Four-wheel drive vehicle crash involvement patterns

August 2006

RACV

Report Summary 06/05

Introduction

This document is a summary of a larger research report prepared by the Monash University Accident Research Centre (MUARC) (Keall et al, 2006) that analysed the crash patterns of four-wheel drive (4WD) vehicles in comparison with other passenger vehicles in Australia and New Zealand. The focus of this document is on summarising the main points of that report, with emphasis on findings that are useful for motorists, especially current or potential 4WD drivers.

Key concepts discussed in this document include:

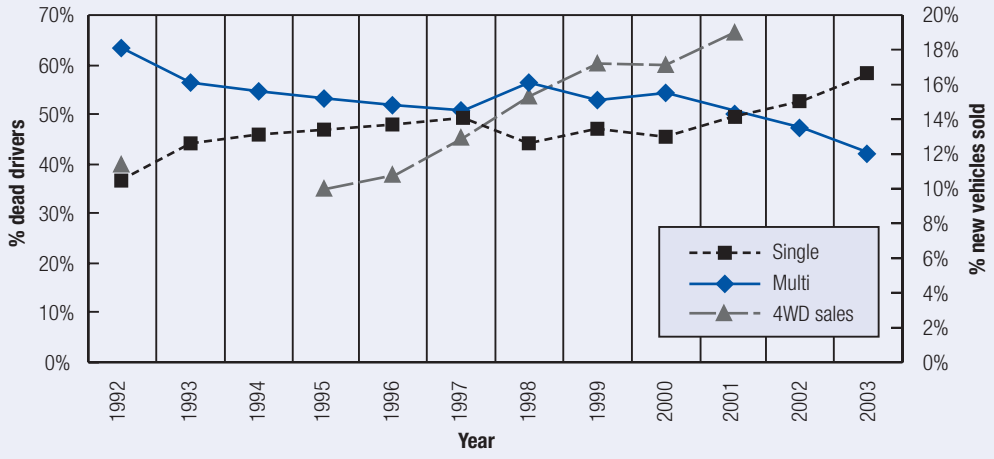
- *Crashworthiness* of vehicles, which is their ability to protect the driver in the event of a crash. 4WD vehicles tend to have good crashworthiness in some types of crashes, but poor crashworthiness in others.
- *Aggressivity* of vehicles, which is a measure of the harm a vehicle may cause to other road users in crashes. 4WD vehicles tend to have high aggressivity compared to cars.
- *Rollover* crashes, in which a vehicle impacts the ground or road surface with its side or top. Vehicles that have a high centre of gravity relative to the width of the wheel track (such as many 4WDs) are more liable to roll over.
- *Single vehicle* crashes occur when a vehicle collides with a road feature such as a guard rail, a pole, a tree, a parked vehicle, a fence, an animal, etc., the vehicle leaves the road to be submerged in water, or the vehicle rolls over.

Data sources include crash data for the years 1999-2003 from Australian states Victoria, New South Wales, Queensland, Western Australia and also from New Zealand. These data had been matched to other data sources in previous MUARC research in order to classify crashed vehicles by make and model and market group. In addition, analyses were conducted to look at trends over time using NSW data for the years 1987-2003.

Main findings

1 Figure 1 shows the steeply increasing sales of new 4WD vehicles in Australia. Also shown are the proportions of fatally injured car drivers in the state of Victoria who were killed in single vehicle crashes or multi-vehicle crashes. Evidently, **the increase in 4WD vehicles on the road does not seem to be associated with increases in the proportion of car drivers being killed in multi-vehicle crashes**.

Figure 1 **Percentages of fatally injured car drivers in Victoria killed in single vehicle and multi-vehicle crashes together with Australian national percentages of new vehicles sold that are 4WD by year**



2 When considering the crash fleet of 4WD vehicles and cars, Table 1 shows that 4WD vehicles make up about 5% of crash involved drivers and a similar proportion of seriously injured or fatally injured drivers. However, 4WD vehicles are considerably overrepresented in rollover crashes (11% of all rollover crashes, compared to only 5% for cars). Further, of all fatally injured 4WD drivers, a large proportion (41%) were killed in rollover crashes, compared to only 10% of fatally injured car drivers. **This shows that rollover crashes are a very important and very dangerous crash type for 4WD drivers.**

Table 1 **Numbers and percentages of all crash-involved, seriously injured and fatally injured drivers in all crashes and rollover crashes and proportion of crash-involved or injured drivers who rolled over. (Data from VIC, NSW, QLD, WA, NZ: 1999-2003).**

	4WD	Car
All crash involved drivers *Total number*	31,368	576,119
% of crash involved drivers	5%	95%
Number of rollover crashes	1,541	11,865
% of rollover crashes	11%	89%
% rollover / crash	5%	2%
Seriously injured drivers *Total number**	1,053	16,495
% of seriously injured drivers	6%	94%
Number seriously injured in rollovers	303	1,376
% of seriously injured in rollovers	18%	82%
% rollover / seriously injured	29%	8%
Fatally injured drivers *Total number*	96	1,672
% of fatally injured drivers	5%	95%
Number fatally injured in rollovers	39	164
% of fatally injured in rollovers	19%	81%
% rollover / fatally injured.	41%	10%

**NSW data not included in totals for seriously injured drivers*

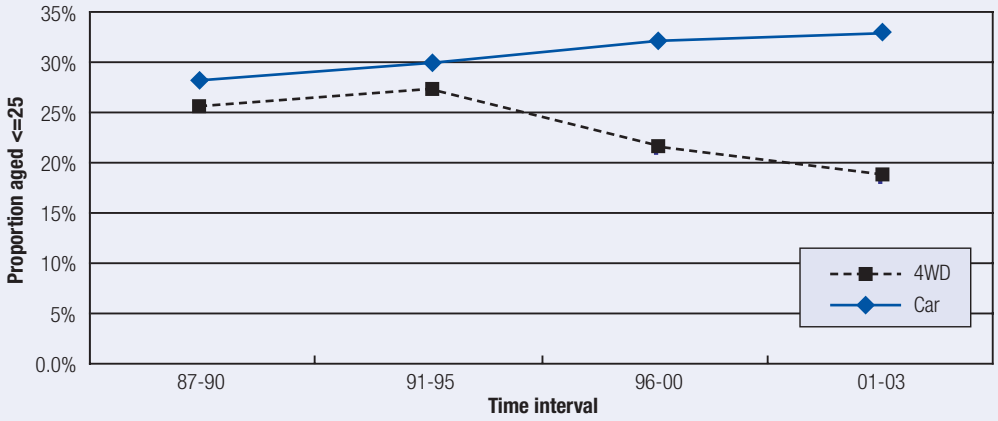
3 Table 2 shows the distribution of drivers in crashes within vehicle type by age and gender. **Crashes for 4WDs tend to involve male drivers more than for cars, particularly the 26-59-year-old age group. Middle-aged drivers dominate in 4WD crashes (72%) compared to only 58% of crash-involved car drivers.** As shown in Table 5, of the three size classes of 4WD considered, Large 4WDs make up about half the crash fleet in the data, with Medium and Compact 4WDs making up the remainder (22% and 28% of the crash fleet respectively).

Table 2 **Proportion by age and sex of drivers of crashed cars/4WDs within vehicle type (data from VIC, NSW, QLD, WA, NZ 1999-2003).**

	4WD			Car		
Age	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
<=25	13%	7%	20%	18%	13%	31%
26-59	45%	28%	72%	30%	28%	58%
60+	7%	1%	8%	6%	4%	10%
Total	**64%**	**36%**	**100%**	**55%**	**45%**	**100%**

4 Approaching half of all crash-involved car drivers were females, compared to just a third of crash-involved 4WD drivers (Table 2). A considerably higher proportion of 4WD crashes happened in higher speed limit areas (26%) compared to car crashes (17%). However, analysis of trends in 4WD crash patterns in NSW showed that a number of features of 4WD crashes were changing, reflecting who drove these vehicles and where they were driven. **Over the period 1987-2003, 4WD drivers involved in crashes were becoming less young, more likely to be female, and more urban in terms of speed limit area** - see Figure 2 and the analysis in Keall, Newstead and Watson (2006). Figure 2 shows that crash-involved drivers of 4WDs in NSW consisted of proportionately fewer young drivers than did crash involved drivers of cars and this disparity seems to be increasing with time (the proportion of 4WD drivers who are young has fallen over the last 12 years, whereas the proportion of car drivers who are young has increased over the same period).

Figure 2 For NSW crash occurrences in time interval and for vehicle type shown, proportion of drivers that were aged 25 and under (out of all drivers with known age).



5 Table 3 shows that **on average, over all crash types combined, Large and Medium 4WDs have good crashworthiness, despite poor protection provided in single vehicle crashes** (see Figure 3). However, Compact 4WDs have poorer crashworthiness than average for passenger vehicles (see Table 3).

Table 3 Estimated Vehicle Crashworthiness by Market Grouping (adapted from Newstead et al, 2005)

Market Group	Injury Risk (%)	Injury Severity (%)	Crashworthiness Rating*	Lower 95% Confidence limit	Upper 95% Confidence limit
Light	22.46	22.50	5.05	4.91	5.21
People Movers	19.64	22.13	4.35	4.07	4.64
Small	19.61	21.02	4.12	4.02	4.23
Compact Four Wheel Drive	20.04	20.47	4.10	3.78	4.45
Commercial - Van	19.04	21.50	4.09	3.84	4.36
Sports	18.15	21.93	3.98	3.77	4.20
Medium	18.06	20.59	3.72	3.61	3.83
Overall Average	**17.46**	**21.12**	**3.69**		
Commercial - Ute	16.20	21.75	3.52	3.39	3.66
Large	15.99	20.52	3.28	3.21	3.36
Luxury	14.74	20.11	2.96	2.84	3.09
Medium Four Wheel Drive	14.53	19.92	2.89	2.62	3.20
Large Four Wheel Drive	12.98	21.19	2.75	2.58	2.93

** Serious injury rate per 100 drivers involved*

6 Table 4 shows that **Large 4WDs are the most aggressive of the vehicle types considered**, killing or seriously injuring an average 5.89 unprotected road users or drivers per 100 crashes. Compact 4WDs on average have similar aggressivity to the overall average of passenger vehicles in the Australian passenger vehicle fleet. Medium 4WDs are less aggressive than Large 4WDs on average, but more aggressive than the Compact 4WDs.

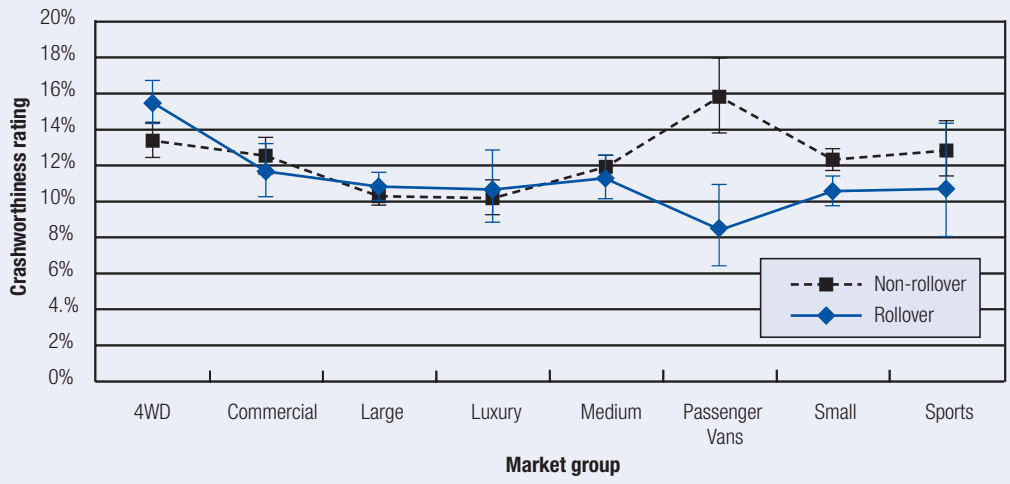
Table 4 Estimated Vehicle Aggressivity towards Other Drivers and Unprotected Road Users by Market Grouping (adapted from Newstead et al, 2005)

Market Group	Aggressivity Rating *(listed in descending order of magnitude)	Lower 95% Confidence limit	Upper 95% Confidence limit
Large Four Wheel Drive	5.89	5.57	6.23
Commercial - Van	4.84	4.53	5.16
Commercial - Ute	4.61	4.42	4.81
Medium Four Wheel Drive	4.33	3.89	4.82
People Movers	4.27	3.95	4.60
Overall Average	**3.78**		
Large	3.64	3.55	3.74
Compact Four Wheel Drive	3.56	3.22	3.93
Sports	3.37	3.13	3.61
Luxury	3.36	3.20	3.54
Medium	3.18	3.07	3.30
Small	2.77	2.69	2.86
Light	2.58	2.48	2.70

** Serious injury rate per 100 drivers of other vehicles and unprotected road users involved in collisions with vehicles from the given market group*

7 Figure 3 shows crashworthiness estimates for various market groups of vehicles for single vehicle crashes, with one line showing crashworthiness for crashes where rollover occurs and the other line, single vehicle crashes in which rollover does not occur. This shows that **for single vehicle rollover crashes, 4WD vehicles have the worst crashworthiness ratings of all the vehicle types considered** (as a high value indicates a high probability of death or serious injury to the driver in the event of this type of crash). This poor performance in this crash type was further confirmed in the main MUARC report on 4WD crash patterns (Keall et al, 2006) in which crashworthiness was estimated in terms of the probability of driver fatality given a rollover crash. This analysis, which compared the performance of 4WDs with that of cars, showed that a driver was about 3.4 times as likely to die compared to a car driver when involved in a rollover. Figure 3 also shows that **4WDs perform poorly in terms of crashworthiness in single vehicle crashes without rollover** (for example, when the vehicle hits an object such as a tree without rolling over), with passenger vans the worst performing vehicle in this crash type.

Figure 3 Crashworthiness of passenger vehicles by market group and rollover status in single vehicle crashes (with 95% confidence limits, from Newstead et al, 2004)



8 As shown in Table 1, **rollover crashes are also much more common for 4WDs than for cars**. Table 5 compares rollover rates between the three 4WD types within speed limit areas. Overall, **there is little to distinguish between the rollover rates of the three 4WD market groups**.

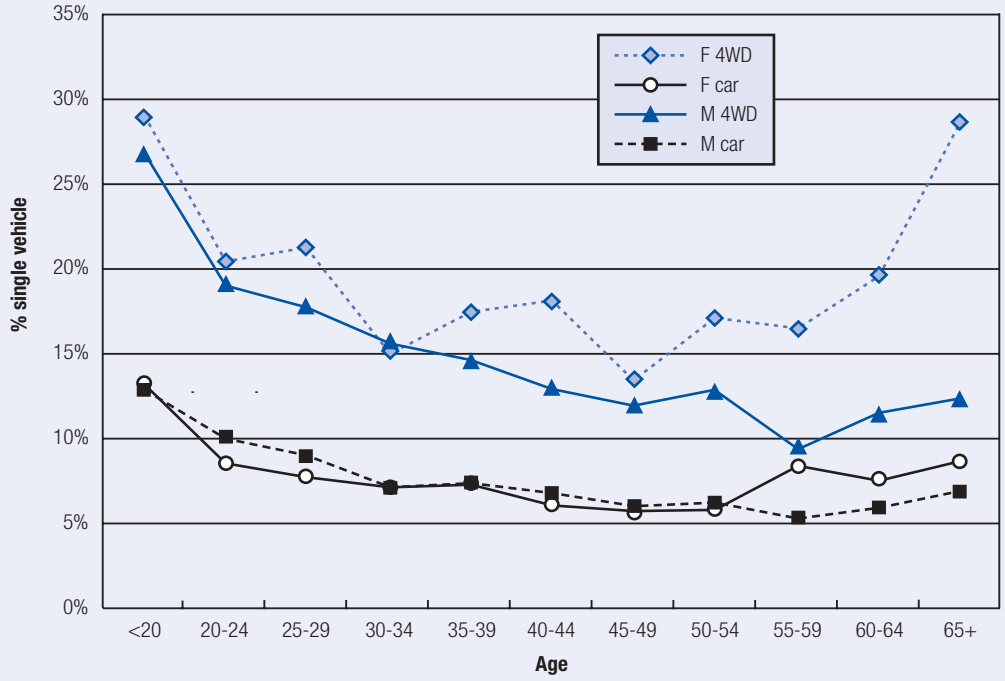
Table 5 **Number and percentage of all 4WD crashes by 4WD type and speed limit of crash location as well as percentage of all rollover crashes and proportion of single vehicle crashes that involved rollover (1999-2003 data from NSW, VIC, QLD, WA, NZ).**

Speed limit area	4WD vehicle type	Number of crashed vehicles	% crashed 4WD vehicles	Rollover rate: % rollover/crash
>=80 km/h	Compact	1,680	6%	16%
	Medium	1,605	6%	18%
	Large	3,918	14%	15%
<80 km/h	Compact	6,198	22%	2%
	Medium	4,471	16%	1%
	Large	10,006	36%	1%
Overall*	Compact	8,799	28%	5%
	Medium	6,763	22%	5%
	Large	15,806	50%	5%

**overall includes crashes where speed limit was unknown*

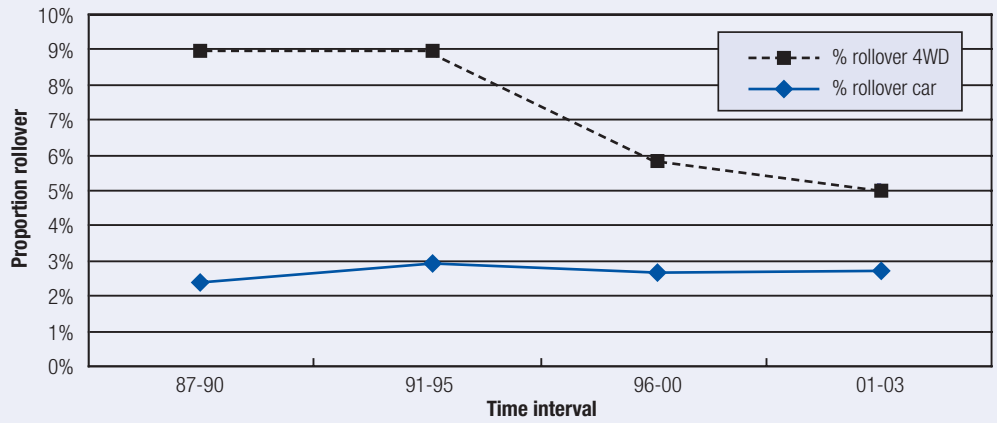
9 As shown in Table 5, **the rollover crash problem is much more serious on higher speed limit roads**, a common phenomenon for rollover data. This is due to the laws of physics, whereby the forces that can overturn vehicles are considerably stronger at higher speeds. The higher energy implicit in higher speed driving increases the instability of any vehicle, but particularly one that has a high centre of gravity relative to the width of its wheel track, such as a 4WD. Figure 4 shows that **rollovers are also more common for younger drivers** (and a limited amount of data suggests high rates for older female drivers of 4WDs in higher speed limit areas). Nevertheless, even the group least liable to roll over in higher speed limit areas in Figure 4 (middle aged car drivers) has a higher rollover rate than the most rollover prone group amongst the lower speed limit crashed drivers (young males in 4WDs – graph not shown).

Figure 4 **Proportion of vehicle rollovers for 4WDs and regular cars in HIGHER speed limit areas by driver age and gender, (1999-2003 data from NSW, VIC, QLD, WA and NZ).**



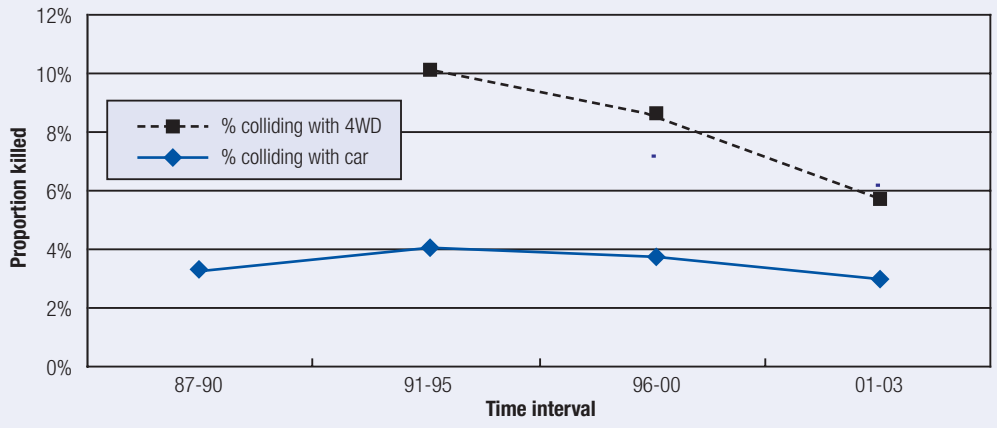
10 Figure 5 shows the proportions of NSW tow-away crashes for 4WDs and cars separately that involved rollover, by grouped year of crash between 1987 and 2003. This shows that the **rate of rollovers for 4WDs is falling relative to the rate for cars**, starting from a much higher rate in the early part of the period studied, but still remaining substantially higher at the end of the period.

Figure 5 **Proportion of NSW tow-away crashes that involved rollover by specified vehicle and year of crash for all speed limit areas.**



11 Figure 6 shows that **there is indicative evidence that car collisions with 4WDs are becoming less likely to lead to fatality** in head on crashes in high speed zones relative to collisions with other cars. In other words, the aggressivity of 4WD vehicles towards regular cars may be improving in this crash type.

Figure 6 **Estimated probability of car driver fatality in a head-on crash in a higher speed limit area when colliding with a 4WD or another car.**



12 **Technological improvements**. Figure 5 and Figure 6 indicate that some of the road trauma particularly identified with 4WDs, namely their propensity to roll over and their liability to harm car drivers in collisions, may be improving over time. The contributions to these improvements due to new design features and the manner in which 4WDs are being driven are difficult to distinguish in the current analysis. A major technological development is becoming available, with particular benefits for 4WD safety. *Electronic Stability Control* (ESC) has been available from the late 1990s, corrects for loss of steering control by applying brakes to individual wheels and reducing engine power where appropriate. A recent report suggests major benefits of this technology in terms of single vehicle crashes (of which rollover is a dominant crash outcome), with reductions in such crashes of about 67% for 4WDs and 35% for passenger cars (Dang, 2004). The technology is gradually becoming more available

in the US, with 7.4% of new light vehicles sold in 2003 having Electronic Stability Control (ibid). Comparable figures for Australia are not available at present but are likely to be considerably less given the historically slow introduction of new safety technology into the Australian vehicle fleet. **A process for accelerating the implementation of ESC technology into Australia vehicles, and particularly 4WD vehicles, could have great potential for reducing the rollover crash problem** and should be seriously considered as a priority action.

Summary

- On average, Large and Medium 4WDs have good crashworthiness.
- They have been shown to be aggressive vehicles, causing significantly more harm when in collision with other vehicles, cyclists and pedestrians. However, the feared increases in trauma to car drivers do not seem to have occurred at the same rate as sales have increased, perhaps indicating low km driven by 4WD vehicles, which is the topic of future research.
- NSW data suggest that 4WD rollover rates are improving with time and the consequences for car drivers of a head-on crash with a 4WD may also be improving with time.
- Despite these positive points, 4WDs are more likely to roll over, a very serious crash type. Generally, 4WDs offer poor protection in this sort of crash and in single vehicle crashes generally.
- These rollover rates appear to be higher for inexperienced 4WD drivers (high for young drivers; also indicative evidence that rates are high for older female drivers) and in higher speed limit areas. There is no evidence of differences in overall rollover rates between the three different size classes of 4WDs considered here.

Implications

- Be careful driving 4WDs if inexperienced, particularly in higher speed limit areas, where rollover risk is highest.
- There may be merit in educational or licensing interventions aimed at inexperienced 4WD drivers, who currently have high rollover rates.
- Compared to Large and Medium 4WDs, Compact 4WDs are less aggressive, and less harmful to the environment in terms of emissions and fuel consumption. Nevertheless, they have relatively poor crashworthiness as a class overall, with some notable exceptions. See www.racv.com.au for up-to-date information on passenger vehicle makes and models that perform well in crashes.
- To substantially reduce rollover and other loss-of-control risks, purchase 4WDs with Electronic Stability Control if possible.
- Although the increasing numbers of 4WDs in the vehicle fleet appear not to be causing increased road trauma for car drivers, there exists the possibility that such problems may develop in the future. It is recommended that research is undertaken to monitor the implications of the growing popularity of 4WDs on fleet safety.

References

Dang J (2004) Preliminary results analyzing the effectiveness of Electronic Stability Control (ESC) systems, *Evaluation Note*. NHTSA, Washington, D.C.

Keall MD, Newstead S, Watson L (2006) Four-wheel drive vehicle crash involvement patterns. Monash University Accident Research Centre, Melbourne.

Newstead S, Cameron M, Watson L (2005) Vehicle safety ratings estimated from police reported crash data: 2005 update. Australian and New Zealand crashes during 1987-2003, Vol Report No. 241. Monash University Accident Research Centre.

Newstead S, Watson L, Delaney A, Cameron M (2004) Crashworthiness and aggressivity of the Australian light vehicle fleet by major crash type, Vol Report No. 227. Monash University Accident Research Centre.

RACV

Royal Automobile Club of Victoria (RACV) Ltd
ABN 44 004 060 833

550 Princes Highway
Noble Park North, Victoria 3174
Australia

Telephone (03) 9790 2863
Facsimile (03) 9790 2629
www.racv.com.au