



MONASH University

Accident Research Centre

CRASHWORTHINESS AND AGGRESSIVITY OF THE AUSTRALIAN LIGHT VEHICLE FLEET BY MAJOR CRASH TYPE

by

Stuart Newstead
Linda Watson
Amanda Delaney
Max Cameron

**Report No. 227
June 2004**

Project Sponsored By



We're there for you



Australian Government

Australian Transport Safety Bureau

**MONASH UNIVERSITY ACCIDENT RESEARCH CENTRE
REPORT DOCUMENTATION PAGE**

Report No. 227	Report Date June 2004	ISBN 0 7326 1738 3	Pages 49 + Appendices
--------------------------	---------------------------------	------------------------------	---------------------------------

Title and sub-title:

Crashworthiness and aggressivity of the Australian light vehicle fleet by major crash type

Author(s)

Newstead, S.V., Watson, L.M., Delaney, A.K. & Cameron, M.H.,

Type of Report & Period Covered

Summary Report, 1982-2000

Sponsoring Organisations - This project was funded as contract research by the following organisations:

Road Traffic Authority of NSW

Royal Automobile Club of Victoria Ltd.

NRMA Ltd. VicRoads

Royal Automobile Club of Western Australia Ltd.

and by a grant from the Australian Transport Safety Bureau

Abstract:

This report examines relative vehicle crashworthiness and aggressivity of the Australian light passenger vehicle fleet in the four major crash types in which they are involved. These are single vehicle crashes, crashes with unprotected road users such as pedestrians and bicyclists, crashes with heavy vehicles and crashes with other light passenger vehicles. Analysis focuses on 1982-2000 model vehicles classified into 8 broad market groups. Crashworthiness ratings measure the relative safety of vehicles in preventing severe injury to their own drivers in crashes whilst aggressivity ratings measure the serious injury risk vehicles pose to drivers of other vehicles or road users with which they collide. Crashworthiness ratings were estimated for drivers of light passenger vehicles in single vehicle collisions, collisions with heavy vehicles and in collisions with other passenger vehicles. Aggressivity ratings by light passenger vehicle market group were also estimated for collisions with unprotected road users.

The ratings used were based on data on crashes in Victoria and New South Wales during 1987-2000 and in Queensland and Western Australia during 1991-2000. Crashworthiness was measured as a combination of injury severity (of injured drivers) and injury risk (of drivers involved in crashes) whilst aggressivity reflected relative injury severity outcomes of unprotected road users in collisions with light passenger vehicles. The ratings were adjusted for the driver or unprotected road user sex and age, the speed limit at the crash location, the state in which the crash occurred and the year in which the crash occurred. These factors were strongly related to injury risk and/or severity for aggressivity and crashworthiness. Both the aggressivity and crashworthiness ratings estimate the risk of the passenger car driver (crashworthiness) or unprotected road user (aggressivity) being killed or admitted to hospital when involved in a tow-away crash, to a degree of accuracy represented by the confidence limits of the rating in each case.

Results of the research have been able to identify the vehicle market groups that have relatively good and bad secondary safety performance in each crash type considered. Results have shown clear differential relative performance between market groups across the major crash types considered. They have also been able to quantify the relative risk of serious injury or death between crash types, further highlighting the high serious injury risk to unprotected road users in particular, as well as to light vehicle drivers in both single vehicle crashes and in crashes with articulated heavy vehicles.

The results of this report are based on a number of assumptions and warrant a number of qualifications that should be noted.

Key Words: (IRR except when marked*)

Injury, Vehicle Occupant, Collision, Passenger Car Unit, Passive Safety System, Statistics

Disclaimer:

This Report is produced for the purposes of providing information concerning the safety of vehicles involved in crashes. It is based upon information provided to the Monash University Accident Research Centre by VicRoads, the Transport Accident Commission, the New South Wales Roads and Traffic Authority, NRMA Ltd, Queensland Transport and the Western Australian Department of Main Roads.

Reproduction of this page is authorised

Monash University Accident Research Centre Building 70, Monash University Victoria 3800,
Australia. Telephone: +61 3 9905 4371, Fax: +61 3 9905 4363

EXECUTIVE SUMMARY

This report examines relative vehicle crashworthiness and aggressivity of the Australian light passenger vehicle fleet in the four major crash types in which they are involved. These are single vehicle crashes, crashes with unprotected road users such as pedestrians and bicyclists, crashes with heavy vehicles and crashes with other light passenger vehicles. Analysis focuses on 1982-2000 model vehicles classified into 8 broad market groups. Crashworthiness ratings measure the relative safety of vehicles in preventing severe injury to their own drivers in crashes whilst aggressivity ratings measure the serious injury risk vehicles pose to drivers of other vehicles or unprotected road users with which they collide. Both measures are estimated from data on real crashes reported to police. The ratings are based on crash data from Victoria and New South Wales during 1987-2000 and from Queensland and Western Australia during 1991-2000.

Crashworthiness was measured by a combination of injury severity (of injured drivers) and injury risk (of drivers involved in crashes). Aggressivity was measured as relative injury severity of injured unprotected road users. The crashworthiness and aggressivity ratings were adjusted for the driver sex and age, the speed limit at the crash location, the year in which the crash occurred and the state in which the crash occurred. These factors were found to be strongly associated with injury risk and injury severity. Adjustments were made with the aim of measuring the effects of vehicle factors alone, uncontaminated by other factors available in the data that affected crash severity and injury susceptibility.

Analysis of crashes between light passenger vehicles and heavy vehicles estimated the crashworthiness of the light passenger vehicle as a function of the heavy vehicle collision partner, defined as a bus, rigid truck or articulated truck. Crashworthiness injury severity for passenger vehicles in collisions with heavy vehicles was based on 9,238 drivers injured in crashes in Victoria during 1987-2000, in New South Wales during 1987-1998 and in Queensland and Western Australia during 1991-2000. Crashworthiness injury risk for this crash type was based on 54,693 drivers involved in heavy vehicle collision crashes in New South Wales during 1987-2000 and Western Australia and Queensland during 1991-2000 and where a vehicle was towed from the crash or someone was injured. The ratings were estimated for each light passenger vehicle market group and heavy vehicle collision partner. Results showed the outcome from a collision with an articulated truck is significantly more severe than the outcome of one with a bus or rigid truck. For a particular class of heavy vehicle crash partner, it was not possible to identify significant differences in the crashworthiness of each passenger vehicle market group because of wide confidence limits on the estimates.

Analysis of single vehicle crashes focused on the crashworthiness of the light passenger vehicle involved in the single vehicle crash. Crashworthiness injury severity in single vehicle collisions was based on 33,690 drivers injured in crashes in Victoria during 1987-2000, in New South Wales during 1987-1998 and in Queensland and Western Australia during 1991-2000. Crashworthiness injury risk for this crash type was based on 93,748 drivers involved in single vehicle collision crashes in New South Wales during 1987-2000 and Western Australia and Queensland during 1991-2000 and where the vehicle was towed away. The ratings were estimated for each vehicle market group as well as for a number of specific makes and models of vehicles. Statistically reliable crashworthiness ratings for vehicles involved in single vehicle collisions were estimated for 53 individual vehicle models manufactured over the years 1982-2000 as well as for the 8 vehicle market groups. The estimates and their associated confidence limits were sufficiently sensitive that they were able to identify 22 models of light passenger vehicles that have superior or inferior crashworthiness characteristics compared with the average crashworthiness across all vehicles involved in single vehicle crashes in the data. Analysis by vehicle market group showed 4WD and commercial vehicles and passenger vans to have relatively poor crashworthiness in single vehicle

crashes, with the 4WD crashworthiness being statistically significantly worse than small, medium, large and luxury vehicles in single vehicle crashes. 4WD vehicles performed poorly in single vehicle collisions irrespective of whether the collision involved a rollover. In contrast, the poor crashworthiness of passenger vans was estimated to be a result of their poor performance in non-rollover single vehicle collisions.

Analysis of crashes between light passenger vehicles and unprotected road users focused on the aggressivity of the light passenger vehicle toward the unprotected road user. The aggressivity ratings estimated the risk of an unprotected road user injured in an impact with a passenger vehicle being killed or seriously injured. Estimates by vehicle market group were based on 19,262 unprotected road users injured in crashes with a single passenger vehicle in New South Wales and Victoria during 1987-2000, and Queensland and Western Australia during 1991 to 2000. The injury outcome for an unprotected road user as a result of a collision with a 4WD vehicle was estimated to be significantly more severe than the outcome of a collision with a vehicle from either the large, medium or small market groups. Similarly the unprotected road user injury outcome is significantly more severe as a result of a collision with a commercial vehicle than a vehicle from either the large or medium vehicle market groups.

Analysis of crashes between two light passenger vehicles focused on the crashworthiness of the one light passenger vehicle as a function of the market group of the other impacting light passenger vehicle. Crashworthiness injury severity in this crash type was based on 33,548 drivers injured in crashes in Victoria during 1987-2000, in New South Wales during 1987-1998 and in Queensland and Western Australia during 1991-2000. Crashworthiness injury risk was based on 253,560 drivers involved in the same crash types in New South Wales during 1987-2000 and Western Australia and Queensland during 1991-2000 and where the vehicle was towed away. Accurate estimates were obtained for 53 different combinations of light passenger vehicle market groups colliding. These results were further interpreted to identify the combinations of light passenger vehicle market groups in collisions with the biggest disparity in average injury outcome between the two colliding vehicle classes. Both 4WD vehicles and small vehicles had the largest observed disparities when colliding with vehicles from other market groups. 4WD vehicle drivers had a consistently lower risk of serious injury than the driver of the collision partner vehicle, a result of the established high aggressivity of this vehicle class. In contrast, small vehicle drivers had a consistently higher risk of serious injury than the driver of the collision partner vehicle, confirming the established low aggressivity and often poor crashworthiness of this vehicle class.

In summary, results of the research have been able to identify the vehicle market groups that have relatively good and bad secondary safety performance in each crash type considered. Results have shown clear differential relative performance between market groups across the major crash types considered. They have also been able to quantify the relative risk of serious injury or death between crash types, further highlighting the high serious injury risk to unprotected road users in particular, as well as to light vehicle drivers in both single vehicle crashes and in crashes with articulated heavy vehicles.

Results of the research have also been valuable in providing insight into understanding and interpreting what is being measured in currently published Australian vehicle secondary safety ratings calculated from analysis of police reported crash outcomes. They have also provided directions for further research into the monitoring and improvement of the secondary safety performance of the light passenger vehicle fleet in Australia.

The results of this report are based on a number of assumptions and warrant a number of qualifications that should be noted.

ACKNOWLEDGMENTS

A project as large and complex as this could not have been carried out without the help and support of a number of people. The authors particularly wish to acknowledge:

- Mr David Attwood of the Transport Accident Commission (TAC) for the provision of TAC claims data
- Mr Geoff Elston of VicRoads Business Services Division for the provision of data from Victorian Police crash reports
- Mr Geoff Murray and Mr Wesley Soet of the Department of Main Roads Western Australia for the provision of data from Western Australia Police crash reports
- Mr Geoff Meers, Mr Wayne Dale and Mr Scott Boyle of Queensland Transport for the provision of data from Queensland Police crash reports and the Queensland vehicle registration system
- Mr Tony Kursius of Queensland Transport for assistance with facilitating the provision of data from the Queensland vehicle registration system
- Dr Graham Brisbane, Mr Harry Vertsonis and Dr Nimmi Magedara of the New South Wales Roads and Traffic Authority (RTA) for their support of the project and the release of data from NSW Police crash reports
- Mr Jack Haley, Mr Owen Johnstone and Dr Tasha Prabhakar of NRMA for their support for the project and for providing procedures to determine the models of vehicles crashing in NSW, Victoria and Queensland.
- Ms Maria Pappas of NRMA who developed and applied the procedures to determine the models of vehicles recorded on NSW and Victoria Police crash reports
- Mr Michael Adams and Mr Robert Ramsay of the NSW RTA who prepared and provided data files from NSW Police crash reports and gave helpful advice on limitations in the NSW crash data.
- Mr John Goldsworthy of the Australian Transport Safety Bureau for his support of the project as well as valuable assistance in providing detail comments on the project report.
- Mr Mike Upton of the RACWA for his support for the project and assistance with facilitating the supply of Western Australian crash data
- Dr Gray Scott and Mr Ross McArthur of VicRoads for their support of the project
- Mr Michael Case and Mr Julian Del Beato of the RACV for their support of the project and for advice on substantive changes in designs of specific models over the years
- Professor Caroline Finch, Mr Tri Minh Le, Mr Michael Skalova and Ms Chau My Le, all formerly of MUARC, for the development of the analysis methods in earlier years that formed the basis of the methods used in this report.

- Dr Alan Miller, formerly of the CSIRO Division of Mathematics and Statistics for suggesting analysis methods used in this report to improve the sensitivity of the results and to determine the confidence limits of the estimates.
- Officers of the Victorian, NSW, Western Australian and Queensland Police Forces and of the Transport Accident Commission who diligently recorded the information on crashes and injuries which formed the basis of this report.

CONTENTS

Page No.

1. INTRODUCTION AND HISTORY.....	1
1.1 CRASHWORTHINESS AND AGGRESSIVITY RATINGS BACKGROUND.....	1
1.2 PROJECT MOTIVATION AND AIMS.....	4
2. CRASH DATA	5
2.1 VICTORIAN CRASHES.....	5
2.1.1 <i>Collisions with Heavy Vehicles</i>	5
2.1.2 <i>Single Vehicle Collisions</i>	5
2.1.3 <i>Collisions Involving Unprotected Road Users</i>	6
2.1.4 <i>Collisions Between Two Passenger Vehicles</i>	6
2.2 NEW SOUTH WALES CRASHES.....	6
2.2.1 <i>Collisions with Heavy Vehicles</i>	6
2.2.2 <i>Single Vehicle Collisions</i>	7
2.2.3 <i>Collisions Involving Unprotected Road Users</i>	7
2.2.4 <i>Collisions Between Two Passenger Vehicles</i>	7
2.3 QUEENSLAND CRASHES.....	8
2.3.1 <i>Collisions with Heavy Vehicles</i>	8
2.3.2 <i>Single Vehicle Collisions</i>	8
2.3.3 <i>Collisions Involving Unprotected Road Users</i>	8
2.3.4 <i>Collisions Between Two Passenger Vehicles</i>	8
2.4 WESTERN AUSTRALIA CRASHES.....	9
2.4.1 <i>Collisions with Heavy Vehicles</i>	9
2.4.2 <i>Single Vehicle Collisions</i>	9
2.4.3 <i>Collisions Involving Unprotected Road Users</i>	9
2.4.4 <i>Collisions Between Two Passenger Vehicles</i>	9
2.5 COMBINED DATA FROM THE FOUR STATES	9
2.5.1 <i>Collisions with Heavy Vehicles</i>	9
2.5.2 <i>Single Vehicle Collisions</i>	10
2.5.3 <i>Collisions Involving Unprotected Road Users</i>	10
2.5.4 <i>Collisions Between Two Passenger Vehicles</i>	10
3 VEHICLE MODEL AND MARKET GROUP IDENTIFICATION	11
3.1 MODEL IDENTIFICATION.....	11
3.2 MARKET GROUP CATEGORIES.....	12
4. ANALYSIS METHODS FOR VEHICLE SAFETY MEASURES	12
4.1 OVERVIEW OF ANALYSIS METHODS: CRASHWORTHINESS.....	13
4.1.1 <i>Obtaining the Covariate Models</i>	13
4.1.2 <i>Formulation of Specific Ratings</i>	14
4.1.3 <i>Combining the Injury Risk and Injury Severity Components</i>	15
4.2 OVERVIEW OF ANALYSIS METHODS: AGGRESSIVITY	16
5. RESULTS: VEHICLE SAFETY MEASURES.....	17
5.1 CRASHWORTHINESS OF PASSENGER VEHICLES COLLIDING WITH HEAVY VEHICLES	17
5.1.1 <i>Injury Risk</i>	17
5.1.2 <i>Injury Severity</i>	18
5.1.3 <i>Crashworthiness by Market Group</i>	18
5.2 CRASHWORTHINESS OF PASSENGER VEHICLES IN SINGLE VEHICLE COLLISIONS	20
5.2.1 <i>Injury Risk</i>	21

5.2.2	<i>Injury Severity</i>	22
5.2.3	<i>Crashworthiness in Single Vehicle Collisions</i>	22
5.2.4	<i>Crashworthiness of Passenger Vehicles in Single Vehicle Collisions by Rollover status</i> 25	
5.3	AGGRESSIVITY OF PASSENGER VEHICLES TOWARDS UNPROTECTED ROAD USERS	30
5.4	CRASHWORTHINESS OF PASSENGER VEHICLES IN TWO CAR COLLISIONS WITH OTHER PASSENGER VEHICLES	32
5.4.1	<i>Injury Risk</i>	32
5.4.2	<i>Injury Severity</i>	33
5.4.3	<i>Crashworthiness in Vehicle to Vehicle Collisions by Market Group Combination</i>	33
6.	DISCUSSION	39
6.1	CRASHWORTHINESS OF PASSENGER VEHICLES IN COLLISIONS WITH HEAVY VEHICLES.....	39
6.2	CRASHWORTHINESS OF PASSENGER VEHICLE IN SINGLE VEHICLE COLLISIONS	40
6.3	AGGRESSIVITY TOWARD UNPROTECTED ROAD USERS	41
6.4	CRASHWORTHINESS IN LIGHT VEHICLE TO LIGHT VEHICLE CRASHES.....	42
6.5	GENERAL DISCUSSION	43
7.	CONCLUSIONS	45
8.	ASSUMPTIONS AND QUALIFICATIONS	46
8.1	ASSUMPTIONS.....	46
8.2	QUALIFICATIONS	46
9.	REFERENCES	48

APPENDICES

- APPENDIX 1.** Frequency of collisions between heavy vehicles and passenger vehicles by market group.
- APPENDIX 2.** Crashworthiness, injury risk and injury severity estimates by market group for passenger vehicles in collisions with heavy vehicles.
- APPENDIX 3.** Frequency of single vehicle collisions by model and market group and by rollover status and market group.
- APPENDIX 4.** Injury risk and injury severity estimates by model and market group for single vehicle collisions.
- APPENDIX 5.** Crashworthiness ratings of 1982-2000 model passenger vehicles involved in single vehicle crashes during 1987-2000.
- APPENDIX 6.** Frequency of unprotected road users in collisions with passenger vehicles by market group.
- APPENDIX 7.** Estimates of aggressivity towards unprotected road users by passenger vehicle market group.
- APPENDIX 8.** Frequency of drivers involved in collisions between two passenger vehicles by market group combination.
- APPENDIX 9.** Crashworthiness, Injury risk and Injury severity estimates by market group and collision partner market group for crashes between two passenger vehicles.
- APPENDIX 10.** Market group composition of crashing vehicles by year of manufacture and year of crash.

CRASHWORTHINESS AND AGGRESSIVITY OF THE AUSTRALIAN LIGHT VEHICLE FLEET BY MAJOR CRASH TYPE

1. INTRODUCTION AND HISTORY

1.1 Crashworthiness and Aggressivity Ratings Background

Provision of consumer information on relative vehicle safety estimated from mass data records has been established in Australia for some years now. In the early stages of the program, development of vehicle safety ratings focussed on vehicle crashworthiness. Crashworthiness ratings, as defined in the Australian program, estimate the relative safety of vehicles in protecting their own occupants in the event of a crash by examining injury outcomes to drivers in real crashes. The crashworthiness rating of a vehicle is a measure of the risk of death or serious injury to a driver of that vehicle when it is involved in a crash. This risk is estimated from large numbers of records of injury to drivers of that vehicle type involved in real crashes on the road.

In 1994, MUARC produced vehicle crashworthiness ratings based on crash data from Victoria and New South Wales during 1987-92 (Cameron et al, 1994a, b). These ratings updated an earlier MUARC set produced by Cameron et al (1992a, b). Crashworthiness was measured in two components:

1. Rate of injury for drivers involved in tow-away crashes (injury risk)
2. Rate of serious injury (death or hospital admission) for injured drivers (injury severity).

Multiplying these two rates together formed the crashworthiness rating. This is a measure of the risk of serious injury for drivers involved in crashes. Measuring crashworthiness in two components reflecting risk and severity of injury was first developed by Folksam Insurance (Gustafsson et al 1989), which publishes the well-known Swedish ratings.

The results of these ratings are summarised in Cameron et al (1994a) with a full technical description of the analysis methods appearing in Cameron et al (1994b). These ratings use an analysis method that was developed to maximise the reliability and sensitivity of the results from the available data. In addition to the speed zone and driver sex, the method of analysis adjusts for the effects of driver age and the number of vehicles involved, producing results with all those factors taken into account.

Subsequent to the ratings of Cameron et al (1994a,b), five further updated sets of crashworthiness ratings were produced during 1996, 1997, 1998, 1999, 2000 and 2003 (Newstead et al 1996, Newstead et al 1997, Newstead et al 1998, Newstead et al 1999, Newstead et al 2000, Newstead et al 2003). These covered vehicles manufactured over the period 1982-94, 1982-95, 1982-96, 1982-97, 1982-98 and 1982-2000 respectively, and crashing during 1987-94, 1987-95, 1987-96, 1987-97, 1987-98 and 1987-2000 respectively, incorporating some enhancements to the methods of statistical analysis. The 1999 and 2000 ratings incorporated police reported crash data from Queensland whereas previously only crash data from New South Wales and Victoria had been used. The 2003 ratings incorporated crash data from Western Australia. The crashworthiness ratings covered individual models of sedans, station wagons, four wheel drives, passenger vans and light commercial vehicles and were given as estimates of risk of severe injury for each model along with 90% and 95% confidence limits on each estimate. For each update, the rating figures were widely distributed in the form of a "Used Car Safety Ratings" brochure. The most recent ratings, published in 2003, rate the crashworthiness of 213 vehicle models from information on over 1 million real crashes in the 4 Australian states from which data are gathered.

In more recent years, a second important concept relating to relative vehicle safety performance has been considered in the Australian rating system, vehicle aggressivity. Aggressivity ratings measure the risk of injury that a vehicle poses to other road users with which it impacts, including other vehicle occupants and unprotected road users such as pedestrians, bicyclists and motorcyclists. Aggressivity ratings represent further consumer advice that purchasers of cars could take into account when choosing a specific model.

Cameron, Newstead and Le (1998) completed an initial study that reviewed methods of rating vehicle aggressivity developed internationally, such as those by Broughton (1994, 1996) and Hollowell and Gabler (1996). Concepts from this review were then taken to develop a methodology for rating the aggressivity of Australian passenger vehicles making appropriate uses of the real crash data available in Australia. The methods developed were then successfully applied to estimate aggressivity ratings for a selection of Australian passenger vehicles that had accumulated sufficient real crash history.

The original study of Cameron et al (1998) investigated the feasibility and methods of providing aggressivity ratings for Australian passenger vehicles in terms of the threat that each subject model represented to:

1. Occupants of other cars colliding with the subject model cars, and
2. Pedestrians, bicyclists and motorcyclists impacted by the subject model cars.

Although the second type of aggressivity rating was considered by Cameron et al (1998) ratings of this type are problematic. In general, crashes involving pedestrians, bicyclists and motorcyclists are seldom reported to the Police unless someone is killed or injured (usually the unprotected road user). This means that an estimate of the risk of injury cannot be calculated for the unprotected road users for inclusion in the second type of aggressivity rating. Consequently, the measure of aggressivity towards unprotected road users, described by Cameron et al (1998), is a measure of injury severity only (i.e. the risk of serious injury given some injury was sustained). As such, this aggressivity measure is less able to discriminate between the performances of individual vehicle models as it is based on relatively small quantities of data.

The problem of estimating aggressivity towards unprotected road users did not occur when measuring aggressivity towards drivers of other cars, for whom the available data allowed estimates of both the risk of injury and injury severity in a manner analogous to the crashworthiness rating described above. The aggressivity rating towards drivers of other vehicles (Cameron et al, 1998) has been based on two-car crashes between light vehicles (i.e. heavy vehicle collisions have been excluded). Crash data from NSW, Western Australia and Queensland on two-car crashes covers all Police reported crashes where at least one vehicle was towed or a pre-defined minimum damage level was attained. Consequently, the number of crashes in which neither driver was injured was available, at least so far as tow-away crashes are concerned. Cameron et al (1998) defined the measure of the aggressivity risk of injury (RO) of the other drivers colliding with the subject model, unadjusted for any other factors, as:

$$\text{Injury risk of other drivers} = \text{RO} = \text{proportion of drivers involved in crashes of tow away or greater severity who were injured}$$

The aggressivity injury severity of other drivers could be measured in a number of ways from the information on injury recorded on Police reports in all Australian states from which data has been used for vehicle safety rating. Injury recorded on Police crash forms in Australia is typically reported at, or can be combined into, three severity levels. These are killed, admitted to hospital or

injury requiring medical treatment. Cameron et al (1998) defined the measure of aggressivity injury severity (SO), unadjusted for the influence of other factors, as:

Injury severity of other drivers = SO = proportion of injured drivers who were
killed or admitted to hospital.

Based on the definition of RO and SO above, an aggressivity measure for each subject car model was then calculated as:

Aggressivity to other car occupants = AO = RO x SO.

This measures the risk of a car driver being killed or admitted to hospital in a collision with the focus vehicle model.

Before this aggressivity measure was calculated, consideration was given to taking into account factors external to the focus vehicle model, such as crash circumstances or occupant characteristics, which may affect injury outcome in a crash. Factors available in the data to consider such differences include:

- speed limit at the crash location
- focus vehicle driver age
- focus vehicle driver sex
- other car occupant age
- other car occupant sex

Logistic regression techniques have been used to adjust RO and SO, separately, for any major differences that emerge between models of the subject cars regarding these factors. The adjusted RO and SO have been multiplied together for each focus car model to provide the final measure of aggressivity, AO.

Cameron et al (1998) also considered adjusting the aggressivity ratings for the injury outcome of the drivers of the focus model vehicles, hence providing an indication of the crash severity. This was found to make little difference to the relative aggressivity ratings between vehicle models and has not been further considered in subsequent ratings updates. Cameron et al (1998) also considered using the injury outcome of the most severely injured occupant of the vehicle colliding with the focus vehicle model in estimating the aggressivity index. Again, little difference was found between the estimated aggressivity ratings based on all vehicle occupants and those considering drivers only so this method was also not pursued further.

Updates of vehicle aggressivity ratings towards drivers of other vehicles have been calculated in both Newstead et al (2000) and Newstead et al (2003). The aggressivity ratings from both these updates have been published along side the crashworthiness ratings in the consumer information "Used Car Safety Ratings" brochure. The most recent release adds reliable vehicle aggressivity rating information for 164 models of vehicles to the crashworthiness rating information published for the 213 vehicle models. Together, the crashworthiness and aggressivity ratings provide the current basis for consumer information on relative vehicle safety when purchasing a second hand vehicle.

1.2 Project Motivation and Aims

The current published crashworthiness and aggressivity ratings rate the secondary safety performance of a vehicle model or market group crashing within a fleet where the mix of vehicle types is represented by the available crash data. Furthermore, the crashworthiness ratings represent vehicle safety performance in the standardised mix of single and multiple vehicle crashes represented in the available crash data. This representation of the ratings is appropriate for presentation as consumer information as it reflects the likely crash exposure a vehicle will be subject to in the current driving environment. However, the ratings fail to explicitly measure the relative safety performance of vehicles in each crash type where the rating represents an aggregate of crash types. Furthermore, where the ratings are based on a mix of vehicle types colliding with each other, they do not explicitly estimate injury outcome probabilities in crashes between specific combinations of vehicle types. The possibility of an interaction between relative vehicle safety and crash type or vehicle type combination in the collision is of primary interest in this project.

Another limitation of using the existing vehicle crashworthiness and aggressivity ratings for this study is that they do not explicitly consider two important major crash types in which passenger vehicles are involved. These are crashes with heavy vehicle such as trucks and buses and crashes with unprotected road users such as pedestrians. Table 1 shows the proportionate involvement of passenger vehicles in the four major crash types based on NSW police reported crash data from 1991 to 1998, which are considered roughly representative of the national average over recent times. Whilst single and multiple passenger vehicle crashes dominate the total crash population, heavy vehicle crashes and crashes with unprotected road users also represent a significant proportion of the total.

Table 1. *Percentage representation of major crash types in the overall population of crashes involving passenger vehicles.*

Passenger Vehicle to Passenger Vehicle	Single Passenger Vehicle	Passenger Vehicle to Heavy Vehicle	Passenger Vehicle to Unprotected Road User	All Passenger Vehicle Crash Types
45.33	28.93	16.00	9.74	100

This project aimed to estimate the vehicle secondary safety in specific crash types. The safety measures estimated have focussed on each of the four crash types detailed in Table 1. The measures estimated are specific derivatives of the crashworthiness and aggressivity ratings described in Newstead et al (2003) and are as follows.

- **Passenger to Passenger Vehicle Crashes:** Vehicle crashworthiness by market group in crashes between two passenger vehicles has been estimated as a function of the market group of the colliding vehicle. These ratings reflect both the crashworthiness of the vehicle market group for which driver injury outcome is being assessed and the aggressivity of the market group of the colliding vehicle. The ratings allow the assessment of whether the aggressivity of a vehicle market group varies depending on the market group of the collision partner.
- **Single Passenger Vehicle Crashes:** Crashworthiness estimates by market group have been obtained for passenger vehicles in single vehicle crashes. There was also sufficient data for this crash type to estimate the crashworthiness ratings for a range of specific makes and models of vehicles as an interesting by product of the project. This has enabled a more detailed study of the types of vehicles that exhibit good and bad crashworthiness in single vehicle crashes.

- **Passenger Vehicle to Heavy Vehicle Crashes:** The crashworthiness of passenger vehicles classified by market group in collisions with heavy vehicles has been estimated. Three classifications of heavy vehicle have been considered: buses, rigid trucks and articulated trucks. Separate ratings by the vehicle market group are estimated for each of these three types of heavy vehicle collision partner.
- **Passenger vehicle to Unprotected Road User Crashes:** Aggressivity ratings by passenger vehicle market group have been estimated for collisions with unprotected road users. These ratings update those estimated by Cameron et al (1998) and consider only the relative injury severity of unprotected road users in collisions with passenger vehicles as crashes involving uninjured unprotected road users are generally not reported.

2. CRASH DATA

The data from Victoria, NSW, Queensland and Western Australia used to produce the crashworthiness and aggressivity ratings of Newstead et al (2003) covering vehicles manufactured over the period 1964-2000 and crashing during the years 1987-2000 was used in the analysis in this project. A subset of the data covering vehicles manufactured over the period 1982-2000 and crashing during the years 1987-2000 was used to estimate each of the crashworthiness measures detailed above. The methods of selecting appropriate cases from each data source to estimate each rating type is detailed here.

2.1 Victorian Crashes

2.1.1 Collisions with Heavy Vehicles

Calculation of crashworthiness ratings by heavy vehicle collision and market group required selecting passenger vehicles involved in crashes with a heavy vehicle. Heavy vehicle identification was possible by examining the secondary vehicle type involved in the crash. Records were restricted to those where the secondary vehicles were one of semi-trailer, truck (excluding semi), bus/coach, mini bus (9-13 seats). Semi-trailers were categorised as ‘articulated’, trucks as ‘rigid truck’ and bus/coach and mini bus as ‘bus’. Passenger vehicles considered were restricted to those manufactured over the period 1982 to 2000 as market group detail information was required. This process identified 1,343 vehicles that had been involved in a crash with a heavy vehicle. Of the drivers, 1,174 were injured and 169 were uninjured. It was not possible to use the uninjured records from the Victorian data, as they are incomplete due to the fact that only crashes involving injury are reliably reported in Victoria. Hence only the 1,174 records of driver injury were used for calculation of the injury severity component of the heavy vehicle collision crashworthiness ratings. Of the 1,174 injured drivers, 538 were severely injured. In the analysis, because of missing values of associated crash factors these numbers were further reduced to 714 injured drivers and 323 severely injured drivers respectively.

2.1.2 Single Vehicle Collisions

Calculation of crashworthiness for single vehicle collisions required the selection of crashes involving only one passenger vehicle traffic unit. This identified 11,486 injured drivers, 4667 of whom were severely injured from 14,515 drivers involved in single vehicle collisions in Victoria in the period 1982 to 2000. Because of missing values of associated crash factors these numbers were reduced to 9,179 involved drivers, 7,106 of whom were injured, for analysis. 2,839 of these injured

drivers were severely injured. Again, it was not possible to use the uninjured records from the Victorian data, as they are incomplete due to the fact that only crashes involving injury are reliably reported in Victoria. Hence only the 7,106 records of driver injury including 2,839 records of severe injury were used for calculation of the injury severity component of the single vehicle collision crashworthiness ratings.

2.1.3 Collisions Involving Unprotected Road Users

Calculation of market group aggressivity injury severity ratings on unprotected road users required the identification of single vehicle collisions with an unprotected road user where the vehicles were restricted to those manufactured between 1982 and 2000 and where market group was identified. Single vehicles impacting with an unprotected road user were identified from the crashworthiness data file of Newstead et al (2003) using a variable identifying accident type. Casualty records for the years 1987 to 2000 were used to identify unprotected road users injured in a collision with one vehicle. The vehicles were then matched with the unprotected road user casualty records to obtain the injury level. Of the total 46,788 unprotected road users in the casualty records for the period 1987 to 2000, 2608 were matched with vehicle records with identified make and model. After removal of records with missing values of associated crash factors these numbers were reduced to 2,439 injured unprotected road users, 978 of whom were severely injured.

2.1.4 Collisions Between Two Passenger Vehicles

Calculation of crashworthiness ratings for passenger vehicles involved in collisions with another passenger vehicle required selecting vehicles involved in two car crashes. Matching of vehicle and occupant injury details for the two cars involved in the crash for those vehicles manufactured over the period 1982 to 2000 that had market group identified followed this. The data matching process identified 20,534 vehicles that had been involved in a crash with one other vehicle where both vehicles were restricted to those manufactured between 1982 and 2000 and had their market group identified. Of the drivers of these vehicles, 11,977 were injured and 8,557 were uninjured across collisions involving all market group combinations. Excluding the uninjured records, only 11,977 records of driver injury were used for calculation of the injury severity component of the two vehicle collision crashworthiness ratings. Of the 11,977 injured drivers, 2,617 were severely injured. Because of missing values of associated crash factors, these numbers were further reduced to 5,391 injured drivers, 1161 of whom were severely injured.

2.2 New South Wales Crashes

2.2.1 Collisions with Heavy Vehicles

Calculation of crashworthiness ratings by heavy collision and market group required selecting vehicles involved. Heavy vehicle identification in two-vehicle crashes was possible because each NSW crash record had variables identifying light truck, rigid truck, articulated truck and bus accidents. Light trucks and rigid trucks were categorised as 'rigid trucks'. Crash selection was restricted to those involving a passenger vehicle manufactured over the period 1982 to 2000 that had identified market group details. This process identified 73,743 passenger vehicles that had been involved in a crash with a heavy vehicle. Of the drivers, 12,211 were injured and 61,436 were uninjured. The presence of uninjured drivers in the data file meant that it was suitable for measuring the risk of driver injury (in crashes of sufficient severity for a vehicle to be towed from the scene). After removal of records with missing values for any of the associated crash factors, 45,269 involved drivers, 8,351 of whom were injured, were used in the injury risk analysis.

It was not possible to use the 1999 and 2000 records from the New South Wales data in the injury severity analysis because as a result of coding changes a reliable measure of injury severity was not available for the years 1999 and 2000. Hence only 8,002 records of driver injury were used for calculation of the injury severity component of the crashworthiness ratings for heavy vehicle collisions. Of the 8,002 injured drivers, 2,009 were severely injured. Because of missing values of associated crash factors these numbers were further reduced to 6,409 injured drivers and 1,634 severely injured drivers respectively.

2.2.2 Single Vehicle Collisions

The selection of crashes involving only one passenger vehicle traffic unit identified 23,552 injured drivers, 6142 of whom were severely injured in New South Wales in 1982 to 2000 year of manufacture vehicles where the model details were identified. Because of missing values of associated crash factors these numbers were reduced to 65,809 involved drivers, 20,399 of whom were injured.

Again, it was not possible to use the 1999 and 2000 records from the New South Wales data in the injury severity analysis because, as a result of coding changes, a reliable measure of injury severity was not available for the years 1999 and 2000. Hence only 16,545 records of driver injury were used for calculation of the injury severity component of the single vehicle collision crashworthiness ratings. Of these 16,545 injured drivers, 5,319 were severely injured.

2.2.3 Collisions Involving Unprotected Road Users

Calculation of aggressivity ratings towards unprotected road users by market group required the identification of crashes between a single vehicle and unprotected road user where the vehicles were restricted to those manufactured between 1982 and 2000 and where market group was identified. The required crashes were identified from the crashworthiness data file of Newstead et al (2003) using a variable identifying accident type. Casualty records for the crash years 1987 to 2000 were used to identify unprotected road users injured in a collision with one vehicle. The vehicles were then matched with the unprotected road user casualty records to obtain the pedestrian or cyclist injury level. Of the total 69,954 unprotected road users involved in all types of crashes and in the casualty records for the period 1987 to 2000, 2,598 matched with records of 1982-2000 passenger vehicles with which they collided. After removal of records with missing values of associated crash factors these numbers were reduced to 2,439 injured unprotected road users, 978 of whom were severely injured.

2.2.4 Collisions Between Two Passenger Vehicles

For NSW data, a matching process identified 227,982 passenger vehicles that had been involved in a crash with one other passenger vehicle where both vehicles were manufactured between 1982 and 2000 and had model details identified. Of the drivers of these vehicles, 28,789 were injured and 199,095 were uninjured across all combinations of vehicle market groups in the collisions. Missing values of associated crash factors further reduced these numbers to 172,217 involved drivers, 22,178 of whom were injured. Again, it was not possible to use the 1999 and 2000 records from the New South Wales data in the injury severity analysis, hence only 15,641 records of driver injury were used for calculation of the injury severity component of the crashworthiness ratings. Of these, 2,857 were severely injured

2.3 Queensland Crashes

2.3.1 Collisions with Heavy Vehicles

In order to determine vehicles involved in a collision with a heavy vehicle, it was necessary to use a variable describing unit type to identify heavy vehicles and then match with the opposing vehicle record. This facilitated obtaining vehicle occupant injury levels in the vehicle involved in the crash with the heavy vehicle. Unit types coded as rigid truck, articulated vehicle and bus/coach were coded as 'rigid truck', 'articulated truck' and 'bus' respectively. 4,858 passenger vehicles manufactured in the years 1964 to 2000 were identified as involved in a crash where the colliding vehicle was a heavy vehicle. Of the drivers of these, 1,800 were injured and 646 were severely injured. These numbers were further reduced to 3,750 involved drivers, 1,394 injured drivers and 497 severely injured drivers after excluding missing values of associated crash factors. These records were used for calculation of vehicle crashworthiness ratings when involved in a heavy vehicle collision.

As with the data from NSW, the presence of uninjured drivers in the data file meant that it was also suitable for measuring both the risk and severity of driver injury.

2.3.2 Single Vehicle Collisions

The selection of crashes involving only one traffic unit identified 10,190 injured drivers, 4,103 of whom were severely injured from 23,422 drivers involved in single vehicle collisions where the vehicle was a passenger vehicle manufactured from 1982 to 2000 with model details identified. Because of missing values of associated crash factors these numbers were reduced to 18,500 involved drivers, 8,240 of whom were injured, 3,312 severely.

2.3.3 Collisions Involving Unprotected Road Users

Records on a total of 18,062 unprotected road users involved in a crash with one vehicle unit were retrieved and identified using variables classifying unit type and number of units in the crash. Single vehicle collisions were identified from the crashworthiness data file of Newstead et al (2003) using a variable identifying unit type and number of vehicles in crash. These vehicles were then matched with the unprotected road user casualty records to obtain the injury level. A total of 6,191 unprotected road users were matched with records on 1982-2000 year passenger vehicles with model details identified. Of these 6,191 involved unprotected road users, 6,168 were injured, 2,423 severely. After removal of records with missing values of associated crash factors these numbers were reduced to 5,572 injured unprotected road users, 2,223 of whom were severely injured.

2.3.4 Collisions Between Two Passenger Vehicles

Records on 20,090 vehicles that had been involved in a crash with one other vehicle where both vehicles were passenger vehicles manufactured between 1982 and 2000 with model details available were identified in the Queensland data. Of the drivers of these vehicles, 4,975 were injured and 15,115 were uninjured. Because of missing values of associated crash factors these numbers were further reduced to 14,145 involved drivers, 3,561 of whom were injured, 735 severely.

2.4 Western Australia Crashes

2.4.1 Collisions with Heavy Vehicles

Two-vehicle collisions involving a heavy vehicle were identified in the WA data using a variable describing unit type to identify heavy vehicles and then match with the opposing vehicle record. Unit types truck & 1 trailer, prime mover and one trailer (semi-trailer) and road train (truck/ prime mover & 2+ trailers) were coded as ‘articulated vehicle’. Truck and prime mover were coded as ‘rigid truck’ and bus as ‘bus’. 11,373 passenger vehicles manufactured in the years 1982 to 2000 were identified as being involved in a crash with a heavy vehicle. Of the drivers of the vehicles involved in a collision with a heavy vehicle, 1,489 were injured and 245 were severely injured. These numbers were further reduced to 6,097 involved drivers, 933 injured drivers and 152 severely injured drivers because of missing values of associated crash factors. These records were used for calculation of crashworthiness injury risk and severity for passenger vehicles involved in a heavy vehicle collision.

2.4.2 Single Vehicle Collisions

Records on 23,465 drivers of 1982-2000 year of manufacture passenger vehicles involved in single vehicle collisions in the period 1991 to 2000 were identified in the WA data. Of these drivers, 5,546 were injured, and 1,911 were severely injured. Because of missing values of associated crash factors these numbers were reduced to 15,693 involved drivers, 4,071 of whom were injured, 1,410 severely.

2.4.3 Collisions Involving Unprotected Road Users

Records involved on unprotected road users in a crash with one vehicle unit for the period 1991 to 2000 were retrieved and identified using variables classifying unit type and number of units in the crash. Of the total 15,241 unprotected road users in the Western Australia crash records, 13,912 were identified as having been involved in a collision with one vehicle. Of these, 5,658 were identified as colliding with a 1982-2000 year of manufacture passenger vehicle with model details identified. Of the 4018 unprotected road users who were injured, 1434 were severely injured. After removal of records with missing values of associated crash factors these numbers were reduced to 2,718 injured unprotected road users, 1,105 of whom were severely injured.

2.4.4 Collisions Between Two Passenger Vehicles

Interrogation of the Western Australia data identified 169,214 vehicles that had been involved in a crash with one other vehicle where both vehicles were passenger vehicles manufactured between 1982 and 2000 with identified model details. Of the drivers of these vehicles, 17,580 were injured and 151,176 were uninjured. Because of missing values of associated crash factors these numbers were further reduced to 67,729 involved drivers, 9,016 of whom were injured, 848 severely.

2.5 Combined Data from the Four States

2.5.1 Collisions with Heavy Vehicles

The combined data for estimation of crashworthiness ratings of passenger vehicles involved in two-vehicle collisions with heavy vehicles covered 91,317 drivers of 1982-2000 model vehicles crashing in Victoria or NSW during 1987-2000 or in Western Australia and Queensland during 1991-2000. After removal of records with missing values for associated crash factors this reduced

to 56,459 involved drivers. Excluding data from Victoria left 55,116 involved drivers, 10,678 of whom were injured, for use in the injury risk analysis. 9,450 injured drivers from all four states, 2,613 of whom were severely injured, were used in the injury severity analysis. Injured drivers from NSW during 1999 and 2000 without a valid injury severity code were not included in the injury severity analysis.

2.5.2 Single Vehicle Collisions

The combined data for estimation of single vehicle collision crashworthiness ratings by model and market group covered 140,673 drivers of 1982-2000 model vehicles involved in a single vehicle crash in Victoria or NSW during 1987-2000 or in Western Australia and Queensland during 1991-2000. After removal of records with missing values for associated crash factors, this reduced to 109,181 involved drivers, 39,816 of whom were injured. The injury risk component of the crashworthiness rating was calculated using the data from crashes occurring in NSW during 1987-2000 and Western Australia and Queensland during 1991-2000. This data related to 100,002 involved drivers, 32,689 of whom were injured. After exclusion of vehicle models not satisfying the analysis inclusion criteria these numbers were reduced to 93,748 involved drivers, 30,660 of whom were injured. 35,961 injured drivers from all four states, 12,853 of whom were severely injured were used in the injury severity analysis. After exclusion of vehicle models not satisfying the analysis inclusion criteria these numbers were reduced to 33,690 injured drivers, 12,075 of whom were severely injured. Again, injured drivers from NSW during 1999 and 2000 were not included in the injury severity analysis.

2.5.3 Collisions Involving Unprotected Road Users

The combined data for estimation of aggressivity towards unprotected road users involved in a collision with a single 1982-2000 model vehicle in Victoria or NSW during 1987-2000 or in Western Australia and Queensland during 1991-2000 covered 39,398 injured unprotected road users. After removal of records with missing values for associated crash factors this was reduced to 29,685 injured unprotected road users, 10,423 of whom were severely injured.

2.5.4 Collisions Between Two Passenger Vehicles

The combined data for estimation of crashworthiness ratings for collisions involving two passenger vehicles covered 437,820 drivers of 1982-2000 model vehicles involved in crashes in Victoria or NSW during 1987-2000 or in Western Australia and Queensland during 1991-2000. After removal of records with missing values for associated crash factors this was reduced to 254,091 involved drivers, 34,755 of whom were injured from crashes occurring in NSW during 1987-2000 and Western Australia and Queensland during 1991-2000. These drivers were used in the injury risk analysis. After exclusion of market group combination crashes not satisfying the analysis inclusion criteria these numbers were reduced to 253,560 involved drivers, 34,691 of whom were injured. 33,609 injured drivers from all four states, 5,604 of whom were severely injured were used in the injury severity analysis. After exclusion of market group combinations not satisfying the analysis inclusion criteria these numbers were reduced to 33,548 injured drivers, 5,589 of whom were severely injured.

3 VEHICLE MODEL AND MARKET GROUP IDENTIFICATION

3.1 Model Identification

All of the vehicle safety ratings estimated in this project rate vehicles classified by market group. In order to assign vehicles to a market group, their model details must first be established. A procedure developed by the NRMA located the crashed vehicles in NSW vehicle registration records after matching by registration number and vehicle make. The Vehicle Identification Number (VIN) or chassis number obtained from the register was decoded to determine the models of light passenger vehicles. The decoding identified some light truck and unusual commercial models that were not considered further. Of the vehicles manufactured during 1982-2000, all but around 4% had their model identified. Further details are given by Pappas (1993). The same VIN decoding procedure was used to identify vehicle models in the Queensland data, achieving a similar level of decoding accuracy to NSW.

The Victorian vehicle register provided the make and year of manufacture of the crashed vehicle but not the model. Models were initially derived for cars manufactured during 1982-88 using logic developed and supplied by the Royal Automobile Club of Victoria (RACV) based on the make, year and power-mass units. Power-mass units (PMU) are the sum of RAC horsepower units (PU) and the vehicle mass in units of 50kg (MU). Refined logic was developed by MUARC based on make, year, PMU, PU, MU and body type, and extended to cover 1989-93 models. The MUARC logic was applied to the combined Victorian data in conjunction with the RACV logic to derive passenger car models for the model years 1982-93.

For vehicles crashing in the years 1994 to 2000, where available, the Victorian vehicle register provided the VIN of each crashed vehicle along with the information described above. VINs are recorded on the Victorian vehicle register for most vehicles from 1989 year of manufacture onwards. Where a VIN was available for a vehicle appearing in the 1994 to 2000 crash data, the model information was decoded from the VIN using the methods of Pappas (1993). Where the VIN was not available, the RACV and MUARC logic, described above, was used to obtain model details.

Attempts were made to obtain VINs from the Western Australian vehicle register, managed by the WA Department of Transport, for vehicles appearing in the Western Australian crash data. Due to an upgrade of the WA registration data system, however, VINs could not be obtained for this update of the vehicle safety ratings although it is possible they may become available for future updates. This meant the VIN decoding system used on data from the other three states to identify vehicle model details could not be used for WA.

Detailed vehicle make and model information along with year of manufacture have been merged onto the WA crash data by Main Roads WA as part of a regular interrogation of the WA vehicle register. The make and model codes proved to be of sufficient detail to be used, along with the year of manufacture, to assign vehicle model groupings to vehicles crashed in WA consistent with the vehicle model groupings that are derived from the VIN decoding system. Only a small number of vehicles, typically in model change-over years, could not be assigned a sufficiently accurate model code for use in the study.

RACV, NRMA and the Australian Transport Safety Bureau (ATSB, formerly FORS) provided advice on the particular models that had experienced substantial changes in design (and hence potential crashworthiness) during model years 1982-2000 and in which years the design was relatively constant. This resulted in certain models being split into ranges of years of manufacture.

4.1 Overview of Analysis Methods: Crashworthiness

The crashworthiness rating (C) is a measure of the risk of serious injury to a driver of a car when it is involved in a crash. It is defined to be the product of two probabilities (Cameron et al, 1992):

i) the probability that a driver involved in a crash is injured (injury risk), denoted by R;

and

ii) the probability that an injured driver is hospitalised or killed (injury severity), denoted by S.

That is

$$C = R \times S .$$

Folksam Insurance, who publishes the well-known Swedish ratings, first measured crashworthiness in this way (Gustafsson et al, 1989).

In the present report, each of the two components of the crashworthiness rating was obtained by logistic regression modelling techniques. Such techniques are able to simultaneously adjust for the effect of a number of factors (such as driver age and sex, number of vehicles involved, etc.) on probabilities such as the injury risk and injury severity.

The general logistic model of a probability, P, is of the form:

$$\log it(P) = \ln\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 X_1 + \dots + \beta_k X_k = f(X).$$

That is, the log of the odds ratio is expressed as a linear function of k associated variables or their interactions, $X_i, i = 1, \dots, k$. Estimates of the parameter coefficients of the logit function, i.e. the $\hat{\beta}_i$ can be obtained by maximum likelihood estimation (Hosmer & Lemeshow, 1989). Newstead et al (2003) details how confidence limits on the logistic regression estimates of injury risk and severity are calculate with these techniques also being used here.

4.1.1 Obtaining the Covariate Models

Before adjusted crashworthiness ratings could be obtained it was necessary to consider logistic models of each of the crashworthiness components separately to identify possible factors, other than vehicle design, that might have influenced the crash outcomes in terms of driver injury severity. A stepwise procedure was used to identify which factors had an important influence. This was done without considering the type of car or year of manufacture in the model, as the aim was to determine which other factors were most likely to have had an influence across a broad spectrum of crashes. Furthermore, the car model or market group variable had to be excluded from the logistic modelling process at this stage because of analysis convergence problems when the car model was competing against the other factors in the stepwise procedure. It was also not considered appropriate to interact vehicle model with other factors in the logistic model as this would imply that relative vehicle crashworthiness varied between models depending on the crash circumstance and occupant characteristics.

Logistic models were obtained separately for injury risk and injury severity because it was likely that the various factors would have different levels of influence on these two probabilities.

The factors considered during this stage of the analysis for both injury risk and injury severity were

- **sex:** driver sex (male, female)
- **age:** driver age (≤ 25 years; 26-59 years; ≥ 60 years)
- **speedzone:** speed limit at the crash location (≤ 75 km/h; ≥ 80 km/h)
- **state:** state of crash (Victoria, NSW, Queensland or Western Australia)
- **year:** year of crash (1987, 1988, ... ,2000)

These variables were chosen for consideration because they were part of the Victorian, Queensland, New South Wales and Western Australia databases. Other variables were only available from one source and their inclusion would have drastically reduced the number of cases that could have been included in the analysis.

All data was analysed using the Logistic Regression procedure of the SAS statistical package (SAS, 1989). Estimates of the coefficients of the logit function, $\hat{\beta}_i, i = 1, \dots, k$, together with their associated standard errors, were obtained by maximum likelihood estimation. In the modelling process, design variables for the various factors were chosen in such a way that the estimated coefficients represented deviations of each of the variable levels from the mean. Each factor in the model, including year of crash, was treated as categorical to allow maximum flexibility in the relationship between each and the outcome measure. All possible first and higher order interactions were considered between all factors in the model. The resultant logistic regression models were referred to as the "covariate" models or equations.

4.1.2 Formulation of Specific Ratings

Injury risk and injury severity for individual cars were estimated after adding a variable representing the focus of the specific rating being estimated to the respective logistic "covariate" models. That is, the rating focus variable was included in the logistic model along with those factors and their interactions that were statistically significantly related to the outcome variable in the stepwise modelling procedure and the model re-estimated in a single step process. Coefficients for individual level of the rating focus variable were computed to represent deviations of that level from the average.

The ratings considered in this report that are based on a crashworthiness type computation are crashworthiness ratings for passenger vehicles in single vehicle crashes, crashworthiness ratings for passenger vehicles colliding with heavy vehicles and crashworthiness ratings for passenger vehicles in two-vehicle collisions with other passenger vehicles. The variable defining the focus of each specific rating, included with the covariate model variables in the final logistic regression analysis, are as follows for each rating.

Crashworthiness ratings for passenger vehicles in single vehicle crashes:

This rating set is similar to the regular crashworthiness ratings set of Newstead et al (2003). The focus rating variable included in the logistic model was a market group indicator with 8 categories defining each of the 8 market groups. The resulting ratings measure the risk of driver death or serious injury in a single vehicle crash as a function of vehicle market group. There was sufficient data for 122 vehicle models to estimate these ratings by vehicle make and model. Although not crucial to the overall aim of the study, the ratings by make and model are of interest none the less.

For the rating of single vehicle collisions by rollover status the focus rating variable included in the logistic model had 16 levels representing all possible combinations of the 8 passenger vehicle market group categories and 2 categories representing whether rollover or non-rollover occurred in

the collision. Each rating is interpreted as the crashworthiness of the passenger vehicle market group 'X' in a non-rollover or rollover single vehicle collision.

Crashworthiness ratings for passenger vehicles colliding with heavy vehicles:

This rating set estimates the risk of passenger car driver death or serious injury when involved in a collision with a heavy vehicle as a function of the vehicle market group of the passenger car and the class of heavy vehicle. The focus rating variable included in the logistic model had 24 levels representing all possible combinations of the 8 passenger vehicle market group categories and 3 heavy vehicle categories in the crash. Each rating is interpreted as the crashworthiness of passenger vehicle market group 'X' when colliding with heavy vehicle category 'Y'. As such it embodies both the crashworthiness of the passenger vehicle class 'X' as well as the aggressivity of heavy vehicle class 'Y' as well as allowing for a potential interaction between crashworthiness and aggressivity between different combinations. A significant interaction can be interpreted in two ways. The first is that the aggressivity of one class of heavy vehicles differs by the class of passenger vehicle with which it collides. Alternately it may be described as a particular passenger vehicle class having different crashworthiness depending on the class of the heavy vehicle collision partner.

Crashworthiness ratings for passenger vehicles colliding with other passenger vehicles:

This set of ratings is essentially the same as the heavy vehicle collision ratings described above except that the collision partner is another passenger vehicle rather than a heavy vehicle. Each rating is interpreted as the crashworthiness of passenger vehicle market group 'X' when colliding with passenger vehicle market group 'Y' and again embodies both the crashworthiness of the passenger vehicle class 'X' as well as the aggressivity of heavy vehicle class 'Y'. The focus rating variable had 64 possible levels representing the combination of each of the 8 market groups with the 8 possible market groups of the collision partner passenger car.

It was important to ensure that the logistic model adequately described the data and did not yield individual focus rating variable level coefficients that were imprecise or unstable. A focus rating variable level was not included in the logistic regression models if there were either:

- i) less than 100 involved drivers; or
- ii) less than 20 injured drivers.

For each estimate a 95% confidence interval for the logit functions of injury risk and injury severity was obtained after first adjusting for the average value in the data and then allowing for the deviation from average for that particular focus variable level.

Estimates of injury risk and injury severity were obtained by de-transforming the logit functions as described above. A 95% confidence interval was determined after adjusting for the average values of the significant factors and their interactions. The precision of the estimates of injury risk and injury severity is measured by the width of these 95% confidence intervals.

4.1.3 Combining the Injury Risk and Injury Severity Components

The final combined ratings of vehicle crashworthiness are given by:

$$\text{Crashworthiness Rating} = \text{Injury risk} \times \text{Injury severity.}$$

For a given focus variable level, j, the crashworthiness rating, C_j , was therefore calculated as:

$$C_j = R_j \times S_j$$

where

- R_j denotes the injury risk for car model or year of manufacture j , and
- S_j denotes the injury severity for car model or year of manufacture j .

Confidence limits were calculated for each crashworthiness rating estimate using the formula given in Newstead et al (2003).

Because each of the two estimated crashworthiness components have been adjusted for the effect of other factors by logistic regression prior to their incorporation into the combined ratings, the resultant crashworthiness rating is also adjusted for the influence of these factors.

4.2 Overview of Analysis Methods: Aggressivity

The measure of aggressivity towards unprotected road users defined by Cameron et al (1998) was used in this study. As noted, this aggressivity measure considers only the relative severity of unprotected road users in collisions with passenger cars (denoted SO), as unprotected road users uninjured in crashes are rarely reported to police.

A logistic model of the same form used for estimation of vehicle crashworthiness ratings was used for estimation of aggressivity towards unprotected road users. The key difference in the logistic models for this aggressivity measure was that the response variables being modelled were not the injury severity of the driver of the focus vehicle, as for crashworthiness. Rather, the injury severity of the unprotected road user impacted by the focus vehicle was modelled as the response variable. Given the similarity of the structure of the aggressivity injury severity, SO, with their crashworthiness parallels, the method of computing confidence limits on each SO was the same as given for the corresponding crashworthiness measures above.

Before adjusted aggressivity ratings could be obtained it was necessary to consider logistic models of to identify possible factors, other than vehicle design, that might have influenced injury severity outcome to the unprotected road user. As for crashworthiness rating estimation, a stepwise procedure was used to identify which factors had an important influence. This was done without considering the market group of the passenger vehicle in the model, as the aim was to determine which other factors were most likely to have an influence across a broad spectrum of crashes.

The factors considered in the covariate models for aggressivity injury severity were

- **speedzone** : speed limit at the crash location (<80km/h, >= 80 km/h)
- **ageoo** : unprotected road user age (<=25 years, 26-59 years, >=60 years)
- **sexoo** : unprotected road user sex (male, female)
- **state** : state in which the crash occurred (Vic, NSW, WA, QLD)
- **year** : year in which the crash occurred (1987, ...,2000)

These variables were chosen for consideration because they were available in each of the New South Wales, Victorian, Western Australia and Queensland crash databases and had been found from prior research to be relevant in determining injury outcome. Logistic regressions were again carried out using the Logistic Regression procedure of the SAS statistical package (SAS, 1989) using maximum likelihood estimation, the marginal method for forming design variables and a hierarchical structure considering all possible interactions in a stepwise procedure.

Aggressivity by passenger vehicle market group was estimated after adding a variable representing the market group to the logistic "covariate" model and a variable representing unprotected road user type. The variables representing market group and unprotected road user type were forced into the logistic equation and individual market group coefficients were computed to represent deviations of the market group from the average. In a similar manner to the calculation of crashworthiness ratings, market groups were to be excluded for the calculation of the aggressivity ratings if there were less than 100 vehicles that had impacted an unprotected road user or there were less than 20 injured unprotected road users.

There were no exclusions and the regression analysis was performed on 8 market groups. The variable representing market group was therefore categorical with 8 nominal levels. The choice of the design for the logistic model allowed the injury severity estimates for each market group to be compared with the overall (average) rating for all market groups. For each car market group, a 95% confidence interval for the logit functions of aggressivity severity was obtained after first adjusting for the average value of the "covariate" model and then allowing for the deviation from average for that particular market group. Estimates of injury severity were obtained by the reverse logistic transform. A 95% confidence interval was determined after adjusting for the average values of the significant factors and their interactions.

5. RESULTS

5.1 Crashworthiness of Passenger Vehicles Colliding with Heavy Vehicles

5.1.1 Injury Risk

Injury risk was estimated from the data on 54,693 involved drivers of passenger cars manufactured from 1982 to 2000 and involved in a collision with a heavy vehicle in NSW during 1987 to 2000 and in Western Australia and Queensland during 1991 to 2000. 10,512 of the involved drivers were injured. Raw data frequencies in total and for each state individually are given in Appendix 1.

The "covariate" model for injury risk was determined from the variables described in Section 4.1.1. The following covariates and their interactions were statistically significantly associated with injury risk and were included in the logistic regression model.

Base effect terms: passenger vehicle driver sex (sex), passenger vehicle driver age (age), state of crash (state), speed zone of crash (speedzone), year of crash (year).

First order interaction terms: sex*speedzone, age*state, speedzone*year, age*year, year*state, age*sex, speedzone*state, sex*state.

No other variable or interaction term significantly improved the fit of the logistic model. Terms representing passenger vehicle market group and heavy vehicle collision partner types were added to the covariate model and the model re-estimated.

The overall (average) injury risk across all market groups for involved drivers in tow-away heavy vehicle crashes in NSW, Western Australia and Queensland was 18.2%. In other words, the estimated probability that a driver involved in a two-vehicle heavy vehicle collision tow-away crash in NSW, Western Australia and Queensland was injured was 18.2%.

Appendix 2 gives the estimates of injury risk derived by logistic regression for passenger vehicle market group and heavy vehicle class combinations. The variability in the injury risk estimates relative to the combination can be seen from the width of the corresponding 95% confidence intervals.

5.1.2 Injury Severity

The data used to estimate injury severity of passenger vehicle drivers in collisions with heavy vehicles covered 9,238 drivers who were injured in crashes in Victoria or NSW during 1987-2000 or Queensland and Western Australia during 1991-2000. 2,522 of these injured drivers were severely injured (killed or admitted to hospital).

The "covariate" model for injury severity was determined from the variables described in Section 4.2.1. The analysis identified a number of statistically significant covariate effects. These were:

Base effect terms: passenger vehicle driver sex (sex), passenger vehicle driver age (age), state of crash (state), speed zone of crash (speedzone).

First order interaction terms: age*speedzone, speedzone*state.

No other variable or interaction term significantly improved the fit of the logistic model. Terms representing passenger vehicle market group and class of heavy vehicle in the collision were added to the covariate model and the model re-estimated.

The overall (average) injury severity for injured drivers was 27.68%. In other words, the estimated probability that a driver injured in a heavy vehicle crash was severely injured was 27.68%.

Appendix 2 gives the estimates of injury severity derived by logistic regression for each passenger vehicle market group by heavy vehicle collision partner class. The variability in the estimates of injury severity relative to market group and heavy vehicle collision can be seen from the width of the corresponding 95% confidence intervals.

5.1.3 Crashworthiness by Market Group

The crashworthiness estimates for each passenger vehicle market group and heavy vehicle collision partner combination were obtained by multiplying the individual injury risk and injury severity estimates. Because each of the two components has been adjusted for the confounding factors, the resultant crashworthiness estimate is also adjusted for the influence of these factors.

Appendix 2 gives the crashworthiness estimates and the associated 95% confidence intervals for each of the 21 combinations of passenger vehicle market group and heavy vehicle class included in the analysis. Three combinations had insufficient data for reliable estimates to be obtained. These were sports cars colliding with buses, luxury cars colliding with buses and passenger vans colliding with articulated trucks. Each of the available estimates is expressed as a percentage, representing the number of drivers killed or admitted to hospital per 100 drivers involved in a tow-away crash. The true risk of a driver being killed or admitted to hospital in a tow-away crash is only estimated by each figure, and as such each estimate has a level of uncertainty about it. This uncertainty is indicated by the confidence limits in Appendix 2. There is 95% probability that the confidence interval will cover the true risk of serious injury (death or hospital admission) to the driver of a vehicle in a particular market group and involved in a crash with a heavy vehicle.

Based on the average crashworthiness injury risk and severity the overall (average) crashworthiness rating for all combinations of market group and heavy vehicle collisions was 5.04%. In other words, the estimated probability that a driver injured in a crash was severely injured was 5.04%.

The crashworthiness estimates and their confidence limits are plotted for each combination of passenger vehicle and heavy vehicle class in Figure 1. The relatively wide confidence intervals observed on the estimates of crashworthiness are a reflection of the smaller numbers of crashes involving heavy vehicles appearing in the data. Figure 1 shows that on the whole the outcome from a collision with an articulated vehicle over all market groups is significantly more severe than the outcome of one with a bus or rigid truck and within each market group there is little difference in the outcome of a collision with either a bus or rigid truck.

The injury risk component of the crashworthiness estimate, together with its 95% confidence limits, is plotted in Figure 2 whilst the crashworthiness injury severity component is plotted in Figure 3.

Figure 1: *Crashworthiness of passenger vehicles by market group and class of heavy vehicle collision partner (with 95% confidence limits)*

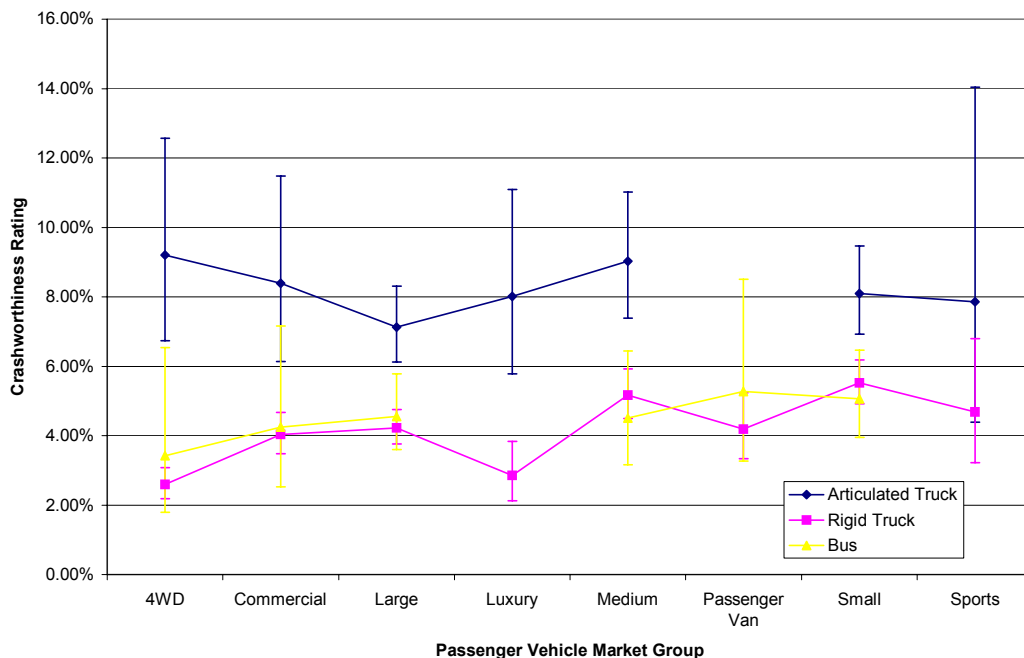


Figure 2: *Injury risk in passenger vehicles by market group and class of heavy vehicle collision partner (with 95% confidence limits)*

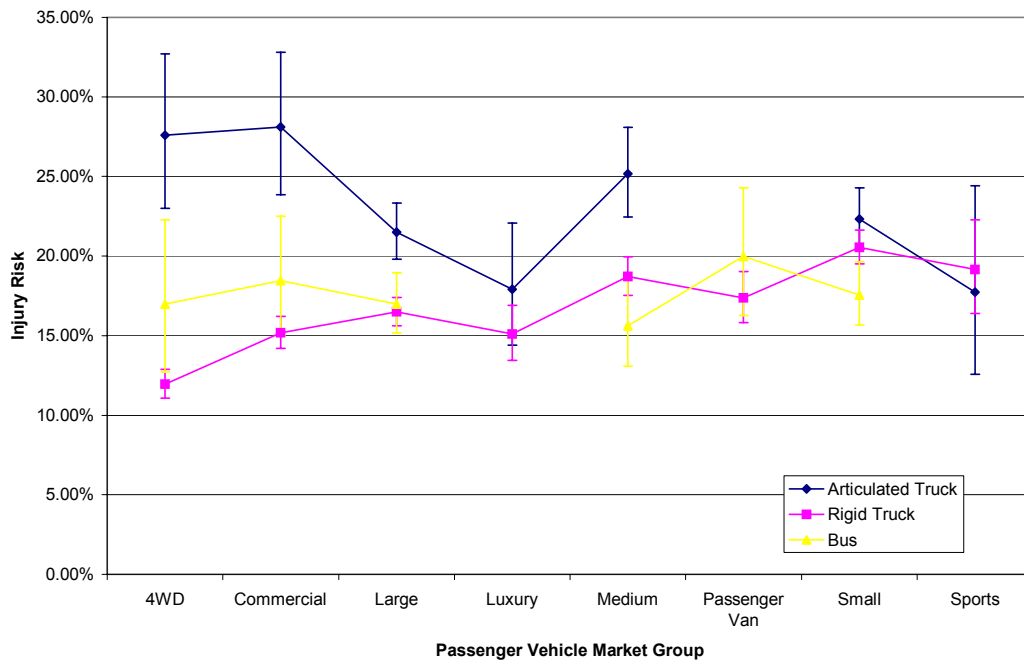
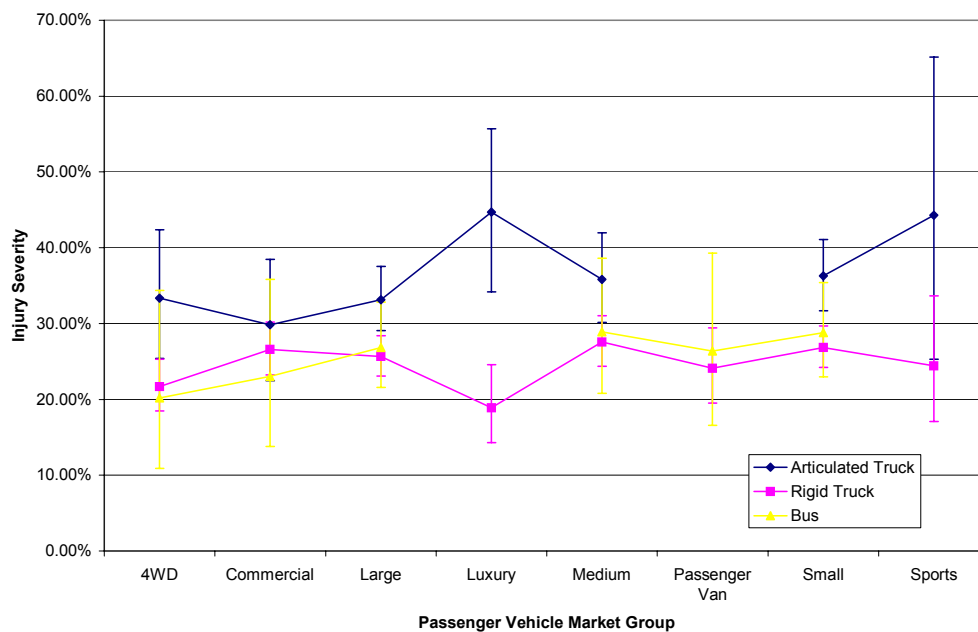


Figure 3: *Injury severity of passenger vehicles by market group and class of heavy vehicle collision partner (with 95% confidence limits)*



5.2 Crashworthiness of Passenger Vehicles in Single Vehicle Collisions

Using the methods of Newstead et al (2003) described in Section 4.1, the crashworthiness of passenger vehicles in single vehicle crashes have been estimated both by vehicle market group as well as for a range of individual makes and model with sufficient crash experience.

5.2.1 Injury Risk

Injury risk was estimated from the data on 126,158 drivers of vehicles manufactured during 1982 to 2000 with identified model and market group details and involved in single vehicle tow-away collisions in NSW during 1987 to 2000, and Western Australia and Queensland during 1991 to 2000. Because of missing values in one or more of the covariates driver sex and age, speedzone and number of vehicles involved in the crash amongst the 126,158 involved drivers, the final data used for analysis consisted of the 100,002 drivers for which all the covariate data was complete. Of these 100,002 drivers, 32,689 were injured. As described in Section 5.1.1 it was important to ensure that the logistic regression model adequately described the data and did not yield individual car model coefficients that were imprecise or unstable. Vehicle models were excluded for the calculation of the crashworthiness ratings if there were less than 100 vehicles that had crashed or there were less than 20 injured drivers. After exclusion, the regression analysis on driver injury outcome in single vehicle collisions was performed on 122 individual car models (or pooled similar models) and involved 93,748 drivers, 30,660 of whom were injured. Raw data counts for single vehicle crashes are given in Appendix 3 in total and by state of crash.

The "covariate" model for crashworthiness injury risk was determined from the variables described in Section 4.1.1. The following covariates and interactions were statistically significantly associated with single vehicle collision crashworthiness injury risk and were included in the logistic regression model.

Base effect terms: driver sex (sex), driver age (age), speed zone of crash (speedzone), state of crash (state), year of crash (year).

First order interaction terms: sex*speedzone, age*speedzone, sex*state, age*state, age*sex, speedzone*state, year*state.

Second order interaction terms: sex*age*speedzone.

No other variable or interaction term significantly improved the fit of the logistic covariate model. A term representing vehicle model or market group was added to the covariate model and the model re-estimated.

The overall (average) injury risk for involved drivers in single vehicle collision tow-away crashes in NSW, Western Australia and Queensland was 32.70 per 100 drivers. In other words, the probability that a driver involved in a single vehicle collision tow-away crash in NSW, Western Australia or Queensland was injured was 32.70%.

Appendix 4 gives the estimates of injury risk derived by logistic regression for 63 individual car models that had a sufficiently accurate crashworthiness rating after post analysis exclusions for wide confidence limits or high co-efficient of variation (see below). Injury risk ranged from 22.41 % for the Volvo 200 Series to 46.02% for the Holden Drover/Suzuki Sierra.

An estimate of the variability in the injury risk estimates was calculated from the width of the corresponding 95% confidence intervals. Individual confidence interval widths ranged from 2.29% for the Holden Commodore VB-VL to 11.20% for the Subaru Liberty.

The estimated injury risk for each market group is also given in Appendix 4. The Luxury vehicles had the lowest injury risk (27.21%) and the Four-Wheel Drive market group had the highest (38.84%).

5.2.2 Injury Severity

The data on "injured drivers" covered 50,774 drivers of 1982-2000 model vehicles who were injured in single vehicle crashes in Victoria or NSW during 1987 to 2000 and Western Australia or Queensland during 1991 to 2000. Because of missing values in one or more of the covariates amongst the 50,774 injured drivers, the final file used for analysis consisted of the 35,961 drivers for which all the covariate data was complete. After exclusion of models not meeting the inclusion criteria this was reduced to 33,690 injured drivers, 12,075 of whom were severely injured.

The "covariate" model for injury severity was determined from the variables described in Section 4.1.1. The following terms were significantly associated with injury severity and were included in the logistic model:

Base effect terms: driver sex (sex), driver age (age), speed zone of crash (speedzone), state of crash (state), year of crash (year).

First order interaction terms: age*sex, year*state.

No other variable or interaction term significantly improved the fit of the logistic covariate model. A term representing vehicle model or market group was added to the covariate model and the model re-estimated.

The overall (average) injury severity for injured drivers in single vehicle collision tow-away crashes in NSW, Victoria, Western Australia and Queensland was 35.84 per 100 drivers. In other words, the probability that a driver injured in a single vehicle collision in NSW, Victoria, Western Australia or Queensland was severely injured was 35.84 %.

Appendix 4 gives the estimates of injury severity derived by logistic regression for 63 individual car models. Injury severity ranged from 23.84% for the Mitsubishi Lancer CE/Mirage to 42.94% for the Ford Fairlane Z & LTD F.

An estimate of the variability in the injury severity estimates was calculated from the width of the corresponding 95% confidence intervals. Individual confidence interval widths ranged from 4.20% for the Holden Commodore VB-VL to 24.07% for the BMW 3 Series.

The estimated injury severity for each market group is also given in Appendix 4. The sports vehicles had the lowest injury severity (33.60%) and the commercial market group had the highest (38.06%).

5.2.3 Crashworthiness in Single Vehicle Collisions

The crashworthiness ratings for each car model and market group were obtained by multiplying the individual injury risk and injury severity estimates. Because each of the two components had been adjusted for the confounding factors, the resultant crashworthiness rating was also adjusted for the influence of these factors.

Appendix 5 gives the single vehicle collision crashworthiness ratings and the associated 95% confidence intervals for each of the 63 car models included in the analyses. Appendix 5 also gives the crashworthiness ratings with 90% confidence limits for each of the 63 vehicle models. Each rating is expressed as a percentage, representing the number of drivers killed or admitted to hospital per 100 drivers involved in a tow-away crash. Overall ratings by market group are also given.

Each crashworthiness rating is an estimate of the true risk of a driver being killed or admitted to hospital in a single vehicle collision tow-away crash and, as such, each estimate has a level of uncertainty about it. This uncertainty is indicated by the confidence limits in Appendix 5. There is 95% probability that the confidence interval will cover the true risk of serious injury (death or hospital admission) to the driver of the particular model of vehicle.

The ratings in Appendix 5 exclude those models where:

- the width of the confidence interval exceeded 7, or
- the ratio of the confidence interval width to the rating score exceeded 1.6 (this criterion was also necessary because smaller confidence intervals tended to occur for the lower rating scores, but the confidence intervals were relatively wide in proportionate terms). This exclusion criterion was used by Newstead et al (2003) and was more stringent than that used by Cameron et al (1994a, b) reflecting the greater accuracy afforded in the current ratings as a result of larger quantities of data.

For the 63 vehicles rated in this study, the average crashworthiness is 11.47 (11.47 serious driver injuries per 100 crash involvements). Confidence limits were used to judge whether the true risk of death or hospitalisation for a driver of a specific model car involved in a single vehicle tow-away crash is really different from the average for all models. An upper limit below the average is indicative of superior crashworthiness, whereas a lower limit above the average suggests inferior crashworthiness. Other models also have crashworthiness ratings at the low or high end of the scale, but their confidence limits overlap the all model average. Although such models may also have superior or inferior crashworthiness characteristics, the database did not contain sufficient numbers of these models for the data to represent scientific evidence that this is the case.

In terms of statistical significance, it should be noted that classifying vehicles as having inferior or superior crashworthiness compared to the defined average means only that vehicle models with 'superior' crashworthiness have statistically significantly better crashworthiness than vehicles in the defined 'inferior' group. It is possible that vehicles within the inferior and superior crashworthiness categories also had statistically significant differences in crashworthiness. This could be assessed by examining overlap in the statistical confidence limits for any pair wise comparison of two vehicles. One of the main points in defining groups of vehicles with inferior and superior crashworthiness is to show that the analysis can differentiate with statistical precision crashworthiness between groups of vehicles within the rated vehicle population.

Eleven models had ratings representing evidence of superior crashworthiness because their upper confidence limits were less than the average rating. Nine of these were large cars and two were classified as small cars. Crashworthiness ranged from 6.56% for the Mitsubishi Lancer CE/Mirage to 10.78% for the Ford Falcon XE/XF. The specific models were (in order of estimated risk of serious driver injury in a crash, from lowest to highest):

- Mitsubishi Lancer CE/Mirage (96-2000)
- Ford Falcon AU (1998-2000)
- Holden Commodore VT/VX (1997-2000)
- Ford Laser (1991-94)
- Holden Commodore VR/VS (1993-97) / Toyota Lexcen (1993-97)
- Ford Falcon EF/EL (1994-98)
- Ford Falcon EB Series II / Falcon ED (Apr 1992-94)
- Mitsubishi Verada KR/KS (1991-96) / Magna TR/TS (1991-96)

- Ford Falcon EA / Falcon EB Series I (1988-Mar 92)
- Holden Commodore VN/VP (1989-93) / Toyota Lexcen (1989-93)
- Ford Falcon XE/XF (1982-88)

Eleven models had ratings representing evidence of inferior crashworthiness because their lower confidence limits were greater than the average rating. Five were four-wheel drives, three were small cars, two were light commercial vehicles and one was a passenger van. Crashworthiness ranged from 13.20% for the Holden Astra / Nissan Pulsar/Vector to 16.94% for the Toyota Landcruiser. The specific models were (in order of estimated risk of serious driver injury in a crash, from highest to lowest):

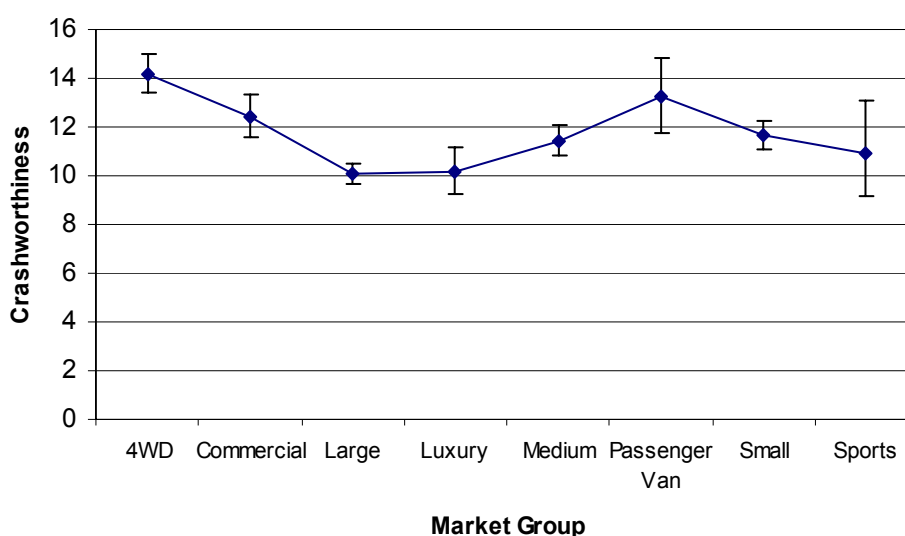
- Toyota Landcruiser (1982-89)
- Toyota 4Runner/Hilux (1982-85)
- Holden Rodeo (1989-95)
- Ford Festiva WA (1991-93) / Mazda 121 (1987-90)
- Subaru Brumby (1982-93)
- Toyota Landcruiser (1990-97)
- Ford Festiva WD/WD/WH/WF (1994-00)
- Toyota Hilux (1989-97)
- Toyota Tarago (1983-89)
- Holden Drover (1985-87) / Suzuki Sierra (1982-2000)
- Holden Astra (1984-86) / Nissan Pulsar / Vector (1984-86)

Table 2 summarises the crashworthiness ratings of passenger vehicles in single vehicle crashes by market group and their 95% confidence limits. Point estimates of injury risk and injury severity are also given in Table 2. The crashworthiness results in Table 2 are also displayed graphically in Figure 4.

Table 2. *Crashworthiness of passenger vehicles by market group in single vehicle crashes*

Market Group	Injury Risk	Injury Severity	Crashworthiness	Lower 95% C.L	Upper 95% C.L
4WD	38.84	36.52	14.19	13.40	15.02
Commercial	32.68	38.06	12.44	11.60	13.33
Large	28.83	34.89	10.06	9.63	10.51
Luxury	27.21	37.38	10.17	9.26	11.17
Medium	32.32	35.34	11.42	10.81	12.06
Passenger Van	36.88	35.81	13.21	11.74	14.86
Small	33.09	35.23	11.65	11.12	12.22
Sports	32.58	33.60	10.95	9.15	13.10

Figure 4: *Crashworthiness of passenger vehicles by market group in single vehicle crashes (with 95% confidence limits)*



5.2.4 Crashworthiness of Passenger Vehicles in Single Vehicle Collisions by Rollover status

To examine rollover effect on injury outcome in single vehicle collisions and in particular whether rollover involvement has any influence on the poor performance of some market groups it was necessary to determine single vehicle collisions where rollover was coded as the primary or first impact on the vehicle. For New South Wales, Victoria and Queensland a variable was available which coded for first impact type or major impact point on the vehicle. For New South Wales the variable specified whether the first impact was a rollover, for Victoria whether the top or roof of the vehicle was the position of initial impact and for Queensland the variable indicated the point on the vehicle of major impact. For Western Australia a variable coded for non-collision accident type was used to identify a rollover. After removal of records with missing values for one or more of the covariates, the data covered 109,181 single vehicle collisions. Data counts are summarized in Appendix 3 in total and by state of crash.

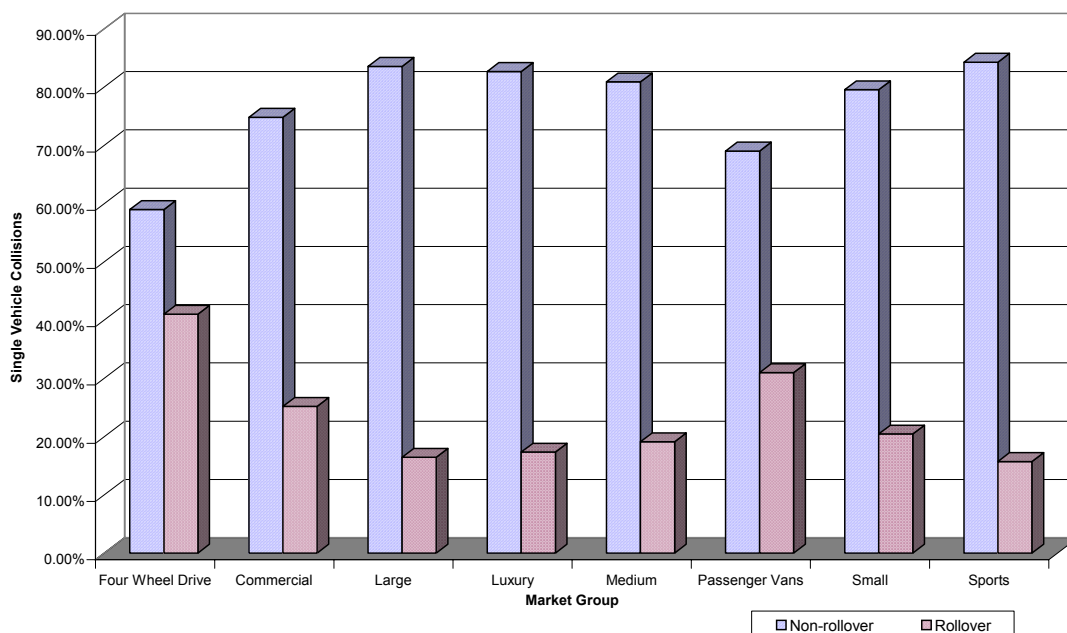
Table 3 provides figures for all states on rollover and non-rollover involvement in single vehicle collisions and the corresponding percentages in order of rollover propensity. Figure 5 displays rollover composition of single vehicle crashes by market group graphically.

Table 3. *Frequency and percentage rollover by market group of passenger vehicles involved in single vehicle crashes.*

Market Group	Single Vehicle Collisions				Total
	Non-rollover		Rollover		
	Number	%	Number	%	
4WD	5,600	58.99	3,893	41.01	9,493
Passenger Van	1,221	69.02	548	30.98	1,769
Commercial	5,393	74.82	1,815	25.18	7,208
Small	21,693	79.54	5,580	20.46	27,273
Medium	11,208	80.88	2,649	19.12	13,857
Luxury	3,777	82.67	792	17.33	4,569
Large	35,695	83.56	7,022	16.44	42,717
Sports	1,934	84.27	361	15.73	2,295
Total	86,521	79.25	22,660	20.75	109,181

The average propensity for rollover across all market groups in single vehicle collisions is 20.75%. At the extremes for specific market groups, 41.0% of 4WDs involved in a single vehicle collision rollover, as do 31.0% of Passenger Vans and 25.2% of Commercial vehicles involved in single vehicle collisions. In contrast, only 15.7% of sports cars and 16.4% of large cars roll in this crash type.

Figure 5: *Rollover propensity of single vehicle crashes by market group*



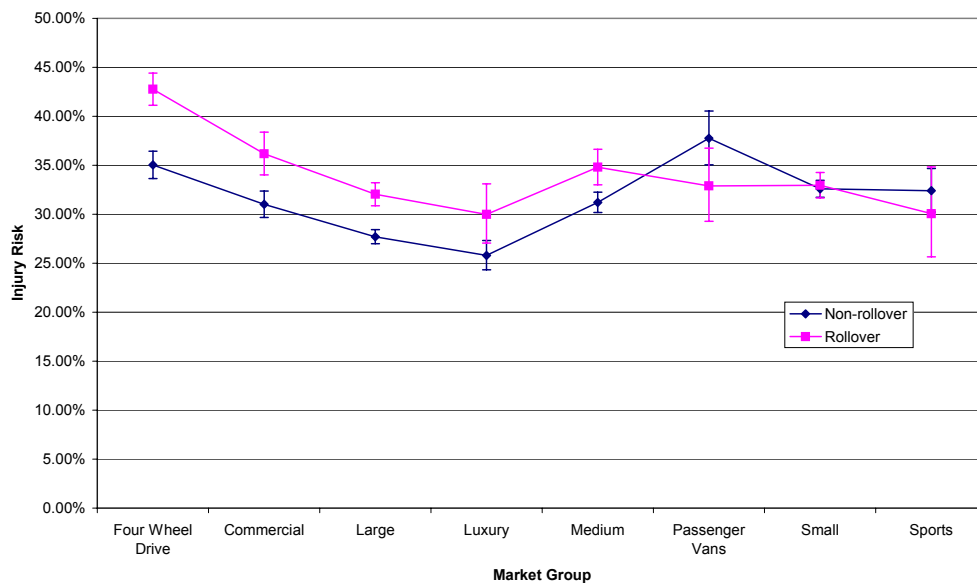
To determine whether the increased proportion of rollovers in some market group single vehicle collisions is a major determining factor in each market group’s estimated crashworthiness in single vehicle collisions, and in particular the poor performance of 4WDs in single vehicle collisions, crashworthiness by vehicle market group was estimated for rollover and non-rollover crashes separately. The results are as follows:

Injury Risk

Injury risk in rollover and non-rollover crashes was estimated from the data on 100,002 drivers, 32,710 of who were injured, of vehicles manufactured during 1982 to 2000 with identified market group details, complete covariate data and involved in single vehicle tow-away collisions in NSW during 1987 to 2000, Western Australia and Queensland during 1991 to 2000. Tables 4 and 5 give the estimates of injury risk derived by logistic regression analysis for each market group and rollover status of collision. Luxury vehicles had the lowest injury risk in a rollover (29.98%) and the Four-Wheel Drive market group had the highest (42.75%).

An estimate of the variability in the injury risk estimates was calculated from the width of the corresponding 95% confidence intervals. Individual confidence interval widths ranged from 2.36% for the Large vehicle market group to 9.18% for Sports vehicles. The injury risk estimates together with 95% confidence intervals are displayed graphically in Figure 6. For 4WD, Commercial, Large and Medium vehicle market groups, injury risk was estimated to be significantly worse in a rollover than in non-rollover single vehicle collisions. For Passenger Vans injury risk was estimated to be worse in a non-rollover single vehicle collision.

Figure 6: *Injury risk by market group and rollover status of single vehicle collision (with 95% confidence limits)*

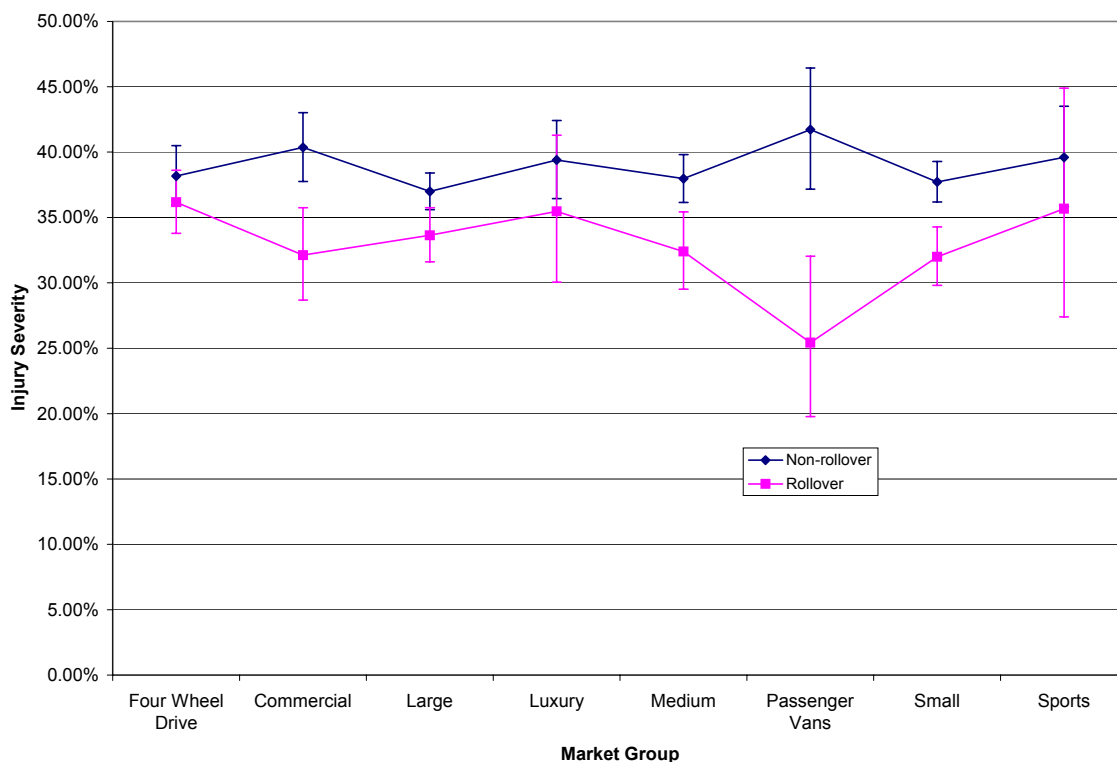


Injury Severity

Injury severity in rollover and non-rollover single vehicle crashes was estimated from 35,962 drivers of 1982-2000 model vehicles who were injured in single vehicle crashes in Victoria or NSW during 1987 to 2000 and Western Australia or Queensland during 1991 to 2000, 12,880 of who were severely injured. Tables 4 and 5 give the estimates of injury severity derived by logistic regression for each market group and rollover status of collision. Passenger Van vehicles had the lowest injury severity in a rollover (25.42%) and the Four-Wheel Drive market group had the highest (36.17%). In each vehicle market group, injury severity was estimated to be lower in rollover crashes than in non-rollover crashes, with statistical significance in many cases.

An estimate of the variability in the injury severity estimates was calculated from the width of the corresponding 95% confidence intervals. Individual confidence interval widths ranged from 4.15% for the Large vehicle market group to 17.50% for Sports vehicles. The injury severity estimates together with 95% confidence intervals are displayed graphically in Figure 7.

Figure 7: *Injury severity by market group and rollover status of single vehicle collision (with 95% confidence limits)*



Crashworthiness

Estimates of crashworthiness in single vehicle crashes by rollover and non-rollover status for each market group were obtained by multiplying the individual injury risk and injury severity estimates. Because each of the two components had been adjusted for the confounding factors, the resultant crashworthiness rating was also adjusted for the influence of these factors. Tables 4 and 5 summarise the crashworthiness ratings of passenger vehicles in single vehicle crashes by market group and rollover status and the associated 95% confidence limits. Point estimates of injury risk and injury severity are also given in Tables 4 and 5. Each rating is expressed as a percentage, representing the number of drivers killed or admitted to hospital per 100 drivers involved in a tow-away crash.

Table 4. *Injury risk, injury severity and crashworthiness of passenger vehicles by market group in single vehicle crashes with rollover*

Market Group	Single Vehicle Collision with Rollover				
	Injury Risk %	Injury Severity %	Crashworthiness		
			%	Lower 95% C.L	Upper 95% C.L
4WD	42.75	36.17	15.46	14.70	16.26
Commercial	36.18	32.11	11.62	10.76	12.54
Large	32.03	33.64	10.78	10.32	11.26
Luxury	29.98	35.47	10.63	9.47	11.94
Medium	34.80	32.40	11.27	10.58	12.02
Passenger Van	32.90	25.42	8.37	7.21	9.70
Small	32.95	32.00	10.55	10.05	11.07
Sports	30.05	35.67	10.72	8.96	12.83

Table 5. *Injury risk, injury severity and crashworthiness of passenger vehicles by market group in non-rollover single vehicle crashes*

Market Group	Non-rollover Single Vehicle Collisions				
	Injury Risk %	Injury Severity %	Crashworthiness		
			%	Lower 95% C.L	Upper 95% C.L
4WD	35.02	38.17	13.37	12.44	14.37
Commercial	31.00	40.36	12.51	11.57	13.53
Large	27.70	36.99	10.25	9.79	10.73
Luxury	25.79	39.39	10.16	9.23	11.18
Medium	31.20	37.97	11.85	11.17	12.56
Passenger Van	37.75	41.72	15.75	13.79	17.99
Small	32.60	37.73	12.30	11.71	12.91
Sports	32.41	39.61	12.84	11.40	14.46

Three market groups had ratings representing evidence of superior crashworthiness in single vehicle collisions involving rollover because their upper confidence limits were less than the average rating. These were (in order of estimated risk of serious driver injury in a crash, from lowest to highest):

- Passenger Vans
- Small
- Large

The 4WD market group rating represented evidence of inferior crashworthiness in a single vehicle rollover because the lower confidence limit was greater than the average rating.

In non-rollover single vehicle collisions two market groups had ratings representing evidence of superior crashworthiness because their upper confidence limits were less than the average rating. These were:

- Luxury
- Large

Three market groups had ratings representing evidence of inferior crashworthiness in a non-rollover single vehicle collision because their lower confidence limit was greater than the average rating. These were (in order of estimated risk of serious driver injury in a crash, from highest to lowest):

- Passenger Van
- 4WD
- Small

The crashworthiness results in Tables 4 and 5 are also displayed graphically in Figure 8.

Figure 8: *Crashworthiness of passenger vehicles by market group and rollover status in single vehicle crashes (with 95% confidence limits)*

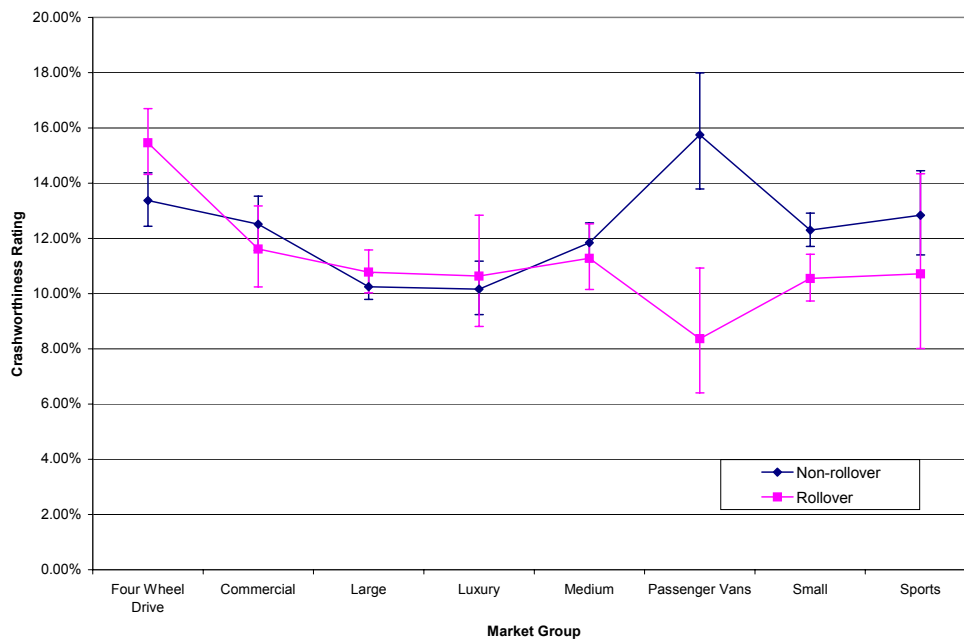


Figure 8 shows that crashworthiness in single vehicle crashes did not vary greatly depending on whether a rollover was involved or not. The only exception to this was for passenger vans and, to a lesser degree, small cars where non-rollover crashes produced a greater risk of death or serious injury than did rollover crashes. This shows that, although 4WD drive vehicles are over represented in rollovers in single vehicle crashes, their estimated poor crashworthiness in all single vehicle crashes is not a result of this over representation. Rather it is a result of poor occupant protection performance in both rollover and non-rollover crashes. Similarly, the good crashworthiness performance of large and luxury cars in single vehicle crashes is not a result of being involved in a low proportion of rollovers.

5.3 Aggressivity of Passenger Vehicles Towards Unprotected Road Users

After removal of records with missing values for one or more of the covariates the data covered 19,262 unprotected road users who were injured in crashes in Victoria or NSW during 1987-2000 or Queensland and Western Australia during 1991-2000. 10,423 of these injured unprotected road users were severely injured (killed or admitted to hospital). Data counts are summarised in Appendix 6 in total and by state of crash.

The "covariate" model for injury severity was determined from the variables described in Section 4.2. The analysis identified a number of statistically significant covariate effects. These were:

Base effect terms: unprotected road user sex (sex), unprotected road user age (age), state of crash (state), speed zone of crash (speedzone), unprotected road user type.

First order interaction terms: age*speedzone, age*state, age*sex, speedzone*state, year*state, sex*unprotected road user type, state*unprotected road user type.

No other variable or interaction term significantly improved the fit of the logistic model. Terms representing market group and unprotected road user type were added to the covariate model and the model re-estimated.

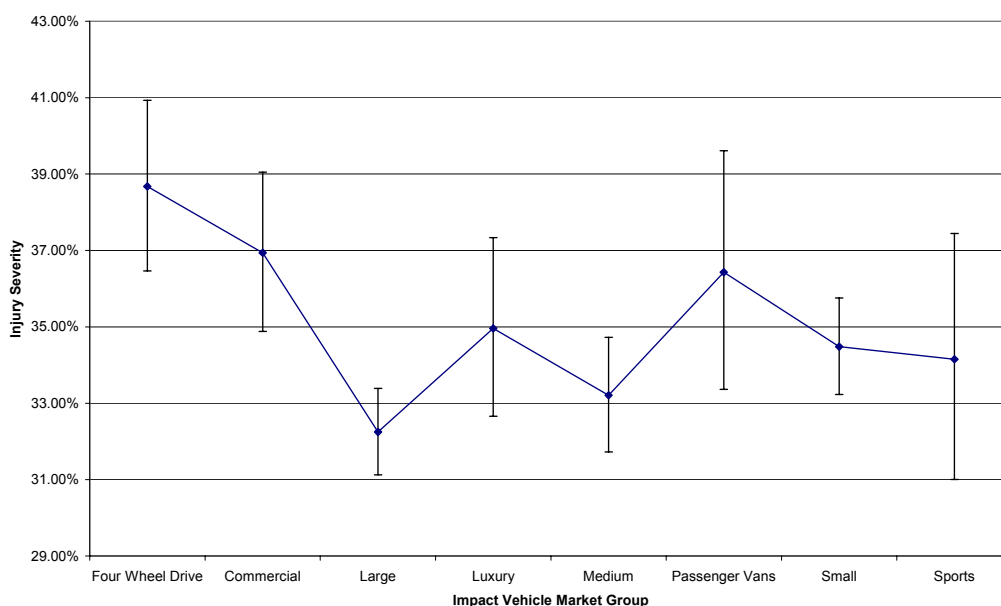
The overall (average) aggressivity injury severity for injured unprotected road users by market group was 35.11%. In other words, the estimated probability that an unprotected road user injured in a collision with a single vehicle was severely injured was 35.11%.

Appendix 7 gives the estimates of aggressivity injury severity derived by logistic regression for each market group. The variability in the estimates of aggressivity injury severity by market group can be seen from the width of the corresponding 95% confidence intervals. Aggressivity injury severity ranged from 32.25% for the large vehicle market group to 38.67% for the four-wheel drive market group. These results are presented graphically in Figure 5.

Figure 9 shows that the injury outcome for an unprotected road user from a collision with a four-wheel drive is significantly more severe than the outcome of one with a vehicle from either the large, medium or small market groups. Similarly the outcome is significantly more severe as a result of a collision with a commercial vehicle than a vehicle from either the large or medium market groups. There appears to be some trend towards increased aggressivity with decreasing vehicle size amongst the regular passenger vehicles although the confidence limits on the estimates show this trend is not statistically significant. A trend to poorer aggressivity with decreasing vehicle size may give some indication to the mechanisms of injury in collisions with unprotected road users. Larger cars generally have longer bonnets that may help prevent pedestrian head strike on the windscreen. It is also possible that large cars have softer frontal structures due to longer crumple zones and greater distance between the bonnet and major mechanical components, both of which would be beneficial in unprotected road user impacts.

These estimates of aggressivity towards unprotected road users presented here are generally consistent with the original estimates of vehicle aggressivity towards unprotected road users of Cameron et al (1998).

Figure 9: *Aggressivity injury severity on unprotected road users by impact vehicle market group (with 95% confidence limits)*



5.4 Crashworthiness of Passenger Vehicles in Two Car Collisions with Other Passenger Vehicles

In the following sections, the vehicle for which the crashworthiness is being rated is referred to as the 'focus' vehicle. The driver of the 'focus vehicle' whose injury outcome is used in the estimation of the crashworthiness ratings is termed the 'focus driver'. The car colliding with the 'focus car' is termed the 'collision partner' car.

5.4.1 Injury Risk

Injury risk was estimated from the data on involved drivers of cars, station wagons or taxis manufactured from 1982 to 2000 and involved in two vehicle matched tow-away crashes in NSW during 1987 to 2000 and in Western Australia and Queensland during 1991 to 2000. Only 53 of the 64 possible combinations of focus car and collision partner car market groups had sufficient data to be included in the analysis. Combinations were excluded if there were less than 100 focus vehicles that had crashed or there were less than 20 injured drivers of the focus car. Because of missing values of some of the factors to be included in the logistic regression and the exclusion of market group combinations, the regression analysis was performed on 253,560 involved focus drivers, 34,691 of whom were injured. Appendix 8 gives the total raw data counts in total and by state of crash.

The "covariate" model for injury risk was determined from the variables described in Section 4.1.1. The following covariates and interactions were statistically significantly associated with injury risk and were included in the logistic regression model.

Base effect terms: focus driver sex (sex), focus driver age (age), state of crash (state), speed zone of crash (speedzone), year of crash (year).

First order interaction terms: age*state, speedzone*state, age*year, year*state, age*sex.

No other variable or interaction term significantly improved the fit of the logistic model. A term representing the market group combination of the colliding vehicles was added to the covariate model and the model re-estimated.

The overall (average) injury risk for involved focus drivers in collisions between two passenger vehicles in NSW, Western Australia and Queensland was 13.68%. In other words, the estimated probability that a driver involved in a tow-away crash involving two passenger vehicles in NSW, Western Australia and Queensland was injured was 13.68%. Injury risk ranged from 7.25% for a driver of a Four Wheel Drive involved in a collision with a vehicle in the Small car market group to 25.17% for the a driver of a Passenger Van involved in a collision with a vehicle in the Four Wheel Drive market group.

Appendix 9 gives the estimates of aggressivity injury risk derived by logistic regression for the market group combinations. The variability in the aggressivity injury risk estimates relative to the market group combination can be seen from the width of the corresponding 95% confidence intervals. Individual confidence interval widths ranged from 0.86% for the rating of the injury risk of a driver of a vehicle in the Large market group colliding with a vehicle in the Small Car market group to 12.22% for the rating of the injury risk of a driver of a vehicle in the Passenger Van market group colliding with a vehicle in the Four Wheel Drive market group.

5.4.2 Injury Severity

Because of missing values in one or more of the covariates and the exclusion of data on crashes between the noted market group combinations with insufficient cases, the final data used in the injury severity analysis covered 33,548 drivers who were injured in crashes in Victoria or NSW during 1987-2000 or Queensland and Western Australia during 1991-2000. 5,589 of these injured drivers were severely injured (killed or admitted to hospital).

The "covariate" model for injury severity was determined from the variables described in Section 5.11. The analysis identified a number of statistically significant covariate effects. These were:

Base effect terms: focus driver age (age), state of crash (state), speed zone of crash (speedzone), year of crash (year).

First order interaction terms: year*state.

No other variable or interaction term significantly improved the fit of the logistic model. A term representing the market group combination of the colliding vehicles was added to the covariate model and the model re-estimated.

The overall (average) crashworthiness injury severity for injured drivers was 16.66%. In other words, the estimated probability that a driver injured in a crash was severely injured was 16.66%. Injury severity ranged from 7.88% for a driver of a Passenger Van involved in a collision with a vehicle in the Medium market group to 31.83% for the a driver of a Commercial vehicle involved in a collision with a vehicle in the Luxury market group.

Appendix 9 gives the estimates of aggressivity injury severity derived by logistic regression for the market group combinations. The variability in the estimates of aggressivity injury severity relative to the market group combination can be seen from the width of the corresponding 95% confidence intervals. Individual confidence interval widths ranged from 3.03% for the rating of the injury severity of a driver of a vehicle in the Large market group colliding with a vehicle in the Large car market group to 33.41% for the rating of the injury risk of a driver of a vehicle in the Four Wheel Drive market group colliding with a vehicle in the Small car market group.

5.4.3 Crashworthiness in Vehicle to Vehicle Collisions by Market Group Combination

The crashworthiness estimates for the focus vehicle in each market group combination were obtained by multiplying the individual injury risk and injury severity estimates. Because each of the two components has been adjusted for the confounding factors, the resultant crashworthiness estimate is also adjusted for the influence of them.

Appendix 9 gives the crashworthiness estimates and the associated 95% confidence intervals for each of the 53 market group combinations included in the analysis. Each estimate is expressed as a percentage, representing the number of drivers killed or admitted to hospital per 100 drivers involved in a tow-away crash. The true risk of a driver being killed or admitted to hospital in a tow-away crash is only estimated by each figure, and as such each estimate has a level of uncertainty about it. This uncertainty is indicated by the confidence limits in Appendix 9. There is 95% probability that the confidence interval will cover the true risk of serious injury (death or hospital admission) to the driver of a vehicle involved in a crash with a vehicle of the market group.

Based on the average injury risk and severity the overall (average) crashworthiness rating for all market group combination crashes was 2.28%. In other words, the estimated probability that a focus

driver injured in a crash was severely injured was 2.28%. Crashworthiness ranged from 0.84% for a driver of a Four Wheel Drive involved in a collision with a vehicle in the Small market group to 4.14% for the a driver of a Passenger Van involved in a collision with a vehicle in the Luxury market group. Confidence interval widths ranged from 0.38% for the crashworthiness rating of a driver of a vehicle in the Large market group colliding with a vehicle in the Small car market group to 6.29% for the crashworthiness rating of a vehicle in the Passenger Van market group colliding with a Luxury vehicle. The crashworthiness estimates are plotted for each market group combination in Figure 10.

The injury risk component of the crashworthiness estimate is plotted in Figure 11 and the crashworthiness injury severity component is plotted in Figure 12.

In each of Figures 10 to 12, the focus car market group is given along the horizontal x-axis. The crashworthiness, injury risk or injury severity of the focus car is plotted as a function of the market group of the collision partner in the crash.

Figure 10: *Crashworthiness by driver vehicle market group and impact partner market group in collisions between two passenger vehicles*

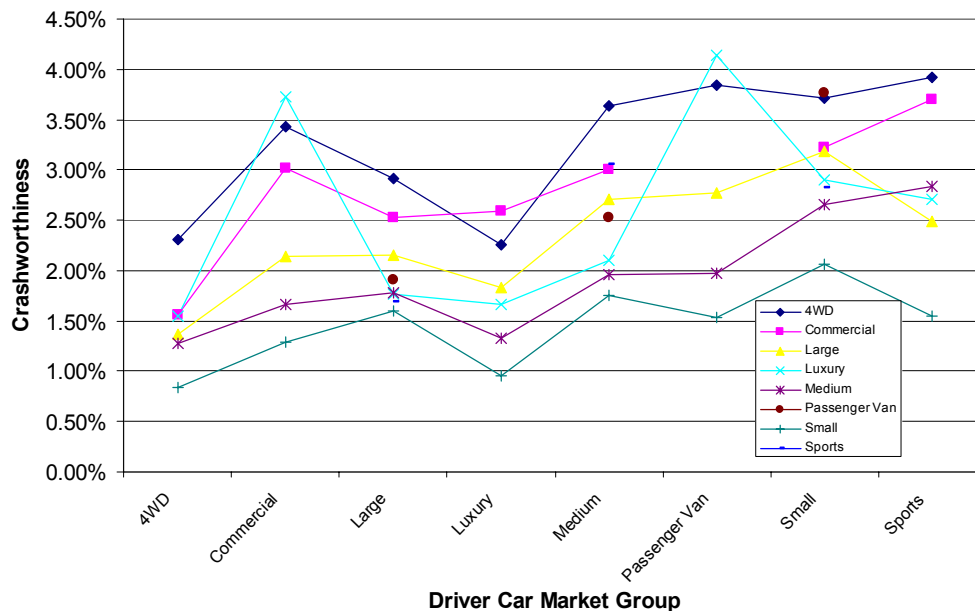


Figure 11: *Injury Risk by driver vehicle market group and impact partner market group in collisions between two passenger vehicles*

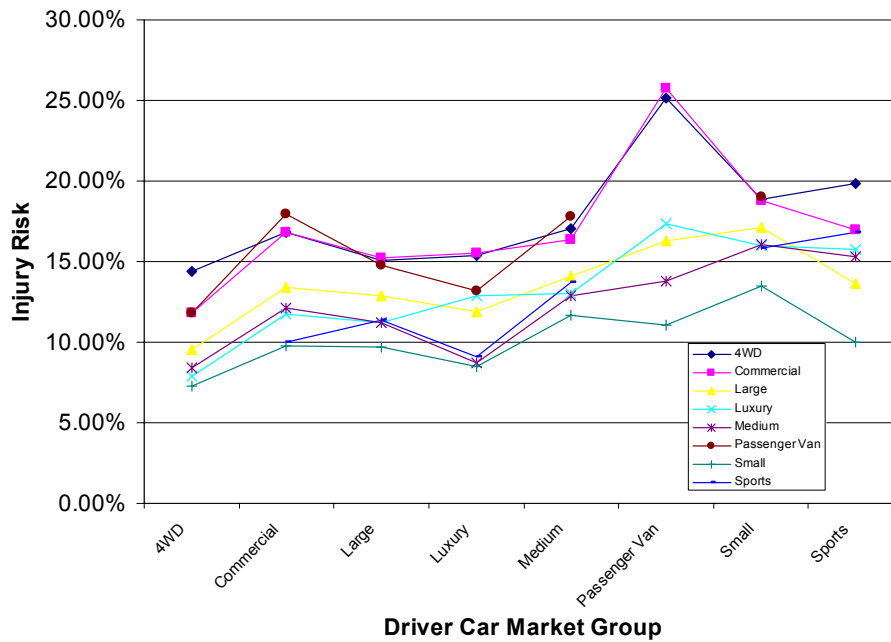
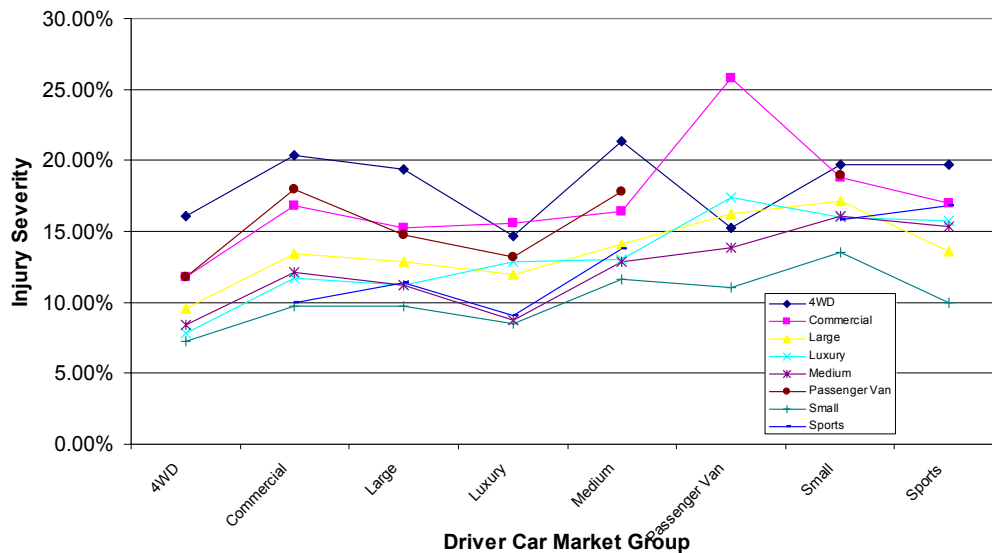


Figure 12: *Injury severity by driver vehicle market group and impact partner market group in collisions between two passenger vehicles*



A further use of the crashworthiness estimates shown in Figure 10 has been made to estimate relative risk of serious injury of the drivers involved in a crash between two passenger cars. To derive the relative risk of a driver in vehicle market group X to a driver in vehicle market group Y in a collision between the two vehicles, the crashworthiness of vehicle X in a collision with vehicle Y is divided by the crashworthiness of vehicle Y in a collision with vehicle X. Table 5 gives the resulting estimates where the column categories define the numerator vehicle in the relative risk and the row categories define the denominator.

The interpretation of each value in the table is the risk of serious injury or death given crash involvement of the driver in the numerator (column) market group vehicle relative to the risk to the driver in the denominator (row) market group car in a collision between the two. For example, in a collision between a 4WD and a small car, the driver of the small car is 4.43 times more likely to be killed or seriously injured than the driver of the 4WD. Similarly, in a collision between a large car and a medium car, the driver of the medium car is 1.51 times more likely to be killed or seriously injured than the driver of the 4WD

Table 5: *Relative risks of serious driver injury by market group in collisions between two passenger vehicles*

Collision Partner Market Group (Denominator)	Driver Car Market Group (Numerator)							
	4WD	Commercial	Large	Luxury	Medium	Passenger Van	Small	Sports
4WD	1.00	2.20	2.12	1.46	2.83	1.50	4.43	N/A
Commercial	0.45	1.00	1.18	0.70	1.80	1.13	2.50	1.38
Large	0.47	0.85	1.00	1.03	1.51	1.46	1.99	1.47
Luxury	0.68	1.44	0.97	1.00	1.59	2.76	3.02	1.64
Medium	0.35	0.55	0.66	0.63	1.00	0.78	1.51	0.93
Passenger Van	0.66	0.89	0.69	0.36	1.28	1.00	2.56	N/A
Small	0.23	0.40	0.50	0.33	0.66	0.39	1.00	0.62
Sports	N/A	0.73	0.68	0.61	1.08	N/A	1.61	1.00

N/A – Not available

For the 53 market group combinations rated in this study, the average crashworthiness is 2.41 (2.41 serious driver injuries per 100 crash involvements). This is significantly better (numerically lower) than the average crashworthiness in any of the other crash types considered and less than the overall average of 3.9 for all crash types. This demonstrates the inherent protection being in a vehicle offers in a crash as opposed to being an unprotected road user, and the relative benefits of having another passenger vehicle as a crash partner in comparison to colliding with a heavy vehicle or fixed object.

As was observed in the analysis of heavy vehicle crashes, the non parallel nature of the lines in Figure 10 suggest there is an interaction between the crashworthiness of the focus car and the type of impact partner in a collision between two passenger cars. The degree of non parallel lines is perhaps not so pronounced as for the heavy vehicle crash analysis suggesting that crashworthiness and aggressivity are more independent when considering crashes between two passenger vehicles.

Confidence limits were used to judge whether the true risk of death or hospitalisation for a driver of a vehicle of a specific market group involved in a collision with another market group vehicle is significantly different from the defined average for all combinations of market groups, i.e. 2.41 per 100 involved drivers. An upper limit below the average is indicative of superior crashworthiness, whereas a lower limit above the average suggests inferior crashworthiness. Other market group combination crashes also have crashworthiness ratings at the low or high end of the scale, but their confidence limits overlap the all market group combination average. Although such market group combination crashes may also have superior or inferior crashworthiness characteristics, the database did not contain sufficient numbers of these combination crashes for the data to represent scientific evidence that this is the case.

In terms of statistical significance, it should be noted that classifying the focus car driver outcome in a particular market group combination crash as having inferior or superior crashworthiness compared to the defined average means only that the market group combinations with ‘superior’

crashworthiness have statistically significantly better crashworthiness than market group combinations in the ‘inferior’ group. It is possible that market group combinations within the inferior and superior crashworthiness categories also had statistically significant differences in crashworthiness. This could be assessed by examining overlap in the statistical confidence limits for any pair wise comparison of two market group combinations. One of the main points in defining groups with inferior and superior crashworthiness is to show that the analysis can differentiate with statistical precision crashworthiness between combinations of vehicles within the rated vehicle population.

Eighteen market group combinations had ratings representing evidence of superior crashworthiness because their upper confidence limits were less than the average rating. The specific market group combinations were (in order of estimated risk of serious driver injury in a crash, from lowest to highest):

Focus Car Market Group	Impact Partner Market Group	Crashworthiness Rating
Four Wheel Drive	Small	0.84
Luxury	Small	0.96
Four Wheel Drive	Medium	1.28
Commercial	Small	1.29
Luxury	Medium	1.32
Four Wheel Drive	Large	1.37
Passenger Van	Small	1.53
Sports	Small	1.54
Large	Small	1.60
Commercial	Medium	1.66
Large	Sports	1.69
Medium	Small	1.75
Large	Luxury	1.77
Large	Medium	1.79
Luxury	Large	1.83
Medium	Medium	1.96
Small	Small	2.06
Large	Large	2.16

A range of focus car market groups had crashworthiness ratings superior to the overall average although only 1 combination with the focus car being a small car and 1 with a sports car were represented. Five of the focus cars were large whilst luxury and 4WD vehicles represented 3 each. In contrast, 8 of the collision partner car market groups leading to low serious injury risk in the focus car are small cars whilst 5 are medium and 3 are large. This demonstrated the relatively low aggressivity of regular passenger cars in the large, medium and, particularly, small classes.

Ten market group combinations had crashworthiness ratings for the focus car representing evidence of inferior crashworthiness because their lower confidence limits were greater than the average rating. The specific market group combinations were (in order of estimated risk of serious driver injury in a crash, from highest to lowest):

Focus Car Market Group	Impact Partner Market Group	Crashworthiness Rating
Small	Passenger Van	3.77
Commercial	Luxury	3.73
Small	Four Wheel Drive	3.72
Medium	Four Wheel Drive	3.63
Commercial	Four Wheel Drive	3.43
Small	Commercial	3.22
Small	Large	3.19
Large	Four Wheel Drive	2.92
Small	Luxury	2.90
Medium	Large	2.70

Small vehicles predominate in the focus vehicles with inferior crashworthiness in combination with other vehicle types, representing the focus car in 5 of the 10 categories. Of the impact partner cars contributing to poor crashworthiness of the focus cars, 4 out of the 10 were 4WDs whilst a further 4 were either large or luxury cars. This reflects primarily the mass incompatibility between combinations of heavy and light vehicles as well as both the relatively poor crashworthiness of small cars and the high aggressivity of 4WDs.

6. DISCUSSION

Analysis carried out in this study has been able to quantify the relative safety of light vehicles in the Australian fleet, classified into 8 broad market groups, in each of the four major crash types represented in the majority of the crash population for these vehicles. As such, it is able to present a more comprehensive view of the safety of the light vehicle fleet than has been available from previously completed research. Following is specific discussion on the analysis outcomes from each of the four major crash types considered, after which general discussion of the results overall follows.

6.1 Crashworthiness of Passenger Vehicles in Collisions with Heavy Vehicles

Figure 1 and Appendix 2 demonstrate a significant difference in light passenger car crashworthiness depending on the class of heavy vehicle impacted. Figure 1 shows that generally the outcome from a collision with an articulated vehicle over all market groups is significantly more severe than the outcome of a collision with a bus or rigid truck. The average serious injury risk for passenger cars in collisions with articulated trucks varies from 7.1% for large cars to 9.2% for 4WDs and averages around 8.5% across all market groups. In contrast, serious injury risk for drivers of light passenger vehicles colliding with rigid trucks or buses ranges between 2.9% and 5.5 % averaging around 4.5%.

It is interesting to compare the injury outcomes in heavy vehicle collisions with injury outcomes in other major crash types. The average serious injury risk to drivers in crashes between two light vehicles is around 2.3%. This is about half that of crashes with buses and rigid trucks and one third to one quarter that of crashes with articulated trucks. Clearly the compatibility between heavy vehicles and light passenger vehicles is far less than for light vehicles crashing with each other. Not surprisingly, the largest incompatibility is between passenger cars and articulated vehicles. This is not unexpected given the high mass and significant geometrical incompatibility of articulated vehicles in comparison to a passenger car. The serious injury risk for a driver colliding with an articulated vehicle is, however, not quite as high as in a single vehicle crash where the average serious injury risk is about 11.7%.

Figure 1 suggests a differential crashworthiness performance between various passenger vehicle market groups in collisions with heavy vehicles. The non-parallel nature of the lines in Figure 1 also suggests that certain market groups of vehicles are more compatible with certain heavy vehicle classes than others. For example, 4WD vehicles show good occupant protection performance in crashes with rigid trucks and buses but not with articulated trucks. Amongst the crashes with buses and rigid trucks, there appears to be a relationship between the mass of the vehicle class and the average serious injury risk with 4WDs estimated to have the best crashworthiness and small cars the worst. The mass relationship does not, however, carry over to crashes with articulated trucks where 4WD vehicles perform the worst of all the market groups and large cars the best. This may reflect the extreme mass disparity between articulated vehicles and all classes of light passenger vehicles with articulated vehicles being around 15 times heavier than even the heaviest 4WD vehicle. Without a mass effect, the resultant ratings then reflect the design properties of the vehicle in preventing serious injury, an area where many large 4WD vehicle often perform poorly because of a relative lack of focus on occupant protection measures in these vehicles as well as lesser requirements for compliance with safety based Australian Design Rules.

Interpretation of the apparent interaction between passenger vehicle market group and heavy vehicle class must be made with caution, however, because of the relatively wide confidence limits on many of the estimates in Figure 1. This comment also applies to comparing differential performance between market groups within a class of heavy vehicle collision partner.

One of the limitations of the heavy vehicle analysis is the inability to classify the heavy vehicle collision partner into more than one of three broad categories due to their description in the available data. Each of the three categories comprises a range of vehicle sizes and masses, with mass of the heavy vehicle also varying widely between laden and un-laden. Buses, for example, can vary in size from a 12 seat mini bus of 4,000kg to a full size tourist coach of 25,000kg. Rigid trucks see a similar size variation whilst articulated trucks include both single and multi articulated vehicles such as B-Doubles ranging from 45 to 75 tonnes fully laden. The ratings estimated reflect the average unknown mix of sizes of vehicle within each heavy vehicle class. Furthermore, it is assumed that each light vehicle class rated crashes with the same mix of vehicle sizes within each heavy vehicle class, beyond any differences that are controlled for through the speed zone variable included in the logistic regression models.

6.2 Crashworthiness of Passenger Vehicle in Single Vehicle Collisions

Both Table 2 and Figure 4 show large variation in the crashworthiness of vehicles in single vehicle crashes by market group. One of the most striking features of the results is the poor performance of 4WD vehicles in single vehicle crashes. This class has the highest point estimate of driver serious injury risk with this estimate being statistically significantly worse than each of the large, luxury, medium and even small vehicle classes. Both the passenger van and commercial vehicle market groups also have relatively poor estimated crashworthiness in single vehicle crashes. In contrast, large and luxury market group vehicles had the best estimated crashworthiness in single vehicle crashes.

Initial interpretation of the results in Table 4 suggested the results may have been driven by the propensity for rollover within each class with vehicle classes more prone to rollover having a worse crashworthiness performance. This was particularly the case given that the crashworthiness estimates for single vehicle crashes were not adjusted for differences in rollover between the vehicle market groups as this was considered a vehicle characteristic. Examination of the propensity for rollover by vehicle class shown in Figure 5 shows a high degree of correlation with the single vehicle crash crashworthiness estimates of Figure 4 supporting the theory that rollover propensity is driving the differences in single vehicle crash crashworthiness by market group. However, further analysis of crashworthiness in single vehicle crashes by rollover and non rollover crashes separately shows this conclusion is not necessarily correct.

Figure 8 shows comparative crashworthiness in rollover and non rollover single vehicle crashes. For the commercial, large, luxury, medium and sports market groups, there is no significant difference in crashworthiness between rollover and non-rollover crashes. Crashworthiness of the 4WD group in rollover crashes was significantly worse than in non-rollover crashes. However, 4WD vehicles were amongst the worse groups in both single vehicle crash types meaning the overall poor crashworthiness of 4WD vehicles seen in Figure 4 is not just a reflection of their high propensity for rollover but a reflection of poor crashworthiness performance in all types of single vehicle crash. In contrast to 4WDs, the crashworthiness of passenger vans and small cars was significantly worse in non-rollover single vehicle crashes than in rollover crashes. This is possibly a reflection of the limited amount of structure in these vehicles to absorb impact energy in non-rollover single vehicle crashes which typically involve impact with a fixed object such as a pole or tree. Passenger vans in particular have very little frontal structure through which to absorb crash energy when colliding with a fixed object. The reason for the comparatively good crashworthiness performance of

passenger vans in rollover crashes is not clear but may reflect greater roof height either helping to prevent full rollover or giving greater head clearance to the occupants to allow some roof crush without contact.

In single vehicle crashes, particularly with fixed objects, vehicle mass might be expected to play less of a part in injury outcome. It is interesting to note then that large and luxury vehicles appear to perform better in terms of occupant protection in this crash type. This could be the result of two factors. The first is the increased amount of occupant survival space in larger vehicles, although clearly occupant survival space is not the only factor dictating good performance, demonstrated by the poor performance of 4WD vehicles. The second is the likely higher level of advanced occupant protection features, such as airbags, in the more expensive large and luxury vehicle classes.

Anecdotally, many people choose to purchase 4WD vehicles based on a perception of high levels of occupant protection in these vehicles. In single vehicle crashes at least, the results show this perception is poorly founded. Commercial vehicles and passenger vans are also classes of vehicle with relatively poor crashworthiness in single vehicle crashes. The best occupant protection in single vehicle crashes is found in regular passenger vehicles with larger size correlating with better crashworthiness.

Comparing the crashworthiness figures for all market groups in single vehicle crashes in Table 2 with the average crashworthiness in all crash types of 3.9 (Newstead et al, 2003) shows the serious nature of single vehicle crashes. Serious injury risk in single vehicle crashes is around 3 times higher than the average from all crash types. It is 2.5 times higher even for the best performing vehicle class. Comparing the results in Figure 4 with those in Figure 1 also show injury outcome in single vehicle crashes is typically more severe than in impacts with articulated trucks. The generally poor occupant protection performance in all vehicle classes highlights the need to either prevent single vehicle crashes or work to reduce injury outcome severity. This could be achieved through infrastructure modification, such as roadside barriers or obstacle clearing, rather than relying on vehicle design improvements to reduce road trauma resulting from crashes of this type.

6.3 Aggressivity toward Unprotected Road Users

Estimates of vehicle aggressivity towards unprotected road users shown in Figure 9 generally parallel early estimates presented by Cameron et al (1998). Four wheel drives, commercial vehicles and passenger vans again here had the highest estimated aggressivity whilst large medium and small vehicles had the lowest estimated aggressivity. The relative ranking of the aggressivity of large and medium cars is reversed in this study compared to that of Cameron et al (1998), although the confidence limits on the estimates indicated there is no statistical difference between aggressivity of the two vehicle groups.

The high aggressivity of 4WD vehicles towards unprotected road users has been identified in many studies now and is believed to be a result of the geometric properties of these vehicles. Such properties include high frontal structures combined with hard contact surfaces often featuring the presence of a bull bar (Attwell and Glase, 2000). Similar features can also be found on many commercial vehicles and passenger vans, also explaining the high aggressivity of these vehicle classes. It is unlikely that relative mass is a specific vehicle feature determining vehicle aggressivity in unprotected road user crashes given all vehicle classes are orders of magnitude heavier than the typical unprotected road user, of which pedestrians make up the majority.

Comparing the aggressivity of small, medium and large cars reveals a trend to decreasing aggressivity with increasing vehicle size. This is possibly a result of longer bonnet structures on

larger cars meaning the unprotected road user is more likely to impact the softer bonnet area on these vehicles than hit the harder windscreen and a-pillar area of the car. This is particularly relevant for the vulnerable head region of the unprotected road user and is generally supported in a review by McLean (1996).

The measure of aggressivity towards unprotected road users in this study is the risk of serious injury given some injury was sustained. The concept of an injury risk measure similar to that used in estimating crashworthiness could be conceived for unprotected road users. However, in practice unprotected road users are almost always injured when a crash involving them is reported to police, meaning the injury risk estimate would be 100% in all cases. Given this, the aggressivity measure used for unprotected road users is in effect an estimate of the risk of death or serious injury to an unprotected road user given involvement in a reportable crash and is comparable on a common basis with the various crashworthiness measures used in this study.

Comparing the unprotected road user aggressivity estimates with injury outcomes of light vehicle occupants in each of single vehicle, light vehicle to light vehicle and light vehicle to heavy vehicle crashes shows the extremely serious nature of unprotected road user crashes. The average risk of death or serious injury for unprotected road users involved in reportable crashes is around 35%. For drivers of light vehicles, the highest average risk of death or serious injury in a reported crash is around 12% in single vehicle crashes or about one third the risk of an unprotected road user. This compares with an average serious injury risk of only 2.3% for light vehicle drivers in crashes with other light vehicles, only one fifteenth the risk of an unprotected road user. Interpreting this in a total serious road trauma context shows the relative importance of reducing crashes involving unprotected road users compared to crashes involving light vehicle drivers.

6.4 Crashworthiness in Light Vehicle to Light Vehicle Crashes

The estimates of crashworthiness by vehicle market group and collision partner shown in Figure 10 embody both the crashworthiness of the driver car market group as well as the aggressivity of the impact partner car market group. Figure 10, for example, shows that the crashworthiness of vehicles in all market groups is best in collisions with small vehicles and generally worst in collisions with 4WD vehicles.

The estimates in Figure 10 are joined by lines to demonstrate the interaction between driver vehicle market group and collision partner vehicle market group in determining driver injury outcome. Parallel lines in Figure 10 would indicate that the relative aggressivity of the impact partner vehicle was not determined by the market group of the vehicle whose driver injury outcome is being rated (the focus driver). Excluding market groups with relatively limited data, including passenger vans, commercial, sports and luxury vehicles, the lines in Figure 10 are consistent in order of height up the chart but are not perfectly parallel. This means the rank ordering of aggressivity by market group will be consistent between market groups, regardless of the vehicle market group of the focus driver. However, the relative aggressivity of each market group will vary depending on the focus driver vehicle market group.

The above observations concerning the results in Figure 10 are important in understanding both the crashworthiness and aggressivity ratings for Australian vehicles calculated by Newstead et al (2003). Because relative aggressivity between market groups varies depending on the focus driver vehicle model, the average aggressivity of a vehicle market group across all crashes will reflect, to a certain degree, the proportionate mix of vehicles by market group driven by the focus drivers. Significant changes in the composition of the vehicle fleet in terms of market group mix could change the relativity between the aggressivity estimates obtained, although Figure 10 suggests the

rank ordering should not be altered. A parallel argument can also be made for the crashworthiness ratings. As for aggressivity, the relative crashworthiness between market groups will be dependent on the mix of vehicle market groups colliding with them as far as the component of the crashworthiness rating dependent on vehicle to vehicle crashes is concerned. Whilst these results have been demonstrated in the context of vehicle market group mix in the fleet, they likely extend to the mix of specific vehicle makes and models in the fleet, although there is insufficient data to investigate model by model interactions.

Table 5 presents a convenient summary of relative injury outcomes to drivers in crashes between specific combinations of vehicle market groups. It allows identification of those combinations of vehicle where there is a major difference in severe injury risk between the drivers of the two vehicle classes involved. The largest discrepancy in injury outcome occurs in crashes between a small car and a 4WD where the risk of death or serious injury to the small car driver is almost four and a half times that of the 4WD driver. Indeed, it is the small car class that shows the greatest discrepancy in serious injury risk when colliding with all other market groups. The 4WD market group shows the next highest degree of incompatibility in injury outcome in collisions with other market groups. Clearly, any attempt to improve the compatibility of the vehicle fleet in terms of relative injury risk should focus first on small cars and 4WD vehicles.

An element of caution should be exercised in interpreting the figures in Table 5. Whilst the table gives information on relative serious injury risk in crashes between combinations of vehicle market groups, it masks information on which combinations result in the highest and lowest aggregate risk to the drivers of both vehicles in the crash. This can only be gleaned by using the information in Table 5 in conjunction with that presented in Figure 10.

6.5 General Discussion

Analysis completed as part of this study has shown clear evidence of differential performance of various vehicle market groups in protecting their own occupants and other road users with which they collide in the four different types of crashes considered. In doing so it has also been able to identify the classes of vehicle that perform comparatively well or badly with respect to injury outcome in each crash type. For example, it has identified the relatively poor performance of 4WD vehicles and passenger vans in single vehicle crashes in contrast to the relatively good performance of large and luxury vehicles. It has also confirmed the relatively high aggressivity of 4WD and commercial vehicle in comparison to medium and large vehicles in crashes involving unprotected road users.

In quantifying the relative performance of each vehicle class in the four major crash types, the research has been useful in identifying areas of focus for improving the safety performance of each vehicle class. For example, attention needs to be paid to 4WD vehicles in improving occupant protection performance in single vehicle crashes and in crashes with articulated vehicles and in reducing aggressivity of this vehicle class towards both unprotected road users and other light vehicle drivers. The focus on small vehicle safety identified in the analysis is in improving occupant protection in crashes with rigid trucks and buses and other larger light passenger vehicles, and to a certain extent in improving aggressivity towards unprotected road users. Focus for other vehicle classes can be derived similarly from direct interpretation of the results presented.

By estimating each of the ratings for each crash type considered in this study on a common basis, analysis has also been able to differentiate the crash types in order of relative injury outcome. It is clear that injury outcomes to unprotected road users in collisions with light passenger vehicles are

the most severe of those studied here, with around 35% of unprotected road users killed or seriously injured in crashes reported to police. Injury outcomes to drivers of light vehicles in single vehicle crashes are the next most severe on average with a risk of serious injury or death in a crash of around 12%. The comparable serious injury risk to light vehicle drivers in crashes with articulated heavy vehicles is only slightly less at around 8.5%. At the other end of the risk scale, the average serious injury risk for light vehicle drivers in collisions with other light vehicles was estimated at 2.3%. Even the most unfavourable injury outcome in light vehicle to light vehicle crashes of a sports car colliding with a 4WD vehicle resulted in an average serious injury risk of 3.92% to the sports car driver. Along with the relative incidence of each crash type considered, these results help give priorities for targeting future efforts in crash prevention and injury management.

Results of analysis presented here give important insight into the interpretation of the Australian crashworthiness and aggressivity ratings of Newstead et al (2003) and indeed into the interpretation of such ratings calculated for any particular vehicle fleet. The Australian crashworthiness measure is calculated from a combination of single vehicle and multiple vehicle crash outcomes with the logistic regression analysis used to standardise the relative proportion of single and multiple vehicle crashes over which the average vehicle crashworthiness estimate is calculated. As there are clear differences in the relative crashworthiness of each market group, and most likely specific makes and models of vehicles, in single and multiple vehicle crashes, the resulting overall crashworthiness rating will be a reflection of the specific mix of single and multiple vehicles in the crash population. It has been noted above through the analysis of crashworthiness in vehicle to vehicle crashes that both the relative crashworthiness and aggressivity of vehicles in vehicle to vehicle crashes reflect, to a certain extent, the mix of vehicles in the fleet. In combination, it means the overall crashworthiness ratings for Australian vehicles reported in Newstead et al (2003) are a function of both the mix of single and multiple vehicle crashes in the crash population as well as the mix of vehicles in the fleet. Similarly, the aggressivity ratings reported in Newstead et al (2003) are a function of the mix of vehicles in the fleet.

On the surface, the dependency of the Australian vehicle safety ratings on both fleet mix and crash type might seem to limit the relevance of the ratings. However, because the weightings of fleet mix and crash type on which the ratings are calculated are representative of the Australian situation, it is strongly argued that this makes the ratings very relevant to Australian consumers as it best represents the average configuration and partner vehicle type in crashes in which they will be involved. What it does identify though is that the ratings might be less relevant to the same vehicles sold in other countries where the mix of crash types and vehicles by market group are vastly different. It is unlikely to be a problem for using the Australian ratings in New Zealand where the key attributes identified are not vastly different to Australia.

Results of the research presented here pose three broad areas to be investigated through further research using the data sources utilised for this study. They are as follows.

1. The high overall injury severity of unprotected road users involved in crashes with light passenger vehicles makes this an important crash type in determining the safety performance of a vehicle. Currently, the regularly published measure of aggressivity for Australian passenger vehicles (Newstead et al, 2003) only considers aggressivity towards drivers of other vehicles. As shown in this report, relative aggressivity between vehicle market groups is different when considering either unprotected road users or drivers of other vehicles. To better reflect the overall aggressivity of vehicles in the Australian fleet towards both unprotected road users and other vehicle drivers, it is recommended that a modified aggressivity measure be developed. The aggressivity measure should represent the average aggressivity of each vehicle model or market group across both crash types with the average weighted to reflect the relative incidence of each crash type in the overall crash population.

2. The Federal Government of Australia is predicting major growth in heavy vehicle travel in Australia over the next decade. Building on the estimates of crashworthiness of light passenger vehicles in collisions with heavy vehicles, it is recommended further study be undertaken to estimate the effects of the predicted heavy vehicle travel growth on total road trauma in the light vehicle fleet. The proposed further study should particularly examine the crash outcome effects of different mixes of travel by different heavy vehicle types, in the broad categories considered in this study. This should be examined both within and outside of urban areas with a view to optimising safety through consideration of likely conflicts in each environment.
3. Results of research reported here have been able to articulate relative vehicle secondary safety performance by market group in each of the four major crash types represented in the crash population. They have also shown differential relative performance between market groups between major crash types. From these results it is possible to build a comprehensive model of crash injury outcome in the light passenger vehicle fleet. The model would estimate the average serious injury risk in crashes involving the light passenger vehicle fleet and is a function of the mix of the four major crash types as well as the mix of vehicles in the light vehicle fleet by market group. Application of the model would allow investigation of changes in safety resulting from altering the mix of the light vehicle fleet as well as the average secondary safety performance of vehicles within each market group. Further research to develop and apply such a model has been undertaken with the results to be detailed in a following report.

7. CONCLUSIONS

Results of research reported here have been able to quantify the relative secondary safety performance of the light passenger vehicle fleet by market group in each of the four major crash types represented in the crash population. The crash types involving the light passenger vehicle fleet considered are single vehicle crashes, crashes involving unprotected road users, crashes with heavy vehicles and crashes between two light passenger vehicles. The secondary safety performance has been assessed using two measures being crashworthiness and aggressivity. Both measure the risk of death or serious injury given involvement of the vehicle in a crash where someone is injured or a vehicle is towed away, the former applying to the injury outcome of the driver of the focus light passenger vehicle, the latter to the injury outcome of other road users with which the focus vehicle collides.

Results of the research have been able to identify various vehicle market groups that have relatively good and bad secondary safety performance in each crash type considered. Results have shown clear differential relative performance between market groups across the major crash types considered. They have also been able to quantify the relative risk of serious injury or death between crash types, further highlighting the high serious injury risk to unprotected road users in particular, as well as to light vehicle drivers in both single vehicle crashes and in crashes with articulated heavy vehicles.

Results of the research have also been valuable in providing insight into understanding and interpreting what is being measured in currently published Australian vehicle secondary safety ratings calculated from analysis of police reported crash outcomes. They have also provided directions for further research into the monitoring and improvement of the secondary safety performance of the light passenger vehicle fleet in Australia.

8. ASSUMPTIONS AND QUALIFICATIONS

The results and conclusions presented in this report are based on a number of assumptions and warrant a number of qualifications that the reader should note. These are as follows.

8.1 Assumptions

It has been assumed that:

- Victorian, New South Wales, Western Australian and Queensland Police crash reports accurately recorded driver injury, hospitalisation and death and that there was no bias in reporting injury at any level associated with the make and model of vehicle involved.
- Crashed vehicle registration numbers were recorded accurately on Police crash reports and that they correctly identified the crashed vehicles in the Victorian, NSW, Western Australian and Queensland vehicle registers. Further, it was also assumed that vehicle identification numbers and make and model details were accurately recorded in the vehicle registers.
- The adjustments for driver sex, age, speed zone, the number of vehicles involved and the state and year in which the crash occurred removed the influences of the other main factors available in the data that affected crash severity and injury susceptibility.
- The form of the logistic models used to relate injury risk and injury severity with the available factors influencing these outcomes (including the car models or market groups) was correct.
- Information contained in the Police crash records allowed accurate matching of both vehicles involved in crashes between two light passenger cars, a light passenger vehicle and a heavy vehicle and a light passenger vehicle and unprotected road user for the purpose of calculating the ratings.
- Classification of heavy vehicle type in the police data was accurate.

8.2 Qualifications

The results and conclusions warrant at least the following qualifications:

- Only light vehicle driver crash involvements and injuries have been considered. Passengers occupying the same model cars may have had different injury outcomes.
- Some models with the same name through the 1982-2000 years of manufacture may have varied substantially in their construction and mass. Although there should be few such models in the results, the rating score calculated for these models may give a misleading impression and should be interpreted with caution. However, because most of the analysis in the report focuses on market groups of vehicles only, this is likely to minimise the chance of vehicle misclassification.
- Other factors not collected in the data (e.g. crash speed) may differ between the models and may affect the results. However, earlier analysis has suggested that the different ratings scores are predominantly due to vehicle factors alone (Cameron et al 1992).

- Results of the analysis presented represent the mix of vehicles in the Australian vehicle fleet in each market group. The results from this study may not necessarily be representative of the likely outcomes from the vehicle fleets of other countries that have a significantly different mix of vehicle makes and models than found in Australia.

9. REFERENCES

- Attwell, R. and Glase, K. (2000). *Bull bars and road trauma*. Report Number CR200, Australian Transport Safety Bureau, Canberra, Australia.
- Broughton, J. (1994) *The theoretical basis for comparing the accident record of car models*, Project Report 70, Safety and Environment Resource Centre, Transport Research Laboratory, Crowthorne, Berkshire, U.K.
- Broughton, J. (1996) 'The theoretical basis for comparing the accident record of car models', *Accident Analysis and Prevention*, Vol. 28, No. 1, pp. 89-99.
- Cameron, M.H., Mach, T., Neiger, D., Graham, A., Ramsay, R., Pappas, M. & Haley, J. (1992a) 'Vehicle Crashworthiness Ratings in Australia', *Proceedings, International Conference on the Biomechanics of Impacts*, Verona, Italy, pp. 105-119.
- Cameron, M.H., Mach, T. & Neiger, D. (1992b) *Vehicle Crashworthiness Ratings: Victoria 1983-90 and NSW 1989-90 Crashes - Summary Report*, Report No. 28, Monash University Accident Research Centre, Melbourne, Australia.
- Cameron, M.H., Finch, C.F. & Le, T. (1994a) *Vehicle Crashworthiness Ratings: Victoria and NSW Crashes During 1987-92 - Summary Report*, Report No. 55, Monash University Accident Research Centre, Melbourne, Australia.
- Cameron, M.H., Finch, C.F. & Le, T. (1994b) *Vehicle Crashworthiness Ratings: Victoria and NSW Crashes During 1987-92 - Technical Report*, Report No. 58, Monash University Accident Research Centre, Melbourne, Australia.
- Cameron, M.H., Newstead, S.V. & Le, C.M. (1998) 'Rating the aggressivity of Australian passenger vehicles towards other vehicle occupants and unprotected road users', *Proceedings, International IRCOBI Conference on the Biomechanics of Impact*, Gothenborg, Sweden.
- Gustafsson, H., Hagg, A., Krafft, M., Kullgren, A., Malmstedt, B., Nygren, A. & Tingvall, C. (1989) *Folksam Car Model Safety Rating 1989-90*, Folksam, Stockholm, Sweden.
- Hollowell, W.T. & Gabler, H.C. (1996) 'NHTSA's Vehicle Aggressivity and Compatibility Research Program', *Proceedings, Fifteenth International Technical Conference on the Enhanced Safety of Vehicles*, Melbourne, Australia.
- Hosmer, D.W. & Lemeshow, S. (1989) *Applied Logistic Regression*, Wiley, New York.
- McLean, A.J. (1996) *Pedestrian friendly vehicle front structures: A review of the literature*. Report Number CR166, Australian Transport Safety Bureau, Canberra, Australia.
- Newstead, S., Cameron, M. & Skalova, M. (1996) *Vehicle Crashworthiness Ratings: Victoria and NSW Crashes During 1987-94*, Report No. 92, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Cameron, M. & Le, C.M. (1997) *Vehicle Crashworthiness Ratings and Crashworthiness by Year of Manufacture: Victoria and NSW crashes during 1987-95*, Report No. 107, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Cameron, M. & Le, C.M. (1998) *Vehicle Crashworthiness Ratings and Crashworthiness by Year of Manufacture: Victoria and NSW crashes during 1987-96*, Report No. 128, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Cameron, M.H. & Le, C.M. (1999) *Vehicle Crashworthiness Ratings and Crashworthiness by Year of Manufacture: Victoria and NSW Crashes During 1987-97, Queensland Crashes During 1991-96*, Report No. 150, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Cameron, M.H. & Le, C.M. (2000) *Vehicle Crashworthiness and Aggressivity Ratings and Crashworthiness by Year of Manufacture: Victoria and NSW Crashes During 1987-98 Queensland Crashes During 1991-98*, Report No. 171, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Cameron, M.H. Watson, L., & Delaney, A. (2003) *Vehicle Crashworthiness and Aggressivity Ratings and Crashworthiness by Year of Manufacture: Victoria and NSW Crashes During 1987-2000 Queensland and Western Australia Crashes During 1991-2000*, Report No. 196, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S. & Cameron, M. (2001), 'Trends in Australian vehicle crashworthiness by year of vehicle manufacture within vehicle market groups', *Proceedings of the 2001 IRCOBI Conference*, Isle of Man, UK.

Oxley, P., Newstead, S. & Cameron, M. (2003), 'Estimation of the Safety Benefits of a Fleet Replacement Program in Victoria', *Proceedings of the 2003 Road Safety Research Policing and Education Conference*, Sydney, Australia.

Pappas, M. (1993) *NSW Vehicle Occupant Protection Ratings Documentation*, Report to NRMA Ltd. and Road Safety Bureau, Roads and Traffic Authority, Sydney, NSW.

SAS Inc. (1989) *SAS STAT Users Guide, Version 6, Fourth Edition, Volume 2*. Carey, NC: SAS Institute.

**FREQUENCY OF COLLISIONS BETWEEN HEAVY VEHICLES AND
PASSENGER VEHICLES BY MARKET GROUP**

**VICTORIAN AND NSW CRASHES DURING 1987-2000
WESTERN AUSTRALIA AND QUEENSLAND CRASHES DURING 1991-2000**

**FREQUENCY OF COLLISIONS BETWEEN HEAVY VEHICLES AND PASSENGER VEHICLES
BY MARKET GROUP
(NSW/VIC/QLD/WA)**

Heavy Collision and Market Group	No. of uninjured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD,WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD,WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	Analysis Inclusion Criteria INV=100 INJ=20
Four Wheel Drive							
Articulated Truck	190	106	296	70	47	117	1
Rigid Truck	5769	771	6540	531	153	684	1
Bus	190	41	231	36	9	45	1
Other	30	24	54	16	11	27	0
Commercial							
Articulated Truck	236	123	359	73	44	117	1
Rigid Truck	6327	1050	7377	625	218	843	1
Bus	337	75	412	49	12	61	1
Other	20	18	38	10	11	21	0
Large							
Articulated Truck	1507	574	2081	339	219	558	1
Rigid Truck	8875	1938	10813	1246	418	1664	1
Bus	1342	285	1627	209	68	277	1
Other	107	52	159	59	22	81	1
Luxury							
Articulated Truck	238	74	312	40	42	82	1
Rigid Truck	1347	273	1620	189	45	234	1
Bus	207	36	243	26	4	30	1
Other	8	10	18	11	7	18	0
Medium							
Articulated Truck	575	274	849	159	113	272	1
Rigid Truck	3940	1045	4985	720	257	977	1
Bus	537	111	648	78	29	107	1
Other	26	19	45	16	16	32	0
Passenger Van							
Articulated Truck	47	28	75	17	10	27	0
Rigid Truck	2178	427	2605	275	72	347	1
Bus	296	76	372	51	14	65	1
Other	1	2	3	2	0	2	0
Small							
Articulated Truck	1222	516	1738	286	192	478	1
Rigid Truck	7007	2225	9232	1370	450	1820	1
Bus	1100	275	1375	185	60	245	1
Other	38	45	83	32	31	63	0
Sports							
Articulated Truck	114	29	143	13	9	22	1
Rigid Truck	540	136	676	87	25	112	1
Bus	85	17	102	14	4	18	0

Heavy Collision and Market Group	No. of uninjured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD,WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD,WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	Analysis Inclusion Criteria INV=100 INJ=20
Other	2	3	5	3	1	4	0
Reference Group	21070	4009	25079	1755	720	2475	
Total (included/criteria=1)	65508 (44181)	14687 (10512)	80195 (54693)	8592 (6716)	3333 (2522)	11925 (9238)	27

Note:

- NSW injury severity data for 1999 and 2000 was not included in the analysis because of changes in injury severity coding that resulted in inaccurate injury severity reporting.
- Records on uninjured drivers in crashes in Victoria are incomplete as only crashes involving injury are reliably reported. Hence Victorian data is not included in the injury risk analysis
- Shaded market group and heavy collision combination not satisfying inclusion criteria not included in analysis

**CRASHWORTHINESS, INJURY RISK AND INJURY SEVERITY ESTIMATES BY
MARKET GROUPS FOR PASSENGER VEHICLES IN COLLISIONS WITH HEAVY
VEHICLES**

**CRASHWORTHINESS INJURY RISK RATINGS FOR MARKET GROUPS
BY HEAVY VEHICLE COLLISIONS**

Market Group and Heavy Collision Partner	Coefficient	Standard Error of Coefficient	Pr(Risk) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE	-1.5026		18.20			
Four Wheel Drive						
Articulated Truck	0.5377	0.1243	27.59	23.00	32.71	9.71
Rigid Truck	-0.4942	0.0438	11.95	11.08	12.89	1.81
Bus	-0.0848	0.1721	16.97	12.73	22.27	9.53
Commercial						
Articulated Truck	0.5634	0.1133	28.11	23.84	32.80	8.96
Rigid Truck	-0.2186	0.0397	15.17	14.20	16.20	2.00
Bus	0.0172	0.1273	18.46	15.00	22.51	7.52
Large						
Articulated Truck	0.2079	0.0533	21.51	19.79	23.32	3.53
Rigid Truck	-0.1198	0.0327	16.49	15.62	17.39	1.77
Bus	-0.0842	0.0681	16.98	15.18	18.95	3.77
Luxury						
Articulated Truck	-0.0193	0.1331	17.92	14.40	22.08	7.68
Rigid Truck	-0.2244	0.0687	15.10	13.45	16.90	3.45
Medium						
Articulated Truck	0.4134	0.0762	25.18	22.47	28.09	5.62
Rigid Truck	0.0341	0.0408	18.72	17.53	19.96	2.43
Bus	-0.1849	0.1048	15.61	13.09	18.51	5.42
Passenger Van						
Rigid Truck	-0.0572	0.0566	17.37	15.83	19.02	3.18
Bus	0.1151	0.128	19.98	16.27	24.29	8.03
Small						
Articulated Truck	0.2552	0.0566	22.31	20.45	24.30	3.85
Rigid Truck	0.1505	0.0329	20.55	19.52	21.62	2.11
Bus	-0.0435	0.0704	17.56	15.65	19.65	4.00
Sports						
Articulated Truck	-0.0320	0.2067	17.73	12.57	24.43	11.86
Rigid Truck	0.0627	0.0967	19.16	16.39	22.26	5.87

**CRASHWORTHINESS INJURY SEVERITY RATINGS OF MARKET GROUPS
BY HEAVY VEHICLE COLLISIONS**

Market Group and Heavy Collision Partner	Coefficient	Standard Error of Coefficient	Pr(Severity) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE	-0.9605		27.68			
Four Wheel Drive						
Articulated Truck	0.2677	0.1967	33.34	25.38	42.38	17.00
Rigid Truck	-0.3235	0.1021	21.69	18.48	25.28	6.80
Bus	-0.4145	0.3719	20.18	10.87	34.39	23.52
Commercial						
Articulated Truck	0.1065	0.1962	29.86	22.47	38.48	16.01
Rigid Truck	-0.0559	0.0909	26.57	23.25	30.19	6.95
Bus	-0.2468	0.319	23.02	13.79	35.85	22.05
Large						
Articulated Truck	0.2591	0.0979	33.15	29.04	37.53	8.49
Rigid Truck	-0.1036	0.0714	25.65	23.08	28.41	5.34
Bus	-0.0426	0.1466	26.83	21.58	32.83	11.25
Luxury						
Articulated Truck	0.7478	0.2258	44.70	34.18	55.72	21.54
Rigid Truck	-0.4950	0.1709	18.92	14.30	24.59	10.29
Medium						
Articulated Truck	0.3784	0.1315	35.85	30.16	41.96	11.80
Rigid Truck	-0.00449	0.0852	27.59	24.38	31.05	6.67
Bus	0.0605	0.223	28.91	20.80	38.63	17.83
Passenger Van						
Rigid Truck	-0.1864	0.1382	24.11	19.50	29.40	9.90
Bus	-0.0654	0.3011	26.39	16.58	39.28	22.70
Small						
Articulated Truck	0.3969	0.1041	36.27	31.70	41.11	9.41
Rigid Truck	-0.0412	0.0711	26.86	24.21	29.69	5.47
Bus	0.0548	0.1555	28.79	22.96	35.41	12.45
Sports						
Articulated Truck	0.7310	0.4358	44.29	25.28	65.13	39.85
Rigid Truck	-0.1683	0.2299	24.44	17.09	33.67	16.58

**CRASHWORTHINESS RATINGS OF MARKET GROUPS
BY HEAVY VEHICLE COLLISIONS**

Market Group and Heavy Collision Partner	Pr(Risk) %	Pr(Severity) %	Serious injury rate per 100 drivers involved	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE	18.20	27.68	5.04			
Four Wheel Drive						
Articulated Truck	27.59	33.34	9.20	6.74	12.56	5.83
Rigid Truck	11.95	21.69	2.59	2.18	3.09	0.91
Bus	16.97	20.18	3.43	1.80	6.53	4.74
Commercial						
Articulated Truck	28.11	29.86	8.39	6.13	11.48	5.35
Rigid Truck	15.17	26.57	4.03	3.48	4.67	1.19
Bus	18.46	23.02	4.25	2.52	7.17	4.65
Large						
Articulated Truck	21.51	33.15	7.13	6.12	8.30	2.18
Rigid Truck	16.49	25.65	4.23	3.76	4.75	0.99
Bus	16.98	26.83	4.56	3.59	5.78	2.19
Luxury						
Articulated Truck	17.92	44.70	8.01	5.79	11.09	5.30
Rigid Truck	15.10	18.92	2.86	2.13	3.83	1.71
Medium						
Articulated Truck	25.18	35.85	9.02	7.39	11.02	3.63
Rigid Truck	18.72	27.59	5.16	4.50	5.92	1.42
Bus	15.61	28.91	4.51	3.16	6.44	3.28
Passenger Van						
Rigid Truck	17.37	24.11	4.19	3.34	5.24	1.90
Bus	19.98	26.39	5.27	3.27	8.51	5.24
Small						
Articulated Truck	22.31	36.27	8.09	6.92	9.46	2.54
Rigid Truck	20.55	26.86	5.52	4.93	6.19	1.26
Bus	17.56	28.79	5.06	3.96	6.46	2.50
Sports						
Articulated Truck	17.73	44.29	7.85	4.39	14.04	9.65
Rigid Truck	19.16	24.44	4.68	3.22	6.80	3.58

**FREQUENCY OF SINGLE VEHICLE COLLISIONS
BY MODEL AND MARKET GROUP**

and

BY ROLLOVER STATUS AND MARKET GROUP

**VICTORIAN AND NSW CRASHES DURING 1987-2000
WESTERN AUSTRALIA AND QUEENSLAND CRASHES DURING 1991-2000**

FREQUENCY OF EACH MODEL FOR SINGLE VEHICLE COLLISIONS (NSW/VIC/QLD/WA)

MAKE/MODEL		MODEL CODE	No. of Uninjured Drivers in NSW(87-2000) And QLD, WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	ANALYSIS INCLUSION CRITERIA INV=100 INJ=20	MARKET GROUP	
Alfa Romeo	164	89-92	AL01Z	3	1	4	1	1	2	0	
Alfa Romeo	33	83-92	AL02Z	46	26	72	17	9	26	0	
Alfa Romeo	75	86-92	AL03Z	9	1	10	1	0	1	0	
Alfa Romeo	90	85-88	AL04Z	4	4	8	3	1	4	0	
Alfa Romeo	GTV	82-84	AL05Z	13	4	17	2	2	4	0	
Alfa Romeo	Sprint	82-88	AL06Z	8	4	12	3	1	4	0	
Alfa Romeo	Alfasud	82-84	AL07Z	16	3	19	2	1	3	0	
Alfa Romeo	Alfetta	82-88	AL08Z	6	4	10	1	3	4	0	
Alfa Romeo	Guilietta	82-86	AL09Z	4	2	6	2	0	2	0	
Alfa Romeo	156	99-00	AL13Z	2	0	2	.	.	.	0	
Alfa Romeo	166	99-00	AL14Z	2	0	2	1	0	1	0	
Audi	A4	95-00	AUD3Z	6	4	10	2	3	5	0	
Audi	A3/S3	97-00	AUD5Z	1	0	1	1	0	1	0	
Audi	TT	99-00	AUD6Z	1	0	1	.	.	.	0	
BMW	Z3	97-00	BM10Z	4	2	6	2	1	3	0	
BMW	3 Series	82-91	BM3 A	218	60	278	41	20	61	1	Luxury
BMW	3 Series	92-98	BM3 B	147	50	197	34	19	53	1	Luxury
BMW	3 Series	99-00	BM3 C	4	3	7	3	0	3	0	
BMW	5 Series	82-88	BM5 A	43	12	55	10	3	13	0	
BMW	5 Series	89-95	BM5 B	32	13	45	9	7	16	0	
BMW	5 Series	96-00	BM5 C	7	1	8	1	0	1	0	
BMW	6 Series	86-89	BM6 Z	1	0	1	.	.	.	0	
BMW	7 Series	82-88	BM7 A	19	1	20	2	0	2	0	
BMW	7 Series	89-94	BM7 B	2	3	5	2	2	4	0	
BMW	7 Series	95-00	BM7 C	1	0	1	1	0	1	0	
Chrysler	Voyager	97-00	CHR1Z	4	2	6	1	1	2	0	
Chrysler	Neon	96-99	CHR2Z	9	4	13	1	1	2	0	
Citroen	BX	86-94	CI1 Z	6	1	7	1	1	2	0	
Citroen	AX	91-93	CI3 Z	1	1	2	1	0	1	0	
Citroen	Xanitia	94-00	CI4 Z	3	2	5	1	1	2	0	
Citroen	Xsara	00-00	CI6 Z	1	0	1	1	0	1	0	
Daihatsu	Charade	82-86	D1 A	138	73	211	57	29	86	1	Small
Daihatsu	Charade	88-92	D1 C	311	198	509	127	67	194	1	Small

MAKE/MODEL		MODEL CODE	No. of Uninjured Drivers in NSW(87-2000) And QLD, WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	ANALYSIS INCLUSION CRITERIA INV=100 INJ=20	MARKET GROUP	
Daihatsu	Charade	93-00	D1 D	219	134	353	68	47	115	1	Small
Daihatsu	Feroza	89-97	D11 Z	65	43	108	33	14	47	1	4WD
Daihatsu	Handivan	82-90	D12 Z	48	37	85	26	8	34	0	
Daihatsu	Hi-Jet	82-90	D13 Z	22	14	36	12	3	15	0	
Daihatsu	Rocky	84-99	D14 Z	80	69	149	40	28	68	1	4WD
Daihatsu	Pyzar	97-00	D15 Z	3	4	7	1	1	2	0	
Daihatsu	Move	97-99	D16 Z	1	2	3	2	0	2	0	
Daihatsu	Sirion	98-00	D17 Z	8	13	21	7	2	9	0	
Daihatsu	Terios	97-00	D18 Z	15	15	30	8	7	15	0	
Daihatsu	Handivan / Cuore	99-00	D19 Z	1	0	1	.	.	.	0	
Daihatsu	Applause	89-99	D2 Z	114	54	168	37	22	59	1	Small
Daihatsu	Mira	90-96	D3 Z	39	30	69	17	11	28	0	
Daewoo	1.5i	94-95	DA01Z	19	5	24	3	2	5	0	
Daewoo	Cielo	95-97	DA03Z	88	57	145	34	28	62	1	Small
Daewoo	Espero	95-97	DA05Z	20	8	28	3	2	5	0	
Daewoo	Nubira	97-00	DA06Z	31	13	44	7	4	11	0	
Daewoo	Lanos	97-00	DA07Z	55	26	81	16	11	27	0	
Daewoo	Leganza	97-00	DA08Z	11	5	16	3	2	5	0	
Daewoo	Musso	98-00	DA09Z	1	2	3	3	0	3	0	
Daewoo	Matiz	99-00	DA10Z	3	3	6	1	0	1	0	
Ford	Laser	91-94	F01 C	577	267	844	210	87	297	1	Small
Ford	Laser	95-98	F01 D	86	39	125	26	21	47	1	Small
Ford	Cortina	82-82	F02 Z	5	4	9	8	1	9	0	
Ford	Escort	82-82	F05 Z	4	1	5	1	0	1	0	
Ford	Falcon XE/XF	82-88	F06 Z	5325	2197	7522	1637	940	2577	1	Large
Ford	Fairlane Z & LTD F	82-87	F07 Z	329	149	478	110	84	194	1	Luxury
Ford	Falcon EA/Falcon EB Series I	88-Mar 92	F08 C	2613	1114	3727	846	429	1275	1	Large
Ford	Falcon EB Series II/Falcon ED	Apr 92-94	F08 D	1088	460	1548	326	185	511	1	Large
Ford	Fairlane N & LTD D	88-94	F09 A	324	114	438	83	58	141	1	Luxury
Ford	Fairlane N & LTD D	95-98	F09 B	51	24	75	23	12	35	0	
Ford	Fairlane & LTD AU	99-00	F09 C	1	1	2	1	1	2	0	
Ford	Mondeo	95-00	F10 Z	38	26	64	18	7	25	0	
Ford	Capri	89-94	F43 Z	47	34	81	25	15	40	0	
Ford	Festiva WD/WD/WH/WF	94-00	F44 B	206	182	388	109	68	177	1	Small
Ford	Falcon Panel Van	82-95	F45 A	343	110	453	73	41	114	1	Commercial
Ford	Falcon Panel Van	96-99	F45 B	89	7	96	9	2	11	0	
Ford/Nissan	Falcon Ute/XFN Ute	82-95/88-90	F46 A	1029	359	1388	207	138	345	1	Commercial

MAKE/MODEL			MODEL CODE	No. of Uninjured Drivers in NSW(87-2000) And QLD, WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	ANALYSIS INCLUSION CRITERIA INV=100 INJ=20	MARKET GROUP
Ford	Falcon Ute	96-99	F46 B	118	46	164	34	17	51	1	Commercial
Ford	Falcon Ute AU	00-00	F46 D	8	2	10	2	1	3	0	
Ford	Ford F-Series	82-92	F47 Z	65	29	94	22	7	29	0	
Ford	Bronco	82-87	F56 Z	7	9	16	5	4	9	0	
Ford	Probe	94-98	F61 Z	6	5	11	3	2	5	0	
Ford	Falcon EF/EL	94-98	F62 Z	1743	706	2449	513	288	801	1	Large
Ford	Transit	94-00	F64 Z	15	6	21	9	2	11	0	
Ford	Falcon AU	98-00	F66 Z	256	102	358	66	27	93	1	Large
Ford	Taurus	96-98	F67 Z	18	8	26	5	3	8	0	
Ford	Ka	99-00	F68 Z	1	1	2	1	1	2	0	
Ford	Cougar	99-00	F69 Z	1	1	2	1	0	1	0	
Ford	Courier	98-00	F70 Z	5	3	8	1	0	1	0	
Fiat	Argenta	83-85	FI01Z	2	2	4	1	1	2	0	
Fiat	Croma	88-89	FI02Z	2	0	2	.	.	.	0	
Fiat	Regata	84-89	FI03Z	19	1	20	1	0	1	0	
Fiat	Superbrava	82-85	FI04Z	6	0	6	2	3	5	0	
Holden/Toyota	Commodore VN/VP/Lexcen	89-93	H1 Z	4080	1777	5857	1259	734	1993	1	Large
Holden	Calibra	91-97	H12 Z	12	4	16	3	2	5	0	
Holden	Statesman/Caprice WB	82-85	H14 A	10	3	13	3	7	10	0	
Holden	Stateman/Caprice VQ	90-93	H14 B	76	33	109	24	18	42	1	Luxury
Holden	Stateman/Caprice VR/VS	94-98	H14 C	114	47	161	34	26	60	1	Luxury
Holden	Commodore Ute VG/VP	90-93	H18 Z	150	74	224	38	27	65	1	Commercial
Holden	Camria	82-89	H2 Z	1087	601	1688	488	233	721	1	Medium
Holden	Jackaroo	82-91	H21 A	59	38	97	32	7	39	0	
Holden	Jackaroo	92-97	H21 B	15	21	36	17	7	24	0	
Holden	Jackaroo	98-00	H21 C	9	10	19	6	5	11	0	
Holden	Piazza	86-88	H23 Z	2	2	4	2	0	2	0	
Holden	Rodeo	82-85	H24 A	56	32	88	17	10	27	0	
Holden	Rodeo	86-88	H24 B	25	14	39	10	4	14	0	
Holden	Rodeo	89-95	H24 C	311	202	513	108	80	188	1	Commercial
Holden	Rodeo	96-98	H24 D	108	80	188	45	21	66	1	Commercial
Holden	Rodeo	99-00	H24 E	38	17	55	7	4	11	0	
Holden	Shuttle	82-87	H26 Z	37	27	64	17	9	26	0	
Holden	WB Series	82-85	H27 Z	223	96	319	41	44	85	1	Commercial
Holden	Gemini	82-84	H3 A	598	301	899	251	119	370	1	Small
Holden	Gemini RB	86-87	H3 C	34	25	59	18	10	28	0	
Holden/Toyota	Commodore VR/VS/Lexcen	93-97	H33 Z	2356	858	3214	629	350	979	1	Large

MAKE/MODEL		MODEL CODE	No. of Uninjured Drivers in NSW(87-2000) And QLD, WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	ANALYSIS INCLUSION CRITERIA INV=100 INJ=20	MARKET GROUP	
Holden	Commodore Ute VR/VS	94-00	H34 Z	413	160	573	93	64	157	1	Commercial
Holden	Frontera	95-00	H35 Z	1	2	3	4	0	4	0	
Holden	Vectra	97-00	H36 Z	20	15	35	9	4	13	0	
Holden	Commodore VT/VX	97-00	H37 Z	643	202	845	137	79	216	1	Large
Holden	Statesman/Caprice WH	99-00	H39 Z	13	6	19	5	2	7	0	
Holden	Astra TR	96-98	H4 D	24	13	37	8	2	10	0	
Holden	Astra TS	98-00	H4 E	12	5	17	1	1	2	0	
Holden	Commodore VU Ute	00-00	H41 Z	3	0	3	.	.	.	0	
Holden	Barina SB	95-00	H5 D	177	113	290	60	45	105	1	Small
Holden	Commodore VB-VL	82-88	H6 Z	5874	2356	8230	1678	954	2632	1	Large
Hyundai	Excel	82-89	HY1 A	153	85	238	76	44	120	1	Small
Hyundai	Excel	90-94	HY1 B	466	276	742	199	111	310	1	Small
Hyundai	Excel	95-00	HY1 C	669	408	1077	260	143	403	1	Small
Hyundai	Sonata	98-00	HY15Z	1	2	3	2	1	3	0	
Hyundai	Sonata	89-97	HY2 Z	103	50	153	40	19	59	1	Large
Hyundai	S Coupe	90-96	HY4 Z	47	32	79	22	11	33	0	
Hyundai	Lantra	91-95	HY5 A	85	39	124	29	17	46	1	Small
Hyundai	Lantra	96-00	HY5 B	76	17	93	14	8	22	0	
Hyundai	Coupe	96-00	HY7 Z	27	9	36	8	4	12	0	
Hyundai	Grandeur	99-00	HY8 Z	3	2	5	1	0	1	0	
Hyundai	Accent	00-00	HY9 Z	1	3	4	1	1	2	0	
Mitsubishi	Colt	82-88	I01 Z	864	513	1377	398	177	575	1	Small
Mitsubishi	Sigma/Scorpion	82-86	I02 Z	921	395	1316	352	182	534	1	Medium
Mitsubishi	Magna TM/TN/TP	85-90	I04 Z	1200	577	1777	447	255	702	1	Large
Mitsubishi	Magna TE/TF/TH/TJ/Verada KE/KF/KH/KJ	96-00	I06 A	532	218	750	158	87	245	1	Large
Mitsubishi	Starion	82-87	I07 Z	19	12	31	6	6	12	0	
Mitsubishi	Lancer CA	88-90	I09 A	243	121	364	89	45	134	1	Small
Mitsubishi	Lancer CC	93-95	I09 C	219	102	321	72	50	122	1	Small
Mitsubishi	Lancer CE/Mirage	96-00	I09 D	232	94	326	56	19	75	1	Small
Mitsubishi	Nimbus	84-91	I10 A	25	16	41	16	5	21	0	
Mitsubishi	Nimbus	92-98	I10 B	14	10	24	4	1	5	0	
Mitsubishi	Nimbus	99-00	I10 C	9	3	12	2	1	3	0	
Mitsubishi	Cordia	82-89	I12 Z	149	49	198	39	20	59	1	Small
Mitsubishi	Verada KR/KS/Magna TR/TS	91-96	I15 Z	488	241	729	191	108	299	1	Large
Mitsubishi	Galant	95-96	I16 B	63	35	98	18	15	33	0	
Mitsubishi	Starwagon/L300	82-86	I23 A	251	138	389	79	49	128	1	Passenger Van

MAKE/MODEL		MODEL CODE	No. of Uninjured Drivers in NSW(87-2000) And QLD, WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	ANALYSIS INCLUSION CRITERIA INV=100 INJ=20	MARKET GROUP	
Mitsubishi	Starwagon	87-94	I23 B	255	167	422	107	58	165	1	Passenger Van
Mitsubishi	Starwagon	95-00	I23 C	53	24	77	15	6	21	0	
Mitsubishi	Pajero	82-90	I25 A	131	96	227	57	39	96	1	4WD
Mitsubishi	Pajero	92-99	I25 C	101	74	175	54	27	81	1	4WD
Mitsubishi	3000GT	92-97	I26 Z	1	0	1	1	0	1	0	
Mitsubishi	Challenger	98-00	I30 Z	2	3	5	3	0	3	0	
Mitsubishi	Pajero iO	99-00	I34 Z	1	0	1	.	.	.	0	
Mitsubishi	Pajero NM	00-00	I35 Z	2	0	2	1	0	1	0	
Jaguar	XJ6	82-86	J01 A	16	8	24	6	2	8	0	
Jaguar	XJ6	87-94	J01 B	22	7	29	5	3	8	0	
Jaguar	XJ6	95-97	J01 C	5	1	6	1	0	1	0	
Jaguar	XJS	82-96	J04 Z	5	2	7	2	0	2	0	
Jaguar	XK8	96-00	J07 Z	2	1	3	.	.	.	0	
Jaguar	S-Type	99-00	J08 Z	1	0	1	.	.	.	0	
Jeep	Cherokee	82-00	JE01Z	29	13	42	11	8	19	0	
Jeep	Grand Cherokee	96-99	JE02Z	4	2	6	1	2	3	0	
Jeep	Wrangler	96-00	JE03Z	7	0	7	1	1	2	0	
Kia	Sportage	98-00	K01 Z	4	1	5	1	0	1	0	
Kia	Ceres	92-00	K02 Z	4	3	7	3	0	3	0	
Kia	Rio	00-00	K05 Z	1	0	1	1	0	1	0	
Land Rover	Defender	92-00	LRO1Z	14	14	28	9	5	14	0	
Land Rover	Discovery	91-00	LRO2Z	26	23	49	15	7	22	0	
Ford/Mazda	Laser/323	82-88	M01 A	2580	1455	4035	1097	522	1619	1	Small
Mazda	323	90-93	M01 C	123	58	181	39	21	60	1	Small
Mazda	323	95-98	M01 E	86	31	117	19	16	35	1	Small
Ford/Mazda	Laser/323	99-00	M01 F	14	5	19	3	0	3	0	
Ford/Mazda	Telstar/626/MX6	83-86	M02 B	512	281	793	203	108	311	1	Medium
Ford/Mazda	Telstar/626/MX6	88-91	M02 D	173	70	243	53	28	81	1	Medium
Ford/Mazda	Telstar/626/MX6	92-97	M02 E	121	62	183	41	29	70	1	Medium
Mazda	626	98-00	M02 F	9	7	16	3	2	5	0	
Mazda	929	82-90	M03 A	196	96	292	75	42	117	1	Luxury
Mazda	929	92-97	M03 C	8	6	14	7	0	7	0	
Ford/Mazda	Festiva WA/121	91-93/87-90	M09 A	301	199	500	127	87	214	1	Small
Mazda	121	94-96	M09 B	74	56	130	45	13	58	1	Small
Mazda	121 Metro	97-00	M09 C	17	17	34	12	8	20	0	
Mazda	RX7	82-85	M10 A	65	29	94	25	12	37	0	
Mazda	RX7	86-91	M10 B	38	5	43	5	1	6	0	

MAKE/MODEL			MODEL CODE	No. of Uninjured Drivers in NSW(87-2000) And QLD, WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	ANALYSIS INCLUSION CRITERIA INV=100 INJ=20	MARKET GROUP
Mazda	RX7	92-98	M10 C	9	2	11	2	1	3	0	
Mazda	MX5	89-97	M11 A	35	12	47	9	1	10	0	
Mazda	MX5	98-00	M11 B	1	0	1	2	2	4	0	
Mazda	MPV	93-99	M15 A	5	1	6	1	1	2	0	
Mazda	Eunos 30X	96-97	M16 Z	18	7	25	7	2	9	0	
Mazda	Eunos 500	96-99	M17 Z	5	3	8	2	2	4	0	
Mazda	Eunos 800	96-99	M18 Z	2	1	3	.	.	.	0	
Mercedes Benz	C-Class W201	87-94	ME11Z	26	7	33	8	1	9	0	
Mercedes Benz	C-Class W202	95-00	ME12Z	30	5	35	5	3	8	0	
Mercedes Benz	CLK C208	97-00	ME13Z	2	0	2	.	.	.	0	
Mercedes Benz	E-Class W123	82-85	ME14Z	14	6	20	4	2	6	0	
Mercedes Benz	E-Class W124	86-95	ME15Z	34	8	42	6	6	12	0	
Mercedes Benz	E-Class W201	96-00	ME16Z	15	5	20	4	1	5	0	
Mercedes Benz	S-Class W126	82-92	ME18Z	22	7	29	3	4	7	0	
Mercedes Benz	S-Class R129	93-00	ME19Z	3	0	3	.	.	.	0	
Mercedes Benz	S-Class C140	93-99	ME20Z	5	0	5	.	.	.	0	
Mercedes Benz	SLK R170	97-00	ME21Z	7	2	9	1	0	1	0	
Mercedes Benz	A-Class W168	98-00	ME22Z	1	0	1	2	1	3	0	
Mercedes Benz	Vito	99-00	ME26Z	2	2	4	1	0	1	0	
Mercedes Benz	Sprinter	98-00	ME30Z	1	0	1	4	0	4	0	
Holden/Nissan	Astra/Pulsar/Vector	84-86	N01 A	706	397	1103	320	171	491	1	Small
Holden/Nissan	Astra/Pulsar/Vector	88-90	N01 C	629	314	943	215	125	340	1	Small
Nissan	Pulsar	92-95	N01 E	251	112	363	77	45	122	1	Small
Nissan	Pulsar	96-99	N01 F	150	72	222	35	22	57	1	Small
Nissan	Pintara	86-88	N02 A	278	134	412	97	59	156	1	Medium
Nissan/Ford	Pintara/Corsair	89-92	N02 B	368	196	564	138	84	222	1	Medium
Nissan	Bluebird	82-86	N03 Z	1077	542	1619	392	213	605	1	Medium
Nissan	Skyline	82-90	N04 Z	373	168	541	122	76	198	1	Large
Nissan	300ZX	86-97	N09 Z	39	12	51	9	9	18	0	
Nissan	Stanza	82-83	N10 Z	50	32	82	25	7	32	0	
Nissan	280C	82-84	N11 Z	6	2	8	2	0	2	0	
Nissan	Gazelle	84-88	N12 Z	33	16	49	48	45	93	0	
Nissan	280ZX	82-84	N13 Z	10	6	16	6	4	10	0	
Nissan	Prairie	84-86	N14 Z	18	12	30	6	4	10	0	
Nissan	Maxima	90-94	N15 A	21	11	32	8	6	14	0	
Nissan	Maxima	95-99	N15 B	14	10	24	5	6	11	0	
Nissan	Maxima	00-00	N15 C	1	1	2	.	.	.	0	

MAKE/MODEL		MODEL CODE	No. of Uninjured Drivers in NSW(87-2000) And QLD, WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	ANALYSIS INCLUSION CRITERIA INV=100 INJ=20	MARKET GROUP	
Nissan	Exa	83-86	N16 A	38	19	57	13	7	20	0	
Nissan	Exa	87-91	N16 B	17	6	23	4	5	9	0	
Nissan	NX/NX-R	91-96	N17 Z	27	23	50	13	14	27	0	
Nissan	300C	84-88	N20 Z	3	6	9	2	3	5	0	
Nissan	720 Ute	82-85	N21 Z	169	74	243	44	23	67	1	Commercial
Nissan	Navara	86-91	N24 A	234	131	365	85	49	134	1	Commercial
Nissan	Navara	92-96	N24 B	61	34	95	28	9	37	0	
Nissan	Navara	97-00	N24 C	11	1	12	1	0	1	0	
Nissan	Patrol	82-87	N26 A	134	53	187	34	22	56	1	4WD
Nissan/Ford	Patrol/Maverick	88-97	N26 B	342	185	527	131	82	213	1	4WD
Nissan	Patrol	98-00	N26 C	27	13	40	13	3	16	0	
Nissan	Pathfinder	88-94	N27 Z	23	13	36	12	6	18	0	
Nissan	Serena	92-95	N30 Z	4	3	7	2	1	3	0	
Nissan	Bluebird	93-97	N32 Z	30	8	38	4	3	7	0	
Nissan	200SX	94-00	N33 Z	45	15	60	4	4	8	0	
Nissan	Micra	95-97	N34 Z	34	17	51	9	8	17	0	
Nissan	Pathfinder	95-00	N36 Z	14	9	23	6	4	10	0	
Nissan	Terrano II	97-99	N38 Z	1	0	1	1	0	1	0	
Nissan	Pulsar	00-00	N39 Z	1	1	2	1	0	1	0	
Lada	Niva	83-98	NIVAZ	29	13	42	14	3	17	0	
Honda	Civic	82-83	O1 A	45	31	76	22	12	34	0	
Honda	Civic	84-87	O1 B	114	57	171	40	28	68	1	Small
Honda	Civic	88-91	O1 C	160	65	225	41	31	72	1	Small
Honda	Civic	92-95	O1 D	163	74	237	42	30	72	1	Small
Honda	Civic	96-00	O1 E	72	26	98	14	6	20	0	
Honda	CRX	87-91	O10 A	38	11	49	6	7	13	0	
Honda	CRX	92-98	O10 B	15	5	20	4	3	7	0	
Honda	Odyssey	95-00	O17 A	7	0	7	.	.	.	0	
Honda	CR-V	97-00	O18 Z	6	4	10	1	4	5	0	
Honda	HR-V	99-00	O19 Z	2	1	3	2	0	2	0	
Honda	Legend	86-95	O2 B	27	8	35	5	3	8	0	
Honda	S2000	99-00	O20 Z	4	0	4	.	.	.	0	
Honda	Civic	1-Jan	O21 Z	1	0	1	.	.	.	0	
Honda	Accord	82-85	O3 A	136	68	204	48	20	68	1	Luxury
Honda	Accord	86-90	O3 B	70	40	110	24	12	36	1	Luxury
Honda	Accord	91-93	O3 C	31	12	43	7	8	15	0	
Honda	Accord	94-98	O3 D	40	13	53	9	8	17	0	

MAKE/MODEL			MODEL CODE	No. of Uninjured Drivers in NSW(87-2000) And QLD, WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	ANALYSIS INCLUSION CRITERIA INV=100 INJ=20	MARKET GROUP
Honda	Accord	99-00	O3 E	3	0	3	.	.	.	0	
Honda	Prelude	82-82	O4 A	17	10	27	9	1	10	0	
Honda	Prelude	83-91	O4 B	148	61	209	50	25	75	1	Sports
Honda	Prelude	92-96	O4 C	44	15	59	12	12	24	0	
Honda	Prelude	97-00	O4 D	14	8	22	5	0	5	0	
Honda	Integra	86-88	O5 A	37	15	52	9	9	18	0	
Honda	Integra	90-92	O5 C	29	10	39	8	4	12	0	
Honda	Integra	93-00	O5 E	19	6	25	7	2	9	0	
Honda	Concerto	88-93	O6 Z	18	13	31	9	4	13	0	
Honda	NSX	91-00	O7 Z	2	0	2	.	.	.	0	
Honda	Acty	83-86	O8 Z	20	13	33	7	6	13	0	
Honda	City	83-86	O9 Z	18	21	39	12	7	19	0	
Peugoet	205	87-94	PE1 Z	24	6	30	4	1	5	0	
Peugeot	405	89-97	PE2 Z	27	8	35	7	1	8	0	
Peugeot	505	82-93	PE3 Z	42	19	61	19	12	31	0	
Peugeot	306	94-00	PE4 Z	20	14	34	10	4	14	0	
Peugeot	605	94-96	PE5 Z	4	0	4	.	.	.	0	
Peugeot	406	96-00	PE7 Z	3	1	4	1	0	1	0	
Peugeot	206	99-00	PE8 Z	2	0	2	1	0	1	0	
Porsche	944	82-91	PO1 Z	7	3	10	1	3	4	0	
Porsche	911	82-00	PO2 Z	4	0	4	2	0	2	0	
Proton	Wira	95-96	PRO1Z	11	7	18	4	5	9	0	
Proton	Satria	97-00	PRO2Z	1	0	1	1	0	1	0	
Renault	20	82-83	RE1 Z	1	0	1	1	0	1	0	
Renault	Feugo	82-87	RE2 Z	23	12	35	11	3	14	0	
Renault	25	85-91	RE4 Z	2	0	2	.	.	.	0	
Renault	19	91-96	RE5 Z	9	3	12	2	0	2	0	
Renault	Laguna	95-96	RE7 Z	1	2	3	1	0	1	0	
Rover	3500	82-87	RO Z	12	4	16	4	0	4	0	
Rover	Quintet	82-86	RO2 Z	23	8	31	5	5	10	0	
Rover	825	87-88	RO3 Z	3	0	3	.	.	.	0	
Rover	MGF	99-00	RO4 Z	9	2	11	1	1	2	0	
Landrover	Freelander	98-00	RO5 Z	1	0	1	.	.	.	0	
Land Rover	Range Rover	82-94	RROV1	67	39	106	39	21	60	1	4WD
Land Rover	Range Rover	95-00	RROV2	1	1	2	4	2	6	0	
Saab	900 Series	82-93	SA1 A	47	20	67	18	11	29	0	
Saab	900/9-3	94-00	SA1 B	19	4	23	3	2	5	0	

MAKE/MODEL		MODEL CODE	No. of Uninjured Drivers in NSW(87-2000) And QLD, WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	ANALYSIS INCLUSION CRITERIA INV=100 INJ=20	MARKET GROUP	
Saab	9000	86-98	SA2 Z	31	7	38	6	1	7	0	
Seat	Ibiza	95-99	SE01Z	2	0	2	2	0	2	0	
Subaru	1800/ Leone	82-95	SU1 Z	629	355	984	248	141	389	1	Medium
Subaru	Liberty	89-94	SU2 A	177	87	264	70	37	107	1	Medium
Subaru	Liberty	95-98	SU2 B	66	24	90	13	9	22	0	
Subaru	Liberty	99-00	SU2 C	12	9	21	3	1	4	0	
Subaru	Vortex	85-89	SU3 Z	4	1	5	1	0	1	0	
Subaru	Sherpa/Fiori	89-92	SU4 Z	52	51	103	39	11	50	1	Small
Subaru	SVX	92-97	SU5 Z	3	0	3	.	.	.	0	
Subaru	Brumby	82-93	SU6 Z	354	198	552	114	80	194	1	Commercial
Subaru	Impreza	93-00	SU7 A	99	40	139	21	19	40	1	Small
Subaru	Forester	97-00	SU8 Z	5	6	11	7	2	9	0	
Suzuki	Swift	82-85	SZ01A	23	14	37	12	3	15	0	
Holden/Suzuki	Barina/Swift	85-88	SZ01B	200	165	365	121	62	183	1	Small
Holden/Suzuki	Barina/Swift	89-93/89-99	SZ01C	627	334	961	217	110	327	1	Small
Suzuki	Vitara	88-98	SZ02A	141	92	233	67	29	96	1	4WD
Suzuki	Grand Vitara	99-00	SZ02B	2	1	3	.	.	.	0	
Suzuki	Hatch	82-85	SZ03Z	72	84	156	57	26	83	1	Small
Holden/Suzuki	Scurry/Carry	85-87/82-00	SZ04Z	75	37	112	26	9	35	1	Commercial
Suzuki	Alto	85-98	SZ05Z	9	11	20	10	2	12	0	
Suzuki	Mighty Boy	85-88	SZ06Z	50	36	86	27	9	36	0	
Holden/Suzuki	Drover/Sierra	85-87/82-00	SZ07Z	444	356	800	252	99	351	1	4WD
Suzuki	Baleno	95-00	SZ08Z	28	16	44	8	2	10	0	
Suzuki	Carry	99-00	SZ09Z	1	0	1	.	.	.	0	
Suzuki	Jimny	98-00	SZ11Z	4	0	4	2	1	3	0	
Toyota	Corolla	82-84	T01 A	587	329	916	251	125	376	1	Small
Toyota	Corolla	86-88	T01 C	964	528	1492	389	192	581	1	Small
Toyota/Holden	Corolla/Nova	89-93	T01 E	1013	572	1585	388	227	615	1	Small
Toyota/Holden	Corolla/Nova	94-98/94-96	T01 F	429	208	637	148	82	230	1	Small
Toyota	Corolla	98-00	T01 G	23	12	35	6	1	7	0	
Toyota	Corona	82-87	T03 Z	1109	531	1640	376	197	573	1	Medium
Toyota	Camry	83-86	T04 Z	202	116	318	78	41	119	1	Medium
Holden/Toyota	Apollo JK/JL/Camry	89-92/88-92	T05 A	1063	600	1663	412	260	672	1	Medium
Holden/Toyota	Apollo JM / JP/Camry	93-97	T05 B	628	327	955	211	120	331	1	Large
Toyota	Camry	98-00	T05 C	86	43	129	15	19	34	1	Large
Toyota	Celica	81-85	T06 A	177	89	266	69	25	94	1	Sports
Toyota	Celica	86-89	T06 B	116	59	175	36	21	57	1	Sports

MAKE/MODEL			MODEL CODE	No. of Uninjured Drivers in NSW(87-2000) And QLD, WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	ANALYSIS INCLUSION CRITERIA INV=100 INJ=20	MARKET GROUP
Toyota	Celica	90-93	T06 C	87	31	118	19	15	34	1	Sports
Toyota	Celica	94-99	T06 D	34	12	46	10	5	15	0	
Toyota	Celica	00-00	T06 E	2	1	3	.	.	.	0	
Toyota	Crown/Cressida	82-85	T07 A	146	65	211	50	26	76	1	Luxury
Toyota	Crown/Cressida	86-88	T07 B	54	28	82	15	12	27	0	
Toyota	Cressida	89-93	T07 C	115	39	154	23	24	47	1	Luxury
Toyota	Tercel	83-88	T09 Z	39	18	57	15	5	20	0	
Toyota	Supra	82-90	T11 Z	48	21	69	12	8	20	0	
Toyota	MR2	87-90	T12 A	13	19	32	9	6	15	0	
Toyota	MR2	91-00	T12 B	16	8	24	7	3	10	0	
Toyota	Paseo	91-99	T13 Z	36	26	62	18	18	36	0	
Toyota	Hiace/Liteace	82-86	T15 A	288	186	474	110	67	177	1	Commercial
Toyota	Hiace/Liteace	87-89	T15 B	113	58	171	41	12	53	1	Commercial
Toyota	Hiace/Liteace	90-00	T15 C	186	119	305	69	35	104	1	Commercial
Toyota	4Runner/Hilux	82-85	T16 A	648	422	1070	247	154	401	1	4WD
Toyota	4Runner/Hilux	86-88	T16 B	484	266	750	173	91	264	1	4WD
Toyota	Hilux	89-97	T16 C	1134	768	1902	499	292	791	1	4WD
Toyota	Hilux	98-00	T16 D	59	48	107	27	18	45	1	4WD
Lexus	ES300	92-00	T17 Z	12	4	16	3	3	6	0	
Toyota	Tarago	83-89	T18 A	374	251	625	160	75	235	1	Passenger Van
Toyota	Tarago	91-99	T18 C	101	35	136	23	13	36	1	Passenger Van
Toyota	Tarago	00-00	T18 D	1	0	1	.	.	.	0	
Toyota	Landcruiser	82-89	T20 A	620	436	1056	260	174	434	1	4WD
Toyota	Landcruiser	90-97	T20 B	596	330	926	207	162	369	1	4WD
Toyota	Landcruiser	98-00	T20 C	86	57	143	37	30	67	1	4WD
Toyota	RAV4	94-00	T21 A	27	11	38	12	5	17	0	
Toyota	Starlet	96-99	T22 Z	80	42	122	28	20	48	1	Small
Lexus	LS400	90-00	T25 Z	2	0	2	1	1	2	0	
Lexus	IS200	99-00	T26 Z	1	0	1	.	.	.	0	
Toyota	Echo	99-00	T27 Z	8	4	12	6	2	8	0	
Lexus	GS300	97-00	T28 Z	3	0	3	.	.	.	0	
Toyota	Avalon	00-00	T29 Z	3	0	3	.	.	.	0	
Toyota	Corolla 4WD Wagon	92-96	T32 Z	7	6	13	3	1	4	0	
Toyota	Spacia	93-00	T33 Z	1	2	3	2	0	2	0	
Volvo	850/S70/V70/C70	92-00	V877Z	30	17	47	8	4	12	0	
Volvo	200 Series	82-93	VO02Z	191	58	249	41	23	64	1	Luxury
Volvo	300 Series	84-88	VO03Z	11	1	12	1	0	1	0	

MAKE/MODEL		MODEL CODE	No. of Uninjured Drivers in NSW(87-2000) And QLD, WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	ANALYSIS INCLUSION CRITERIA INV=100 INJ=20	MARKET GROUP	
Volvo	700/900 Series	84-92	VO07Z	112	32	144	24	7	31	1	Luxury
Volvo	960/S90/V90	90-98	VO10Z	4	3	7	2	1	3	0	
Volvo	S40/V40	97-00	VO40Z	4	2	6	2	0	2	0	
Volkswagon	Caravelle / Transporter	88-00	VS01Z	37	17	54	11	6	17	0	
Volkswagen	Golf	82-94	VS02A	6	2	8	2	0	2	0	
Volkswagen	Golf	95-98	VS02B	23	12	35	4	5	9	0	
Volkswagen	Golf / Bora	99-00	VS02C	3	0	3	.	.	.	0	
Volkswagen	Passat	95-97	VS04A	1	0	1	1	0	1	0	
Volkswagen	Passat	98-00	VS04B	1	3	4	1	0	1	0	
Volkswagen	Polo	96-00	VS08A	6	3	9	3	1	4	0	
Total (Included /criteria=1)				67313 (63088)	32689 (30660)	100002 (93748)	23108 (21615)	12853 (12075)	35961 (33690)	122	

Note:

- NSW injury severity data for 1999 and 2000 was not included in the analysis because of changes in injury severity coding that resulted in inaccurate injury severity reporting.

**FREQUENCY OF SINGLE VEHICLE COLLISIONS BY MARKET GROUP
(NSW/VIC/QLD/WA)**

Market Group	No. of uninjured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured (but not severely) drivers in NSW* and Victoria (87-2000) and QLD, WA (91-2000)	No. of severely injured drivers in NSW* and Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)
Four Wheel Drive	5460	3558	9018	2334	1370	3704
Commercial	4712	2225	6937	1340	789	2129
Large	27417	11408	38825	8283	4674	12957
Luxury	2951	1145	4096	827	516	1343
Medium	8305	4283	12588	3189	1758	4947
Passenger Van	1058	628	1686	391	206	597
Small	15956	8824	24780	6262	3298	9560
Sports	1433	639	2072	456	269	725
Total (included)	67292 (63088)	32710 (30660)	100002 (93748)	23082 (21615)	12880 (12075)	35962 (33690)

Note:

- NSW injury severity data for 1999 and 2000 was not included in the analysis because of changes in injury severity coding that resulted in inaccurate injury severity reporting.
- Records on uninjured drivers in Victoria are incomplete as only crashes involving injury are reliably reported and hence Victorian data is not included in the injury risk analysis.

**FREQUENCY OF PASSENGER VEHICLES INVOLVED IN SINGLE VEHICLE COLLISIONS BY
MARKET GROUP AND ROLLOVER STATUS
(NSW/VIC/QLD/WA)**

Market Group	Rollover status	No. of uninjured drivers in NSW (87-2000) and QLD,WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD,WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	Analysis Inclusion Criteria INV=100 INJ=20
Four Wheel Drive	Non-rollover	3358	1818	5176	1243	745	1988	1
	Rollover	2102	1740	3842	1091	625	1716	1
Commercial	Non-rollover	3600	1533	5133	904	578	1482	1
	Rollover	1112	692	1804	436	211	647	1
Large	Non-rollover	22976	8940	31916	6734	3858	10592	1
	Rollover	4441	2468	6909	1549	816	2365	1
Luxury	Non-rollover	2434	883	3317	665	424	1089	1
	Rollover	517	262	779	162	92	254	1
Medium	Non-rollover	6711	3273	9984	2512	1446	3958	1
	Rollover	1594	1010	2604	677	312	989	1
Passenger Van	Non-rollover	703	437	1140	257	162	419	1
	Rollover	355	191	546	134	44	178	1
Small	Non-rollover	12571	6729	19300	4899	2694	7593	1
	Rollover	3385	2095	5480	1363	604	1967	1
Sports	Non-rollover	1187	533	1720	389	233	622	1
	Rollover	246	106	352	67	36	103	1
All Market Groups	Non-rollover	53540	24146	77686	17603	10140	27743	
	Rollover	13752	8564	22316	5479	2740	8219	
Total		67,292	32,710	100,002	23,082	12,880	35,962	

Note:

- NSW injury severity data for 1999 and 2000 was not included in the analysis because of changes in injury severity coding that resulted in inaccurate injury severity reporting.
- Records on uninjured drivers in Victoria are incomplete as only crashes involving injury are reliably reported and hence Victorian data is not included in the injury risk analysis.

**INJURY RISK AND INJURY SEVERITY ESTIMATES BY MODEL AND
MARKET GROUP FOR SINGLE VEHICLE COLLISIONS**

CRASHWORTHINESS INJURY RISK RATINGS FOR SINGLE VEHICLE COLLISIONS
NSW Data (1987-2000), Queensland and Western Australia Data (1991-2000)

Make	Model of Car	Years of Manufacture	Pr(Risk) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
ALL MODEL AVERAGE			32.70			
4 Wheel Drive			38.84	37.70	39.99	2.29
Nissan / Ford	Patrol / Maverick	88-97	31.68	27.78	35.85	8.06
Holden / Suzuki	Drover / Sierra	85-87 / 82-00	46.02	42.46	49.62	7.15
Toyota	4Runner/Hilux	82-85	40.81	37.80	43.89	6.09
Toyota	4Runner/Hilux	86-88	36.59	33.12	40.22	7.10
Toyota	Hilux	89-97	39.59	37.30	41.92	4.62
Toyota	Landcruiser	82-89	42.47	39.40	45.60	6.20
Toyota	Landcruiser	90-97	35.60	32.46	38.87	6.42
Commercial			32.68	31.47	33.91	2.44
Ford	Falcon Panel Van	82-95	29.44	25.14	34.15	9.01
Ford / Nissan	Falcon Ute / XFN Ute	82-95 / 88-90	28.21	25.77	30.78	5.01
Holden	Rodeo	89-95	38.81	34.57	43.22	8.66
Holden	Commodore Ute VR/VS	94-00	27.34	23.77	31.23	7.45
Subaru	Brumby	82-93	35.50	31.54	39.67	8.12
Large			28.83	28.14	29.54	1.40
Ford	Falcon XE/XF	82-88	29.63	28.47	30.82	2.35
Ford	Falcon EA / Falcon EB Series I	88-Mar 92	29.85	28.30	31.45	3.15
Ford	Falcon EB Series II / Falcon ED	Apr 92-94	28.05	25.81	30.41	4.60
Ford	Falcon EF/EL	94-98	26.68	24.90	28.55	3.65
Ford	Falcon AU	98-00	27.03	22.66	31.91	9.26
Holden / Toyota	Commodore VN/VP / Lexcen	89-93 / 89-93	30.22	28.94	31.53	2.60
Holden / Toyota	Commodore VR/VS / Lexcen	93-97	25.70	24.13	27.33	3.20
Holden	Commodore VT/VX	97-00	23.30	20.50	26.36	5.86
Holden	Commodore VB-VL	82-88	30.09	28.95	31.25	2.29
Mitsubishi	Magna TM/TN/TP	85-90	30.85	28.69	33.09	4.40
Mitsubishi	Magna TE/TF/TH/TJ / Verada KE/KF/KH/KJ	96-00	31.57	28.14	35.21	7.08
Mitsubishi	Verada KR/KS / Magna TR/TS	91-96	28.93	25.76	32.31	6.55
Nissan	Skyline	82-90	32.17	28.25	36.35	8.09
Holden / Toyota	Apollo JM / JP / Camry	93-97	31.10	28.20	34.16	5.96

Make	Model of Car	Years of Manufacture	Pr(Risk) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
Luxury			27.21	25.74	28.72	2.98
BMW	3 Series	82-91	23.01	18.31	28.50	10.19
Ford	Fairlane Z & LTD F	82-87	30.55	26.54	34.87	8.33
Ford	Fairlane N & LTD D	88-94	24.88	21.03	29.16	8.13
Volvo	200 Series	82-93	22.41	17.67	27.98	10.32
Medium			32.32	31.36	33.29	1.93
Holden	Camira	82-89	34.70	32.39	37.09	4.70
Mitsubishi	Sigma/Scorpion	82-86	31.12	28.57	33.79	5.22
Ford / Mazda	Telstar / 626/MX6	83-86	34.86	31.55	38.32	6.76
Ford / Mazda	Telstar / 626/MX6	88-91	26.78	21.60	32.69	11.08
Nissan	Pintara	86-88	31.22	26.90	35.89	9.00
Nissan / Ford	Pintara / Corsair	89-92	33.63	29.79	37.71	7.92
Nissan	Bluebird	82-86	33.71	31.35	36.15	4.80
Subaru	1800/ Leone	82-95	33.07	30.17	36.11	5.94
Subaru	Liberty	89-94	31.30	25.97	37.17	11.20
Toyota	Corona	82-87	31.48	29.21	33.85	4.64
Holden / Toyota	Apollo JK/JL / Camry	89-92 / 88-92	33.71	31.42	36.09	4.68
Passenger Van			36.88	34.71	39.10	4.39
Mitsubishi	Starwagon	87-94	38.97	34.36	43.80	9.44
Toyota	Tarago	83-89	39.98	36.13	43.95	7.83
Small			33.09	32.26	33.92	1.66
Daihatsu	Charade	88-92	35.66	31.59	39.95	8.36
Ford	Laser	91-94	28.73	25.77	31.89	6.12
Ford	Festiva WD/WD/WH/WF	94-00	38.56	33.81	43.54	9.73
Holden	Gemini	82-84	33.89	30.76	37.16	6.40
Hyundai	Excel	90-94	33.85	30.49	37.39	6.90
Hyundai	Excel	95-00	34.47	31.62	37.43	5.81
Mitsubishi	Colt	82-88	34.43	31.91	37.04	5.13
Mitsubishi	Lancer CA	88-90	31.05	26.48	36.02	9.54
Mitsubishi	Lancer CC	93-95	27.52	22.98	32.58	9.60
Mitsubishi	Lancer CE/Mirage	96-00	27.52	22.87	32.71	9.84
Ford / Mazda	Laser / 323	82-88	35.28	33.70	36.89	3.19
Ford / Mazda	Festiva WA / 121	91-93 / 87-90	36.59	32.43	40.96	8.53
Holden / Nissan	Astra / Pulsar/Vector	84-86	35.10	32.27	38.05	5.78
Holden / Nissan	Astra / Pulsar/Vector	88-90	33.24	30.22	36.40	6.19
Nissan	Pulsar	92-95	29.23	24.74	34.15	9.41
Holden / Suzuki	Barina / Swift	89-93 / 89-99	33.86	30.86	37.00	6.14
Toyota	Corolla	82-84	35.07	31.97	38.31	6.34
Toyota	Corolla	86-88	33.58	31.16	36.09	4.93
Toyota / Holden	Corolla / Nova	89-93	32.23	29.93	34.62	4.69
Toyota / Holden	Corolla / Nova	94-98 / 94-96	30.19	26.73	33.90	7.16
Sports			32.58	29.64	35.68	6.04

CRASHWORTHINESS INJURY SEVERITY RATINGS FOR SINGLE VEHICLE COLLISIONS
NSW Data (1987-2000), Queensland and Western Australia Data (1991-2000)

Make	Model of Car	Years of Manufacture	Pr(Severe) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
ALL MODEL AVERAGE			35.84			
4 Wheel Drive			36.52	34.75	38.33	3.58
Nissan / Ford	Patrol / Maverick	88-97	35.91	29.74	42.59	12.86
Holden / Suzuki	Drover / Sierra	85-87 / 82-00	29.56	24.88	34.70	9.82
Toyota	4Runner/Hilux	82-85	40.02	35.19	45.06	9.87
Toyota	4Runner/Hilux	86-88	35.01	29.40	41.06	11.66
Toyota	Hilux	89-97	35.29	31.93	38.80	6.87
Toyota	Landcruiser	82-89	39.89	35.26	44.71	9.45
Toyota	Landcruiser	90-97	41.05	36.06	46.23	10.17
Commercial			38.06	35.84	40.32	4.48
Ford	Falcon Panel Van	82-95	37.43	28.93	46.78	17.85
Ford / Nissan	Falcon Ute / XFN Ute	82-95 / 88-90	39.87	34.74	45.23	10.49
Holden	Rodeo	89-95	40.81	33.98	48.01	14.04
Holden	Commodore Ute VR/VS	94-00	37.78	30.58	45.57	15.00
Subaru	Brumby	82-93	42.25	35.38	49.43	14.05
Large			34.89	33.62	36.18	2.56
Ford	Falcon XE/XF	82-88	36.37	34.31	38.49	4.18
Ford	Falcon EA / Falcon EB Series I	88-Mar 92	32.46	29.82	35.21	5.39
Ford	Falcon EB Series II / Falcon ED	Apr 92-94	33.55	29.54	37.81	8.27
Ford	Falcon EF/EL	94-98	32.85	29.60	36.27	6.67
Ford	Falcon AU	98-00	25.20	17.67	34.59	16.92
Holden / Toyota	Commodore VN/VP / Lexcen	89-93 / 89-93	35.35	33.11	37.66	4.55
Holden / Toyota	Commodore VR/VS / Lexcen	93-97	33.07	30.10	36.19	6.09
Holden	Commodore VT/VX	97-00	33.63	27.65	40.19	12.54
Holden	Commodore VB-VL	82-88	36.94	34.86	39.06	4.20
Mitsubishi	Magna TM/TN/TP	85-90	35.71	32.13	39.47	7.34
Mitsubishi	Magna TE/TF/TH/TJ / Verada KE/KF/KH/KJ	96-00	33.92	28.18	40.16	11.98
Mitsubishi	Verada KR/KS / Magna TR/TS	91-96	32.74	27.67	38.24	10.57
Nissan	Skyline	82-90	38.82	32.18	45.90	13.72
Holden / Toyota	Apollo JM / JP / Camry	93-97	33.43	28.55	38.69	10.14

Make	Model of Car	Years of Manufacture	Pr(Severe %)	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
Luxury			37.38	34.58	40.28	5.70
BMW	3 Series	82-91	35.40	24.29	48.36	24.07
Ford	Fairlane Z & LTD F	82-87	42.94	36.06	50.10	14.05
Ford	Fairlane N & LTD D	88-94	37.87	30.29	46.09	15.80
Volvo	200 Series	82-93	36.76	25.77	49.33	23.56
Medium			35.34	33.73	36.98	3.25
Holden	Camira	82-89	34.17	30.60	37.93	7.33
Mitsubishi	Sigma/Scorpion	82-86	35.28	31.17	39.62	8.44
Ford / Mazda	Telstar / 626/MX6	83-86	34.65	29.49	40.21	10.72
Ford / Mazda	Telstar / 626/MX6	88-91	33.15	23.83	44.01	20.19
Nissan	Pintara	86-88	37.23	29.96	45.14	15.18
Nissan / Ford	Pintara / Corsair	89-92	35.93	29.85	42.50	12.65
Nissan	Bluebird	82-86	36.92	33.00	41.01	8.01
Subaru	1800/ Leone	82-95	36.30	31.56	41.32	9.76
Subaru	Liberty	89-94	31.53	23.54	40.77	17.23
Toyota	Corona	82-87	34.82	30.90	38.96	8.06
Holden / Toyota	Apollo JK/JL / Camry	89-92 / 88-92	36.99	33.31	40.82	7.51
Passenger Van			35.81	32.25	39.53	7.29
Mitsubishi	Starwagon	87-94	34.31	27.44	41.90	14.45
Toyota	Tarago	83-89	34.43	28.47	40.93	12.46
Small			35.23	33.84	36.64	2.80
Daihatsu	Charade	88-92	35.93	29.35	43.10	13.75
Ford	Laser	91-94	27.88	23.06	33.27	10.21
Ford	Festiva WD/WD/WH/WF	94-00	36.95	30.12	44.34	14.22
Holden	Gemini	82-84	34.24	29.40	39.43	10.03
Hyundai	Excel	90-94	34.72	29.56	40.26	10.70
Hyundai	Excel	95-00	35.50	30.86	40.43	9.57
Mitsubishi	Colt	82-88	32.45	28.58	36.57	7.99
Mitsubishi	Lancer CA	88-90	33.93	26.33	42.45	16.13
Mitsubishi	Lancer CC	93-95	38.15	29.99	47.05	17.06
Mitsubishi	Lancer CE/Mirage	96-00	23.84	15.66	34.55	18.89
Ford / Mazda	Laser / 323	82-88	34.65	32.13	37.27	5.14
Ford / Mazda	Festiva WA / 121	91-93 / 87-90	41.46	34.93	48.30	13.37
Holden / Nissan	Astra / Pulsar/Vector	84-86	37.62	33.24	42.21	8.96
Holden / Nissan	Astra / Pulsar/Vector	88-90	37.50	32.38	42.90	10.52
Nissan	Pulsar	92-95	35.18	27.23	44.04	16.80
Holden / Suzuki	Barina / Swift	89-93 / 89-99	34.60	29.52	40.05	10.54
Toyota	Corolla	82-84	35.44	30.59	40.60	10.01
Toyota	Corolla	86-88	34.85	30.91	39.01	8.09
Toyota / Holden	Corolla / Nova	89-93	35.46	31.68	39.44	7.76
Toyota / Holden	Corolla / Nova	94-98 / 94-96	34.15	28.29	40.54	12.25

Make	Model of Car	Years of Manufacture	Pr(Severe %)	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
Sports			33.60	28.65	38.93	10.27

**CRASHWORTHINESS RATINGS OF
1982-2000 MODEL PASSENGER VEHICLES INVOLVED IN
SINGLE VEHICLE CRASHES DURING 1987-2000**

**With
95 % CONFIDENCE LIMITS**

**CRASHWORTHINESS RATINGS FOR SINGLE VEHICLE CRASHES
(WITH 95% CONFIDENCE LIMITS)**

Victoria and NSW Data (1987-2000), Queensland and Western Australia Data (1991-2000)

Make	Model of Car	Years of Manufacture	Serious injury rate per 100 drivers involved	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
ALL MODEL AVERAGE			11.72			
4 Wheel Drive			14.19	13.40	15.02	1.62
Nissan / Ford	Patrol / Maverick	88-97	11.38	9.13	14.18	5.06
Holden / Suzuki	Drover / Sierra	85-87 / 82-00	13.60	11.32	16.35	5.03
Toyota	4Runner/Hilux	82-85	16.33	14.14	18.87	4.74
Toyota	4Runner/Hilux	86-88	12.81	10.56	15.54	4.99
Toyota	Hilux	89-97	13.97	12.47	15.65	3.18
Toyota	Landcruiser	82-89	16.94	14.73	19.47	4.74
Toyota	Landcruiser	90-97	14.61	12.53	17.04	4.51
Commercial			12.44	11.60	13.33	1.74
Ford	Falcon Panel Van	82-95	11.02	8.28	14.66	6.38
Ford / Nissan	Falcon Ute / XFN Ute	82-95 / 88-90	11.25	9.59	13.19	3.59
Holden	Rodeo	89-95	15.84	12.89	19.46	6.57
Holden	Commodore Ute VR/VS	94-00	10.33	8.11	13.16	5.05
Subaru	Brumby	82-93	15.00	12.24	18.37	6.13
Large			10.06	9.63	10.51	0.89
Ford	Falcon XE/XF	82-88	10.78	10.05	11.56	1.51
Ford	Falcon EA / Falcon EB Series I	88-Mar 92	9.69	8.78	10.69	1.91
Ford	Falcon EB Series II / Falcon ED	Apr 92-94	9.41	8.11	10.91	2.80
Ford	Falcon EF/EL	94-98	8.76	7.75	9.91	2.15
Ford	Falcon AU	98-00	6.81	4.67	9.95	5.28
Holden / Toyota	Commodore VN/VP / Lexcen	89-93 / 89-93	10.68	9.89	11.54	1.65
Holden / Toyota	Commodore VR/VS / Lexcen	93-97	8.50	7.60	9.50	1.89
Holden	Commodore VT/VX	97-00	7.84	6.26	9.82	3.57
Holden	Commodore VB-VL	82-88	11.11	10.38	11.90	1.52
Mitsubishi	Magna TM/TN/TP	85-90	11.02	9.72	12.49	2.77
Mitsubishi	Magna TE/TF/TH/TJ / Verada KE/KF/KH/KJ	96-00	10.71	8.68	13.21	4.53
Mitsubishi	Verada KR/KS / Magna TR/TS	91-96	9.47	7.77	11.54	3.77
Nissan	Skyline	82-90	12.49	10.04	15.53	5.49
Holden / Toyota	Apollo JM / JP / Camry	93-97	10.40	8.68	12.44	3.76

Make	Model of Car	Years of Manufacture	Serious injury rate per 100 drivers involved	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
Luxury			10.17	9.26	11.17	1.91
BMW	3 Series	82-91	8.15	5.40	12.29	6.88
Ford	Fairlane Z & LTD F	82-87	13.12	10.59	16.25	5.65
Ford	Fairlane N & LTD D	88-94	9.42	7.22	12.30	5.08
Volvo	200 Series	82-93	8.24	5.53	12.28	6.75
Medium			11.42	10.81	12.06	1.25
Holden	Camira	82-89	11.86	10.44	13.46	3.02
Mitsubishi	Sigma/Scorpion	82-86	10.98	9.48	12.71	3.23
Ford / Mazda	Telstar / 626/MX6	83-86	12.08	10.06	14.51	4.45
Ford / Mazda	Telstar / 626/MX6	88-91	8.88	6.12	12.87	6.75
Nissan	Pintara	86-88	11.62	9.04	14.94	5.90
Nissan / Ford	Pintara / Corsair	89-92	12.08	9.77	14.95	5.18
Nissan	Bluebird	82-86	12.44	10.93	14.17	3.24
Subaru	1800/ Leone	82-95	12.00	10.21	14.12	3.91
Subaru	Liberty	89-94	9.87	7.10	13.71	6.60
Toyota	Corona	82-87	10.96	9.55	12.58	3.02
Holden / Toyota	Apollo JK/JL / Camry	89-92 / 88-92	12.47	11.03	14.10	3.08
Passenger Van			13.21	11.74	14.86	3.12
Mitsubishi	Starwagon	87-94	13.37	10.47	17.07	6.60
Toyota	Tarago	83-89	13.76	11.20	16.92	5.73
Small			11.65	11.12	12.22	1.10
Daihatsu	Charade	88-92	12.81	10.23	16.05	5.83
Ford	Laser	91-94	8.01	6.48	9.90	3.43
Ford	Festiva WD/WD/WH/WF	94-00	14.25	11.31	17.96	6.65
Holden	Gemini	82-84	11.60	9.74	13.82	4.08
Hyundai	Excel	90-94	11.75	9.77	14.14	4.38
Hyundai	Excel	95-00	12.24	10.43	14.35	3.92
Mitsubishi	Colt	82-88	11.17	9.67	12.91	3.23
Mitsubishi	Lancer CA	88-90	10.53	7.92	14.00	6.08
Mitsubishi	Lancer CC	93-95	10.50	7.89	13.97	6.07
Mitsubishi	Lancer CE/Mirage	96-00	6.56	4.24	10.15	5.91
Ford / Mazda	Laser / 323	82-88	12.23	11.21	13.33	2.13
Ford / Mazda	Festiva WA / 121	91-93 / 87-90	15.17	12.42	18.53	6.11
Holden / Nissan	Astra / Pulsar/Vector	84-86	13.20	11.42	15.27	3.85
Holden / Nissan	Astra / Pulsar/Vector	88-90	12.46	10.53	14.75	4.23
Nissan	Pulsar	92-95	10.28	7.69	13.74	6.04
Holden / Suzuki	Barina / Swift	89-93 / 89-99	11.71	9.81	13.99	4.19
Toyota	Corolla	82-84	12.43	10.51	14.70	4.20
Toyota	Corolla	86-88	11.70	10.20	13.43	3.23
Toyota / Holden	Corolla / Nova	89-93	11.43	10.02	13.04	3.02
Toyota / Holden	Corolla / Nova	94-98 / 94-96	10.31	8.31	12.79	4.48

Make	Model of Car	Years of Manufacture	Serious injury rate per 100 drivers involved	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
Sports			10.95	9.15	13.10	3.94

**FREQUENCY OF UNPROTECTED ROAD USERS
IN COLLISIONS WITH PASSENGER VEHICLES BY MARKET GROUP**

**VICTORIAN AND NSW CRASHES DURING 1987-2000
WESTERN AUSTRALIA AND QUEENSLAND CRASHES DURING 1991-2000**

**FREQUENCY OF UNPROTECTED ROAD USERS IN COLLISIONS WITH
PASSENGER VEHICLES BY MARKET GROUP
(NSW/VIC/QLD/WA)**

Unprotected Road User by Market Group	No. of injured (but not severely) in NSW* and Victoria (87-2000) and QLD,WA (91-2000)	No. of severely injured in NSW* and Victoria (87-2000) and QLD, WA (91-2000)	No. of Injured in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	Analysis Inclusion Criteria INV=100 INJ=20
Four Wheel Drive				
Pedestrian	573	461	1034	
Cyclist	466	262	728	
Total	1039	723	1762	1
Commercial				
Pedestrian	774	549	1323	
Cyclist	462	204	666	
Total	1236	753	1989	1
Large				
Pedestrian	4383	2667	7050	
Cyclist	2815	987	3802	
Total	7198	3654	10852	1
Luxury				
Pedestrian	610	380	990	
Cyclist	341	138	479	
Total	951	518	1469	1
Medium				
Pedestrian	1849	1108	2957	
Cyclist	1063	367	1430	
Total	2912	1475	4387	1
Passenger Van				
Pedestrian	326	217	543	
Cyclist	182	70	252	
Total	508	287	795	1
Small				
Pedestrian	3155	2088	5243	
Cyclist	1804	679	2483	
Total	4959	2767	7726	1
Sports				
Pedestrian	301	207	508	
Cyclist	158	39	197	
Total	459	246	705	1
Reference Group				
Pedestrian	186	157	343	
Cyclist	257	147	404	
Total	443	304	747	1
Total	19262	10423	29685	

- NSW injury severity data for 1999 and 2000 was not included in the analysis because of changes in injury severity coding that resulted in inaccurate injury severity reporting.
- Records on uninjured drivers in Victoria are incomplete as only crashes involving injury are reliably reported and hence Victorian data is not included in the injury risk analysis.

**ESTIMATES OF AGGRESSIVITY TOWARDS UNPROTECTED ROAD USERS BY
PASSENGER VEHICLE MARKET GROUP**

**ESTIMATES OF AGGRESSIVITY TOWARDS UNPROTECTED ROAD USERS BY
PASSENGER VEHICLE MARKET GROUP**

Market Group	Coefficient	Standard Error of Coefficient	Pr(Severity %)	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE	-0.6141		35.11			
Four Wheel Drive	0.1531	0.0481	38.67	36.46	40.93	4.47
Commercial	0.0793	0.0457	36.94	34.88	39.05	4.17
Large	-0.1283	0.0264	32.25	31.13	33.39	2.26
Luxury	-0.00664	0.0525	34.96	32.66	37.34	4.68
Medium	-0.0846	0.0345	33.21	31.73	34.73	3.00
Passenger Van	0.0574	0.0689	36.43	33.36	39.61	6.25
Small	-0.0278	0.0285	34.48	33.23	35.75	2.52
Sports	-0.0425	0.0731	34.15	31.00	37.44	6.44

**FREQUENCY OF DRIVERS INVOLVED IN COLLISIONS BETWEEN TWO
PASSENGER VEHICLES BY MARKET GROUP COMBINATION**

**VICTORIAN AND NSW CRASHES DURING 1987-2000
WESTERN AUSTRALIA AND QUEENSLAND CRASHES DURING 1991-2000**

FREQUENCY OF DRIVERS INVOLVED IN TWO CAR COLLISIONS BETWEEN TWO PASSENGER VEHICLES BY MARKET GROUP COMBINATION (NSW/VIC/QLD/WA)

Market Group (vehicle one)	Market Group (vehicle two)	No. of uninjured drivers in NSW (87-2000) and QLD,WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD,WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	Analysis Inclusion Criteria INV=100 INJ=20
Four Wheel Drive	Four Wheel Drive	941	169	1110	154	29	183	1
	Commercial	664	91	755	91	13	104	1
	Large	4328	448	4776	432	75	507	1
	Luxury	596	48	644	45	13	58	1
	Medium	1592	137	1729	125	25	150	1
	Passenger Van	169	22	191	18	5	23	1
	Small	3970	306	4276	272	33	305	1
	Sports	232	15	247	13	4	17	0
Commercial	Four Wheel Drive	658	117	775	97	26	123	1
	Commercial	702	126	828	93	22	115	1
	Large	4135	549	4684	446	83	529	1
	Luxury	570	63	633	46	20	66	1
	Medium	1672	185	1857	145	22	167	1
	Passenger Van	195	36	231	25	5	30	1
	Small	3606	329	3935	257	36	293	1
	Sports	237	21	258	16	6	22	1
Large	Four Wheel Drive	4213	787	5000	718	168	886	1
	Commercial	4049	746	4795	602	121	723	1
	Large	27644	4050	31694	3483	721	4204	1
	Luxury	4013	492	4505	430	89	519	1
	Medium	11427	1368	12795	1135	223	1358	1
	Passenger Van	1208	201	1409	154	23	177	1
	Small	23933	2576	26509	2035	386	2421	1
	Sports	1729	209	1938	178	31	209	1
Luxury	Four Wheel Drive	563	108	671	95	16	111	1
	Commercial	538	106	644	81	17	98	1
	Large	3939	552	4491	472	96	568	1
	Luxury	697	104	801	91	14	105	1
	Medium	1669	157	1826	138	26	164	1
	Passenger Van	194	32	226	24	3	27	1
	Small	3825	369	4194	313	41	354	1
	Sports	311	30	341	24	5	29	1
Medium	Four Wheel Drive	1465	327	1792	268	73	341	1
	Commercial	1601	327	1928	248	56	304	1
	Large	11036	1854	12890	1466	363	1829	1
	Luxury	1609	237	1846	193	39	232	1
	Medium	5008	723	5731	608	121	729	1
	Passenger Van	545	117	662	84	14	98	1
	Small	9366	1275	10641	1032	184	1216	1

Market Group (vehicle one)	Market Group (vehicle two)	No. of uninjured drivers in NSW (87-2000) and QLD,WA (91-2000)	No. of injured drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of involved drivers in NSW (87-2000) and QLD, WA (91-2000)	No. of injured (but not severely) drivers in NSW*, Victoria (87-2000) and QLD,WA (91-2000)	No. of severely injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	No. of injured drivers in NSW*, Victoria (87-2000) and QLD, WA (91-2000)	Analysis Inclusion Criteria INV=100 INJ=20
	Sports	708	109	817	78	23	101	1
Passenger Van	Four Wheel Drive	146	50	196	43	7	50	1
	Commercial	167	58	225	40	6	46	1
	Large	1168	219	1387	150	30	180	1
	Luxury	190	40	230	24	7	31	1
	Medium	564	84	648	66	10	76	1
	Passenger Van	73	21	94	14	4	18	0
	Sports	82	14	96	11	2	13	0
Small	Four Wheel Drive	3659	1001	4660	823	177	1000	1
	Commercial	3248	856	4104	632	130	762	1
	Large	22174	5137	27311	3956	852	4808	1
	Luxury	3558	745	4303	563	122	685	1
	Medium	8988	1870	10858	1465	279	1744	1
	Passenger Van	1117	284	1401	199	47	246	1
	Small	20916	3678	24594	2873	478	3351	1
	Sports	1515	303	1818	221	45	266	1
Sports	Four Wheel Drive	209	52	261	45	10	55	1
	Commercial	233	46	279	35	10	45	1
	Large	1723	257	1980	218	45	263	1
	Luxury	293	50	343	39	7	46	1
	Medium	708	116	824	92	19	111	1
	Passenger Van	80	14	94	8	5	13	0
	Small	1617	170	1787	130	23	153	1
	Sports	135	25	160	19	2	21	1
Total (included/criteria=1)		219336 (218869)	34755 (34691)	254091 (253560)	28005 (27959)	5604 (5589)	33609 (33548)	60

Note:

- NSW injury severity data for 1999 and 2000 was not included in the analysis because of changes in injury severity coding that resulted in inaccurate injury severity reporting.
- Shaded market group combinations not satisfying inclusion criteria not included in analysis.
- Frequencies refer to drivers of vehicle one.
- Records on uninjured drivers in Victoria are incomplete as only crashes involving injury are reliably reported and hence Victorian data is not included in the injury risk analysis.

**CRASHWORTHINESS, INJURY RISK AND INJURY SEVERITY ESTIMATES BY
VEHICLE MARKET GROUP AND COLLISION PARTNER MARKET GROUP FOR
CRASHES BETWEEN TWO PASSENGER VEHICLES**

**CRASHWORTHINESS INJURY RISK
BY VEHICLE MARKET GROUP AND COLLISION PARTNER MARKET GROUP FOR
CRASHES BETWEEN TWO PASSENGER VEHICLES**

Market Group	Collision Partner Market Group	Coefficient	Standard Error of Coefficient	Pr(Risk) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE		-1.8420		13.68			
Four Wheel Drive	Four Wheel Drive	0.0566	0.0852	14.36	12.43	16.54	4.11
	Commercial	-0.1682	0.1124	11.81	9.70	14.31	4.60
	Large	-0.4062	0.0515	9.55	8.71	10.46	1.75
	Luxury	-0.6208	0.1496	7.85	5.97	10.25	4.28
	Medium	-0.5475	0.0897	8.40	7.14	9.85	2.71
	Small	-0.7072	0.0607	7.25	6.49	8.09	1.60
Commercial	Four Wheel Drive	0.2447	0.1013	16.84	14.24	19.80	5.57
	Commercial	0.244	0.0977	16.83	14.31	19.68	5.37
	Large	-0.0241	0.0475	13.40	12.36	14.52	2.16
	Luxury	-0.1785	0.1328	11.71	9.27	14.68	5.40
	Medium	-0.1392	0.0783	12.12	10.58	13.85	3.27
	Small	-0.3848	0.059	9.74	8.77	10.80	2.03
Large	Four Wheel Drive	0.1109	0.0415	15.04	14.03	16.11	2.08
	Commercial	0.1237	0.0423	15.21	14.17	16.31	2.14
	Large	-0.0695	0.0219	12.88	12.41	13.37	0.96
	Luxury	-0.228	0.0496	11.20	10.27	12.21	1.94
	Medium	-0.2308	0.0317	11.18	10.57	11.81	1.23
	Passenger Van	0.0876	0.0774	14.75	12.94	16.76	3.82
	Small	-0.3862	0.025	9.72	9.30	10.16	0.86
	Sports	-0.2095	0.0742	11.39	10.00	12.94	2.94
Luxury	Four Wheel Drive	0.1379	0.106	15.39	12.88	18.30	5.42
	Commercial	0.151	0.1074	15.56	12.99	18.54	5.54
	Large	-0.157	0.0474	11.93	10.99	12.94	1.95
	Luxury	-0.0689	0.1056	12.89	10.74	15.40	4.66
	Medium	-0.5048	0.0841	8.73	7.50	10.14	2.63
	Small	-0.5392	0.056	8.46	7.65	9.35	1.70
Medium	Four Wheel Drive	0.2578	0.063	17.02	15.35	18.84	3.49
	Commercial	0.2123	0.0624	16.39	14.78	18.13	3.35
	Large	0.0342	0.0287	14.09	13.42	14.79	1.36
	Luxury	-0.0581	0.0708	13.01	11.52	14.66	3.14
	Medium	-0.0698	0.0422	12.88	11.98	13.83	1.86
	Passenger Van	0.3148	0.1028	17.84	15.08	20.99	5.91
	Small	-0.1849	0.0329	11.64	10.99	12.32	1.33
	Sports	0.00568	0.1036	13.75	11.51	16.34	4.83
Passenger Van	Four Wheel Drive	0.7526	0.1659	25.17	19.55	31.77	12.22
	Large	0.2028	0.0749	16.26	14.36	18.36	4.00
	Luxury	0.282	0.1748	17.36	12.98	22.84	9.86
	Medium	0.0116	0.1174	13.82	11.30	16.79	5.49
	Small	-0.2457	0.0881	11.03	9.45	12.84	3.40
Small	Four Wheel Drive	0.385	0.0387	18.89	17.76	20.08	2.32
	Commercial	0.3768	0.0411	18.77	17.57	20.03	2.46

	Large	0.2658	0.0212	17.13	16.55	17.73	1.18
	Luxury	0.1831	0.0428	15.99	14.90	17.15	2.25
	Medium	0.1883	0.0292	16.06	15.30	16.85	1.54
	Passenger Van	0.3918	0.0681	19.00	17.03	21.14	4.11
	Small	-0.0157	0.0230	13.50	12.98	14.03	1.05
	Sports	0.1694	0.0644	15.81	14.20	17.56	3.36
Sports	Four Wheel Drive	0.4483	0.1560	19.88	15.45	25.20	9.75
	Commercial	0.2519	0.1623	16.94	12.92	21.89	8.97
	Large	-0.00604	0.0683	13.61	12.11	15.26	3.15
	Luxury	0.1664	0.1537	15.77	12.17	20.19	8.03
	Medium	0.1303	0.1009	15.29	12.90	18.04	5.13
	Small	-0.3593	0.0814	9.96	8.62	11.49	2.87

**CRASHWORTHINESS INJURY SEVERITY
BY VEHICLE MARKET GROUP AND COLLISION PARTNER MARKET
GROUP FOR CRASHES BETWEEN TWO PASSENGER VEHICLES**

Market Group	Collision Partner Market Group	Coefficient	Standard Error of Coefficient	Pr(Severity) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE		-1.6099		16.66			
Four Wheel Drive	Four Wheel Drive	-0.0445	0.2088	16.05	11.27	22.35	11.09
	Commercial	-0.2761	0.2988	13.17	7.79	21.41	13.62
	Large	-0.1746	0.1321	14.37	11.47	17.86	6.39
	Luxury	0.2025	0.3213	19.66	11.54	31.48	19.95
	Medium	-0.1049	0.2249	15.25	10.38	21.86	11.48
	Small	0.321	0.5069	21.60	9.26	42.67	33.41
Commercial	Four Wheel Drive	0.2450	0.2282	20.34	14.04	28.54	14.51
	Commercial	0.0873	0.2422	17.91	11.95	25.96	14.01
	Large	-0.0472	0.1256	16.01	12.97	19.61	6.63
	Luxury	0.8484	0.2744	31.83	21.43	44.43	23.00
	Medium	-0.2277	0.2317	13.73	9.18	20.04	10.86
	Small	-0.2706	0.1819	13.23	9.65	17.89	8.24
Large	Four Wheel Drive	0.1844	0.0948	19.38	16.64	22.45	5.81
	Commercial	-0.00435	0.1067	16.60	13.90	19.70	5.80
	Large	0.00756	0.0554	16.76	15.30	18.34	3.03
	Luxury	-0.0647	0.1235	15.78	12.82	19.27	6.45
	Medium	-0.0502	0.0825	15.97	13.92	18.27	4.34
	Passenger Van	-0.2993	0.2265	12.91	8.68	18.77	10.08
	Small	-0.0127	0.067	16.48	14.75	18.37	3.62
	Sports	-0.139	0.1994	14.82	10.53	20.45	9.93
Luxury	Four Wheel Drive	-0.1531	0.2749	14.64	9.10	22.72	13.62
	Commercial	-0.00082	0.2715	16.65	10.50	25.38	14.88
	Large	-0.0987	0.1194	15.33	12.54	18.62	6.09
	Luxury	-0.3037	0.2887	12.86	7.73	20.62	12.89
	Medium	-0.1127	0.2194	15.15	10.41	21.54	11.13
	Small	-0.4465	0.1708	11.34	8.38	15.17	6.78
Medium	Four Wheel Drive	0.305	0.1396	21.33	17.10	26.28	9.18
	Commercial	0.114	0.1536	18.30	14.22	23.24	9.02
	Large	0.1719	0.0697	19.18	17.16	21.39	4.24
	Luxury	-0.0338	0.1809	16.20	11.94	21.60	9.66
	Medium	-0.1074	0.1074	15.22	12.70	18.14	5.44
	Passenger Van	-0.1902	0.2899	14.18	8.56	22.58	14.02
	Small	-0.1193	0.0886	15.07	12.98	17.43	4.45
	Sports	0.3592	0.2435	22.26	15.08	31.57	16.49
Passenger Van	Four Wheel Drive	-0.1042	0.4102	15.26	7.46	28.70	21.24
	Large	0.0274	0.2037	12.11	23.45	11.33	12.11
	Luxury	0.4475	0.4301	11.86	42.08	30.22	11.86
	Medium	-0.1828	0.3398	7.88	24.48	16.60	7.88
	Small	-0.2162	0.2619	8.79	21.20	12.41	8.79
Small	Four Wheel Drive	0.2032	0.0917	19.67	16.99	22.67	5.68
	Commercial	0.0353	0.1036	17.16	14.46	20.24	5.78

	Large	0.1342	0.053	18.61	17.08	20.23	3.15
	Luxury	0.103	0.1071	18.14	15.23	21.47	6.24
	Medium	-0.00886	0.0753	16.54	14.60	18.68	4.08
	Passenger Van	0.2132	0.1669	19.83	15.14	25.55	10.41
	Small	-0.1028	0.0621	15.28	13.77	16.92	3.15
	Sports	0.0855	0.1689	17.88	13.52	23.27	9.74
Sports	Four Wheel Drive	0.2044	0.3549	19.69	10.90	32.96	22.06
	Commercial	0.3336	0.3594	21.82	12.12	36.08	23.96
	Large	0.111	0.1691	18.26	13.82	23.73	9.91
	Luxury	0.0393	0.4107	17.21	8.51	31.74	23.24
	Medium	0.1324	0.256	18.58	12.14	27.37	15.23
	Small	-0.0867	0.2311	15.49	10.44	22.38	11.94

CRASHWORTHINESS
BY VEHICLE MARKET GROUP AND COLLISION PARTNER MARKET GROUP FOR
CRASHES BETWEEN TWO PASSENGER VEHICLES

Market Group	Collision Partner Market Group	Pr(Risk) %	Pr(Severity) %	Serious injury rate per 100 drivers involved	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE		13.68	16.66	2.28			
Four Wheel Drive	Four Wheel Drive	14.36	16.05	2.31	1.59	3.34	1.76
	Commercial	11.81	13.17	1.56	0.90	2.68	1.78
	Large	9.55	14.37	1.37	1.08	1.74	0.66
	Luxury	7.85	19.66	1.54	0.87	2.74	1.87
	Medium	8.40	15.25	1.28	0.85	1.92	1.07
	Small	7.25	21.60	0.84	0.59	1.19	0.59
Commercial	Four Wheel Drive	16.84	20.34	3.43	2.31	5.07	2.76
	Commercial	16.83	17.91	3.01	1.98	4.59	2.61
	Large	13.40	16.01	2.15	1.72	2.68	0.96
	Luxury	11.71	31.83	3.73	2.42	5.74	3.33
	Medium	12.12	13.73	1.66	1.10	2.52	1.42
	Small	9.74	13.23	1.29	0.93	1.79	0.86
Large	Four Wheel Drive	15.04	19.38	2.92	2.47	3.44	0.97
	Commercial	15.21	16.60	2.52	2.09	3.05	0.96
	Large	12.88	16.76	2.16	1.96	2.38	0.42
	Luxury	11.20	15.78	1.77	1.42	2.21	0.79
	Medium	11.18	15.97	1.79	1.54	2.07	0.53
	Passenger Van	14.75	12.91	1.90	1.27	2.86	1.60
	Small	9.72	16.48	1.60	1.42	1.80	0.38
	Sports	11.39	14.82	1.69	1.18	2.41	1.23
Luxury	Four Wheel Drive	15.39	14.64	2.25	1.38	3.69	2.31
	Commercial	15.56	16.65	2.59	1.61	4.18	2.57
	Large	11.93	15.33	1.83	1.48	2.27	0.79
	Luxury	12.89	12.86	1.66	0.98	2.80	1.82
	Medium	8.73	15.15	1.32	0.89	1.96	1.07
	Small	8.46	11.34	0.96	0.70	1.31	0.61
Medium	Four Wheel Drive	17.02	21.33	3.63	2.86	4.61	1.75
	Commercial	16.39	18.30	3.00	2.30	3.91	1.62
	Large	14.09	19.18	2.70	2.40	3.05	0.65
	Luxury	13.01	16.20	2.11	1.53	2.90	1.37
	Medium	12.88	15.22	1.96	1.62	2.38	0.76
	Passenger Van	17.84	14.18	2.53	1.51	4.23	2.72
	Small	11.64	15.07	1.75	1.50	2.05	0.56
	Sports	13.75	22.26	3.06	2.03	4.61	2.58
Passenger Van	Four Wheel Drive	25.17	15.26	3.84	1.86	7.92	6.06
	Large	16.26	12.11	2.77	1.95	3.94	2.00
	Luxury	17.36	11.86	4.14	2.05	8.35	6.29
	Medium	13.82	7.88	1.97	1.08	3.61	2.53
	Small	11.03	8.79	1.53	0.96	2.44	1.48
Small	Four Wheel Drive	18.89	19.67	3.72	3.18	4.35	1.17
	Commercial	18.77	17.16	3.22	2.69	3.86	1.17

	Large	17.13	18.61	3.19	2.91	3.49	0.58
	Luxury	15.99	18.14	2.90	2.41	3.49	1.08
	Medium	16.06	16.54	2.66	2.33	3.03	0.70
	Passenger Van	19.00	19.83	3.77	2.84	5.00	2.17
	Small	13.50	15.28	2.06	1.85	2.30	0.46
	Sports	15.81	17.88	2.83	2.11	3.78	1.67
Sports	Four Wheel Drive	19.88	19.69	3.92	2.13	7.21	5.08
	Commercial	16.94	21.82	3.70	2.01	6.81	4.80
	Large	13.61	18.26	2.49	1.85	3.34	1.49
	Luxury	15.77	17.21	2.71	1.33	5.54	4.21
	Medium	15.29	18.58	2.84	1.83	4.42	2.59
	Small	9.96	15.49	1.54	1.03	2.32	1.30

**MARKET GROUP COMPOSITION OF CRASHING VEHICLES BY YEAR OF
MANUFACTURE AND YEAR OF CRASH**

**VICTORIAN AND NSW CRASHES DURING 1987-2000
WESTERN AUSTRALIA AND QUEENSLAND CRASHES DURING 1991-2000**

**VEHICLE CRASH COMPOSITION BY MARKET GROUP AND YEAR OF MANUFACTURE
(UNSMOOTHED BY FREQUENCY AND PERCENTAGE)**

Year of Manufacture	Market Group Frequency (%)								Total
	Four Wheel Drive	Commercial	Large	Luxury	Medium	Passenger Van	Small	Sport	
1982	2,289 (3.43)	3,203 (4.81)	17,029 (25.55)	4,265 (6.40)	18,556 (27.84)	791 (1.19)	18,629 (27.95)	1,895 (2.84)	66657
1983	2,543 (4.23)	2,540 (4.23)	13,272 (22.08)	3,214 (5.35)	16,909 (28.13)	2,057 (3.42)	17,986 (29.93)	1,579 (2.63)	60100
1984	4,082 (5.37)	4,177 (5.49)	19,617 (25.80)	3,865 (5.08)	18,793 (24.72)	2,127 (2.80)	21,777 (28.64)	1,597 (2.10)	76035
1985	5,506 (6.98)	4,413 (5.60)	26,223 (33.25)	4,664 (5.91)	15,619 (19.80)	1,787 (2.27)	19,154 (24.29)	1,504 (1.91)	78870
1986	3,440 (4.94)	4,212 (6.05)	27,402 (39.36)	2,856 (4.10)	9,015 (12.95)	970 (1.39)	20,143 (28.93)	1,588 (2.28)	69626
1987	2,306 (3.97)	3,451 (5.94)	27,615 (47.52)	2,401 (4.13)	7,051 (12.13)	631 (1.09)	13,593 (23.39)	1,069 (1.84)	58117
1988	4,174 (5.76)	4,426 (6.10)	28,010 (38.63)	3,139 (4.33)	10,494 (14.47)	1,107 (1.53)	19,501 (26.90)	1,654 (2.28)	72505
1989	5,711 (7.06)	4,737 (5.85)	31,917 (39.44)	4,301 (5.32)	12,175 (15.05)	1,378 (1.70)	18,965 (23.44)	1,734 (2.14)	80918
1990	5,318 (7.46)	3,918 (5.50)	25,906 (36.35)	3,869 (5.43)	10,472 (14.69)	803 (1.13)	18,836 (26.43)	2,147 (3.01)	71269
1991	4,054 (6.88)	3,227 (5.48)	19,678 (33.40)	2,345 (3.98)	7,941 (13.48)	906 (1.54)	19,312 (32.78)	1,447 (2.46)	58910
1992	4,781 (8.05)	2,954 (4.97)	20,210 (34.01)	2,669 (4.49)	6,684 (11.25)	962 (1.62)	19,538 (32.88)	1,626 (2.74)	59424
1993	4,443 (7.74)	2,852 (4.97)	24,385 (42.46)	2,388 (4.16)	2,582 (4.50)	815 (1.42)	18,794 (32.72)	1,177 (2.05)	57436
1994	4,159 (7.39)	3,264 (5.80)	25,387 (45.10)	2,831 (5.03)	2,754 (4.89)	754 (1.34)	16,125 (28.64)	1,021 (1.81)	56295
1995	2,909 (5.81)	3,091 (6.17)	20,473 (40.89)	2,599 (5.19)	2,325 (4.64)	477 (0.95)	17,581 (35.11)	618 (1.23)	50073
1996	2,612 (6.49)	2,639 (6.56)	16,476 (40.96)	2,108 (5.24)	1,847 (4.59)	415 (1.03)	13,477 (33.50)	655 (1.63)	40229
1997	2,377 (6.81)	2,321 (6.65)	12,328 (35.31)	1,817 (5.20)	1,680 (4.81)	479 (1.37)	13,277 (38.02)	638 (1.83)	34917
1998	2,197 (7.55)	1,853 (6.37)	10,413 (35.81)	1,220 (4.20)	1,659 (5.70)	345 (1.19)	11,020 (37.89)	375 (1.29)	29082
1999	1,316 (8.68)	1,117 (7.37)	5,716 (37.71)	695 (4.59)	908 (5.99)	219 (1.44)	4,990 (32.92)	197 (1.30)	15158
2000	348 (7.50)	385 (8.30)	1,591 (34.29)	239 (5.15)	300 (6.47)	59 (1.27)	1,649 (35.54)	69 (1.49)	4640
Total	64,565 (6.21)	58,780 (5.65)	373,648 (35.92)	51,485 (4.95)	147,764 (14.20)	17,082 (1.64)	304,347 (29.26)	22,590 (2.17)	1040261

**VEHICLE CRASH COMPOSITION BY MARKET GROUP AND YEAR OF CRASH
(SMOOTHED BY FREQUENCY AND PERCENTAGE)**

Year of Crash	Market Group Frequency (%)								Total
	Four Wheel Drive	Commercial	Large	Luxury	Medium	Passenger Van	Small	Sport	
1987	1,483 (4.92)	2,085 (6.91)	9,059 (30.03)	1,594 (5.28)	6,982 (23.15)	710 (2.35)	7,549 (25.03)	700 (2.32)	30,162
1988	1,484 (4.96)	1,964 (6.57)	9,811 (32.80)	1,591 (5.32)	6,487 (21.69)	672 (2.25)	7,231 (24.17)	673 (2.25)	29,913
1989	1,673 (5.00)	2,260 (6.75)	11,206 (33.48)	1,720 (5.14)	6,899 (20.61)	716 (2.14)	8,230 (24.59)	768 (2.29)	33,472
1990	2,054 (5.73)	2,387 (6.66)	11,970 (33.42)	1,796 (5.01)	7,223 (20.16)	787 (2.20)	8,761 (24.46)	844 (2.36)	35,822
1991	3,444 (6.40)	3,242 (6.02)	18,308 (34.00)	2,432 (4.52)	10,268 (19.07)	933 (1.73)	14,065 (26.12)	1,154 (2.14)	53,846
1992	3,921 (6.56)	3,507 (5.86)	20,097 (33.60)	2,787 (4.66)	10,891 (18.21)	1,060 (1.77)	16,303 (27.26)	1,241 (2.08)	59,807
1993	4,442 (6.53)	3,846 (5.66)	23,329 (34.32)	3,055 (4.49)	11,688 (17.20)	1,131 (1.66)	18,968 (27.91)	1,514 (2.23)	67,973
1994	5,306 (6.87)	4,293 (5.56)	27,372 (35.45)	3,544 (4.59)	11,976 (15.51)	1,213 (1.57)	21,790 (28.22)	1,720 (2.23)	77,214
1995	5,146 (5.92)	4,707 (5.42)	31,993 (36.83)	4,105 (4.73)	12,711 (14.63)	1,270 (1.46)	25,021 (28.80)	1,912 (2.20)	86,865
1996	6,100 (6.14)	5,450 (5.48)	37,005 (37.22)	4,883 (4.91)	13,143 (13.22)	1,428 (1.44)	29,251 (29.42)	2,154 (2.17)	99,414
1997	5,135 (5.81)	4,507 (5.10)	32,520 (36.78)	4,537 (5.13)	11,031 (12.48)	1,347 (1.52)	27,456 (31.05)	1,888 (2.14)	88,421
1998	6,189 (5.83)	5,467 (5.15)	40,413 (38.06)	5,232 (4.93)	11,912 (11.22)	1,564 (1.47)	33,218 (31.29)	2,176 (2.05)	106,171
1999	9,459 (7.03)	7,498 (5.57)	49,659 (36.91)	6,778 (5.04)	13,505 (10.04)	2,149 (1.60)	42,639 (31.69)	2,848 (2.12)	134,535
2000	8,729 (6.39)	7,567 (5.54)	50,906 (37.25)	7,431 (5.44)	13,048 (9.55)	2,102 (1.54)	43,865 (32.10)	2,998 (2.19)	136,646
Total	64,565 (6.21)	58,780 (5.65)	373,648 (35.92)	51,485 (4.95)	147,764 (14.20)	17,082 (1.64)	304,347 (29.26)	22,590 (2.17)	1,040,261