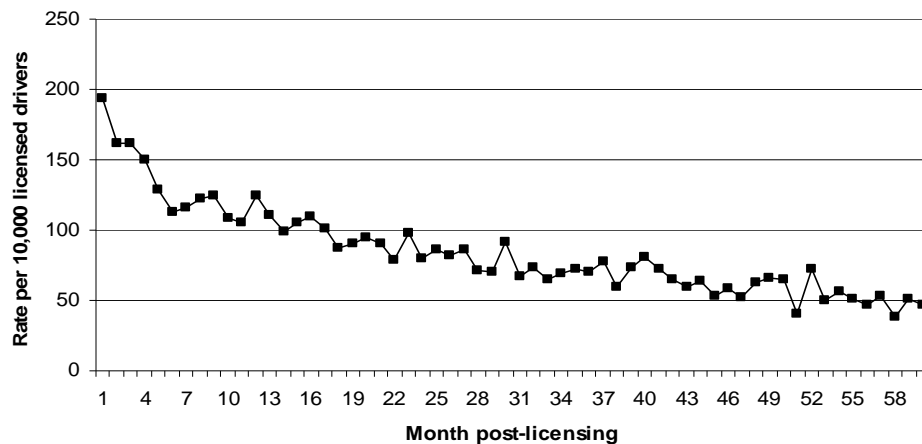


Figure 1.1 Rate of police recorded crash involvement for Western Australian drivers first licensed at 17 years of age in 1998; by month of licensure up to 60 months post-licensing (source: Palamara, 2005)

The developmental immaturity of novice drivers serves to exacerbate the risk of crashing because of an associated heightened disposition to engage in on-road risk taking behaviour. For example, young and novice drivers are significantly more likely than older more experienced drivers to self-report a higher frequency of speeding (e.g., Cercarelli, Hendrie, Dyke & Ryan, 1997; Cercarelli, Hendrie, Legge & Ryan, 1997; Cercarelli, Hendrie, Ryan, Legge & Kirov, 1997; Cercarelli, Hendrie, Ryan, Legge & Kirov, 1998; Smart & Vassallo, 2005); to be charged for speeding (e.g., Rosman, 2000; Kloeden, 2008), and to be involved in speed related crashes (McKnight & McKnight, 2000; Harrison, Triggs & Pronk, 1999). While behaviours such as speeding unequivocally increase the risk of crash involvement, it is reasonable to question whether all instances of risk taking by drivers, such as speeding, are deliberate and motivated by personal gain rather than being unintentional and the result of inexperience (Williams, 1998). This issue does not however mitigate the need for appropriate countermeasures to manage risk taking and risky behaviours among those drivers who have the least experience and maturity.

In summary, there is a substantial body of research evidence to confirm that the inexperience and youthfulness of young novice drivers means that they are more likely than older, experienced drivers to engage in risky on-road behaviours - either deliberately or unintentionally - and to be involved in a crash. To counter these

outcomes, Graduated Driving Licensing systems have developed across countries such as North America, New Zealand, the United Kingdom and Australia that aim to control, to varying degrees, the exposure of novices to known, high crash risk factors (e.g., night-time driving; consumption of alcohol; presence of passengers; use of mobile phones) while allowing novices the opportunity to gain experience and safe driving skills under low risk situations. To date there is good evidence of the effectiveness of the format of graduated licensing and its varying components in North America (Foss & Evenson, 1999; Shope, Molnar, Elliott, & Waller, 2001; McKnight & Peck, 2002; Vanlaar, Mayhew, Marcoux, Wets, Brijs, & Shope, 2009; McCartt, Teoh, Fields, Braitman & Hellinga, 2010) and New Zealand (Begg & Stephenson, 2003).

Graduated Driver Licensing systems vary somewhat from country to country and even across Australia. Unlike their overseas counterparts, some Australian systems include restrictions on the power or performance of the vehicle novices are permitted to drive. Legislation prohibiting novices from driving vehicles exceeding 125 kilowatts per tonne of kerbside weight was first introduced in the state of Victoria in 1995 (Palamara & Gavin, 2005). In more recent years other versions of a vehicle restriction scheme have been introduced by New South Wales, Queensland, South Australia, and Victoria that include specific reference to the number of engine cylinders and method of aspiration (see Chapter 4 for a summary of these restrictions).

The need to introduce a restricted vehicles scheme for Western Australian novice drivers has been debated since the turn of the century as part of the on-going redevelopment of the state's Graduated Driver Licensing system. To assist the debate a limited investigation of the relationship between vehicle performance and crash risk for WA. novice drivers (Palamara & Gavin, 2005; see Chapter 2 for a review) was commissioned. The investigation primarily noted that high performance vehicles (defined as those exceeding a power to weight ratio of 125 kilowatts per tonne of vehicle weight, the Victorian restriction at the time) were only marginally represented in the serious injury crashes of novice drivers. Notwithstanding the many and varied limitations of this investigation the government of the day dismissed the need for a restricted vehicle scheme. However, over the intervening years a number of high profile novice driver crashes have occurred which has led to the

reconsideration of the need to introduce such a scheme as part of the state's Graduated Driver Licensing system.

1.1 Aim and Objectives

This program of research was commissioned by the Road Safety Council of Western Australia to provide more definitive contemporary evidence of the relationship between vehicle performance factors, age of driver, and risk of involvement in a serious injury crash to reconsider the need for a restricted vehicles scheme for novice drivers.

The specific objectives of the program of research were as follows:

Objective One

To investigate the relationship between vehicle performance and serious injury crash involvement among Western Australian drivers (i) aged 17-19 years holding a provisional, restricted 'C' class motor car drivers' licence and (ii) drivers older than 19 years holding a full, unrestricted 'C' class motor car drivers' licence

Objective Two

To compare the finding from Objective 1 with the findings of the previous investigation undertaken by Palamara & Gavin (2005).

Objective Three

To consider the recent experiences of other Australian jurisdictions with respect to vehicle performance restrictions for novice drivers

Objective Four

To provide recommendations to the Road Safety Council of Western Australia regarding the need for vehicle performance restrictions for novice drivers and the form of those restrictions.

1.2 Project Activities

The main project activities to address the aims and objectives were as follows:

Activity One

The identification and review of published scientific literature to describe the existing relationship between vehicle performance factors and driver behaviour and crash involvement.

Activity Two

The analysis of Western Australian motor vehicle crashes 2001-2008 resulting in serious injury (killed or hospitalised) linked with driver licensing, vehicle registration, and vehicle performance data to determine the statistical relationship between vehicle performance and risk of crashing.

Activity Three

A critical comparison of the findings of Activity Two with the findings of other relevant research, particularly the research undertaken by Palamara & Gavin (2005).

Activity Four

The retrieval of on-line information from relevant Transport and Licensing websites across Australia and telephone interviews with key Transport, Licensing and Roads Safety stakeholders to describe the development, form, and management of restricted vehicle programs operating in Australia.

Activity Five

Based on the findings of Activities One to Four, the development of a series of recommendations for the Road Safety Council on the need or otherwise of a restricted vehicles program, its form if required, and/or other related initiatives to manage novice driver behaviour and their risk of crash involvement.

1.3 Project Management

The project was undertaken by the Curtin-Monash Accident Research Centre (C-MARC) (Curtin University, Western Australia and Monash University, Victoria) in collaboration with the Centre for Automotive Safety Research (CASR). The former institution was primarily responsible for the management of the project and Activities One, Three and Four. The CASR was primarily responsible for Activity Two and the production of the technical supplement. Both institutions contributed to Activity Five.

1.4 Ethics

The program of research was undertaken with the approval of the Human Research Ethics Committee of the School of Public Health, Faculty of Health Sciences, Curtin University of Technology (approval SPH-38-2011). Approval was also provided by

the Human Research Ethics Committees of The University of Adelaide and Monash University.

2. LITERATURE REVIEW

2.1 Search and retrieval of the scientific literature

The search for literature on the relationship between vehicle performance, driver behaviour, and crash involvement was undertaken using the following databases: Google scholar, ProQuest, Transportation Research Broad databases; Current Contents, Scopus, Factiva and EconLit. 'Key words' were used to identify and retrieve relevant local, national and international publications (books, reports, scientific journal articles, conferences papers). Numerous studies of the relationship between vehicle characteristics and driver behaviour and driving outcomes were identified but most were excluded from the review because they did not explicitly consider the performance of the vehicle per se but focused on issues such as vehicle type and vehicle size and weight. Very few published investigations of the relationship between vehicle performance factors and driver behaviour and driving outcomes were identified. Further still, only a minority of studies considered the relationship among the youngest and most inexperienced novice drivers.

2.2 Vehicle performance and on-road driver behaviours

As vehicle performance influences both the ability to accelerate and to achieve high travel speeds it is not surprising that speeding and speed related behaviours have been the primary focus of on-road behaviours associated with driving a high performance vehicle. Somewhat related are the investigations of the relationship between vehicle performance and driving aggression and road rage.

In the first of a series of investigations undertaken by Horswill & Coster (2002), vehicle performance (based on the summation of the observed vehicles' top speed, acceleration and brake horsepower) was analysed for its influence on the observed speed of drivers in the United Kingdom while controlling for driver age and gender, location of travel and slope of road. An independent linear relationship was found between vehicle performance and observed driver speed, in that drivers of higher performance vehicles were more likely to travel at higher speeds. Driver age was also significantly related to observed speed though the interaction between driver age and vehicle performance was not addressed. Subsequent investigations to determine the causal nature of the relationship led Horswill & Coster (2002) to conclude that the relationship is bi-directional: drivers who take more risk are also likely to choose faster cars, while driving a faster high performance car is also likely to influence one's intention to take risks such as speeding. One possible implication of the

suggested bi-directional nature of the relationship is that drivers who are predisposed to risk taking will most likely choose the most available and affordable car they can to satisfy this motivation, while the risk taking of other drivers may be dependent on their access to a high performance vehicle.

A qualitative examination of the crash reports of 3,000 drivers aged 17-25 years in the United Kingdom (Clarke, Ward & Truman, 2002) provides some evidence to suggest that driving a high performance vehicle is associated with exceeding the speed limit, which in turn was identified as a 'trigger factor' for involvement in a fatal or serious injury crash. Based on their review of crash records the authors concluded that crash involved young drivers of performance vehicles were more likely to have been exceeding the speed limit or driving recklessly compared with a driver not in a performance vehicle. Unfortunately little information was provided to describe the operational definition of a vehicle of 'above average performance other than a reference to vehicles with a 16 valve engine.

Other investigators have considered whether driving a high performance vehicle necessarily increases the risk of driving aggressively (Krahe & Fenske, 2000) and displaying road rage (Smart, Stoduto, Mann & Adlaf, 2004). In the first study of aggressive driving 150 German male drivers aged 20-67 years were surveyed. The performance of the driver's vehicle was defined by horsepower (without reference to weight) and related to the drivers responses on a range of survey instruments measuring driving aggression. Multiple regression analysis showed that the horsepower of the vehicle accounted for just under 4% of the variance in driving aggression scores, while 25% of the variance was explained by a measure of driver masculinity ('macho' personality'). Age of driver accounted for a further 6% of variance in scores. Interestingly, when questioned about their car preferences, drivers who gave highest priority to the speed or sportiness of the car scored highest on a measure of masculinity or 'macho' personality. This later finding perhaps suggests that driver personality is an important element in the choice of vehicle and also driving style.

In the related telephone survey study of 1,600 Canadian drivers aged 18+ years, Smart et al. (2004) reported that drivers of high performance cars (categorised from respondents description of their cars as a 'muscle' or 'sports' car) were significantly more likely than drivers of other cars to report having perpetrated acts of minor road rage (e.g., shouting, cursing, threatening behaviour toward other drivers without

assault or property damage) in the previous 12 months. Performance car drivers were no more likely than drivers of other vehicles to have committed more serious acts of road rage (property damage and assault). While the definition of a performance car in this study is somewhat loose and subjective, the trend is consistent with other studies that suggest drivers of performance vehicles are somewhat more likely to be antisocial and aggressive as displayed by their speeding behaviour.

2.3 Vehicle performance and crash involvement

2.3.1 Australasian research

The first published investigation of the relationship between vehicle performance and crash involvement was undertaken by Drummond & Healy (1986) in the Australian state of Victoria. Using an on-road driving exposure survey methodology linked with crash and vehicle (i.e., brake horsepower) data, the authors found that drivers holding a licence for less than one year and driving a vehicle exceeding 150 brake horsepower (approximately equivalent to 112.5 Kilowatts) had a crash rate (adjusted for exposure) some 20% higher than similarly licensed drivers in vehicles less than 150 brake horsepower. No information was provided on the statistical significance of the difference in the rate. It is also worth noting that the measure of performance in this study, brake horsepower, did not consider the weight of the vehicle which is known to influence vehicle acceleration and speed. Drummond & Healy (1986) concluded that “...*increased vehicle power does not contribute disproportionately to inexperienced driver risk - in absolute terms...*” (page 158).

In a later review of this work, the first author (Drummond, 1994) described the investigation as preliminary rather than conclusive, as it provided only tentative and limited findings because of the small number of vehicles in the 150+ brake horsepower group studied. Drummond (1994) also stated the findings did not provide “...*sufficient justification for the implementation of a novice driver vehicle power restriction...*” (page 54) and that any such restriction would likely yield a crash reduction in the vicinity of only 2%. Contrary to this recommendation Victoria introduced their restricted vehicles scheme in 1995 banning novices from vehicles with a power to weight ratio $\geq 125\text{kw/tonne}$.

The second Australian investigation of the relationship between vehicle performance and crash risk was undertaken by Palamara & Gavin (2005). In this Western Australian study, serious injury crashes (resulting in death or hospitalisation)

involving a driver aged under 20 years and licensed for less than two years (equivalent to the provisional licensing period) were identified and the power to weight ratio of the crashing vehicle calculated. Crashes involving an illegal driver Blood Alcohol Concentration Level were excluded from analysis on the presumption that alcohol was likely to be the main cause of the crash. A total of 1,065 crashes met the criteria for inclusion but was later reduced to 662 as a Vehicle Identification Number (VIN) could not be retrieved from the Department of Transport database to assist with the identification of the vehicle's power output (kilowatts) and kerbside weight from the manufacturer's database of vehicle specifications.

Of the 662 relevant crashed vehicles, 65% had a PWR $\geq 50\text{kw/tonne}$ and $< 75\text{kw/tonne}$, while 2.9% (n=19) had a PWR $\geq 100\text{kw/tonne}$. Only two vehicles had a PWR exceeding 125kw/t which was the exclusion PWR under Victorian vehicle restriction scheme at the time of the research. The remainder evidenced a power to weight ratio less than 50kw/tonne. An associated case-control investigation based on n=84 crashing drivers matched for age, gender, year of licensure and length of licensure with the vehicle performance information obtained via a survey of n=84 drivers who had not crashed showed that increasing vehicle power to weight ratio was not statistically associated with a significantly increased risk of crashing.

Though the research by Palamara & Gavin (2005) provided some descriptive evidence that young driver serious injury crashes occurring within two year of licensure are not characterised by high vehicle power to weight ratios, the findings from the case-control study are of limited value due to the small number of case-control pairs. The general findings are also limited by a number of other methodological issues. For example, excluding crashes involving illegal BAC levels may have inadvertently excluded drivers of high performance vehicles if on-road risk taking of this sort and the decision to drive a high performance vehicle are inter-correlated via driver characteristics. Secondly, some 38% of novice driver serious injury crashes occurring during the two year study period were excluded because a VIN was not available to retrieve vehicle performance information. Thirdly, the authors made no attempt to categorise the crashes by type (speed related; single vehicle run off road etc) to investigate the possible impact of vehicle performance on crashes that have a higher probability of being speed related. Finally, the vehicle performance information retrieved from the on-line database of

manufacturer information was pertinent to ‘base model’ vehicles only and therefore may have underestimated the crashed vehicle’s power to weight ratio if the vehicle in question was anything other than a base model.

The absence of strong evidence and the limitations on the validity of the findings led Palamara & Gavin (2005) to judiciously recommend that “*Western Australian Provisional drivers should not be subject to a vehicle power to weight ratio restriction*” (page 24) and that “*..the speeding behaviour of the young novice driver be targeted and regulated through changes to the licensing system and penalty structure*” (page 24).

The most recent Australian study of the effect of vehicle performance on the risk of crashing among young drivers was undertaken by Keall & Newstead (2012). The study specifically sought to determine the potential safety benefits of a restricted vehicle program using crash and vehicle registration data from five Australian (New South Wales; Victoria; Queensland; South Australia, and Western Australia) states and New Zealand. In this study vehicles were categorised as ‘high performance’ in accord with the criteria applied by *any* of the three Australian states (Victoria, New South Wales, Queensland) operating a restricted vehicles program at the time of the study.

In the first instance the authors identified that less than 1% (0.84%) of all vehicles manufactured 1990-2008 and registered to drivers aged 15-24 in New Zealand were classified as high performance. When analysed by market group, this percentage was highest for those in the 4WD large vehicle range (3.77%). The annual rate of crash involvement over the period 2004-2009 per vehicle in New Zealand was calculated for all ages and those aged 15-24 years. The rate of crash involvement for high performance vehicles involving drivers aged 15-24 years (1.08%) was somewhat higher than that for all age drivers (0.28%) of high performance vehicles and slightly higher than that for younger age drivers of non-high performance vehicles (0.85%). The authors concluded that if New Zealand restricted high performance vehicles in accord with those restrictions operating in Australia the estimated injury savings for young drivers could be up to 1.9% and up to 3.9% if the restrictions included other vehicles identified to be involved in crashes where excessive speed was deemed to be a contributing factor.

Analysis of the Australian crash data showed that up to 7.2% of males and 2.1% of females under 25 years involved in a crash across the five Australian jurisdictions studied were driving a high performance vehicle defined by any of the three states where a restriction applies. When restricted to crashes where the driver was killed or hospitalised (KSI), high performance vehicles accounted for 10.6% and 1.5% of KSI respectively among male and female drivers under 25 years of age. Of particular interest was the finding that 3.4% of crashes in Western Australia involving provisional drivers less than 25 years of age were driving a vehicle that would be categorised as high performance under the various existing Australian restrictions.

Based on crashes over the period 2005-2009 in Western Australia *and* South Australia (who did not have vehicle restrictions during the study period) where the proportion of the crash fleet involving drivers under 25 years meeting the restricted vehicles criteria was 4.7%, Keall & Newstead (2012) estimated that drivers in such vehicles were nearly twice as likely to crash compared with those in non-restricted vehicles, and that the potential injury saving was around 2.2% for this driver age group. A near three-fold increase in the estimated injury saving was calculated if the restricted vehicles included those previously identified from the analysis of New Zealand data to be involved in high-speed collisions. These estimates do not however, distinguish between young novice (provisional) and more experienced (non-provisional) young drivers. The other issue of note is that potential estimates are based on the assumptions of perfect compliance with the proposed restrictions, and second, that the move to driving a non-high performance or speed crash related vehicle will effectively change the crash risk of the target drivers (Keall & Newstead, 2012).

The various findings led Keall & Newstead (2012) to conclude that the restricted vehicles in question “*..have a statistically significant higher crash and injury risk than other vehicles for young drivers*” (page 33) and that their restriction as part of a graduated licensing program is rational. However, this conclusion was tempered by the relatively small number of vehicles the current restrictions apply to and the associated modest safety benefits being outweighed by the cost of implementation (Keall & Newstead, 2012).

2.3.2 International research

An early investigation of the association between vehicle performance and crash involvement undertaken by Fontaine (1994) considered crashes occurring in France during the period 1991-1992. The crash risk per kilometres travelled was calculated for categories of crash involved male and female drivers based on age, vehicle power to weight ratio (in vehicle weight ranges), and location of crash. Fontaine (1994) noted that the highest relative risk of crash involvement (all types) was found for the category of drivers who were less than 30 years of age, driving vehicles with a PWR $\geq 75\text{kw}/1,000\text{ kg}$ (within the 800kg to 1,000kg vehicle weight range) in non-urban areas. When single vehicle crashes were specifically considered, a significant effect of PWR on the probability of being killed was identified, but only for the category of *male drivers under 30 years of age*. Based on the derived estimates for the effect of PWR, the probability of a young male driver being killed when driving a vehicle with a PWR of 100kw/1,000kg was 0.11, compared with 0.08 for a vehicle with a PWR of 50kw/1,000kg. Fontaine (1994) concluded that this difference was most likely due to vehicle speed. Overall, the findings suggested that drivers under 30 years of age show a higher risk of crash involvement when driving a high performance car of *medium weight* (ie., sports type cars) in non-urban areas (presumably where permissible speeds and illegal speeds are higher relative to urban areas). The findings also suggested that driving a vehicle with a high PWR is particularly problematic for young males (less than 30 years of age) in the case of single vehicle fatal crashes rather than for all younger age drivers and across all crash types. Unfortunately this study did not specifically address novice drivers.

The aforementioned qualitative investigation of young driver crashes in the United Kingdom (Clarke et al., 2002) reported some evidence to support the increased risk of crashing when driving an above average performance vehicle. In approximately 8% of crashes where the young driver was either fully or partially 'at fault', a vehicle of 'above average' performance' was being driven. Clarke et al. (2002) also noted that a higher proportion of crashes involving above average performance vehicles occurred at night (which perhaps coincides with recreational/leisure driving) and were driven by males. Young drivers who crashed in performance cars were also more likely to have taken the car without the owner's consent. This finding potentially confounds the relationship between exposure to a higher performance vehicle and crash risk, since driver characteristics associated with the

illegal use of the (higher performance) car may be highly correlated with other risk taking behaviours related to crashing. Overall, it is difficult to determine the significance of these findings as the operational definition of the category of 'above average' performance vehicles was not well described, nor was any other information provided to indicate whether 8% is an over-representation for the number of 'above average' performance vehicles registered to young drivers.

2.4 Conclusion

A limited number of studies of vehicle performance and driver behaviour and driving outcomes were available for review. Furthermore, even fewer of these studies focussed on young novice drivers and used acknowledged, standard definitions of vehicle performance such as power to weight ratio. The considerable variability in the research methodologies in relation to the driver groups, independent and dependent variables, and data collection methods makes it difficult to identify strong and valid findings regarding a consistent and quantifiable influence of vehicle performance on driving outcomes. That said, the research shows a reasonably consistent theme of drivers of high performance vehicles, including young drivers and males, as being more likely to engage in anti social and risk taking behaviour on the road and of having a higher risk of involvement in a crash. In relation to the last point, the Australasian research provides the strongest evidence of this though it also notes that young drivers in high performance vehicles involved in a crash represent a relatively small proportion of crashes among this age group.

What is most apparent from the above review is that little attention has focussed on the relationship between driver characteristic and vehicle selection and the interaction between these in relation to driving outcomes. It is not entirely clear whether driving outcomes are directly influenced by vehicle performance per se or whether drivers with certain dispositions or personality traits - such as sensation seeking which has been significantly and consistently associated with on-road risk taking behaviour and crash outcomes (see the review by Palamara et al., 2012) - seek out certain types of vehicles to express their behavioural style. If so, would restricting high sensation seeking drivers to lower performance vehicles significantly alter their likelihood of engaging in risky behaviours and becoming involved in a crash? It is quite likely they would seek to drive the highest performance vehicle they were legally able to and drive it in a manner that maintains their higher crash risk. This issue requires further investigation.

3. ANALYSIS OF WESTERN AUSTRALIAN SERIOUS INJURY CRASH DATA 2001-2008

Police reported serious injury crashes occurring in Western Australia 2001-2008 were analysed to determine the statistical relationship between vehicle performance and risk of serious injury crash involvement. This work was undertaken by the Centre for Automotive Safety Research, The University of Adelaide and reported by Hutchinson & Anderson (2012). The full technical report documenting the methods and findings is presented as a supplement. A general discussion of the findings, particularly in relation to the previous Western Australian research undertaken by Palamara & Gavin (2005) is presented in Chapter 5..

4. REVIEW OF EXISTING VEHICLE PERFORMANCE RESTRICTION SCHEMES

4.1 Retrieval of information

The review was limited to Australia as vehicle performance restriction schemes are not known to operate elsewhere. At present, schemes operate in Victoria, New South Wales, Queensland and South Australia. Accordingly, the Transport and/or Licensing websites of these jurisdictions were accessed and information retrieved on the nature of the schemes. In addition, key Transport and/or Licensing personnel were identified and consulted in each of these jurisdictions to obtain further information (over the period 2010-2012) regarding the circumstances and evidence leading to the introduction of the restriction, the nature of exemptions if any, and current procedures for implementing, monitoring/enforcing, and evaluating the system. Similarly, relevant personnel in Tasmania, the Australian Capital Territory, and the Northern Territory were contacted to enquire why restrictions have not been introduced to date and whether restrictions are likely to be introduced in the future and under what circumstances.

4.2 Overview of existing Australian vehicle restriction schemes

Restriction on the access of Australian novice drivers to 'high performance' vehicles was first introduced in Victoria, 1995. Under the scheme, provisional drivers were prohibited from driving a motor vehicle that exceeded 125 kilowatts per tonne of vehicle kerbside weight or with an engine capacity to weight ratio exceeding 3.5 litres per tonne. New South Wales was the next jurisdiction to introduce vehicle restrictions in 2005, followed by Queensland in 2007 and South Australia in 2010. At present, all four jurisdictions operating a vehicle restriction scheme define a high performance vehicle by the number of cylinders (vehicles with eight or more cylinders are restricted), method of aspiration (turbo/super charged are generally restricted), fuel type (exclusions may be provided to diesels fuel vehicles) and kilowatt output (which varies across the jurisdictions). Victoria abandoned their Power to Weight Ratio criteria in 2007 to be consistent with the broader criteria first introduced by New South Wales. The main elements of each jurisdiction's vehicle restriction scheme are presented in Table 4.1. The information does not represent a definitive description of the existing schemes as some administrative and technical details have been omitted for the sake of brevity (e.g., those related to acceptable and unacceptable engine performance modifications).

Table 4.1 Summary of novice driver vehicle performance restriction schemes operating throughout Australia[^]

Jurisdiction	Details of Provisional Driver Restricted Vehicles			
	Eight or more Cylinders	Six-Cylinder	Turbo/Supercharged	Conditions and Exemptions
Victoria	All	Certain [^] nominated [^] high performance vehicles per published list (not exhaustive but indicative). Criteria are based on whether the vehicle is 'family' type or sports (2 door) vehicle. No defined PWR or KW rating identified.	Diesel fuel vehicles exempted, as are low powered petrol vehicles with a PWR <100 and those with a PWR 100-125 and considered to be a family, non-sports, vehicle.	Restriction applies to Provisional drivers. Exemption to drive a 'high performance' vehicle can be granted if the vehicle is required for genuine employment purposes or would otherwise cause undue hardship.
New South Wales	All, except that 8-cylinder 4WD vehicles may be driven by those in rural/remote areas if no practical alternative is available.	Designated list of restricted vehicles that has not been updated since 2007. Originally vehicles over 200kw power output were restricted but this was found to include some 'appropriate' vehicles. 135 PWR is now the 'cut point' but this has not been publicly stated nor has the public list been updated to reflect this.	Diesel fuel vehicles exempted, as are low powered petrol vehicles with a PWR <125	Restriction applies to Provisional drivers. Exemption to drive a 'high performance' vehicle can be granted if the vehicle is required for genuine employment purposes or the car was owned prior to July 2005.
Queensland	All	Vehicles with an engine output of more than 200kw. This will soon be increased to 210kw to permit certain 'family' type vehicles to be driven.	Diesel fuel vehicles exempted, as are moderate powered petrol vehicles (as per published list).	Restriction applies to drivers on P1 and P2 under 25 years and to those returning from disqualification and younger than 25 years. Exemption to drive a 'high performance' vehicles can be granted if the vehicle is required for work or study purposes or to obtain medical treatment for self or other family member or was owned prior to June 30 th 2007.
South Australia	All	Certain [^] nominated [^] high performance vehicles per published list (last updated May 2011).*	Diesel fuel vehicles exempted, as are moderate powered petrol vehicles (as per published list).*	Restriction applies to P1 and P2 drivers under 25 years of age, and those under 25 years returning to driving after disqualification. Exemption to drive a 'high performance' vehicle can be granted if the vehicle is required for work purpose or no other vehicle is available for use. Exemption also granted if vehicles was owned prior to September 2010.

[^]As at February 2012. *Further technical details were sought from South Australia but were not provided.

Table 4.1 shows that there is consistency across the jurisdictions in regards to the restriction of vehicles with eight or more cylinders but some variation in regard to the restriction on certain six-cylinder vehicles, turbocharged vehicles, and vehicle

power to weight ratio limits. All jurisdictions apply the restriction through the entire provisional driver period and consider applications for exemptions.

Consultation with representatives from the jurisdictions restricting access to high performance vehicles revealed that some jurisdictions are experiencing difficulty maintaining updates of restricted vehicles via published lists, while most find it difficult to manage the overwhelming level of administration required to process applications for exemptions to drive restricted vehicles. In at least one jurisdiction, Victoria, the application to drive a restricted vehicle (a V8 BMW 7 Series) has resulted in court action by the applicant (*Robertson versus VicRoads*). Whilst the presiding Magistrate ruled in favour of VicRoads to uphold the restriction on the use of the vehicle it is understood the applicant is considering pursuing the matter in a higher court with support from vehicle manufacturers Mercedes, BMW and Volkswagen (Robertson, personal communication 2011).

All jurisdictional representatives acknowledged that a combination of community, media and political pressure was largely responsible for the introduction of the initiative. The initiative was not based on reliable scientific evidence of a relationship between vehicle performance and novice driver crash risk or calculations of the safety benefit of restricting the access of young novice drivers to high performance vehicles. Most representatives stated that vehicle restrictions were introduced and ‘marketed’ as being supportive of their graduated licensing schemes and/or to combat ‘hooning’ behaviour.

The jurisdictional representatives were not at the time able to provide reliable information on the level of compliance with their restricted vehicle schemes. It was acknowledged however, that ‘enforcing’ the restriction is problematic since it may be difficult for police to be certain which vehicle is restricted (particularly if lists of restricted vehicles are not regularly updated). This issue was cited as one of the reasons why a standardised measure of ‘high performance’ based on vehicle power to weight ratio is being proposed for use nationally (see Section 4.3).

To date, Victoria and New South Wales (the longest operating programs) have not per se evaluated the impact of their vehicle restriction programs on novice driver crashes. Queensland is reportedly doing so as part of an on-going comprehensive review of their graduated licensing scheme and South Australia stated it will consider

an evaluation in the future. New South Wales claimed that their recently identified reduction in novice driver crashes and traffic offences had more to do with the overall package of recently introduced graduated licensing initiatives than vehicle restrictions per se. Of the many initiatives recently introduced in NSW, it was reported that the automatic suspension of provisional drivers for three months upon incurring *any speeding offence* had been particularly successful in curbing speeding behaviour (21% reduction in speeding offences from 06/07 to 07/08) and related crashes. In NSW, as in Western Australia, provisional drivers are automatically suspended when they have accrued four demerit points. Unlike Western Australia however, the demerit point penalty for the lowest level speeding offence committed by a provisional driver in New South Wales is four points-which by default will result in the automatic suspension of the driver's licence.

The jurisdictional representatives acknowledged that a vehicle performance restriction is an initiative that does not target the broader population of novice drivers and the most important factors contributing to their over-representation in crashes, which include inexperience, risk taking, and speeding. The representatives agreed that a restriction on high performance vehicles appears to target only minority of 'at risk' drivers, while other noteworthy and effective initiatives of graduated licensing target the broader population of novice drivers at risk and who account for the majority of crashes and traffic offences.

Licensing and/or Transport representatives from the Australian Capital Territory and the Northern Territory advised they were not in the near future considering the introduction of a restricted vehicle scheme. Both jurisdictions advised there was no reason to believe that high performance vehicles were a significant contributor the novice driver crash problem in their jurisdictions or nationally. The Northern Territory also considered that their 'anti-hoon' policies introduced in 2009 would indirectly target the behaviours of those who might risk take in high performance vehicles.

Tasmania advised that vehicle restrictions had been previously considered as part of a review of Novice Driver Reforms, and supported by key stakeholders, but there was however no compelling evidence of an associated road safety benefit. Hence there is currently no intention to introduce restrictions.

4.3 The establishment of a national definition of ‘high performance’

Although there is some consistency across jurisdictions in the broad definition of a ‘high performance’ vehicle, the *Austroads* Registration and Licensing Program Task Force has been approached by the Federal Chamber of Automotive Industries (FCAI) to develop a nationally consistent policy regarding the restriction of high performance vehicles. This request was prompted by criticisms of the existing vehicle restriction schemes by FCAI members in regard to the at-times variable definition of a high performance vehicle and how the restrictions are applied. After a number of workshops on the issue involving representatives from the FCAI and Australian Transport and/or Licensing agencies, an in-principle agreement has been reached for a national definition based on a simplified single Power to Weight Ratio (PWR) measure of 130 kilowatts per tonne of tare weight. Activation of the measure could be as early as 2013/2014, subject to modifications of the national database of drivers and vehicles, known as the National Exchange of Vehicle and Driver Information System (NEVDIS). NEVDIS would be used to provide all jurisdictions with accurate information on vehicles banned under the new national measure. It should be noted however, that agreement on a PWR of 130kw/tonne was reached despite acknowledgement by the Task Force that there is currently no reliable empirical evidence supporting a relationship between vehicle performance and crash risk for young novice drivers.

Jurisdictional representatives from the ACT and the Northern Territory commented that the establishment of a national definition for a high performance vehicle would not necessarily mean they would adopt the initiative.

4.4 Summary and concluding comments

Four Australian jurisdictions currently operate a restricted vehicles scheme for novice drivers that restrict the driving of:

- all eight-cylinder vehicles;
- some normally aspirated high performance six-cylinder vehicles (at times based on a power to weight ratio limit or kilowatt output that varies across jurisdictions), and,
- turbo charged vehicles unless they are ‘low powered’ or diesel fuelled.

The definition of a high performance normally aspirated six-cylinder vehicle varies somewhat across the jurisdictions and perhaps for this reason there is strong interest,

promoted by vehicle manufacturers, in the development of a national standard based on a simplified power to weight ratio of 130kw/tonne tare weight. The administrative efficiency of this definition is seemingly tied to the redevelopment of and access to the NEVDIS database to enable the ready retrieval by jurisdictions of the required manufacturer's information on vehicle characteristics (e.g., kilowatt output, tare weight). However, this may not be possible for another two to three years. At present, WA.'s TRELIS system provides no useful information to assist with the administration and enforcement of a restricted vehicles program since it *does not* contain *all required information* to apply any of the criteria of the existing schemes or the proposed national definition based on power to weight ratio.

From the discussions with representatives from jurisdictions that operate a restricted vehicle scheme there is reason to believe:

- the schemes can be difficult to support, defend and promote given the absence of empirical evidence in support of a relationship between vehicle performance and crash risk;
- some schemes have difficulty in informing and advising the motoring public (and police) on permissible and restricted vehicles; for example, lists of vehicles are not readily updated, leaving the onus on the motorist and police to determine if the vehicle is unrestricted or restricted;
- the exemption process can be onerous, resource intensive, and open to abuse, which ultimately undermines the intent and possible effectiveness of the scheme; and,
- that to date, there has been little commitment to an evaluation of the effectiveness of the schemes.

To conclude, it would appear that the existing Australian vehicle performance restriction schemes were primarily introduced in response to political and community pressure rather than strong existing evidence in support of higher performance vehicles being a significant contributor to the crash problem of young novice drivers. Consequently, the operational definitions of a high performance vehicle across the schemes do not necessarily align with a known increased risk of crashing for this driver group. From an administrative and enforcement point of view the schemes can be cumbersome and vague and readily circumvented and undermined through the

exemption process. Finally, the interest in a national, standardised definition of a high performance vehicle using power to weight ratio suggests that WA. should in any event delay the introduction of a scheme (if the need exists) until the national definition is finalised and the supporting data systems (NEVDIS) are available.

5. DISCUSSION

In this Chapter the findings relating to Objectives One to Three are discussed.

5.1 Objective One

Investigation of the relationship between vehicle performance and the risk of serious injury crash involvement among young novice drivers compared with older age Western Australian drivers

The findings related to this objective, based on the analysis of crash and other data, were presented in the report by Hutchinson & Anderson (2012) (see the Technical Supplement). The report also provided a cogent discussion of the findings which should be read in conjunction with this section.

Bearing in mind the identified methodological limitations, there was some persuasive rather than definitive evidence to support the view that young novices in high performance vehicles are more likely to be involved in crashes resulting in a serious injury (i.e., death or hospitalisation). Furthermore, other evidence suggested that higher performance vehicles were more likely to be involved in single vehicle as opposed to two vehicle crashes. This later finding suggests that the combination of driver and high performance vehicle factors are more likely to be causally responsible for such crashes compared with those involved in two vehicle crashes where fault or responsibility may be shared between the two drivers and vehicle combination.

These findings alone do not however, provide the level and strength of evidence to make a compelling case for the introduction of vehicle restrictions or what form they should take. This study, like the previous investigations undertaken by Palamara & Gavin (2005) and Keall & Newstead (2012), was not able to disentangle the effect of vehicle performance on crash risk from the effect of driver characteristics (other than age). For example, it may be that drivers who are more inclined to drive a high performance vehicle are also highly disposed to risky behaviours such as speeding and drink driving. If so, restricting such risky drivers to lower performance vehicles may have little impact on their behaviour and risk of crashing. Alternatively, it may be more productive to implement additional initiatives to broadly decrease speeding among young novice drivers, irrespective of the vehicle they drive.

One of the most significant limitations of this study in determining the increased risk of crashing associated with high performance vehicles was the low number of serious

injury crashes involving young novice drivers. Indeed the low number of fatal and hospitalisation crashes involving young novice drivers in high performance vehicles is a telling observation on the size of the problem. Given the low number of crashes, Hutchinson & Anderson (2012) noted that even the most effective vehicle restriction policy would at best have minimal impact on the overall level of crashes and injury. This point was also made by Drummond (1994) who suggested that restrictions based on vehicle performance might at best lead to a 2% reduction in crashes. When the granting of exemptions and the unknown level of compliance is taken into account there is even more reason to question the likely effectiveness and cost-benefit of vehicle restriction programs to reduce road injury.

5.2 Objective Two

To compare the finding from Objective One with the findings of the previous investigation undertaken by Palamara & Gavin (2005).

5.2.1 Methods issues

Before comparing and contrasting the findings of this study with those of the earlier WA. investigation conducted by Palamara & Gavin (2005), it is worth noting the main differences between the studies in the methods and analytical techniques employed.

Both studies considered serious injury crashes only, though the earlier study was restricted to the investigation of crashes occurring 1999 and 2000 compared with crashes occurring 2001-2008 for this study. While both studies addressed crashes involving provisional drivers aged 17-19 years, *most* crashing drivers in the current study were licensed under a revised Graduated Driver Training and Licensing program (introduced 2002), which may in itself reduce the crash risk of novice drivers relative to drivers investigated in the earlier study. The earlier study also sought to control for the effect of alcohol on the risk of crashing by excluding alcohol related crashes from the analyses, whereas the current study did not do so. The exclusion of such crashes in the earlier study may have inadvertently excluded crashes involving high performance vehicles. Unfortunately this was issue was not verified.

Most importantly, there were marked differences between the studies in the retrieval and validity of vehicle performance data and the classification of vehicles as ‘high performance’. While both studies used the Vehicle Identification Number of the

crashed vehicle to retrieve manufacturer's information to determine the performance of the vehicle, the earlier study could not retrieve information for the exact vehicle using the complete VIN but used a restricted VIN to retrieve generic information on the base model/variant of the vehicle. This may have resulted in the invalid retrieval of information for some vehicles if the crashing vehicle was of a higher specification. In contrast, the current study was able to access full manufacturer's details for the specific crashed vehicle as recorded for the vehicle when first registered.

In relation to the classification of vehicle performance, performance in the earlier study was simply and solely based on the vehicle's power to weight ratio with $PWR \geq 125$ denoting a 'high performance' vehicle (as per the Victorian scheme at the time). In contrast, this study considered vehicle performance in relation to the number of cylinders (4, 6 and 8) and the PWR of the vehicle *within* the various cylinder groups.

The methodological design and statistical techniques used to investigate the relationship between vehicle performance and crash risk also differed across the studies. In the earlier study by Palamara & Gavin (2005) a matched case-control design and conditional logistic regression was employed. 'Cases' were drivers who had crashed while 'Controls' (matched for gender, age and year of licensure) were those who had not crashed. 'Control' drivers were identified from the WA. motor vehicle driver licence database and asked to supply information on the car they mostly drove during the year their corresponding 'Case' driver crashed. Unfortunately this design was statistically underpowered as the analysis was restricted to just n=84 matched pairs. Further to this, no information was collected and used to adjust for exposure. In contrast, the current study employed a number of analytical methods to determine the statistical relationship between vehicle performance and crash risk. Firstly, the relative rate of serious injury crash involvement was calculated for owner-drivers (by age) in different vehicle performance categories. The denominator (the measure of 'exposure') for these rates was based on a sample of the registered vehicle fleet, 2001-2008. Second to this, the proportion of crashing vehicles by performance categories in single and two car crashes was calculated to investigate whether drivers of high performance vehicles have a higher representation in single vehicle crashes in which the responsibility for the crash rests solely with the driver rather than (potentially) shared with another driver in a two-car crash. Multivariate analyses were then undertaken to investigate

the confounding effect of other driver, vehicle and crash factors on the relationship between vehicle performance and the ratio of involvement in single and two-car crashes.

Compared with the previous investigation by Palamara & Gavin (2005) - which at the time had limited access to resources and information and was undertaken with a very modest budget - the present study was more considered and expansive and thus provides a more rigorous investigation of the relationship between vehicle performance and crash involvement among young novice drivers.

5.2.2 Findings

Bearing in the mind the aforementioned methodological differences between the studies, there are three main points of comparison of the findings:

- the identified proportion of high performance vehicles crashed by young novice drivers;
- the calculated crash risk for young novices when driving a high performance vehicle; and,
- the crash worthiness of vehicles crashed by young novice drivers.

Both studies showed that crashes involving young novice drivers in high performance vehicles account for a minority of crashes among this group. In the earlier study, approximately 2.9% of crashing vehicles had a PWR $\geq 100\text{kw/t}$, with just two crashing vehicles (0.3%) exceeding a PWR of 125kw/t , which was at the time the Victorian definition of a high performance vehicle. In the present study 7.6% of crashing vehicles involving a 17-19 year old driver were in the higher performance category (PWR $\geq 90\text{kw/t}$ across all cylinder groups). Additional analysis not presented in the technical supplement found only 2% of vehicles had a PWR $\geq 130\text{kw/t}$, the proposed national standard for a high performance vehicle. The greater proportion of high performance vehicles identified in this study compared with the previous may be due to a number of reasons including methodological differences between the studies and variation over time in the access to high performance vehicles by novice drivers.

In relation to the second point, the earlier investigation provided methodologically limited evidence to suggest that young novice drivers do not have a higher risk of crash involvement when driving a higher performance vehicle compared with a non high performance vehicle. In contrast, the present study provided evidence of a

relationship based on relative rates of crash involvement and the ratio of involvement of higher performance vehicles in single car crashes versus two car crashes. That said, the statistical evidence was reported to be more persuasive than definitive. It would seem that the findings of both studies were limited to lesser and greater degrees by methodological issues, particularly in regard to the number of relevant crashes for analysis.

In relation to the crash worthiness of crash involved study vehicles, the earlier study did not attempt to describe or measure this characteristic or indeed any vehicle safety feature. Palamara & Gavin (2005) nevertheless noted that restricting novices to vehicles with lower PWR ratings might inadvertently force them into older vehicles with lower crash worthiness ratings as well as lower performance specifications. In contrast, the current study did consider the safety ratings and features of a 2008 sample of the registered fleet in Western Australia in relation to vehicle performance. Hutchinson & Anderson (2012) noted that:

“..higher performance vehicles were more likely to have ESC (Electronic Stability Control), side curtain airbags and even driver airbags. The vehicles were newer and (at least in 4 cylinder categories) were more likely to have a 5-star ANCAP rating” (page 37) [italics added]

Both studies have raised the concern that vehicle restriction programs may inadvertently compromise the access of novices to vehicles with technologies that assist crash avoidance and improve occupant protection in the event of a crash. Whilst safety features and vehicle performance have been shown to be relatively coupled, Hutchinson & Anderson (2012) note that in time such safety features will be more available in vehicles across the various categories of vehicle performance.

5.3 Objective Three

To consider the recent experiences of other Australian jurisdictions with respect to vehicle performance restrictions for novice drivers

Four Australian jurisdictions - Victoria, New South Wales, Queensland and South Australia - currently restrict the access of young novice drivers to high performance vehicles. To the best of our understanding these restrictions (dating back to 1995 in Victoria) were not introduced because of evidence showing an increased risk of crash involvement for novices who drive a high performance vehicle. Rather, it seems the restrictions were introduced in response to community and political pressure. Some

jurisdictions also justified the restrictions as being consistent with the objectives of graduated licensing and other initiatives to combat ‘hoon’ driving. It is reasonable to assume that biased reporting by the media of young driver crashes and ‘hoon behaviour’ involving high performance vehicles has played some part in fostering the mistaken perception that such vehicles are a substantial road safety problem and that restrictions are a logical countermeasure to the young driver problem.

In addition to an absence of empirical evidence to support the introduction of these schemes, there appears to have been no attempt to date to evaluate the impact of the vehicle restrictions programs on novice driver crashes and other driving outcomes (e.g., traffic offences and injuries). This is particularly relevant to Victoria where vehicle restrictions based on power to weight ratio were first introduced in 1995. Clearly there is a need to establish the merit of these programs. At best, the investigation undertaken by Keall & Newstead (2012) suggest that the effectiveness of vehicle restriction programs are likely to be undermined by the common place granting of exemptions to drive restricted vehicles. The authors also questioned the cost-effectiveness of the programs given the relatively small number of crashes involving high performance vehicle, the limited potential injury savings and the high administration costs.

In the course of this project other information was gathered to suggest that some members of the community, including vehicle manufacturers, are less supportive of a vehicle restriction scheme if it denies young novice drivers access to vehicles with high crash worthiness and crash avoidance technologies. The case of Robertson vs VicRoads exemplifies this. In this case, the young novice driver unsuccessfully sought an exemption to drive a restricted eight-cylinder BMW on the basis that it was the family vehicle and that the vehicle has superior crash worthiness. The conclusion to this case highlights the somewhat contradictory and inconsistent nature of Victoria’s restriction scheme. The father of the novice driver has since reported that his son currently drives an *unrestricted* 2006 Lexus GS 450 Hybrid (Robertson, 2012 personal communication). This vehicle has a 3.5 litre six-cylinder hybrid (petrol and electric) engine and is equivalent in performance to a 4.5 litre eight-cylinder engine capable of achieving 0-100km/hour in 6 seconds (<http://www.topspeed.com/cars/lexus/2006-lexus-gs-450h-ar1946.html>; Hard & Dorman, 2012 personal communication). With a maximum output of 254kilowatts and a kerbside weight of 1,930kg, the PWR of this vehicle is approximately

132kw/tonne (Hard & Dorman, 2012 personal communication; <http://www.carbuddy.com.au/car/values/specification/viewspecs.aspx?gid=49864>). This is not a restricted vehicle in Victoria, despite its performance, because it is a normally aspirated six-cylinder engine and Victoria does not specify either a PWR or kilowatt output for restricting certain 'high performance' six-cylinder vehicles. This situation highlights the difficulties that can arise when attempting to restrict vehicles solely on the number of cylinders.

Following on from this point, while the review of the various restriction schemes showed a reasonably high level of consistency across the jurisdictions in regards to which vehicles were restricted, the one area of inconsistency and difference related to high performance six-cylinder engines. For example, the aforementioned Lexus GS 450 Hybrid vehicle is unrestricted in Victoria but would be restricted in Queensland because the power output exceeds Queensland's limit of 200 kilowatts. Inconsistencies such as this underscore the need to standardise the definition of a high performance vehicle, which is what *Austroads* is seeking to do based on a single measure of the ratio of power (kilowatts) to tare weight. To date, a $PWR \geq 130$ has been advocated but not agreed to. Even if this measure was accepted, jurisdictions would require access to the redeveloped NEVDIS database to administer and enforce the restriction. However, the redeveloped database might not be available for some years yet, which makes the implementation of the standardised measure a much longer term reality and certainly not a viable option in the near future for Western Australia.

In summary, the review of the vehicle restriction schemes operating throughout Australia has provided insight of the absence of empirical evidence to support their introduction and an absence of effort to determine the road safety impact of these schemes. For the most part the schemes exclude similar vehicles from use though difference was noted across the jurisdiction in regard to what is a normally aspirated high performance six-cylinder vehicle. It is also apparent that vehicle restriction schemes can be cumbersome to administer and enforce because of the provision of exemptions and lack of clarity on occasion around which vehicles are excluded and exempted. For these reasons it is reasonable to question the value of contemporary vehicle restriction programs.

6. RECOMMENDATIONS

Based on the suite of findings presented the following recommendations are provided to the Roads Safety Council for consideration.

1. Reject the introduction of a vehicle performance restriction scheme for Western Australian novice drivers

This study has failed to provide compelling evidence to support the introduction of a vehicle performance restriction scheme; such a scheme is therefore not recommended at this point in time. Notwithstanding the identified methodological problems for the study, there are a number of reasons to reject the introduction of a vehicle restriction scheme:

- crashing high performance vehicles driven by novice drivers do not represent a sizable road safety problem;
- a statistical association between vehicle performance and crash risk for young novice drivers was observed but it was not overwhelming strong or unequivocal;
- no evaluations of the existing Australian vehicle performance restriction schemes have been undertaken; therefore, it is not known whether such schemes effectively reduce novice driver crashes and injury or whether they are cost-effective;
- Western Australia does not presently have, nor is likely to have in the near future, ready access to the vehicle performance information required to administer and enforce a vehicle restriction scheme; and that,
- restricting access to some high performance vehicles may inadvertently restrict the access of young novices to vehicles which feature a high level of vehicle safety technology.

2. Progress the introduction of outstanding and empirically supported graduated driver training and licensing initiatives in Western Australia

Compared with some other Australian and overseas jurisdictions, Western Australia's existing graduated training and licensing system could be strengthened by the adoption of other initiatives related to increased driving

experience as a learner and reduced exposure to crash risk factors as a provisional driver. In relation to these issues, the State should:

- expedite a thorough reexamination, particularly in relation to access and equity issues, of the current requirement for supervised driving during the learner phase to consider an increase in both the number of required hours and the conditions under which those hours are obtained (e.g., daytime versus nighttime; types of roads); and,
 - move to introduce other licensing initiatives such as peer passenger restrictions and restrictions on the use of mobile phones during the provisional period. Both initiatives are likely to reduce the occurrence of distracted driving and possible risk taking when driving in the company of peers.
3. Further investigation and development of a broad platform of initiatives to more broadly target the problem of speeding and reckless driving by young novice drivers

Whilst it is acknowledged that high performance vehicles have an increased ability to accelerate and maintain higher speeds, speeding and other reckless behaviour among young novice drivers is not confined to those driving high performance vehicles. For this reason then, it is recommended that the State investigate and develop initiatives that target the behaviour of the young novice driver, rather than the vehicle per se, in an effort to reduce speeding and other reckless behaviour across this target population. For example, consideration should be given to:

- the introduction of differential speeding penalties for novice drivers that would effectively result in the suspension of a provisional driver in the first 12 months for a single speeding offence (or at the very least a subsequent offence). Such a system operates in New South Wales and could be applied here as Western Australia similarly suspends provisional drivers in the first 12 months of licensure upon the loss of four demerit points.

- the imposition of vehicle restrictions on provisional drivers who are caught speeding or engaging in reckless or dangerous driving, including BAC offences, while driving a high performance vehicle;
 - the introduction of ‘offence free’ periods as a prerequisite for novice drivers progressing from P1 to P2 stages and from a P2 stage to full licensure; and,
 - the development and implementation of a trial education program targeting novice drivers committing any speeding offence, utilising a monitored Intelligent Speed Adaptation (ISA) device fitted to their vehicle.
4. Encourage the purchase of safer vehicles by all young drivers by providing information about safe first car choices and the provision of financial incentives to purchase safer vehicles

Young novice drivers have a higher risk of crash involvement compared with older and more experienced drivers. For this reason it is important that young drivers have access to vehicles with emerging technologies that will reduce their likelihood of crashing and also provide them with superior protection in the event of a crash. The secondary analysis in this study of a 2008 sample of vehicles registered in Western Australia showed that vehicles with superior safety features such as Electronic Stability Control, side curtain airbags, and even in some cases driver airbags, were far more common in vehicles that might otherwise be classified as high performance from a power to weight ratio point of view, especially among four and six-cylinder vehicles. Indeed, this finding suggests that any possible restriction on the access of novices to higher performance vehicles might, in the shorter term, also inadvertently restrict their access to vehicles with high safety ratings –at least until these technologies filter down over time to be more common among cheaper and lower performance vehicles. In the meantime the state government should:

- strongly encourage the purchase of safer vehicles by young novice drivers through an educational campaign on ‘safe first car choice’, along the lines of campaigns undertaken in New South Wales and Victoria; and,

- consider vehicle registration rebates or discounts to young novice drivers who purchase vehicles meeting the 'safe first car' criteria.

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Centre for Automotive Safety Research, The University of Adelaide

Vehicle performance and crash risk amongst novice drivers in Western Australia

TP Hutchinson and RWG Anderson
Centre for Automotive Safety Research

Final report

16 February 2012



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1 Introduction

The aim of this study was to investigate the relationship between vehicle performance (defined by the number of cylinders and the power-to-weight ratio of the vehicle) and the risk of serious injury crash involvement among Western Australian drivers, particularly for those drivers aged 17-19 years of age (young novice drivers).

Western Australian crash data were analysed in two main ways. Firstly, the rates of crashing by young novice drivers were compared across categories of vehicle performance. The objective was to see if young drivers in high powered vehicles crash more often than young drivers in lower powered vehicles. Crash rates for older drivers were also calculated.

Secondly, the ratio of single-vehicle to multiple vehicle crashes was calculated for various categories of driver-vehicle combinations. This ratio is designed to be a sensitive indicator of crash risk on the basis that as riskiness increases, the number of single vehicle crashes increases more than the number of two-vehicle crashes. This second analysis used multiple logistic regression, which is a method that allows various other factors that are likely effect the ratio to be accounted for.

Specially constructed datasets were used for the study, as additional data was required on the driver and the performance of each crash involved vehicle. To this end, linkages were made between crash data and TRELIS, the WA registration and licensing database, and with automotive data maintained by RL Polk Australia. The former database provided information on the driver and owner of the vehicle, while the latter provided information on the make, model, performance and other characteristics of each crash involved vehicle.

Crash rates were expressed as crashes per registered vehicle. Hence, a snapshot of the registered vehicle fleet was obtained from Licensing division of Main Roads WA. Additional information on these vehicles was also provided by RL Polk Australia.

A secondary aim was to characterise the WA passenger fleet in respect of performance levels and levels of safety. The registered sample was used for this purpose as well.

The process of data extraction and data linkage is described in more detail in section 2. Section 3 describes the rate of crashing of various driver and vehicle combinations, and section 4 examines how driver age and vehicle performance affects the ratio of single- and two-vehicle crashes. Finally section 5 describes the availability of safety features across categories of vehicle performance.

The study was approved by the Institutional Human Ethics Committees of Monash University, Curtin University and the University of Adelaide.

2 Crash and registration data

2.1 Crash data

2.1.1 Supplied data

Main Roads WA (MRWA) provided a complete record of all crashes that occurred in Western Australia from 2001-2008. Data fields that were provided related to the crash in which the vehicle was involved, the vehicle itself, the driver of the vehicle (age, sex, licence information etc.), and the owner of the vehicle.

2.1.2 Database query

The crash data were queried to return all information on crashes that were serious or fatal. The data were processed to determine the overall severity of the crash, the severity of injuries to all drivers (or other unit controllers) in the crash, the number of units involved in the crash, the number of units that were passenger vehicles, and the number of days between the date of the driver's licensure and the crash date. A "unit" in most cases means a motor vehicle in traffic, but the term also includes parked vehicles, pedal cycles, pedestrians, etc.

Subsequently, further details on the vehicles were added to the results of the query (see section 2.3) and on the basis of this, the performance of each vehicle was categorised.

Analysis was of a dataset in which each record referred to a vehicle (not a crash).

2.2 Registration data

A sample of vehicles that represented the registered passenger vehicle fleet, as it existed in each of the crash years was needed in order to calculate crash rates. A database of all vehicles ever registered in Western Australia was sampled to create such a dataset, with the objective of calculating the proportion of the registered fleet in different categories of vehicle performance.

A sample was used, rather than all records, because the process of categorising a vehicle into a performance category required that vehicle to be matched with vehicle data from RL Polk. There is a cost associated with every vehicle matched using this method, so it was not feasible to process every passenger vehicle registered in Western Australia from 2001 to 2008. Consequently, a sample of 30,000 vehicles representing registered vehicles over the period was obtained.

To create the sample of 30,000 vehicles, records were randomly selected from the complete database. If the vehicle was actively registered on the 30 June 2001, and was a passenger vehicle, the vehicle was retained. This was repeated until a dataset of 3,750 vehicles was assembled, the dataset representing a random sample of vehicles registered in Western Australia on 30 June 2001. This process was repeated for registration years 2002-2008. The result was eight sets of 3,750 vehicle records, each consisting of a random sample of vehicles with an active registration on the 30th of June of one of the eight years for which crash data had been obtained.

The dataset of registered vehicles included the following information:

- Body type, make and model

- The number of cylinders
- The VIN
- The licence category of the owner
- The date of first licensure of the owner of the vehicle on the census date
- The sex and birth month and year of the owner of the vehicle on the census date.

2.3 Polk specification data

For both crash involved vehicles and for the registered fleet samples, additional data were obtained from RL Polk Australia. VINs were provided to Polk, and Polk returned a series of fields from their VFACTS database and their price and specification database. Of interest were fields related to the performance of the vehicle: the number of cylinders, the peak power output and the kerb weight of the vehicle.

VINs are only regularly present in Western Australian registration data for vehicles first registered after 1988. Furthermore, Polk is only able to return records for vehicles sold after 1990. Hence the data were restricted during this step to vehicles sold new in Australia from 1991 onwards.

2.4 Performance categories

Power to weight ratio (PWR) is commonly used as an indicator of overall performance of a vehicle. It is defined as the peak power output of the engine divided by the kerb mass of the vehicle and has units of W/kg (or kW/1000 kg). In this study, vehicles were categorised by PWR within categories defined by the number of cylinders. Ten categories were derived from the number of cylinders and power-to-weight ratio (PWR).

4 cylinders, PWR 59 and less

4 cylinders, PWR 60-74

4 cylinders, PWR 75-89

4 cylinders, PWR 90 and more

6 cylinders, PWR 99 and less

6 cylinders, PWR 100-109

6 cylinders, PWR 110 and more

8 cylinders, PWR 109 and less

8 cylinders, PWR 110-139

8 cylinders, PWR 140 and more

The reasons behind this choice of categories were as follows.

- For each number of cylinders, the highest PWR category is quite extreme. In the case of 4-cylinder cars, PWR 90 and more accounts for about 3 per cent of crashes to 4-cylinder cars. For 6-cylinder cars, PWR 110 and more accounts for about 2 per cent of crashes to 6-cylinder cars. For 8-cylinder cars, PWR 140 and more accounts for about 25 per cent of crashes to 8-cylinder cars.

Consequently, we were able to ask whether categories that are extreme in respect of PWR differ from others in respect of the relative numbers of single- and two-car crashes, and in respect of their rates of crashing.

- For each number of cylinders, the remaining two or three categories of PWR permit an examination of whether the variation of PWR within its usual or common range is associated with variation in the relative numbers of single- and two-car crashes, and variation in their rates of crashing.
- In the case of 4-cylinder cars, there were some indications that cars with a PWR below about 60 had a crash experience rather different from that expected, and so an additional category was created.

Table 2.1 lists some of the most common vehicle models within the crash data in each performance category.

2.5 Analysis of crash data

The process of obtaining a set of crash-involved cars that could be analysed involved excluding many for which information was unknown. This process is illustrated in Tables 2.2 and 2.3.

The first set of analyses, in section 3, involved calculating crash rates per registered vehicle. These crash rates refer to crashes in which any person was seriously injured or killed.

The second set of analyses, in section 4 and 7, involved calculating the relative numbers of vehicles in single- and two-car crashes. These crashes are ones in which a driver was seriously injured or killed.

Table 2.1
Common vehicle models in each vehicle performance category.

Performance category	Example vehicle models
4 cylinders, PWR 59 and less	FORD WF FESTIVA TRIO 2D Hatchback TOYOTA HILUX DOUBLE CAB SR5 Utility - 4X4 NISSAN D22 NAVARA ST-R 4X4 DOUBLE CAB Utility - T/Dies 2002 HOLDEN SB BARINA CITY 2D Hatchback HOLDEN R9 RODEO LX Crew Cab - 4x4 T/Dies NISSAN GU II PATROL ST 3.0 4D Wagon - 5 man T/Diesel
4 cylinders, PWR 60-74	NISSAN GU II PATROL ST 3.0 4D Wagon - 5 man T/Diesel MITSUBISHI CE LANCER GLI 1.5 2D Coupe TOYOTA SXV20R CAMRY CSI 4D Sedan MITSUBISHI TR MAGNA EXECUTIVE 4D Sedan DAEWOO LANOS SE 2D Hatchback TOYOTA AE101 COROLLA CSI SECA 4D Hatchback MITSUBISHI CE MIRAGE 2D Hatchback
4 cylinders, PWR 75-89	HYUNDAI X3 EXCEL SPRINT 2D Hatch HYUNDAI ACCENT 2D Hatch NISSAN N15 PULSAR LX 4D TOYOTA AE101 COROLLA CSI SECA HYUNDAI GETZ GL MITSUBISHI CE LANCER GLI 1.8 2D Coupe
4 cylinders, PWR 90 and more	MITSUBISHI CH LANCER ES SUBARU IMPREZA WRX AWD MAZDA MAZDA3 SP23 HONDA ACCORD EURO LUXURY HONDA PRELUDE SI 2D Coupe TOYOTA ACA23R RAV4 CV 4D TOYOTA ZZE122R COROLLA
6 cylinders, PWR 99 and less	TOYOTA HZJ75 LANDCRUISER HOLDEN VX COMMODORE EXECUTIVE HOLDEN VP COMMODORE EXECUTIVE FORD EB II FALCON GLi FORD EL FALCON GLi
6 cylinders, PWR 100-109	HOLDEN VS COMMODORE EXECUTIVE FORD AU II FALCON FORTE MITSUBISHI TJ II MAGNA EXECUTIVE HOLDEN VZ COMMODORE EXECUTIVE FORD EL FALCON FUTURA FORD BA FALCON XT
6 cylinders, PWR 110 and more	HOLDEN VT COMMODORE S S/charged FORD BA FALCON XR6 TURBO FORD BA FALCON UTE XL Cab Chassis FORD BF II FALCON XR6 TURBO HOLDEN VE CALAIS FORD BF II FALCON XT
8 cylinders, PWR 109 and less	HOLDEN VS STATESMAN V8 HOLDEN VQ II STATESMAN V8 HOLDEN VR STATESMAN V8 LAND ROVER DISCOVERY SE FORD NC FAIRLANE GHIA V8 HOLDEN VT COMMODORE SS
8 cylinders, PWR 110-139	HOLDEN VU UTE SS Utility HOLDEN VT COMMODORE SS HOLDEN VSIII UTE S Utility V8 HOLDEN WH STATESMAN V8 HOLDEN VR COMMODORE EXECUTIVE V8 HOLDEN VU UTE SS Utility
8 cylinders, PWR 140 and more	HOLDEN VX COMMODORE SS HOLDEN VY UTE SS Utility HOLDEN VY COMMODORE SS HOLDEN VZ UTE SS FORD BA FALCON XR HOLDEN V2 III MONARO CV8 2D Coupe

Table 2.2
Disaggregation of all crash involved passenger vehicles in Western Australia 2001-2008 in serious or fatal crashes.

		Exclusions		
		10,553 vehicles sold pre-1991		
Inclusions	25,399 crash involved vehicles with known number plates	14,846 vehicles sold in 1991 or later	175 vehicles with an unknown number of cylinders, or a number of cylinders other than 4, 6 or 8	
			14,671 vehicles with Number of cylinders = 4, 6 or 8	508 vehicles with power to weight unknown
		14,163 vehicles with known PWR		1,388 drivers aged under 17 or unknown age
			12,775 subject vehicles	

Table 2.3
Disaggregation of subject vehicles in Western Australia 2001-2008 in serious or fatal crashes with respect to ownership status.

12,775 subject vehicles	1,454 vehicles with a driver with an inactive or indeterminate licence status	
	11,321 vehicles with drivers with an active licence	5,663 vehicles crashed by a driver who was not the registered owner
		5,658 vehicles that were crashed by the owner of the vehicle

3 Crash rates and crash numbers by categories of driver and categories of vehicle performance

The objective of this part of the analysis was to determine the crash rates of vehicle by performance and ownership status, and to determine whether relative crash rates amongst younger drivers are affected by the performance of the vehicle.

A particular factor in the approach taken was that no information on the exposure of certain drivers in particular vehicles was known apart from ownership. For many drivers, and young drivers in particular, it is likely that a large proportion of driving is in a vehicle registered in another person's name (e.g. a parent). Those young drivers that own their own vehicles may drive a different amount and in different environments to those young drivers who do not own a car but borrow one from someone else. This limitation should be borne in mind.

Nevertheless, for calculated rates to be meaningful, it was necessary to restrict attention to a category of driver-vehicle combination that is identifiable in both the crash and the registration data: that is vehicles owned and crashed by a driver in a particular age group (in the crash data) and vehicles owned by people in an equivalent age group.

For the purposes of the analysis, vehicles (crashed and registered) were grouped into one of several categories of owner age (17-19/20-24/25+) and vehicle performance (defined in section 2). Two younger age groups were defined so that any changes in crash rates experienced by young drivers over the first few years of driving might be observed. Also, it was noted that drivers 17-19 owned high performance vehicles only in small numbers. Therefore the second young driver category (20-24) became useful in examining the interrelationship between age, performance and crash involvement. (But not with a view that this group of drivers might be the subject of potential regulation.)

Owner-driver crashes were further disaggregated according to the length of time that the driver was in possession of a driver's licence so that rates amongst novice drivers could be differentiated from drivers with some experience.

3.1 Method

Use was made of the linked crash and registration data to determine whether the driver of the subject vehicle in the crash was also the owner of the vehicle. A match between the birth month and year in the relevant driver field of the crash record and the owner field from TRELIS was used to identify such vehicles. The crashed vehicles were classified as according to the performance categories defined earlier. Only vehicles of 4, 6 or 8 cylinders sold after 1990 were considered. Because of relatively low ownership rates of high performance vehicles by 17-19 year old drivers, a second young driver category (20-24) was used to examine the interrelationship between age, performance and crash involvement.

The denominators used to calculate crash rates were the number of vehicles in the sample of registered vehicles that fell into the equivalent categories of owner age and performance. Rates were calculated for vehicles involved in all crashes resulting in serious or fatal injuries.

Initially, the intention was to examine crash rates separately for each year of crash and registered vehicle data. But the numbers of crashes in each of the higher performance

category became sparse at this level of disaggregation and so the decision was made to aggregate over all years 2001-2008.

The first analysis focussed only on categories of age of driver and vehicle performance. A second analysis also examined additional differences in the rate of crashing according to the time over which the driver had held a driver’s licence.

This second analysis was an attempt to examine the crash rates in the provisional period for both 17-19 year old drivers and 20-24 year old drivers. Although the licence type was held in the crash record and so was known directly, the equivalent variable in the registration database appeared unreliable (there were too few provisional licence holders to be credible) and so it was not possible to perform an analysis based on licence type. Duration of licence was thought to be an appropriate proxy for this.

3.2 Results

3.2.1 Crash incidence

As a preliminary step, the relative incidence of crashes for each combination of driver age and vehicle performance category was calculated. Table 3.1 shows the relative involvement of vehicles in crashes by performance category and driver age. Attention is drawn to the small percentage of crashes involving young drivers crashing in high performance vehicle categories.

Table 3.1
Percentages of vehicles (post-1990) involved in serious and fatal crashes (2001-2008) by performance category and driver age (active licence holders only, owner-driver and non owner-driver crashes).

Number of cylinders	Performance category	Driver age group			Overall
		17-19	20-24	25+	
	Overall	6.5%	9.5%	40.2%	56.2%
4 cylinder	PWR 59 and less	1.0%	1.5%	7.8%	10.3%
	PWR 60-74	3.0%	3.8%	16.2%	22.9%
	PWR 75-89	2.4%	3.8%	15.1%	21.2%
	PWR 90 and more	0.2%	0.4%	1.2%	1.8%
	Overall	4.0%	5.6%	29.8%	39.4%
6 cylinder	PWR 99 and less	2.7%	3.7%	21.1%	27.5%
	PWR 100-109	1.3%	1.7%	8.0%	10.9%
	PWR 110 and more	0.1%	0.2%	0.7%	0.9%
	Overall	0.5%	1.1%	2.8%	4.5%
8 cylinder	PWR 109 and less	0.2%	0.3%	1.1%	1.6%
	PWR 110-139	0.2%	0.4%	1.0%	1.7%
	PWR 140 and more	0.1%	0.3%	0.7%	1.2%
Overall		11.1%	16.1%	72.8%	100.0%

Table 3.1 is based on a total of 11,321 vehicles. The drivers of 1,285 of these vehicles were 17-19 years of age. 7.6 per cent of the 1,285 vehicles were in higher performance categories of 4 cylinder – PWR 90 and more, 6 cylinder – PWR 110 and more, and 8

cylinders. Sixty-six vehicles out of the 1,285 with a driver aged 17-19 were involved in a fatal crash. In 15 per cent of these fatal crashes, the young driver was driving a vehicle in the higher performance categories just mentioned.

The vehicles driven by 17-19 year olds involved in crashes were grouped according to their ownership status (Table 3.2). About 1/3 of all such crash involved vehicles were also registered in the name of the driver, but the owner was more likely to be the registered owner when the vehicle was in a higher performance category.

Table 3.2
Post-1990 vehicles involved in serious and fatal crashes (2001-2008) amongst drivers 17-19, by vehicle performance category and vehicle ownership status (active licence holders only).

Number of cylinders	Performance category	Ownership		Overall
		Own	Not own	
	Overall	18.7%	40.2%	59.0%
4 cylinder	PWR 59 and less	2.3%	5.3%	7.6%
	PWR 60-74	9.8%	17.7%	27.5%
	PWR 75-89	5.8%	16.2%	22.0%
	PWR 90 and more	0.8%	1.0%	1.8%
	Overall	14.4%	21.7%	36.1%
6 cylinder	PWR 99 and less	9.5%	14.5%	24.0%
	PWR 100-109	4.8%	6.9%	11.6%
	PWR 110 and more	0.2%	0.3%	0.5%
	Overall	2.4%	2.5%	4.9%
8 cylinder	PWR 109 and less	0.7%	0.9%	1.6%
	PWR 110-139	1.1%	1.0%	2.1%
	PWR 140 and more	0.6%	0.6%	1.2%
Overall		35.6%	64.4%	100.0%

3.2.2 Crash rates of vehicles according to the age of the owner-driver

As mentioned previously, the calculation of crash rates only makes sense if the rates are based on owner-driver crashes. The numbers of owner-driver crashes in each combination of vehicle category and driver age groups were counted (Table 3.3).

Table 3.3
Distribution of owner-driver vehicles* by cylinder and power to weight ratio category^ and driver age involved in a serious injury crash; Western Australia, 2001-2008.

Cylinders Power Class	Age Group							
	17-19 years		20-24 years		25+ years		All Ages	
	n	%	n	%	n	%	n	%
4	231	54.2	557	57.7	2555	59.9	3343	59.1
PWR 59 and less	28	6.6	71	7.4	398	9.3	497	8.8
PWR 60-74	122	28.6	225	23.3	1057	24.8	1404	24.8
PWR 75-89	71	16.7	237	24.6	1016	23.8	1324	23.4
PWR 90 and more	10	2.3	24	2.5	84	2.0	118	2.1
6	166	39.0	317	32.8	1535	36.0	2018	35.7
PWR ≤99	107	25.1	207	21.5	1101	25.8	1415	25.0
PWR 100-109	57	13.4	100	10.4	412	9.7	569	10.1
PWR ≥110	2	0.5	10	1.0	22	0.5	34	0.6
8	29	6.8	91	9.4	177	4.1	297	5.2
PWR ≤109	8	1.9	22	2.3	55	1.3	85	1.5
PWR 110-139	13	3.1	39	4.0	70	1.6	122	2.2
PWR ≥140	8	1.9	30	3.1	52	1.2	90	1.6
Total	426	100.0	965	100.0	4267	100.0	5658	100.0

*vehicles first sold 1991 and onwards ^vehicle power (W) / vehicle mass (kg)

The crash rates in age/performance categories are reported as a relative rate, with the reference category being the average crash rate of 17-19 owner-drivers in all four cylinder vehicles (which was set to 1.0). A driver-vehicle group with a relative crash rate less than 1.0 indicates that a driver in that group crashes their vehicle less often than a driver in average of all 17-19 year olds who drive and own 4 cylinder vehicles.

The results of the analysis are shown in Table 3.4. In this table, a blue bar indicates a lower crash rate than the average rate for 17-19 owner-drivers in four cylinder vehicles. Red bars indicate an increased rate. The length of the bars indicate the size of the relative crash rate and are proportional to the logarithm of the relative rate. The advantage of presenting the logarithm of the ratio is that, for example, a ratio of 2 and a ratio of 0.5 are given equal weight in the results which is appropriate given that they are simply the inverse of each other.

Table 3.4

Relative crash rates (per registered vehicle) of vehicles according to the number of cylinders, power class and age of driver. (A graphical representation of relative risk is not shown for drivers 25+.)

Cylinders	Power class	Owner-driver age		
		17-19 years	20-24 years	25+ years
4		1.0	0.6	0.2
	PWR 59 and less	0.7	0.7	0.2
	PWR 60-74	1.1	0.6	0.2
	PWR 75-89	0.9	0.6	0.2
	PWR 90 and more	1.4	0.6	0.2
6		1.4	0.6	0.2
	PWR 99 and less	1.6	0.6	0.2
	PWR 100-109	1.2	0.6	0.2
	PWR 110 and more		1.4	0.2
8		1.5	1.1	0.2
	PWR 109 and less	2.3	2.1	0.2
	PWR 110-139	1.2	0.9	0.3
	PWR 140 and more	1.5	1.0	0.3

A decreasing crash rate with age, and an increasing crash rate with performance are apparent in Table 1.

Rates are not displayed where there were less than 5 crashes in the numerator. Hence, no rate is displayed for 17-19 year olds owning and driving very high powered 6 cylinder vehicles. Note, though, that the elevated rate of crashing of vehicles owned and driven 20-24 year olds; it is therefore reasonable to assume that the relative crash rate of 17-19 year olds might also be elevated (noting that the incidence of such crashes is very small).

Chi-square tests were also conducted for the 17-19 age group. Here, the test is of the hypothesis that the proportions of vehicles crashing in each category of performance were the same as the proportions of vehicles registered in each category. Rejection of the hypothesis (i.e. a significant result) would indicate that the apparent over-representation of crashes amongst higher performance categories of vehicles is real. A non-significant result implies that the over-representation could be ascribed to chance.

Considering the 10 power categories, the test was not significant for 17-19 year old drivers. Aggregating into three cylinder groups, the test was again non-significant. However, the numbers of both crashes and registered vehicles were small, and hence the non-significance may be due to a lack of statistical power. Similar tests for the 20-24 age group were significant.

3.2.3 Crash rates of vehicles according to the age of the owner-driver and driving experience

Owner-driver crashes were disaggregated according to the duration that the driver had held a drivers licence. This period was defined as the period that had elapsed between

the date of the crash and the date of first licensure held in TRELIS. The sample of registered vehicles was similarly disaggregated according to the age of the owner and the length of time the owner had held a drivers licence.

In a proportion of licence holder records, the date of first licensure appeared to have a different meaning than it did in the majority of records. There were instances where the date appeared to refer to the date on which a learner licence was issued (as the driver would have been 16 on the date recorded). In the majority of cases, the date appeared to refer to the date on which the provisional licence was issued. (This was assumed based on the fact that there were a significant number issued on a date when the drivers would have been 17-20, with a long tail of older driver ages).

Despite this inconsistency and ambiguity in the meaning of the date of first licensure recorded in TRELIS, the time elapsed between the recorded date of first licensure and the crash date was used to group together those crashes that occurred during the “novice” period of licensure. For the purposes of this analysis, drivers 17-19 years old, holding a licence less than 2 years are regarded as young-novice drivers. It was thought that discrepancies in the meaning of the date of first licensure were unlikely to significantly affect the results. Crash rates are reported relative to such drivers who owned a 4-cylinder vehicle.

The results of this analysis are shown in Table 3.5.

Table 3.5
Relative crash rates (per registered vehicle) of owner-driven vehicles according to the number of cylinders, power class and age of owner-driver, and according to the period elapsed since they first obtained a driver’s licence.

	Driver age			
	Less than 2 years since licence issued		2 years or more since licence issued	
	17-19 years	20-24 years	18-19 years	20-24 years
4	1.00	0.89	0.92	0.52
PWR 59 and less	0.66	0.95	0.74	0.62
PWR 60-74	1.16	0.92	1.16	0.51
PWR 75-89	0.93	0.90	0.76	0.50
PWR 90 and more	1.29			0.60
6	1.63	0.90	1.07	0.55
PWR 99 and less	2.23	0.96	0.95	0.53
PWR 100-109	1.03	0.78	1.32	0.57
PWR 110 and more				1.38
8	2.07	0.78	1.26	1.05
PWR 109 and less			2.58	1.72
PWR 110-139	2.58		1.03	0.85
PWR 140 and more				1.07

As in previous tables, no rate was calculated if there were less than five crashes in the relevant cell. As the data starts to become sparse at this level of disaggregation, Table 3.5 has several gaps. Further, it should be noted that the majority of drivers aged 18-19 with 2 years or more since the date of first licensure in Table 3.5 are in fact 19 years of age (109 of 144 drivers).

Table 3.5 is an attempt to differentiate crash rates according to age and driving experience. As the data is sparse, no clear picture is present, except possibly that age and experience has an effect on crash rates: there is some evidence here that 18-19 year old drivers with 2 or more years of driving experience have lower crash rates than the 17-19 year olds with less than 2 years driving experience; the dependence of the crash rate on the number of cylinders is less in the slightly older and more experienced group. Amongst the 20-24 year old driver groups, crash rates are reduced in all categories, with the exception for drivers with less than 2 years experience in the four-cylinder categories. Patterns consistent with a positive association between crash rates and vehicle performance, youth and inexperience are apparent, but with very small cell counts, statistical significance cannot be demonstrated.

3.3 Discussion

The analysis was somewhat constrained by the following factors.

- The necessity of restricting attention to owner-drivers: it would have been relevant to examine the crash rates of 17-19 year old drivers according to the performance of the vehicle, irrespective of ownership. But the difficulty would have been the ability to estimate a suitable denominator, as no data existed on the amount of driving performed in each class of vehicle by driver age. As they are, the rates we have calculated have a consistent denominator (the number of vehicles owned) and numerator (the number of vehicles crashed by an owner, and total crashes). While this restriction was necessary, it does make interpretation more difficult, as about two thirds of crashes involving 17-19 year olds were excluded. In addition, the proportions of vehicles crashed by young drivers in a vehicle registered to someone else was highest for lower power categories. We are unable to say what kind of bias (if any) might be introduced by this method of analysis.
- The lack of statistical power: crash rates for 17-19 year old drivers reported in Tables 3.4 and 3.5 are based on relatively few crashes and registered vehicles. It is possible that a larger sample of registered vehicles alone would enable the significance of the variation in crash rates to be established.

Despite these limitations, the analysis supports the view that the serious and fatal crash rates of young drivers 17 to 19 years of age are higher in those that own and drive higher performance vehicles. However, the number of crashes behind these elevated rates is relatively small, reducing our confidence in the strength of the result. Consistent results were seen for 20-24 year old drivers too, and in that case, the results were statistically significant.

These results are based on serious and fatal crashes combined but are dominated by the number of non-fatal crashes in the database. Estimates of increase in risk made using serious injury crashes are likely to be amplified in the case of fatal crashes, both because speed is the chief reason for increased risk and because the term “serious injury” covers such a range of injuries. Hence, increased rates reported here may underestimate increased rates in the case of fatal crashes.

4 Relative numbers of single- and two-car crashes

The crash rates calculated in the previous section indicate that young owner-drivers in high performance vehicle appear to have increased rates of crashes compared with young owner-drivers of lower powered vehicles and compared with drivers over 19 years of age. A potential shortcoming of the analysis of crash rates is that other variables that can determine crash risk that are correlated with performance might lie behind the differences in different categories of driver-vehicle combinations.

The analysis in this section contrasts crashes involving only the subject vehicle (i.e., a single vehicle crash) with those involving the subject vehicle and one other car. Single-vehicle accidents are more likely to be attributable to (or, the fault of) the particular combination of driver and vehicle than two-vehicle accidents are, as in the latter type of crash might be attributable to either of the vehicles.

4.1 Data

The data used for this part of the study was that described earlier in section 2. Interest was in the car and the driver --- for the car, the make and model, year of manufacture, power-to-weight ratio, etc., and for the driver, their age and sex). There were also background variables such as time (time of day, weekend vs. weekday) and place (speed limit, metro vs. country).

The ratio of single- to two-vehicle accidents will be related to the density of traffic and to the speed of traffic in the locality where the accident happens. The characteristics of cars may also be related to the locality. Hence there is opportunity for spurious effects, and consequently variables were used and combined in an effort to account for such effects. (See section 5.1.2.)

4.1.1 *Inclusion criteria*

The analysis is of vehicles rather than crashes. Thus each car in a two-car crash appears separately. Vehicle-based statistics are rather different from crash-based statistics: equal numbers of single- and two-car crashes, for example, would mean twice as many cars in two-car crashes as in single-car crashes.

- The analysis was restricted to crashes in which the driver of a car was seriously injured or killed.
- The only crashes included were those in which there were exactly 1 or 2 cars and 0 other units. This excludes pedestrian, pedal cycle, motorcycle, and truck crashes. Note that these were included in the analyses presented in section 3.
- In addition, all the explanatory variables needed to be available for each of the vehicles in the regression. This means pre-1991 cars were excluded, because various characteristics of these variables were not available, such as power-to-weight ratio. A variable describing the geography of the crash location was also not available for quite a substantial proportion of crashes (see below).

4.1.2 *Dependent and explanatory variables*

The regression sought to relate the relative numbers of single- and two-car crashes to several possibly explanatory variables. These might be considered as concerned with the vehicle, with the driver, or the background circumstances.

- (vehicle) categories derived from the number of cylinders and power-to-weight ratio, as described in section 2.4;
- (vehicle) the car year, grouped;
- (driver) the driver's age, grouped;
- (driver) the driver's sex;
- (background) categories derived from the day of week and hour of day;
- (background) categories derived from (a) speed limit, (b) whether the crash was in or outside Perth metro area, and (if it was inside) (c) approximate distance from city centre, based on the suburb, it not being practicable to code the exact location in this way.

The vehicle and its driver are of chief interest. Background variables are included because they might be related to both the dependent variable and the vehicle/driver variables, and thus could lead to spurious results if they were excluded. Among the possible reasons for importance of background variables are an association with speed of traffic (one would expect high speed to lead to relatively more single-car crashes) or density of traffic (one would expect high density to lead to relatively more two-car crashes). To give a concrete example, different places are known to have different densities of population and different densities of traffic on the road. Places also differ in what proportion of drivers are young, and quite possibly in what proportion of cars are high powered.

Further details of the variables are as follows.

- Four categories of car year were used, 1990-1994, 1995-1999, 2000-2004, and 2005-2008.
- Seven categories of driver age were used, up to 19, 20-29, 30-39, 40-49, 50-59, 60-69, and 70+.
- 28 categories were derived from the day of week and hour of day, that is, all combinations of four groups of days (Mon-Thurs, Fri, Sat, Sun) and seven groups of hours (00-01, 02-05, 06-11, 12-18, 19-20, 21-22, 23).
- A "geography" variable was created from (a) speed limit, (b) whether the crash was in or outside Perth metro area, and (c) in the case of crashes in the Perth metro area, the distance from city centre. There were 22 categories, as follows.
 - Non-metro crashes: 7 categories of speed limit (50, 60, 110)
 - Metro crashes, 50 km/h speed limit: 3 categories, according to the distance from the city centre of the postcode or the local government area of the crash (0.0 to 2.9 km, 3.0 to 9.9 km, 10 km or more);
 - Metro crashes, 60 km/h speed limit: 3 categories, as for 50 km/h

- Metro crashes, 70 km/h speed limit: 2 categories, according to the distance from the city centre of the postcode or the local government area of the crash (0.0 to 9.9 km, 10 km or more);
- Metro crashes, 80 km/h speed limit: 2 categories, as for 70 km/h
- Metro crashes, 90 km/h speed limit: 1 category
- Metro crashes, 100 km/h speed limit: 2 categories, as for 70 km/h
- Metro crashes, 110 km/h speed limit: 2 categories, as for 70 km/h

(The number of geography categories within a speed limit reflects how many crashes there were.)

4.2 Results: Cross-tabulations

This section presents some simple tabulations relating the numbers and proportions of single- and two-car crashes to the explanatory variables taken one at a time. The figures to be given may differ from those elsewhere: this may be the result of applying the inclusion criteria described above, or because the basic unit counted is the vehicle (rather than the crash).

As variables are taken one at a time, any associations found could be due to confounders. For example, an association of high PWR with a high proportion of single-car crashes will be found.











- High PWR could be *causing* the high proportion of single-car crashes.
- On the other hand, perhaps the association is spurious: it might be that powerful cars are more often driven in country areas, and in country areas there is a higher proportion of single-car crashes because traffic density is low.

Multiple logistic regression, to be reported in section 4.3, simultaneously considers several variables. In principle, this makes allowance for confounders. However, it is impossible to make allowance for confounders that are not represented in the variables available. For example, driver age and sex are included, but there is no measure of driver personality or behaviour.

4.2.1 *Number of cylinders and power-to-weight ratio*

Table 4.1 shows the proportion of vehicles in the dataset (described in section 4.1.1) in single-vehicle crashes.

Table 4.1
Proportion of cars in single car crashes for categories of number of cylinders and power-to-weight ratio.

Number of cylinders	Performance category	Proportion single vehicle	
4 cylinder	PWR 59 and less	0.36	
	PWR 60-74	0.24	
	PWR 75-89	0.26	
	PWR 90 and more	0.38	
6 cylinder	PWR 99 and less	0.38	
	PWR 100-109	0.37	
	PWR 110 and more	0.37	
8 cylinder	PWR 109 and less	0.49	
	PWR 110-139	0.50	
	PWR 140 and more	0.57	

The proportion of cars in single-car crashes tends to be higher for 6-cylinder cars, 8-cylinder cars, and 4-cylinder cars with very high PWR than for 4-cylinder cars with PWR in the range 60 to 89. That is, it tends to be higher for the high-performance categories.









Further details are as follows.

- The 36 per cent for the first category seems anomalously high, and is the reason for considering the lowest PWR group separately. Part of the explanation is the presence of a higher proportion of cases of SUV-style vehicles.
- The extreme PWR groups are associated with a higher proportion of single-car crashes in the case of 4-cylinder and 8-cylinder cars, but not 6-cylinder cars. It is possible, perhaps even likely, that an extreme PWR is associated with a higher proportion of single-car crashes in 6-cylinder cars also, and that the result found has occurred by chance.
- There seems to be no effect of PWR within what has been considered to be its ordinary range (i.e., below 90 for 4-cylinder cars, below 100 for 6-cylinder cars, and below 140 for 8-cylinder cars).
- 6- and 8-cylinder cars have a higher proportion of single-car crashes than 4-cylinder cars.
- An alternative description could be given based on PWR alone: a PWR of over about 90 is associated with a higher proportion of single-car crashes.

4.2.2 Year of car

The proportions of single-car crashes according to the year of manufacture are shown in Table 4.2.

Table 4.2
Proportions of cars in single car crashes in different categories of vehicle year.








Vehicle year	Proportion single vehicle	
1970-1974	0.42	
1975-1979	0.37	
1980-1984	0.40	
1985-1989	0.36	
1990-1994	0.35	
1995-1999	0.33	
2000-2004	0.30	
2005-2008	0.30	

There seems to be a decrease with car year. In the logistic regression, it will only be possible to study this for cars from 1991 onwards.

4.2.3 Age of driver

The proportions of single-car crashes according to the age of the driver are shown in Table 4.3.

Table 4.3
Proportions of cars in single car crashes in different categories of driver age.

Driver age	Proportion single vehicle	
Up to 19	0.46	
20-29	0.41	
30-39	0.34	
40-49	0.26	
50-59	0.23	
60-69	0.22	
70+	0.24	

There seems to be a decrease with age of driver until about age 40.

4.2.4 Sex of driver

The proportions of single-car crashes were as follows.

- Male drivers: 37 per cent.
- Female drivers: 28 per cent.

4.2.5 Day and hour

As noted in section 4.1.2, 28 categories were derived from all combinations of four groups of days (Mon-Thurs, Fri, Sat, Sun) and seven groups of hours (00-01, 02-05, 06-11, 12-18, 19-20, 21-22, 23).

Table 4.4 gives the proportions of single-car crashes by time of day and day of week.

The factors leading to a higher number of single-car crashes at some times rather than others are likely to be light traffic, high speed, and errant driver behaviour other than high speed (e.g., driving impaired by alcohol).

Table 4.4

Proportions of cars in single car crashes on different days of the week and at different hours of the day.

Hour	Mon-Thurs	Friday	Sat	Sun
00-01	0.72	0.75	0.64	0.56
02-05	0.59	0.56	0.66	0.68
06-11	0.23	0.25	0.31	0.42
12-18	0.23	0.22	0.27	0.33
19-20	0.34	0.38	0.41	0.51
21-22	0.45	0.43	0.37	0.54
23	0.65	0.55	0.65	0.67

4.2.6 Speed limit and geography

As noted in section 4.1.2, 22 categories were created from speed limit, whether the crash was in or outside Perth metro area, and (if it was inside) the distance from city centre (represented by the distance from the city centre of the postcode or the local government area of the crash).

Table 4.5 gives the proportions of single-car crashes for these 22 categories.

The factors leading to a higher proportion of single-car crashes at some places rather than others are likely to be light traffic and high speed. The findings in Table 4.5 may be described as follows. (a) As distance increases from the centre of Perth, so does the proportion of single-car crashes. (b) As speed limit increases, so does the proportion of single-car crashes. (c) However, in 50 km/h areas, there is a higher proportion of single-car crashes than would be expected from the pattern so far described, presumably because traffic is relatively light there.

Table 4.5

Proportions of cars in single-car crashes in different speed limit zones and different geographical areas.

Speed limit (km/h)	Metro area			Outside metro area
	0.0 - 2.9 km	3.0 - 9.9 km	10 km or more	
50	0.15	0.21	0.30	0.45
60	0.14	0.14	0.19	0.35
70	0.18		0.17	0.29
80	0.27		0.30	0.49
90	0.33			0.60
100	0.38		0.46	0.52
110	0.57		0.49	0.77

4.3 Results: Accounting for several variables simultaneously, using logistic regression

Logistic regressions were carried out in which the dependent variable was the ratio of single vehicle crashes to two-vehicle crashes, and the independent variables were those described in section 4.1.2. Details of several logistic regressions are given in the Appendix (section 7). A summary of results is given here as section 4.3.1, and then as vehicle performance and driver age are of particular interest, results for these variables are described in sections 4.3.2 and 4.3.3.

Logistic regression is a term for a method of analysis in which the outcome can only be one of two things --- in the present case, a vehicle is in either a single or a two-vehicle crash --- and the probabilities of these alternatives are affected by several explanatory variables.

The effects of the several independent variables are assumed to combine additively. No attempt is made to fit a model in which (for example) the effect of car performance is different for different age groups of driver. Such questions are better addressed by restriction of the set of crashes analysed: section 7.4.1 reports an analysis restricted to drivers aged 17-19 holding a Provisional licence. The total number of crashes is not large enough to give reliable results for various subsets of crashes that might be considered relevant.

A few words are needed about the numerical results.

- For each of the explanatory variables, one category is specified as the baseline and effects of the other categories are expressed relative to the baseline. (A frequently-occurring category was always taken as the baseline.)
- These effects are in terms of the change in the natural logarithm of the ratio of the two types of crash: 0 means no effect, a positive number implies an increased number of single-car crashes relative to the baseline category, and a negative number implies a reduced number of single-car crashes. The advantage of presenting the natural logarithm of the ratio is that, for example, a ratio of 2 and a ratio of 0.5 are given equal weight in the results (i.e. 0.7 and -0.7), as they should, given that they are simply the inverse of each other.
- The meaning of the numerical results may be seen in the following example. Results from section 4.2.1 included the following.

4 cylinders, PWR 75-89: 26 per cent

4 cylinders, PWR 90 and more: 38 per cent

These figures referred to single-car crashes as a proportion of the sum of single- and two-car crashes, and were vehicle-based statistics. The ratios of the two types of crash were thus $26/74 = 0.35$ and $38/62 = 0.61$. The difference between the logarithms of these ratios is $\ln(0.61) - \ln(0.35) = 0.56$. This is the effect size that would be seen if adjusting for all the other variables made no difference at all. In section 4.3.1 (Table 4.6) below, the effect will be found to be roughly of this size, 0.7. That is, the adjustment made quite a small change to the size of the effect.

- Some attention is given to statistical “significance”, but it is not emphasised. It is a convenient tool in summarising results. However, it reflects random variation

only, and fails to reflect any error in specifying the regression model, for example. (A specific case of this would be that the effects of the several independent variables might not truly combine additively.) There is some further discussion in section 7.6.

4.3.1 Summary of results

A summary of the results are as follows: if statistical significance (5 per cent level) is taken at its face value, results are as follows.

- The performance variable, derived from the number of cylinders and power-to-weight ratio (PWR): statistically significant.
- Year of car (grouped): statistically significant (but only just).
- Age of driver (grouped): statistically significant.
- Sex of driver: not significant.
- Categories derived from the day of week and hour of day: statistically significant.
- Categories derived from speed limit, whether the crash was in or outside Perth metro area, and (if it was inside) distance from city centre: statistically significant.

It will be argued in the Appendix (section 7.6), though, that each individual statistical test is not very meaningful on its own, and that the totality of results from several regressions should be considered.

As vehicle performance and driver age are of particular interest, results for these variables are described below.

4.3.2 Number of cylinders and power-to-weight ratio

Results for number of cylinders and PWR were as shown in Table 4.6.

Table 4.6

Effect of vehicle performance categories on the proportion of crashed vehicles in single-vehicle crashes.

Number of cylinders	Performance category	Effect size on the log of the ratio of single- and two-car crashes
4 cylinder	PWR 59 and less	0.0
	PWR 60-74	-0.1
	PWR 75-89	0 (baseline)
	PWR 90 and more	0.7
6 cylinder	PWR 99 and less	0.2
	PWR 100-109	0.3
	PWR 110 and more	-0.1
8 cylinder	PWR 109 and less	0.5
	PWR 110-139	0.5
	PWR 140 and more	1.1

The greater the number of cylinders, the higher the ratio of single- to two-car crashes. As to PWR, (a) PWR, within its usual range, has no effect within number of cylinders, but (b) an exceptional PWR has an effect for 4- and 8-cylinder cars (it is possible, perhaps even likely, that an extreme PWR is associated with a higher proportion of single-car crashes in 6-cylinder cars also, and that the result found has occurred by chance).

Comparing with the results in section 4.2.1, two comments about points of detail can be added. (a) The first category (4 cylinders, PWR 0-59) no longer stands out as anomalous. (b) The other surprising result – that whereas the extreme PWR groups are associated with a higher proportion of single-car crashes in the case of 4-cylinder and 8-cylinder cars, but not 6-cylinder cars – is still present.

An analysis was also carried out restricted to conventional cars only, i.e., SUVs were excluded. This was done because conventional cars are of most interest, and it is possible that there is over-involvement of SUV-style vehicles in single vehicle (rollover) crashes. The vehicles included were the market segments Large, Light, Luxury, Medium, Prestige, Small, and Sports. Results for number of cylinders and PWR were as in Table 4.7. The straightforward way of describing this set of results is similar to, but slightly different from, the earlier results. The greater the number of cylinders, the higher the ratio of single- to two-car crashes. As to PWR, (a) for 4-cylinder cars, PWR has a progressive effect, and (b) for 6- and 8-cylinder cars, PWR has no effect.

If a further restriction is made to drivers aged 17-19 holding a Provisional licence, the results are as in Table 4.8. On their own, these results are very unreliable --- but they are broadly consistent with the data for all age groups.

As already mentioned, further regressions are reported in the Appendix (section 7).

Table 4.7
Effects of vehicle performance categories on the ratio of single- to two-vehicle crashes for conventional cars only.

Number of cylinders	Performance category	Effect size on the log of the ratio of single- and two-car crashes
4 cylinder	PWR 59 and less	-0.4
	PWR 60-74	-0.2
	PWR 75-89	0
	PWR 90 and more	0.6
6 cylinder	PWR 99 and less	0.2
	PWR 100-109	0.3
	PWR 110 and more	0
8 cylinder	PWR 109 and less	0.7
	PWR 110-139	0.4
	PWR 140 and more	0.7

Table 4.8

Effects of vehicle performance categories on the ratio of single- to two-vehicle crashes for conventional cars only, and further restricted to drivers aged 17-19 holding a Provisional licence.

Number of cylinders	Performance category	Effect size on the log of the ratio of single- and two-car crashes
4 cylinder	PWR 59 and less	1.2
	PWR 60-74	-1.0
	PWR 75-89	0
	PWR 90 and more	-0.5
6 cylinder	PWR 99 and less	1.0
	PWR 100-109	1.1
	PWR 110 and more	(no data)
8 cylinder	PWR 109 and less	1.2
	PWR 110-139	3.3
	PWR 140 and more	(no data)

4.3.3 Age of driver

The simple tabulations (section 4.2.3) showed a fairly steady decrease of the proportion of single-car crashes with driver age, until about age 40. The logistic regression results confirm this (Table 4.9).

In the analysis, previously referred to in section 4.3.2, in which vehicles were restricted to conventional cars only (i.e., SUVs were excluded), the effects of age of driver hardly changed from those shown in Table 4.9: see Table 4.10.

Table 4.9

Effect of driver age on the proportion of crashed vehicles in single-vehicle crashes

Driver age	Effect size on the log of the ratio of single- and two-car crashes
14-19	0.3
20-29	0 (baseline)
30-39	-0.4
40-49	-0.7
50-59	-0.8
60-69	-0.8
70+	-0.5

Table 4.10
Effect of driver age on the proportion of crashed vehicles in single-vehicle crashes for conventional cars only.

Driver age	Effect size on the log of the ratio of single- and two-car crashes
14-19	0.2
20-29	0 (baseline)
30-39	-0.3
40-49	-0.7
50-59	-0.8
60-69	-1.0
70+	-0.5

5 Characteristics of Western Australian vehicles: Performance and safety features

Vehicle safety features are often packaged with other vehicle features in higher grades of vehicle model. Hence, there might be a concern that restricting some vehicles to use by non-novice drivers may have the unintended consequence of preventing access to desirable safety features such as electronic stability control or vehicles rated highly by ANCAP.

This section of the report examines the evolution of the Western Australian registered light vehicle fleet to examine the introduction of several safety features, and focuses on the 2008 registered fleet. The registered vehicle fleet sample described in section 2.2 was used as a basis for this analysis, and hence the latest sample of vehicles available for this analysis came from 2008.

Four examples of safety systems are examined: electronic stability control, side-curtain airbags, four- or five-star ANCAP rating, and driver airbags. Additionally, the median vehicle age of each performance category is given.

In 2008, the first three of the features examined would still have been reasonably novel, and hence these represent technologies in their early stages of introduction into new vehicles. Driver airbags are an example of a more established safety feature.

5.1 Method

The sample of registered vehicles used to provide the denominators for the crash rates calculated in section 3 were used to characterise the fleet. The 2008 sample provided the sample from the most recent time-point.

The samples from each registration year were then disaggregated by year of manufacture, and the prevalence of each technology (or in the case of the ANCAP rating, the prevalence of four- or five-star ratings) in each year-of-manufacture cohort was calculated. Further, vehicles in each year-of-sale cohort were split into the performance categories defined earlier in this report. Presented as time-series, these data give an estimate of the history of the introduction of the safety features in each vehicle performance category.

5.2 Results

5.2.1 Vehicles registered on 30 June 2008

Electronic stability control (ESC) systems detect excessive yaw angles and wheel slip, and intervene to create stabilising moments on the vehicle through selective application of brakes to individual wheels. While effectiveness estimates have varied, large reductions in fatal single vehicle crashes have been noted.

In 2008, ESC systems were not available across all new vehicles, but were being introduced into higher-grade models.

Table 5.1 shows that ESC was present in around 10% of the Western Australian passenger vehicle fleet in 2008. But it is notable that it was present in 37% and 50% of the very high performance four- and six-cylinder vehicles registered at that time.

Table 5.1
Availability of electronic stability control in the 2008 WA passenger vehicle fleet.

Cylinders	Performance category	Not available	Optional	Standard	Total
4	Overall	89.7%	3.5%	6.8%	100%
	PWR 59 and less	96.0%	1.3%	2.7%	100%
	PWR 60-74	92.0%	4.3%	3.6%	100%
	PWR 75-89	87.6%	4.0%	8.4%	100%
	PWR 90 and more	61.4%	1.4%	37.1%	100%
6	Overall	90.8%	0.3%	8.9%	100%
	PWR 99 and less	92.3%	0.3%	7.4%	100%
	PWR 100-109	94.6%	0.0%	5.4%	100%
	PWR 110 and more	47.9%	2.1%	50.0%	100%
8	Overall	86.0%	0.0%	14.0%	100%
	PWR 109 and less	87.5%	0.0%	12.5%	100%
	PWR 110-139	86.1%	0.0%	13.9%	100%
	PWR 140 and more	84.2%	0.0%	15.8%	100%
Overall		89.9%	2.2%	7.9%	100%

Side curtain airbags are designed to protect occupants at risk of ejection, partial-ejection or direct head contact with an object outside the vehicle during a crash. Table 5.2 shows that in 2008, only 3% of vehicles in the registered fleet had side-curtain airbags as standard. Yet, at that time, 17.5% and 21% of vehicles in the very high power four- and six-cylinder categories had side curtain airbags as standard.

Table 5.2
Availability of side curtain airbags in the 2008 WA passenger vehicle fleet.

Cylinders	Performance category	Not available	Optional	Standard	Total
4	Overall	95.2%	1.8%	3.0%	100%
	PWR 59 and less	99.4%	0.2%	0.4%	100%
	PWR 60-74	96.8%	1.5%	1.7%	100%
	PWR 75-89	92.5%	2.7%	4.8%	100%
	PWR 90 and more	77.1%	5.4%	17.5%	100%
6	Overall	96.5%	0.5%	3.0%	100%
	PWR 99 and less	96.3%	0.6%	3.1%	100%
	PWR 100-109	98.7%	0.2%	1.1%	100%
	PWR 110 and more	78.8%	0.0%	21.2%	100%
8	Overall	94.1%	0.0%	5.9%	100%
	PWR 109 and less	91.7%	0.0%	8.3%	100%
	PWR 110-139	94.3%	0.0%	5.7%	100%
	PWR 140 and more	98.1%	0.0%	1.9%	100%
Overall		95.7%	1.2%	3.1%	100%

The Australasian New Car Assessment Program (ANCAP) publishes the results of crash tests to inform the public of the safety of vehicles. Up to four crash tests are performed: an offset frontal crash test, a side impact crash test, a pole impact test (used only where there is a side curtain airbag), and pedestrian safety assessments through subsystem impact testing. The results of the offset frontal and side impact tests are used to generate an occupant rating, which is modified according to the presence of other safety features such as seat belt reminders and electronic stability control. The result of the pedestrian assessment is currently separate from the occupant assessment, but both will soon be integrated into an overall assessment.

Vehicles are assigned points based on aspects of the crash test results and these are then converted to a star rating with 5 stars being the highest level of performance in the occupant assessment and 4 stars the highest in the pedestrian assessment. On a model-by-model basis, ANCAP ratings have been improving over time: 62% of models tested by ANCAP in 2009-10 achieved a 5-star ANCAP occupant rating. This compares with 14% in the years 2000-2004 (Michael Paine, personal communication). More information on the program and details on the assessment procedure can be found at <http://www.ancap.com.au>.

Table 5.3 shows the percentage of vehicles (not vehicle models) in each performance category in each of the respective ANCAP star rating categories. It should be noted that as the sample of vehicles is from the fleet as it was mid-2008, the proportion unrated is higher than it would be in 2011, and the proportion of vehicles in the 5-star category would also now be higher. However, this sample of vehicles may be more representative of vehicles likely to be purchased by a young driver in 2011 than a more contemporary sample of vehicles.

Notable is the positive correlation between the proportion in the four- and five-star categories and PWR within the four cylinder and the six cylinder categories of vehicle. Also notable is that the lower PWR vehicles in the four- and six-cylinder were more likely to be unrated.

Table 5.3

Percentages of vehicles in the 2008 Western Australian passenger vehicle fleet in each performance category and ANCAP rating.

Cylinders	Performance category	1 star	2 star	3 star	4 star	5 star	Unrated
4	Overall	0%	1%	7%	20%	3%	70%
	PWR 59 and less	0%	2%	7%	6%	0%	84%
	PWR 60-74	1%	0%	5%	12%	1%	80%
	PWR 75-89	0%	0%	9%	32%	4%	55%
	PWR 90 and more	0%	0%	4%	27%	9%	60%
6	Overall	0%	1%	6%	22%	1%	71%
	PWR 99 and less	0%	1%	4%	17%	1%	76%
	PWR 100-109	0%	0%	11%	26%	0%	63%
	PWR 110 and more	0%	0%	2%	67%	2%	29%
8	Overall	0%	0%	2%	27%	0%	72%
	PWR 109 and less	0%	0%	0%	36%	0%	64%
	PWR 110-139	0%	0%	0%	3%	0%	97%
	PWR 140 and more	0%	0%	5%	39%	0%	55%
Overall		0%	1%	6%	21%	2%	70%

The percentage of vehicles with driver airbags is given in Table 5.4. Notable here is general availability of driver airbags in the 2008 registered fleet. Nevertheless, the positive association between PWR and the availability of driver airbags is still present, reflecting probable differences in the rate of installation in earlier years when airbags were not yet common across the range of available vehicles.

Finally, the median age of vehicles in each category of vehicle performance is given in Table 5.5. An association between vehicle year and high performance is evident with the latest median in the highest PWR category of each cylinder class.

Table 5.4

Percentages of vehicles in the 2008 Western Australian passenger vehicle fleet with a driver airbag as standard.

Cylinders	Performance category	Not available	Optional	Standard	Total
4	Overall	17%	17%	66%	100%
	PWR 59 and less	36%	34%	29%	100%
	PWR 60-74	22%	15%	63%	100%
	PWR 75-89	5%	13%	82%	100%
	PWR 90 and more	9%	3%	89%	100%
6	Overall	15%	15%	70%	100%
	PWR 99 and less	20%	16%	64%	100%
	PWR 100-109	1%	18%	81%	100%
	PWR 110 and more	0%	0%	100%	100%
8	Overall	12%	6%	82%	100%
	PWR 109 and less	28%	0%	72%	100%
	PWR 110-139	6%	19%	75%	100%
	PWR 140 and more	0%	0%	100%	100%
Overall		16%	16%	68%	100%

Table 5.5

Median year of vehicles first sold between 1991-2008 in the 2008 Western Australian passenger vehicle fleet.

Cylinders	Performance category	Median year
4	Overall	2002
	PWR 59 and less	2000
	PWR 60-74	2001
	PWR 75-89	2003
	PWR 90 and more	2004
6	Overall	2000
	PWR 99 and less	2000
	PWR 100-109	2000
	PWR 110 and more	2006
8	Overall	2003
	PWR 109 and less	2002
	PWR 110-139	2001
	PWR 140 and more	2004
Overall		2001

5.2.2 Introduction of features into Western Australian vehicles

The following figures indicate the introduction of the various safety features amongst vehicles in each performance category, over time. As mentioned above, these data were derived from the combined registered vehicle samples that were then disaggregated according to the year of manufacture of the vehicle.

- Figure 5.1 shows the introduction of ESC into vehicles sold in Western Australia by performance category
- Figure 5.2 shows the introduction of side curtain airbags into vehicles sold in Western Australia by performance category
- Figure 5.3 shows the increase in the proportion of vehicles sold with a four- or five-star ANCAP rating in Western Australia by performance category

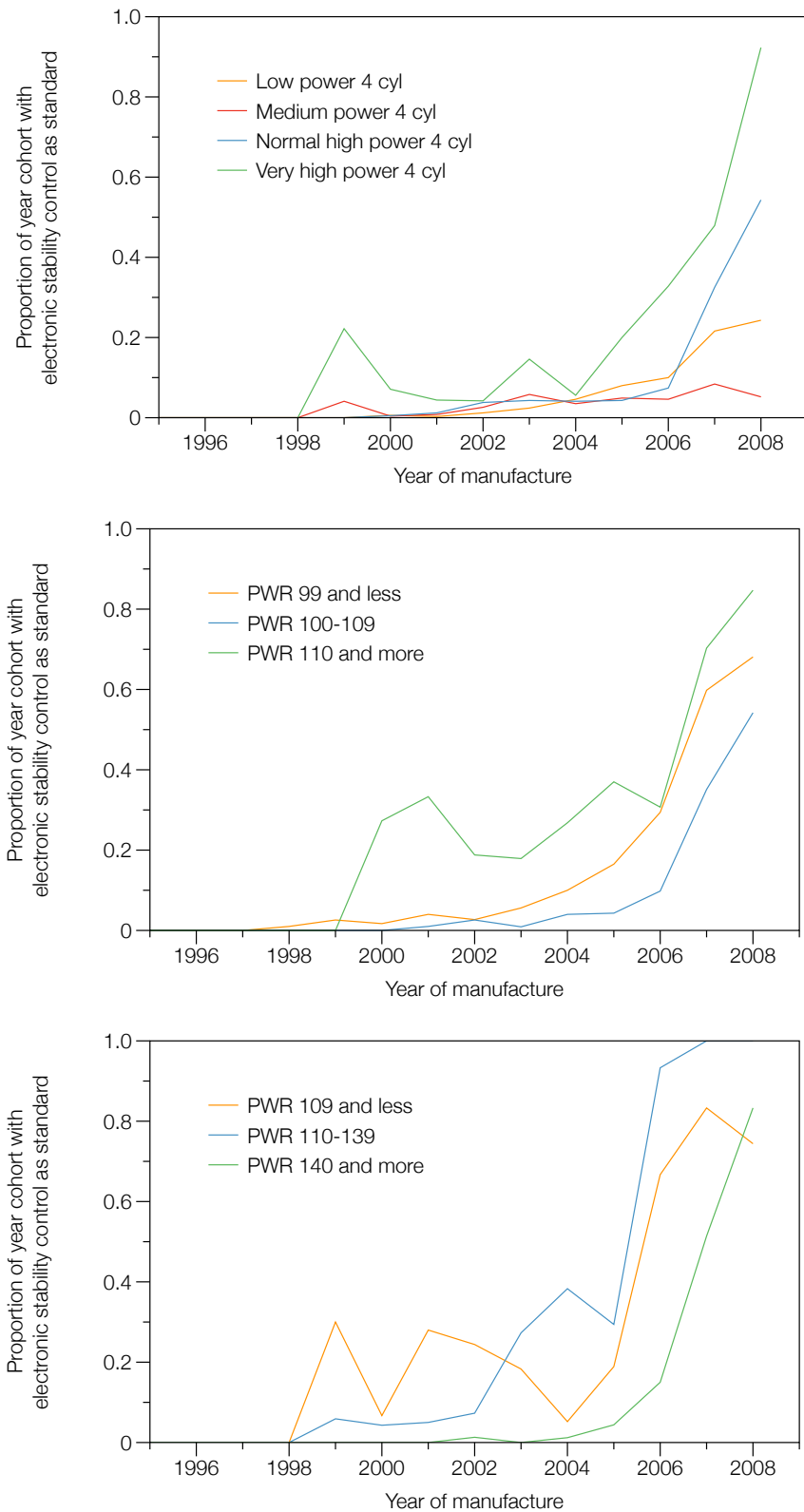


Figure 5.1
 Proportion of vehicles in each year of manufacture cohort with ESC as standard by performance category: four-cylinder vehicles (top); six-cylinder vehicles (middle); eight-cylinder vehicles (bottom).

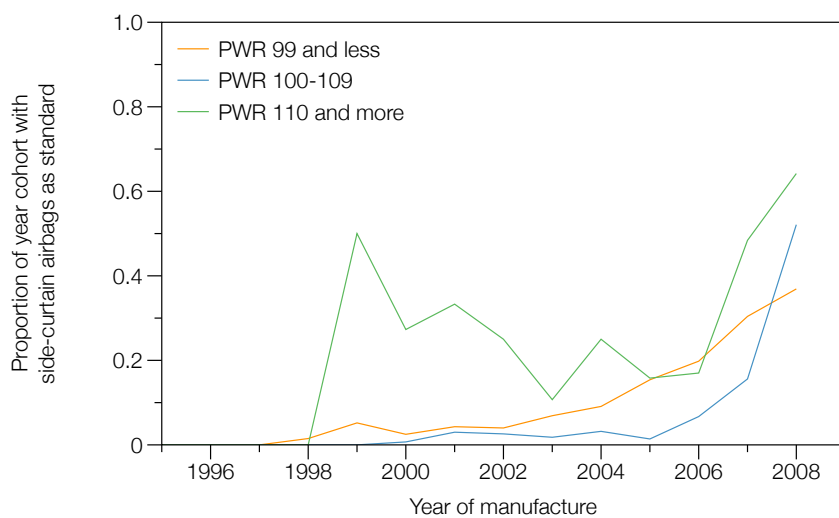
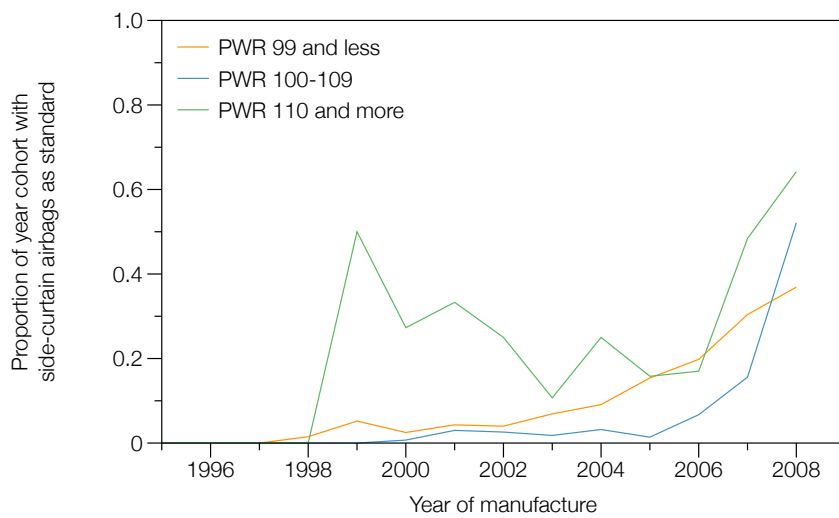
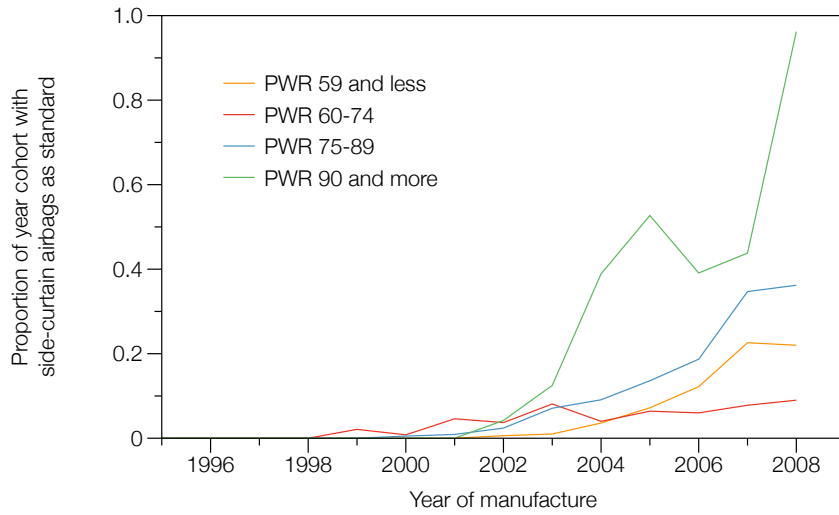


Figure 5.2

Proportion of vehicles in each year of manufacture cohort with side-curtain airbags as standard by performance category: four-cylinder vehicles (top); six-cylinder vehicles (middle); eight-cylinder vehicles (bottom).

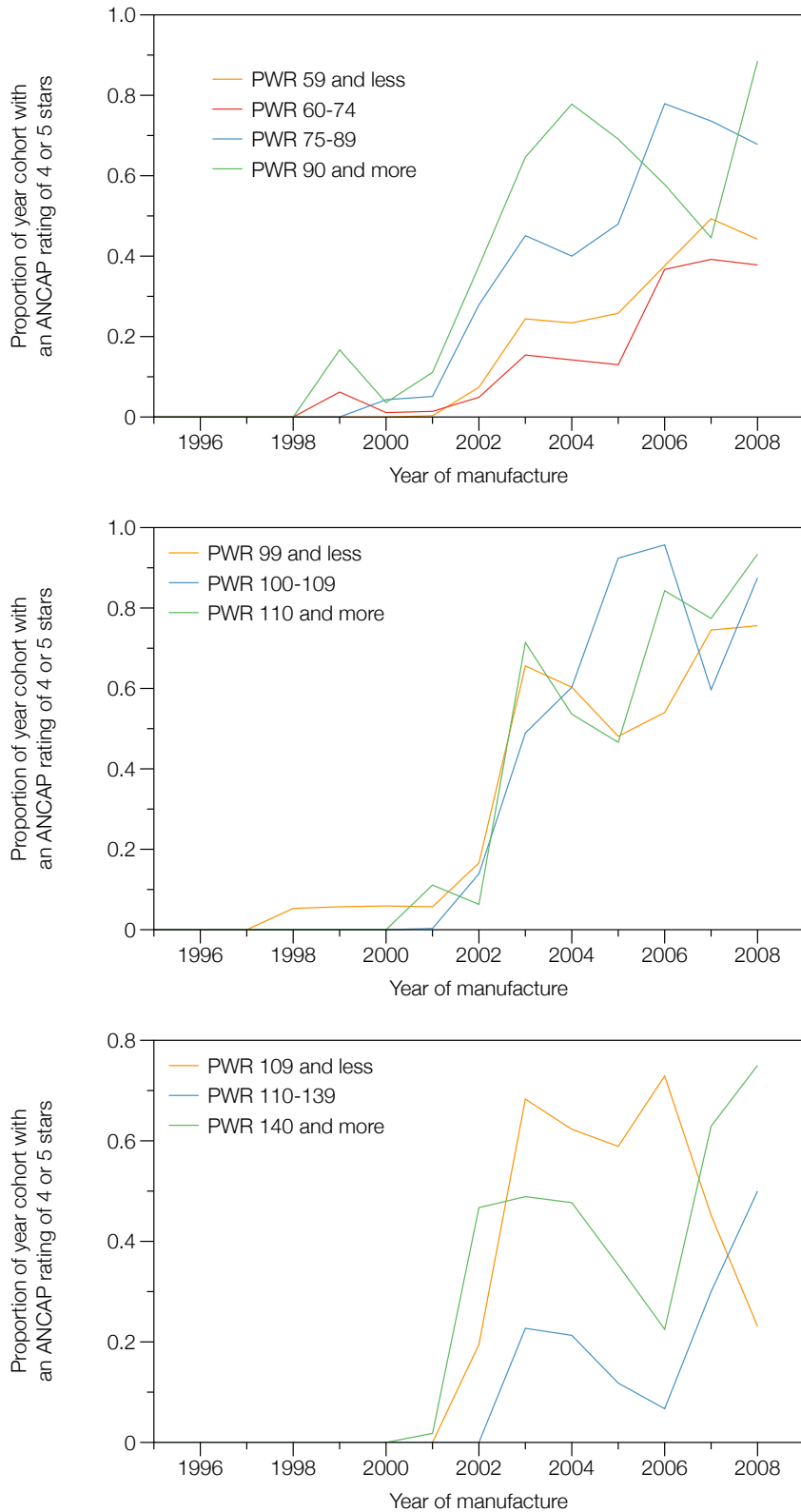


Figure 5.3

Proportion of vehicles in each year of manufacture cohort rated four- or five-stars by ANCAP, by performance category: four-cylinder vehicles (top); six-cylinder vehicles (middle); eight-cylinder vehicles (bottom).

5.3 Comments

Over time, vehicle safety technology becomes commonplace among vehicles across the range available to consumers. But typically, such features are installed only in the most expensive vehicles first, and as the technology becomes cheaper, it is installed into progressively more vehicles across the range.

The differences in the availability of safety features reflect the rate at which features are engineered into vehicles across the range. Safety features initially may be installed into only high-end models, and these models have tended to be higher performance. Hence, safety and performance are to some extent coupled in the new and second-hand vehicle markets.

With time, safety features become more widely installed and become potentially available to vehicle buyers of vehicles in any category of performance. Nevertheless, differences in installation rates may persist in the stock of vehicles within Western Australia, as has been the case with the availability of driver airbags.

This brief analysis has examined three of the aspects of vehicle safety that are coded in Polk data in a recent sample of registered vehicles (from 2008). The sample represents vehicles on the road during a period when several of the safety features we have examined were at an early stage of introduction into new vehicles. It is clear from the tables and figures in this section that these features were being introduced first into vehicles that also fell into higher PWR categories, particularly within four- and six-cylinder vehicles.

In summary, in 2008, higher performance vehicles were more likely to have ESC, side curtain airbags and even driver airbags. The vehicles were newer and (at least in 4 cylinder categories) were more likely to have a 5-star ANCAP rating.

6 Discussion

In this project, a database has been created in which information about road crashes has been supplemented with extra details about the vehicles, their drivers, and their owners. That database has been analysed in relation to high-powered cars driven by young drivers. Thus the emphasis of this project is on objective data. It has been conducted, however, in the context of some Australian states having restrictions on what cars can be driven by young drivers, and of other states considering similar restrictions. It has also been conducted in the context of the occasional but very tragic occurrence of deaths of, or caused by, young drivers in high performance vehicles. Some brief comments directly on these contexts are offered below.

The results support the case for some form of policy response: in various analyses, a picture of extra crashes of young drivers and extra crashes of high-powered cars has appeared. This was true both for crashes per registered vehicle and the ratio of single- to two-car crashes. The details of a policy response are outside the scope of this study, as even 8 years of crash data were not sufficient to determine exactly what power-to-weight ratio or what age range of drivers should be the focus of attention

The results are not so clear and certain that they make, on their own, a compelling case for response. In view of uncertainties in how the analysis should best be conducted, the results themselves are persuasive rather than conclusive. Furthermore, arguments can be made against restrictions. (a) The number of deaths and injuries involving young drivers in high-performance cars is a small fraction of total road deaths and injuries, and hence even a very effective policy will have only a limited effect on the overall road toll. (b) New high-powered cars tend to be fitted with safety features. Before restricting access to high-powered cars, consideration should be given to what car a novice driver will drive if denied access to their first choice of a high-powered vehicle.

These comments are not intended to be in any way dismissive of the higher risks that some combinations of drivers and vehicles may present to themselves and to others. The uncertainties that are discussed above relate mainly to aspects of the analysis and to the ability of the statistical tools we have employed to try and detect the presence of increased risk within the crash dataset assembled for this project. There is nothing in the results of this report that contradict perceptions that crashes involving young drivers in high performance vehicles are more likely to be severe or even catastrophic. They are so few that it was not possible to conduct an analysis to detect an increase in risk, but that they occur is undeniable.

7 Appendix

Section 4.3 summarised results of a logistic regression in which the dependent variable was the ratio of single vehicle crashes to two-vehicle crashes, and the independent variables were those described in section 4.1.2. This appendix gives further details.

The view taken here is that in analyses such as these, little emphasis should be placed on "statistical significance" of any individual result: individual results might change from significant to non-significant if some detail of the analysis changes. See sections 7.3 and 7.6 for discussion of this. Rather than take statistical significance at face value, the totality of the results should be considered.

7.1 Further results accounting for several variables simultaneously, using logistic regression

7.1.1 *Number of cylinders and power-to-weight ratio*

Results for number of cylinders and PWR were as shown in Table 7.1 (also given as Table 4.6).

Table 7.1

Effect of vehicle performance categories on the proportion of crashed vehicles in single-vehicle crashes.

Number of cylinders	Performance category	Effect size on the log of the ratio of single- and two-car crashes
4 cylinder	PWR 59 and less	0.0
	PWR 60-74	-0.1
	PWR 75-89	0 (baseline)
	PWR 90 and more	0.7
6 cylinder	PWR 99 and less	0.2
	PWR 100-109	0.3
	PWR 110 and more	-0.1
8 cylinder	PWR 109 and less	0.5
	PWR 110-139	0.5
	PWR 140 and more	1.1

The greater the number of cylinders, the higher the ratio of single- to two-car crashes. As to PWR, (a) PWR, within its usual range, has no effect within number of cylinders, but (b) an exceptional PWR has an effect for 4- and 8-cylinder cars (it is possible, perhaps even likely, that an extreme PWR is associated with a higher proportion of single-car crashes in 6-cylinder cars also, and that the result found has occurred by chance).

Comparing with the results in section 4.2.1, two comments about points of detail can be added. (a) The first category (4 cylinders, PWR 0-59) no longer stands out as anomalous. (b) The other surprising result – that the extreme PWR groups are

associated with a higher proportion of single-car crashes in the case of 4-cylinder and 8-cylinder cars, but not 6-cylinder cars – is still present.

7.1.2 Year of car

Univariate results (section 4.2.2) showed a fairly steady decrease of the proportion of single-car crashes with car year, from 1970-1974 to 2005-2009. The logistic regression is restricted to cars from 1991 onwards, and shows a less convincing effect (Table 7.2).

Table 7.2
Effect of vehicle year on the proportion of crashed vehicles in single-vehicle crashes.

Vehicle year	Effect size on the log of the ratio of single- and two-car crashes
1990-1994	0.2
1995-1999	0 (baseline)
2000-2004	-0.1
2005-2008	-0.1

7.1.3 Age of driver

The simple tabulations (section 4.2.3) showed a fairly steady decrease of the proportion of single-car crashes with driver age, until about age 40. The logistic regression results confirm this (Table 7.3, given earlier as Table 4.9).

Table 7.3
Effect of driver age on the proportion of crashed vehicles in single-vehicle crashes.

Driver age	Effect size on the log of the ratio of single- and two-car crashes
14-19	0.3
20-29	0 (baseline)
30-39	-0.1
40-49	-0.7
50-59	-0.8
60-69	-0.8
70+	-0.5

7.1.4 Sex of driver

In the simple tabulations, male drivers had a higher proportion of single-car crashes than female drivers (section 4.2.4). Using regression to make allowance for the other variables, there was no significant difference.

7.1.5 Day and hour

Univariate results were given in Table 4.5. The effects found in the logistic regression fell into a similar pattern, see Table 7.4.

Table 7.4
Effects of day of week and hour of day found in the logistic regression.

Hour	Mon- Thurs	Friday	Sat	Sun
00-01	2.4	1.7	1.5	1.7
02-05	1.8	1.6	1.9	1.9
06-11	0.0	0.0	0.3	0.5
12-18	0 (baseline)	-0.4	0.0	0.1
19-20	0.6	0.7	0.8	1.2
21-22	1.1	0.8	0.9	1.3
23	2.2	1.7	1.5	1.7

7.1.6 Speed limit and geography

Univariate results were given in Table 4.6. The effects found in the logistic regression fell into a similar pattern, see Table 7.5.

Table 7.5
Effects of speed limit and geography found in the logistic regression.

	Metro area			Outside metro area
	0.0 - 2.9 km	3.0 - 9.9 km	10 km or more	
50	-3.8	-3.1	-2.3	-1.8
60	-3.7	-3.5	-3.0	-2.2
70	-3.1		-3.2	-2.3
80	-2.8		-2.6	-1.5
90	-2.2			-0.9
100	-2.2		-1.6	-1.3
110	-0.9		-1.2	0 (baseline)

7.1.7 Interpretation

As noted in the Introduction, the basis of this analysis is that as riskiness increases, the number of single vehicle crashes increases more than the number of two-vehicle crashes. Unfortunately, there is no quantitative interpretation.

The analysis contrasts single- with two-car crashes. This can indeed be interpreted in terms of riskiness if it is assumed that riskiness in two-car crashes is exactly the same as riskiness in single-car crashes. Unfortunately, some features of this dataset (and of previously-analysed datasets) suggest this is not the case. Instead, riskiness in two-car crashes is similar to, or correlated with, riskiness in single-car crashes. This makes a quantitative interpretation impossible, because the interpretation would depend on what the degree of similarity or correlation is, and this is unknown.

For a quantitative view of the results, there are a couple of options. (a) Crashes per registered vehicle can be examined, as in section 3, provided it is accepted that the rate is per vehicle rather than per kilometre. (b) Reference can be made to the relative proportion of cars in single- and two-car crashes, as in section 4.2, provided it is accepted that it is not the same thing as risk.

7.2 Restriction to conventional cars

In this analysis, SUVs were excluded. This was done because conventional cars are of most interest, and it is possible that there is over-involvement of SUV-style vehicles in single vehicle (rollover) crashes. The vehicles included were the market segments Large, Light, Luxury, Medium, Prestige, Small, and Sports.

Results for number of cylinders and PWR are given in Table 7.6 (and previously in Table 4.7). The straightforward way of describing this set of results is similar to, but slightly different from, the earlier results. The greater the number of cylinders, the higher the ratio of single- to two-car crashes. As to PWR, (a) for 4-cylinder cars, PWR has a progressive effect, and (b) for 6- and 8-cylinder cars, PWR has no effect.

Table 7.6
Effects of vehicle performance categories on the ratio of single- to two-vehicle crashes for conventional cars only.

Number of cylinders	Performance category	Effect size on the log of the ratio of single- and two-car crashes
4 cylinder	PWR 59 and less	-0.4
	PWR 60-74	-0.2
	PWR 75-89	0 (baseline)
	PWR 90 and more	0.6
6 cylinder	PWR 99 and less	0.2
	PWR 100-109	0.3
	PWR 110 and more	0.0
8 cylinder	PWR 109 and less	0.7
	PWR 110-139	0.4
	PWR 140 and more	0.7

7.3 Stability of results

7.3.1 What results will be examined

One way of gauging the reliability of results is to see how stable or unstable are the results when considering different time periods. Table 7.7 presents the estimated effects of the variable formed from number of cylinders and PWR, in logistic regressions that were restricted to crashes in three calendar months (of the years 2001-2008, as before).

- Note that results from all twelve calendar months are shown in the final column (as in Table 4.6).
- The table also draws attention to five categories being relatively uncommon: 4 cylinders with extreme PWR, 6 cylinders with extreme PWR, and the three 8-cylinder categories.

Table 7.7

Logistic regression results relating to the variable formed from number of cylinders and PWR: consistency when the analysis is repeated for different three-month periods.

		Months 1-3	Months 4-6	Months 7-9	Months 10-12	Original results
4 cylinder	PWR 59 and less	.1	-.2	-.3	.4	.0
	PWR 60-74	.1	-.1	-.3	-.3	-.1
	PWR 75-89	.0	.0	.0	.0	.0
	PWR 90 and more*	.6	.7	.6	1.1	.7
6 cylinder	PWR 99 and less	.2	.2	.2	.4	.2
	PWR 100-109	.1	.3	.3	.6	.3
	PWR 110 and more*	.2	.0	-.2	-.3	-.1
8 cylinder	PWR 109 and less*	-.3	2.1	.1	.7	.5
	PWR 110-139*	-.4	.2	1.4	.6	.5
	PWR 140 and more*	1.6	1.3	1.5	.7	1.1

* These five categories were relatively uncommon: they had an average of between 12 and 27 cases per three calendar months summed over the eight crash years.

7.3.2 Consideration of results in order of magnitude

The larger results are likely to be the most interesting and important, if they could be relied upon. Consequently, the original results will be considered below in order of their magnitude. It transpires that the first four results refer to categories of car that are relatively uncommon and hence may not be reliable.

- 1.1 (8 cylinders, PWR 140+): there is a lot of variation over the four sets of months, but it seems that the effect is strong enough to be consistently positive.
- 0.7 (4 cylinders, PWR 90+): there is a lot of variation over the four sets of months, but again it seems that the effect is strong enough to be consistently positive.

- 0.5 (8 cylinders, PWR 110-139): there is a lot of variation over the four sets of months, and the effect is not strong enough to be consistently positive.
- 0.5 (8 cylinders, PWR up to 109): there is a lot of variation over the four sets of months, and the effect is not strong enough to be consistently positive.

The next two results refer to more common categories of car.

- 0.3 (6 cylinders, PWR 100-109): the effect, though of modest size, is consistently positive.
- 0.2 (6 cylinders, PWR up to 99): again the effect, though of modest size, is consistently positive.

For the remaining categories, the effect is estimated as close to zero and is not consistently positive or negative.

7.3.3 *Summing-up*

In view of the consistency or lack of it reported above, we regard the 1.1 and 0.7 (for, respectively, 8 cylinders, PWR 140+, and 4 cylinders, PWR 90+) as reliable, and the 0.3 and 0.2 (for, respectively, 6 cylinders, PWR 100-109, and 6 cylinders, PWR up to 99) as reliable also.

Taken in isolation, we would not regard the 0.5 (for both 8 cylinders, PWR 110-139, and 8 cylinders, PWR up to 109) as reliable, but in view of the findings for other categories (namely, the 1.1, 0.7, 0.3, and 0.2), we think this can be taken as reliable also.

7.4 Subgroups of drivers

7.4.1 *Drivers aged 17-19 holding a Provisional Licence*

In a similar format to section 4.3.1, results for 17-19 year old drivers holding a Provisional licence were as follows.

- The performance variable, derived from the number of cylinders and power-to-weight ratio (PWR): statistically significant, but somewhat different from previously.
- Year of car (grouped): not statistically significant.
- Age of driver (grouped): this variable is now omitted, of course.
- Sex of driver: not significant (quite).
- Categories derived from the day of week and hour of day: not statistically significant (quite).
- Categories derived from speed limit, whether the crash was in or outside Perth metro area, and (if it was inside) distance from city centre: statistically significant.

Table 7.8
Effects of vehicle performance categories on the ratio of single- to two-vehicle crashes for drivers aged 17-19 holding a Provisional licence.

Number of cylinders	Performance category	Effect size on the log of the ratio of single- and two-car crashes
4 cylinder	PWR 59 and less	1.3
	PWR 60-74	-0.5
	PWR 75-89	0 (baseline)
	PWR 90 and more	-0.3
6 cylinder	PWR 99 and less	1.2
	PWR 100-109	1.4
	PWR 110 and more	-0.5
8 cylinder	PWR 109 and less	1.7
	PWR 110-139	2.9
	PWR 140 and more	3.4

The pattern of results for the performance categories is now as in Table 7.8. However, the number of cases is now small, and so standard errors are large. While it can be said that high performance cars are associated with a higher proportion of single-car crashes, further detail than this would not be appropriate. No particular effect of the extreme PWR categories can be seen.

It appears that 4-cylinder cars with low PWR are also associated with a higher proportion of single-car crashes. The effect is still present when SUVs are excluded (Table 4.8). However, there are very few recent cars in this category, and it seems likely that what should have been attributed to car year has instead turned up as an apparent effect of low PWR. (Car year is included in the equation also, and so its effect is in principle distinguishable, but the small number of cases may have prevented this.)

7.4.2 Drivers aged 17-24

If the analysis is repeated for drivers aged 17-24, the following results are obtained.

- The performance variable, derived from the number of cylinders and power-to-weight ratio (PWR): statistically significant.
- Year of car (grouped): not statistically significant.
- Age of driver (grouped): this variable is now omitted, of course.
- Sex of driver: not significant.
- Categories derived from the day of week and hour of day: statistically significant.
- Categories derived from speed limit, whether the crash was in or outside Perth metro area, and (if it was inside) distance from city centre: statistically significant.

The pattern of results for the performance categories is now as in Table 7.9. Again it seems that high performance cars are associated with a higher proportion of single-car crashes, but further detail than this would not be appropriate.

Table 7.9
Effects of vehicle performance categories on the ratio of single- to two-vehicle crashes for drivers aged 17-24.

Number of cylinders	Performance category	Effect size on the log of the ratio of single- and two-car crashes
4 cylinder	PWR 59 and less	0.2
	PWR 60-74	0.0
	PWR 75-89	0 (baseline)
	PWR 90 and more	0.7
6 cylinder	PWR 99 and less	0.3
	PWR 100-109	0.6
	PWR 110 and more	-1.0
8 cylinder	PWR 109 and less	0.9
	PWR 110-139	1.0
	PWR 140 and more	1.1

7.4.3 Drivers aged 20+ holding a standard licence

For drivers aged 20+ holding a standard licence, the following results are obtained.

- The performance variable, derived from the number of cylinders and power-to-weight ratio (PWR): statistically significant (just).
- Year of car (grouped): not statistically significant.
- Age of driver (grouped): statistically significant.
- Sex of driver: not significant.
- Categories derived from the day of week and hour of day: statistically significant.
- Categories derived from speed limit, whether the crash was in or outside Perth metro area, and (if it was inside) distance from city centre: statistically significant.

The pattern of results for the performance categories is now as in Table 7.10. Thus 8-cylinder cars, but not 6-cylinder cars, are associated with a higher proportion of single-car crashes, and so also are the 4-cylinder cars with extreme PWR.

Table 7.10

Effects of vehicle performance categories on the ratio of single- to two-vehicle crashes for drivers aged 20+ holding a standard licence.

Number of cylinders	Performance category	Effect size on the log of the ratio of single- and two-car crashes
4 cylinder	PWR 59 and less	-0.1
	PWR 60-74	-0.2
	PWR 75-89	0 (baseline)
	PWR 90 and more	0.7
6 cylinder	PWR 99 and less	0.0
	PWR 100-109	0.1
	PWR 110 and more	-0.5
8 cylinder	PWR 109 and less	0.4
	PWR 110-139	0.5
	PWR 140 and more	0.8

7.4.4 Comment on drivers in different age groups

Although the results in sections 7.4.1 and 7.4.3 hint at stronger effects for young drivers than older drivers, it is not suggested that this is statistically significant or proven by these results.

7.5 Further logistic regressions: Perth metro area

Results restricted to the Perth metro area were as below.

- The performance variable, derived from the number of cylinders and power-to-weight ratio: statistically significant.
- Year of car (grouped): not statistically significant (quite).
- Age of driver (grouped): statistically significant.
- Sex of driver: statistically significant.
- Categories derived from the day of week and hour of day: statistically significant.
- Categories derived from speed limit and distance from city centre: statistically significant.

The pattern of results for the performance categories is now as in Table 7.11. It is not very different from that for the state as a whole given in Tables 4.6 and 7.1.

As to sex of driver being statistically significant, females were associated with a lower proportion of single-car crashes.

Table 7.11

Effect of vehicle performance categories on the proportion of crashed vehicles in single-vehicle crashes, Perth metro area only.

Number of cylinders	Performance category	Effect size on the log of the ratio of single- and two-car crashes
4 cylinder	PWR 59 and less	-0.2
	PWR 60-74	-0.2
	PWR 75-89	0 (baseline)
	PWR 90 and more	0.9
6 cylinder	PWR 99 and less	0.3
	PWR 100-109	0.5
	PWR 110 and more	-0.1
8 cylinder	PWR 109 and less	0.8
	PWR 110-139	0.7
	PWR 140 and more	1.0

7.6 Comments on the analysis

An important part of the background to this project was the idea that young drivers and high-performance cars are a particularly unsafe combination, and it may be practicable to restrict the access of young drivers to high-performance cars by some form of regulation. Thus the results concerning the car and the young driver are central.

7.6.1 *Limitations*

This type of research is always open to the objection that the results are distorted by confounding variables.

One set of possible confounding variables may be summarised under the heading of driver personality and behaviour. The possibility that high-powered cars are driven disproportionately by dangerous drivers, who would be predisposed to crashes whatever car they were driving, has to be accepted: there were no variables available to represent driver personality except age and sex. It seems likely, though, that factors related to the driver (e.g., choice of high speed, lack of skill, lack of experience, irresponsibility) would be aggravated rather than reduced by a high-powered car.

Another set of possible confounding variables may be summarised as geography. It is likely that the ratio of single- to two-car crashes will tend to be high on roads on which speed is high, and low on roads on which traffic density is high. If different cars are

used in different places, a spurious association with crash type may thus arise. This possibility may be allowed for by including speed limit as one of the regressor variables. However, this may not be an adequate answer, as it could be that there are two respects in which Australia is unusual. Firstly, a higher proportion of people live in either large metropolitan areas (Perth, in the case of Western Australia) or very remote areas than do so in other countries; consequently, individuals may get less variety of driving experiences, and this may affect their choice of car. Secondly, large cars are cheap and popular, particularly the Holden Commodore and Ford Falcon. These factors mean that the need to take account of speed limit and geography may be more acute for Australian data than for that from other countries. A variable was therefore constructed that incorporated speed limit, whether the crash was in or outside Perth metro area, and (if it was inside) approximate distance from city centre. On the positive side, the various analyses conducted in this project seemed to give similar results in respect of the vehicle and driver variables, however speed limit and geography were coded. On the negative side, this is quite an important variable, and so it is highly desirable to treat it correctly in the analysis, but there cannot be full confidence that has been the case: there are many alternative possible ways of coding such a variable.

7.6.2 Choices regarding details

Results for all drivers together, rather than results solely for young drivers, have been emphasised. Quite extreme groups of high-powered cars have been distinguished from others, rather than PWR being assumed to have a progressive effect across its whole range. These and many other details of the analysis could be changed, and the results would change somewhat.

7.6.3 Statistical significance

We recommend against taking too much notice of whether an individual result is "statistically significant" or not. There are several distinct reasons for this.

- Much of the analysis is exploratory: there was insufficient knowledge to specify the questions for test before starting the project, but these were defined and refined as the project proceeded. In a classic experimental setting, a significance test has a well-defined meaning. In the present study, though, many decisions -- e.g., what subgroups of the total dataset to consider, what explanatory variables to include, and how these should be categorised --- are guided by preliminary tabulations and analyses. It would thus be quite possible for the choice to be influenced by what appear (perhaps by chance) to be positive results.
- There is always the possibility that the model specification was not exactly right, in which case the results will not be exactly right either.
- There is extra year-to-year variation in road crash data beyond that predicted by statistical theory. The reasons are poorly understood, but probably include year-to-year variation in the things that affect road crashes --- weather, speeds, alcohol consumption, the enforcement practices of the police, and so on.

- The number of tests performed --- on several variables, in analyses of several subsets --- means that some "significant" results would be expected by chance.
- Once a statement is obtained about significance, or lack of it, of a variable with (say) 10 categories (there were 10 categories of vehicle performance), it is not clear how to change that into a statement about the significance, or lack of it, of differences between subsets of those categories. So no comment is offered on, for example, the significance or otherwise of a difference between 4-cylinder high performance cars and 8-cylinder high performance cars.

7.6.4 *Summing-up*

There are three points to be made.

- The general thrust of the conclusions here is believed to be reliable.
- Criticisms of the statistical methods could be made that we would be unable to dismiss as baseless. And any change in the detail of the methods does change the detail of the results.
- Details of results are generally based on small numbers of crashes and are thus likely to be unreliable. Details of policies influenced by the results should therefore similarly be regarded as debatable.