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THE EFFECT OF MARKET GROUP MIX ON CRASH RISK IN THE AUSTRALASIAN LIGHT VEHICLE FLEET

by

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Abstract:
The objective of this study was to examine potential crash risk and injury effects of wholesale changes in market preference within the light passenger vehicle fleets of New Zealand, NSW and Victoria Analysis was carried out on the registers of licensed vehicles in these jurisdictions which were linked via licence plate numbers to crash data. This enabled an assessment of the composition of the vehicle fleet to be made as well the estimation of crash involvement rates per licensed vehicle.

The study found important differences between the New Zealand light passenger vehicle fleet and the fleets in NSW and Victoria. The New Zealand fleet, probably influenced by the widespread importation of used cars from Japan, was older on average than the NSW and Victorian fleets, but also had proportionately fewer older vehicles. There were also marked differences in crash patterns, with a much larger proportion of crashes in New Zealand occurring on higher speed limit roads than in either Victoria or NSW. This is likely to be a reflection of substantial differences in driving patterns which may also influence the composition of the vehicle fleet that achieves the lowest crash involvement rates. Passenger vehicle market groups were evaluated in terms of their crash rates per vehicle in the three fleets studied. In New Zealand, large cars were generally found to have lower crash involvement rates, whereas in the Australian states, medium cars were superior in terms of crash involvement.

By modelling crash involvement rates using the available data on the vehicles and their owners, various scenarios were tested that involved shifts in market group preferences in each vehicle fleet. In particular, the effects on crash involvement rates were tested where entire market groups were removed from the vehicle fleet and replaced by market groups with lower crash involvement rates. These cannot be seen as realistic scenarios, but rather as extreme shifts that indicate the direction in which vehicle fleet safety could move, given shifts in market group preference. These extreme shifts from large cars to medium cars were predicted to result in as much as a 10% injury crash involvement rate decrease for Victoria and a 5% reduction in tow-away crash involvement in NSW. For New Zealand an overall switch from medium, small and light cars to large cars was predicted to yield an almost 4% decrease in injury crash involvement. Purely lowering the average *aggressivity* of the fleets by switching from large cars to medium cars was predicted to yield only a very modest reduction in road injury.

Key Words: (IRRD except when marked*)
Injury, Collision, Statistics, Crashworthiness, Primary Safety, Secondary Safety, Risk

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EXECUTIVE SUMMARY

The Monash University Accident Research Centre (MUARC) has conducted and published extensive research into the safety of the vehicle fleets in Australia and New Zealand. A principal focus of this research has been on secondary safety, both the ability of vehicles to protect their occupants in the event of a crash (crashworthiness) and the potential for a given vehicle to harm other road users when in collision with them (aggressivity). MUARC has also conducted research on the primary safety of vehicles, which is the ability of vehicles to avoid crashes. Vehicle features that may contribute to primary safety include the ability of the vehicle to steer well, its stability when cornering, effective braking, adequate headlights etc. All these features can assist the driver to maintain good control of the vehicle and avoid crashes.

The objective of the present study was to examine potential crash risk and injury effects of wholesale changes in market group preferences within the light passenger vehicle fleets of New Zealand, NSW and Victoria. Analysis was carried out on data from the registers of licensed vehicles, which were linked via licence plate numbers to crash data for these jurisdictions. This enabled an assessment to be made of fleet composition as well as crash involvement rates per licensed vehicle.

The study found important differences between the New Zealand light passenger vehicle fleet and the fleets in NSW and Victoria. The New Zealand fleet, probably influenced by the widespread importation of used cars from Japan, was older on average than these two Australian fleets, but also had proportionately fewer older vehicles. There were also marked differences in crash patterns, with a much larger proportion of crashes in New Zealand occurring on higher speed limit roads than in either Victoria or NSW. This is likely to be a reflection of substantial differences in driving patterns, which may also influence the composition of the vehicle fleet that achieves the lowest crash involvement rates. Passenger vehicle market groups were evaluated in terms of their crash rates per vehicle in the three fleets studied. In New Zealand, large cars were generally found to have lower crash involvement rates; in the Australian states, medium cars were superior.

By modelling crash involvement rates using the available data on the vehicles and their owners, various scenarios were tested that involved shifts in market group preferences in each vehicle fleet. In particular, the effects on crash involvement rates were tested where entire market groups were removed from the fleet and replaced by market groups with lower estimated crash involvement rates. These cannot be seen as realistic scenarios, but rather as extreme shifts that indicate the direction in which vehicle fleet safety could move, given shifts in market group preference. These extreme shifts from large cars to medium cars were predicted to result in as much as a 10% injury crash involvement rate decrease for Victoria and a 5% reduction in tow-away crash involvement in NSW. For New Zealand an overall switch from medium, small and light cars to large cars was predicted to yield an almost 4% decrease in injury crash involvement. Purely lowering the average *aggressivity* of the fleets by switching from large cars to medium cars was predicted to yield only a very modest reduction in road injury.

The main qualification to be applied to the results of the scenarios is that the scenarios present an idealised situation where *all* vehicles of a given type change. Therefore, the effects should be seen as being an indication of the *direction* of potential effects that could occur via policy changes or changes in consumer behaviour that may or may not be influenced by government information programmes, policy or legislation.

PREFACE

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Contributor Statement

Proposal / Study Design –MK, SN

Data Acquisition and Analysis - MK

Draft Report –MK, SN

Report Review and Finalisation – MK, SN

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1 BACKGROUND

The Monash University Accident Research Centre (MUARC) has conducted extensive research into the safety of the vehicle fleets in Australia and New Zealand. A principal focus of this research has been on secondary safety, both the ability of vehicles to protect their occupants in the event of a crash (crashworthiness) and the potential for a given vehicle to harm other road users when colliding with them (aggressivity) (Newstead et al, 2008). Research has also been conducted on the primary safety of vehicles, which is the ability of vehicles to avoid crashes (Keall and Newstead, 2007; Keall and Newstead, 2008). Vehicle features that may contribute to primary safety include the ability of the vehicle to steer well, its stability when cornering, effective braking and adequate headlights. All these features can assist the driver to maintain good control of the vehicle and avoid crashes.

In order to conduct the above research, MUARC has developed methods for identifying vehicle makes and models and assigning thee to key market groups amongst the light passenger vehicle fleets in Australia and New Zealand. These methods can be applied to crash data and to registration data. The availability of registration data opens up the possibility of research that examines the makeup of the vehicle fleet and models scenarios for changes to the fleet. Such research gains greater significance when changes are happening in vehicle fleets. By mid-2008, steep increases in petrol prices were impacting on vehicle buying patterns that may have influenced the composition of the vehicle fleet and its safety performance. It is the impact of changes in the composition of the vehicle fleet on crash involvement rates and to a lesser extent injury rates that is the focus of the current report.

The study has several objectives:

1. To describe the *licensed vehicle* fleets in the jurisdictions considered (New South Wales, Victoria and New Zealand) in terms of the proportion of the fleet belonging to the main passenger vehicle market groups and in terms of vehicle age and ownership characteristics (to the extent that the motor vehicle registers provide ownership data).
2. To describe the *crash* fleets of these three jurisdictions in terms of market group, vehicle age and ownership characteristics.
3. To estimate the *risk* of crash involvement per licensed vehicle in each jurisdiction.
4. To describe *scenarios for changes* in the vehicle fleet composition and potential resultant changes in crash involvement rates.

2 METHODS

This section describes the data sets used and the methods applied to describe each jurisdiction's vehicle fleet, crash fleet and crash risk profile, and then to estimate the crash effects of some scenarios for changes to the composition of the vehicle fleets.

In summary, data for one or two years from each jurisdiction's motor vehicle register were coded into market group classifications using methods developed by MUARC. The crashed vehicle fleets were matched to the motor vehicle registers using the licence plate number of the vehicle. In terms of the analysis, only vehicles crashing in a given jurisdiction that were also licensed in that jurisdiction were considered as part of that jurisdiction's crash fleet. Crash rates were calculated using both raw figures and models fitted to the data that could explain the way that factors such as vehicle market group, vehicle age and ownership characteristics affected the risk of crash involvement.

2.1 Defining crash risk

Two concepts central to the estimation of crash risk per vehicle are primary safety and secondary safety. The *secondary safety* of vehicles is the ability of the vehicle to protect its occupants in the event of a crash. Secondary safety can be expressed in terms of *crashworthiness*, which has two components, *injury risk* (the risk of injury given tow-away crash involvement) and *severity risk* (the risk of fatal or serious injury given that an injury has occurred). *Primary safety* is the ability of the vehicle to avoid a crash. As the NZ and Victorian crash reporting systems only record injury crashes consistently, the estimates of primary risk derived solely from these data include the *injury risk* component of crashworthiness, as represented below. As a result these estimates are not pure estimates of primary risk.

Crashworthiness	= (injury risk) x (severity risk)
NZ/VIC primary risk estimates	= (tow-away crash risk) x (injury risk)
NSW primary risk estimates	= (tow-away crash risk)

In two-vehicle crashes, the NZ and Victorian crash data include a given vehicle A that crashes into vehicle B only if there is an injury in vehicle A and/or there is an injury in vehicle B. This is influenced by:

- the primary safety of vehicle A and of vehicle B;
- the crashworthiness of vehicle A and of vehicle B; and
- the aggressivity of vehicle A and of vehicle B.

In contrast, the NSW data include all tow-away crashes, so, in theory, NSW primary risk estimates do not include an injury risk component. In practice, non-injury crashes are likely to suffer from a greater degree of underreporting than injury crashes. Therefore, vehicles that provide better than average protection to their occupants are also likely to have lower reported crash rates, even if the actual crash rate is identical to the average.

2.2 The effect of fleet composition on crash risk

As a result of the issues discussed in section 2.1, the composition of the vehicle fleet must be accounted for in the estimation of crash risk for each jurisdiction. For a given vehicle, a more crashworthy fleet will *decrease* the number of reported crash involvements of vehicle A and a more aggressive fleet will *increase* the number of reported crash involvements of that vehicle, irrespective of the characteristics of vehicle A itself.

In estimating the effects of changing the composition of the vehicle fleet, changes in the crashworthiness of the vehicle fleet must be accounted for. In the scenarios tested in this study, it was expected that the effects of changing the proportions of particular market groups in the vehicle fleet would have a fairly minor influence on crash rates. These effects were estimated according to the following formula.

$$p_{fs(other)}(Large) = p(riskother) \times p(Large) \times agg(Large) \qquad (1)$$

Where

$p_{fs(other)}(Large)$	= estimated proportion of all tow-away crash involved vehicles that are large cars causing fatal or serious injury to another road user
p(riskother)	= proportion of all tow-away crash involved vehicles that cause injury to other road users
p(Large)	= proportion of the vehicle fleet that is large cars
agg(Large)	= aggressivity of large cars (the risk that a crash involving a large car results in a serious/fatal injury to another road user)

Using this formula, the fleet effect on fatal and serious injury rates where vehicle *x* is substituted for vehicle *y* in the fleet can be estimated by:

$$p_{fs(riskother)}(x) - p_{fs(riskother)}(y) \qquad (2)$$

2.3 Partitioning the vehicle fleet, the crash fleet and crash risk

To facilitate the modelling of crash risk and the effects of changes in the composition of the vehicle fleet, the vehicle fleet data, the crash data, and vehicle crash risk (primary safety risk) were partitioned in the form of Table 1.

Table 1 Structure of the data used to predict the effects of changes in the composition and age of the vehicle fleet on primary safety

	Owner age group=15-19																			
	Male										**Female**									
	Rural					**Urban**					**Rural**					**Urban**				
Vehicle age	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Vehicle market group																				
4WD L	a	b	c	d	e	f	g	h	i	j	.	.	.	.	.	.				
4WD M	k	l	m	n	o	.	.	.	.	.	.	.								
4WD C	p	q	r	.	.	.	.	.	.	.	.									
PM	s	t	u	.	.	.	.	.	.	.	.									
Large Car	v	w	x	.	.	.	.	.	.	.	.									
……	y	z	.	.	.	.	.	.	.	.	.									

Three separate tables were created. To create the crash risk (primary safety) table (R), crash involvement risk estimates were placed in the cells of the table (indicated by the lower case letters: a, b, c, etc). These values were produced by fitting statistical models to the crash and motor vehicle register data. Let the cells of this table have the values Ra, Rb, Rc etc. The second table, the proportions table (P), contains the proportion of all vehicles in the vehicle fleet relevant to each cell. Let the cells of this table have values Pa, Pb, Pc etc. The third table, the crashes table (C), contains the number of all crash-involved vehicles relevant to each cells. Let the cells of this table have values Ca, Cb, Cc etc.

Crashes can be modelled as a function of the vehicle fleet table (P) and the primary safety risk table (R) by creating a table whose cells are the multiple of the fleet proportions and the primary safety risk, viz: Ca=(Pa*Ra)*N, Cb=(Pb*Rb)*N, etc., where N is the total number of vehicles in the fleet. For simplicity, the N can be dropped as the most important estimate is the proportional change in the crash rates, which does not require N to be specified.

Two classes of variables were used to partition each of the three tables (R, P and C); those that were considered to be relatively fixed in the short-term, such as owner age group, gender and level of urbanisation of the vehicle owner's address and those that were considered to be able to be influenced by policy interventions or changing fuel costs, such as vehicle market group and vehicle age. Note that the only owner variable available for the NSW data was the level of urbanisation of the owner's address and the Victorian data had no owner variables available.

2.4 Modelling the effect of changes in the crash fleet

A number of scenarios for changes in the composition of the crash fleet are considered in this report. The non-fixed variables were used to model variations in the age and composition of the vehicle fleet and control for the effects of the owner variables where they are available. The scenarios involved a shift in consumer preference from one market group to another, or, a shift in terms of the age of the vehicles being purchased. The scenarios are put into effect by altering the table P, which contains the proportion of all vehicles in the fleet classified by the variables shown in Table 1. For example, Table 2 shows a scenario where there is a total shift away from large 4WDs towards medium 4WDs in all ownership and vehicle age categories. The proportions of the fleet that were large 4WDs (a, b, c, etc) have been added to the appropriate cells for the medium 4WDs. Thus, there has been no change in the number of vehicles in the fleet, just a change in its composition.

Table 2 Vehicle fleet proportions (P): testing a total shift away from large 4WDs to medium 4WDs

	Owner age group=15-19																			
	Male										**Female**									
	Rural					**Urban**					**Rural**					**Urban**				
Vehicle age	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Market group																				
4WD L	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.				
4WD M	k+a	l+b	m+c	n+d	o+e	.	.	.	.	.	.	.								
4WD C	p	q	r	.	.	.	.	.	.	.	.									
PM	s	t	u	.	.	.	.	.	.	.	.									
Large Car	v	w	x	.	.	.	.	.	.	.	.									
……	y	z	.	.	.	.	.	.	.	.	.									

The effect of this shift in the composition of the vehicle fleet can then be modelled by using the table of primary crash risk estimates, R, which was formed by fitting statistical models to the crash and motor vehicle register data. The cells of the new crash table, C, are of the form shown in Table 3. Note that only the rows referring to large 4WDs and medium 4WDs have changed in this example: there are zeros for the whole row for large 4WDs and the row for the medium 4WDs has now been augmented by the proportions of the fleet that were large 4WDs, forming cells: (Pk+Pa)×Rk, (Pl+Pb)×Rl, etc.

Table 3 The number of vehicle crashes (C) following a total shift away from large 4WDs to medium 4WDs

	Age=15-19																			
	Male										**Female**									
	Rural					**Urban**					**Rural**					**Urban**				
Vehicle age	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Mkt. grp.																				
4WD L	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.				
4WD M	(Pk+Pa) ×Rk	(Pl+Pb) ×Rl	.	.	.	.	.	.	.	.	.	.								
4WD C	Pp×Rp	Pq×Rq	.	.	.	.	.	.	.	.	.									
PM	Ps×Rs	Pt×Rt	.	.	.	.	.	.	.	.	.									
Large Car	.	.	.	.	.	.	.	.	.	.	.									
……			.	.	.	.	.	.	.	.	.									

In a simple case, where medium 4WDs have a lower crash risk than large 4WDs in all the situations modelled, there will be a straightforward decrease in the crash rate. However, many risk patterns will be more complex. A vehicle may have a lower estimated crash risk than another vehicle under certain conditions, but a higher estimated crash risk under other conditions. The overall crash rate under the new scenario can be estimated by summing all the cells in Table 3 and multiplying by the total number of vehicles in the fleet.

There are certain fundamental assumptions involved in modelling changes in the composition of the vehicle fleet. The key assumption is that there are differences between market groups that can be attributed to the features of the vehicles in the market groups themselves, not to aspects of their exposure (such as when and where and how much they are driven) or the behaviour related personal risks of the drivers who prefer that market group. If this assumption holds then we can say confidently that the replacement of all vehicles A in the fleet with vehicles B will improve crash outcomes because of some fundamental benefit of vehicle A over vehicle B. Such benefits can include better crashworthiness, lower aggressivity and better features to avoid crash occurrence such as braking and handling. However, previous work on investigating primary safety of vehicles (e.g., Keall and Newstead, 2008) has indicated that there are strong driver effects in the safety estimated for vehicle market groups such that drivers with a particular driving style may select a given market group because it suits this driving style. These sorts of effects cannot be accounted for in the scenario modelling, hence the scenarios avoid certain fleet configurations where exposure and/or driver effects cannot be accounted for. There is additional uncertainty about the extent of any improvement in crash rates (but not about the direction of the change) because of associations between exposure and vehicle type.

2.5 Definitions of Vehicle Market Groups

Based on the vehicle make and model details, vehicles in the light passenger vehicle fleet were assigned to one of 10 market group categories as follows:

- Passenger cars and station wagons:
    - Large (typically >1500kg tare mass)
    - Medium (typically 1300-1500kg tare mass)
    - Small (typically 1100-1300kg tare mass)
    - Light (typically <1100kg tare mass)
    - Sports (coupe or convertible body style)
    - Luxury (highly specified vehicle)
- Four-wheel drive vehicles (off-road vehicles with raised ride height):
    - Large (typically >2000kg tare mass)
    - Medium (typically 1700-2000kg tare mass)
    - Small (typically <1700kg tare mass)
- People Movers (single box body style vehicle with seating capacity > 5 people)

The market group categories listed are generally consistent with those used by the Australian Federal Chamber of Automotive Industries (FCAI) in reporting vehicle sales, although some categories used by the FCAI have been combined here to ensure sufficient numbers of vehicles for analysis. The classification of 4WD vehicles is based on an index developed by VFACTS that considers gross vehicle mass, maximum engine torque and the availability of a dual range transmission. The index typically classifies the vehicles roughly by tare mass as indicated on the classifications above. The commercial vehicle types (utilities and vans) were generally excluded from the analysis, as they appear to be driven in quite a different manner to the passenger vehicles, leading to quite different patterns of crash risk. Further, as commercial vehicles tend to be used for a specific purpose, and are unlikely to be able to be replaced by another vehicle market group, they were not considered as candidates for the scenarios modelled.

2.6 Motor Vehicle Register data and crash data

This section describes the data used in the analysis. Each of the three jurisdictions, New Zealand, New South Wales and Victoria provided both passenger vehicle licensing data (the motor vehicle registers) and crash data that was able to be linked to the licensing data via the licence plate number of each vehicle.

2.6.1 New Zealand data

The New Zealand Motor Vehicle Register (MVR)

The Motor Vehicle Register (MVR) contains data on all vehicles currently registered in New Zealand, including both licensed and unlicensed vehicles. This includes data on vehicle type, age, make and model. Each vehicle driven on public roads in New Zealand is legally required to be registered and is also required to have a current Warrant of Fitness (WoF) or Certificate of Fitness (CoF). These are granted based on an inspection of the vehicle that establishes that there are no significant safety-related problems with the vehicle. Light vehicles first registered anywhere less than six years ago must have a WoF inspection every 12 months. All other vehicles have WoF inspections every six months. Heavy vehicles, taxis and buses have six-monthly CoF inspections. There are fines for drivers who are caught driving a vehicle that is either unlicensed (unregistered) or does not have its WoF/CoF. A driver can also be fined for driving a vehicle that is licensed but has become un-roadworthy (e.g., with worn tyres etc) since its WoF/CoF inspection.

A small proportion of vehicles used on-road in New Zealand is unlicensed. Such vehicles were not included as part of this study unless they had been licensed within the last year (for vehicles more than 6 years old) or 18 months (newer vehicles). The following variables were supplied for each vehicle: MVR vehicle id, vehicle type, vehicle make, vehicle model, cc rating, gross vehicle mass, fuel type, year of manufacture, odometer distance unit, owner location (Local Authority of owner address), latest inspection odometer reading, latest inspection date, latest inspection location, previous inspection odometer reading, previous inspection date, previous inspection location, owner date of birth, owner gender. The last two fields were only available where the owner was an individual. For about 9% of vehicles, the owner of the vehicle was a company.

Vehicle market group was determined using an Excel spreadsheet of vehicle makes and models classified by market group. This spreadsheet was based on analysis of the NZ vehicle fleet completed by MUARC. The vehicle model name was used to classify most vehicles. Where more than one market group was included within the same model name, vehicle year of manufacture was also used to classify the vehicle. The classification “Unknown” was used for vehicles not identified by this process.

Land Transport New Zealand provided a file of 3,206,510 licensed motorised vehicles (all active self-propelled vehicles in New Zealand) as at March 2005 together with owner data as at May 2005 plus 3,322,332 vehicles from February 2006. Fields included vehicle registration number, customer type (individual/company/other), owner date of birth, gender, and town/suburb address of owner (where the owner was an individual). The owner address was converted into the Local Authority code (of which there are 74) which was used to provide information on the location of driving exposure of the vehicle on the assumption that a vehicle is likely to be used more in the vicinity of its owner’s address than in other areas. If for a given vehicle, owner data had changed between the two files used, owner data from the latter date was used. This meant that the population of vehicles studied was primarily that of early 2006, with relatively few vehicles with owner data from 2005 (only 3% of the population studied that were not licensed in 2006). This was considered appropriate as the mid-point of the period of the crash data matched to the MVR (see below) was early 2006. A pilot study of the matching of crash data to MVR data (Keall and Newstead, 2006) had found that a much lower proportion of crashed vehicles could be matched to the MVR when the crash date preceded the MVR extraction date, probably because a proportion of crashed vehicles ceased to be licensed, having been written off or scrapped following the damage sustained in the crash. By including vehicles licensed in early 2005 in the population studied, crash data from the remainder of 2005 could be used without concerns about low matching rates, expanding the amount of data available for analysis.

The level of urbanisation of the owner's address was defined in four levels according to the Local Authorities: Auckland; Local Authorities of other main urban areas with population over 50,000; Local Authorities of smaller main urban areas; all other Local Authorities. As the area of the owner's address can be expected to be the main area of driving exposure, these classifications provide a proxy for the types of roads on which the vehicles are used and which are known to present different levels of risk. For example, urban speed limit roads present the highest risk of injury crash involvement per distance driven (Keall and Frith, 2004). The MVR data of May 2005 did not have a Local Authority classification, so a link was made to MVR data from August 2004 to obtain the Local Authority codes of the owner's address as well as the place where the vehicle last underwent a periodic vehicle inspection. This link was made using the vehicle identification codes, which are less subject to change than licence plate numbers (which can be transferred from one vehicle to another vehicle in the case of personalised plates). Initial modelling estimated similar coefficients for the two non-Auckland urban classifications. As a result, these areas were combined to form a single category for the analysis leaving three urbanisation classifications for the owners' address: "Auckland", "other urban" and "rural".

NZ Crash data

The NZ Ministry of Transport provided a file of 17,245 crash-involved vehicles (together with degree and number of injuries, driver age and gender) from 2005 and a further 16,795 crash-involved vehicles from 2006. The vast majority (98%) had a licence plate number specified. Multiple vehicle crashes were identified in the crash data according to whether another motor vehicle had been involved in the crash or not. 18% of crashed vehicles were not able to be matched to the MVR, leaving a total of 23,826 crashed vehicles available to be analysed, after removing duplicates (vehicles that crashed a second or third time). Owner and vehicle data were derived from MVR information for the vehicle. These variables are described above.

2.6.2 NSW data

Registration and crash data

There were 7,033,017 vehicles supplied from NSW registration data for the year 2004. Of these, 5,210,687 were identified as being cars, vans, utes by using the BSHPE variable that defines broad vehicle classes. Market groups were defined for these vehicles by decoding vehicle identification numbers using procedures developed over several years by MUARC. The vehicles in the registration data base that had market group defined were allocated to quintiles of age (the oldest 20%, the next oldest 20%, etc, defining five groups). There were also 218,428 motorcycles, which were not analysed below.

Also provided was a file of 149,630 vehicles, including cars, vans and utes, that crashed in 2004 or 2005 and had a year of manufacture of 1982 or later. Of the available crash data, 31% could not be matched to the registration data by the licence plate, leaving 100,596 crashed vehicles to be analysed. A vehicle in the registration data was identified as being crash involved if it was matched to the crash data. Vehicles that crashed more than once were treated in the same way as vehicles that crashed once.

Classification by owner's address location

The postcode of the owners' address was firstly classified according the Australian Bureau of Statistics' Statistical Divisions (SDs). There is some overlap of the postal codes and the SDs, resulting in some postal codes spreading across more than one SD, mainly in more urbanised areas. The SDs are listed in sequence by the Australian Bureau of Statistics and where there was overlap, the postcode was allocated to the SD occurring first in this sequence. Although this approach was fairly arbitrary, the final stage of aggregation accounted for almost all of the overlapping postcodes. In this final stage, the SDs were classified into three areas: the Sydney metropolitan area ("Sydney"); other NSW SDs adjacent to the coast ("Coastal") and all other areas ("Inland").

2.6.3 Victorian data

There were 4,265,069 vehicles provided in the Victorian registration data for 2005 with vehicle type (vtype) defined to be cars or vans. Vehicles contained in the registration data were decoded into vehicle market groups using vehicle identification numbers.

The 2005 and 2006 crash data contained 25,895 cars and vans that had valid licence plate numbers. Vehicles with a year of manufacture of 2005 or 2006 were excluded as they were very poorly matched to the registration data (probably because many were not licensed until after the date of the licensing data extraction). Of the remaining 24,192 crashed vehicles, 20,617 were able to be matched to the registration data by the licence plate number, an 83% matching rate. A vehicle in the registration data was identified as being crash involved if it was matched to the crash data. Vehicles that crashed more than once were not treated differently to vehicles that crashed once.

As for NSW, the vehicles in the registration database with a defined vehicle market group were allocated to quintiles of age. The modelling of scenarios for changes in the composition of the vehicle fleet was restricted to data for passenger vehicles (excluding vans and utes) with a defined vehicle market group. These data totalled 2,996,883 vehicles, as shown in Table 8.

3 ANALYSIS OF THE RISK OF CRASH INVOLVEMENT

This section describes the analytical approach used to estimate crash involvement risk per vehicle. The use of these risk estimates to evaluate the potential effects of changes in the composition of the three vehicle fleets is also described.

3.1 Variables

All variables, apart from crash involvement, were derived from the owner details in the registration data as follows:

- Owner age group (only available in NZ): was defined to be relatively homogeneous in terms of risk (according to prior NZ research, viz. Keall and Frith, 2004) - 15-19, 20-29, 30-59 and 60 plus
- Owner gender (only available in NZ)
- Market group of the vehicle was defined as described previously
- Vehicle age: defined in terms of quintiles of years since manufacture for vehicles for which market group was able to be assigned. Each of the three fleets had its quintiles calculated separately
- The level of urbanisation of the owner's address (only available for NZ and NSW)

3.2 Modelling process for risk

Multivariate logistic regression models were used to estimate crash risk. In order to avoid overly complex models, no third order interactions of terms entered into the model were allowed for New Zealand, but the relatively restricted range of explanatory variables for NSW and Victoria meant that third order terms were acceptable, potentially leading to saturated models. Backwards variable selection was used, in which results of the Wald test for individual parameters were examined by the algorithm. The SAS procedure LOGISTIC uses a process in which at each stage of variable selection, the least significant effect that does not meet the 0.05 level for staying in the model is removed. Once an effect is removed from the model, it remains excluded. The process is repeated until no other effect in the model meets the specified level for removal (SAS Institute, 1998).

For New Zealand, the Hosmer and Lemeshow Test for lack of fit was non-significant (Pr > ChiSq=0.65 with 8 degrees of freedom), indicating no problems with the fit of the model. The NSW and Victorian models were saturated models. Appendix 2 shows the output from fitting these models.

4 RESULTS

4.1 Introduction

The results of the analysis are presented in four parts as follows:

- Description of the composition of the three *vehicle fleets* considered (New South Wales, Victoria and New Zealand). The composition of the vehicle fleet is described in terms of the main passenger vehicle market groups, vehicle age and ownership characteristics
- Description of the *crashed vehicle fleets* of each jurisdictions in terms of market group, vehicle age and ownership characteristics
- Estimated *risk* of crash involvement per licensed vehicle in each jurisdiction
- Describing *scenarios* for changes in the vehicle fleet composition and the estimated resultant changes in crash occurrence.

4.2 NZ vehicle fleet and ownership patterns

The following section describes the ownership and market group features of the privately owned New Zealand licensed passenger vehicle fleet. As described above, the vehicle fleet examined is restricted to vehicles manufactured from 1979 onwards.

The tables describing the NZ fleet are very large owing to the large number of descriptive variables available. They are presented in Appendix 1. Vehicles owned by teenagers in the NZ licensed vehicle fleet (Table 19 in the Appendix) were predominantly small and medium cars. Few teenagers owned newer vehicles. People movers, which are most useful for people with larger families, were also rarely owned by teenagers. Small cars were still favoured by owners in their 20s, then lost favour with those in their 30s, 40s and 50s before regaining popularity with owners aged 60 plus, who presumably seek cars suited to low-occupancy, shorter trips and cheaper running costs, which typify older driver travel (Keall and Frith, 2006). These patterns are easy to see graphically in Figure 1 which shows the distribution of vehicles within each owner age group by market group.

The proportion of the vehicle fleet that was unable to be identified as belonging to a particular market group remained relatively constant between about 16% and 21% across all owner age groups. 4WD vehicles were rarely owned by young people and were still relatively rare in the age group 30-59. However, when the three types of 4WDs were combined, the total number of 4WDs amounted to more than 12% of vehicles owned by 30 to 59 year olds, compared to 21% and 18% for small and medium cars respectively.

Figure 1 **Distribution of vehicles within each owner age group by market group: New Zealand 2005 and 2006 data**

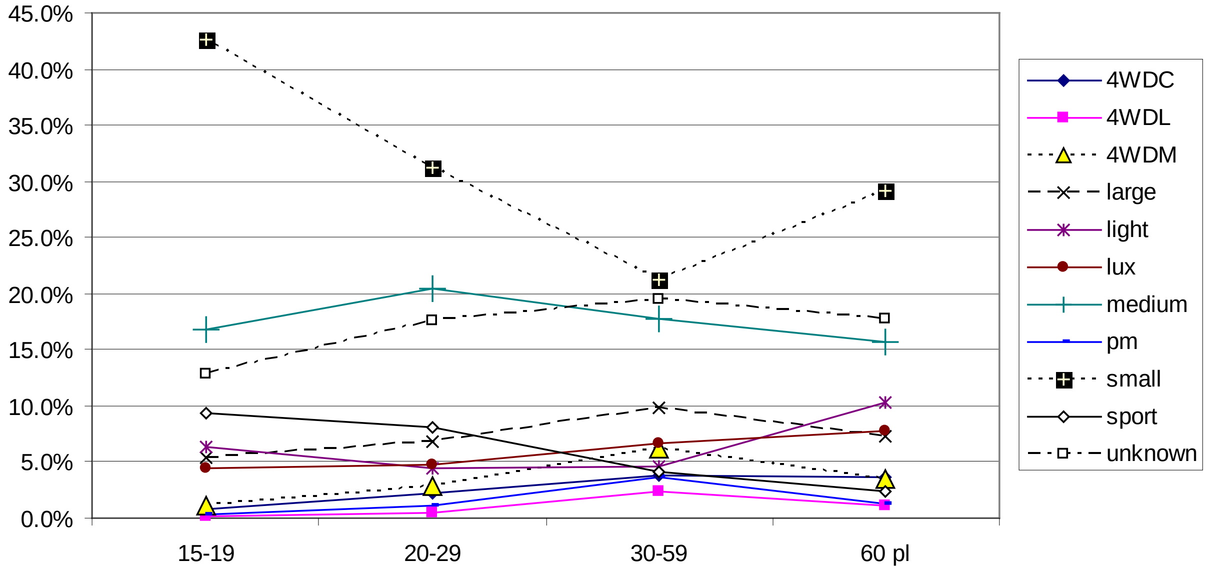


Figure 2 shows the overall distribution of vehicles in the NZ fleet by market group and owner age group. This shows that, although small cars lost popularity relative to other cars for middle-aged owners compared to younger owners, middle aged owners were still the dominant owner group for these cars. Small cars were also the most popular market group in the NZ passenger vehicle fleet.

The proportion of the vehicle fleet owned by people in each of the age groups is shown in Figure 3. This shows clearly that teenage vehicle owners were relatively rare. However, these drivers are identified separately in the analysis that follows as they have a rate of crash involvement considerably higher than any other owner age group.

Figure 2 Distribution of the licensed passenger vehicle fleet by vehicle market group and owner age group: New Zealand 2005 and 2006 data

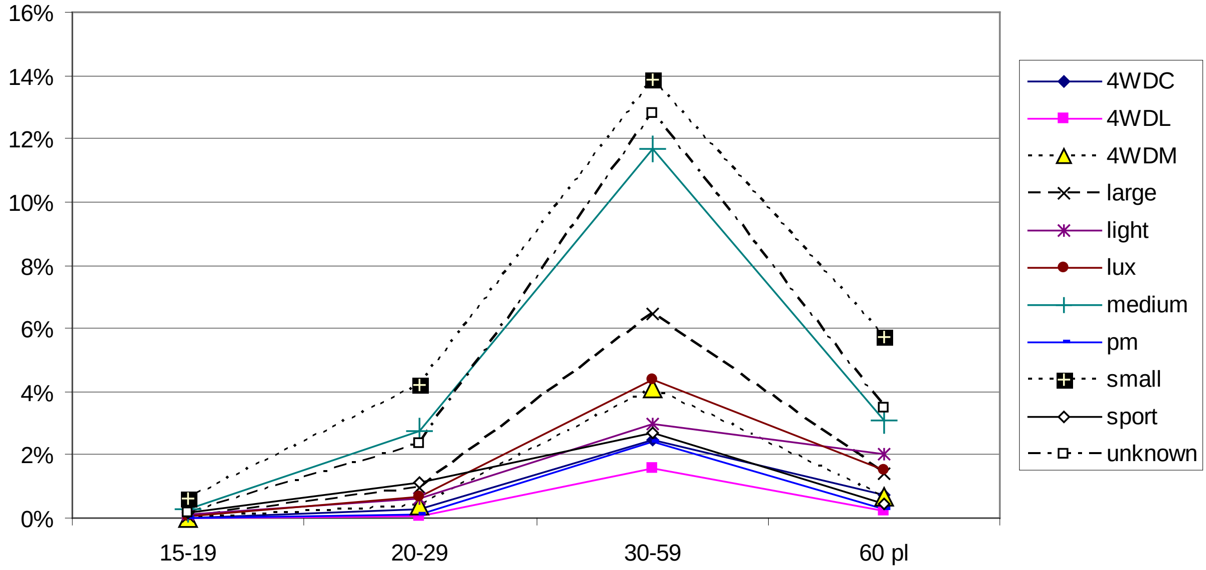
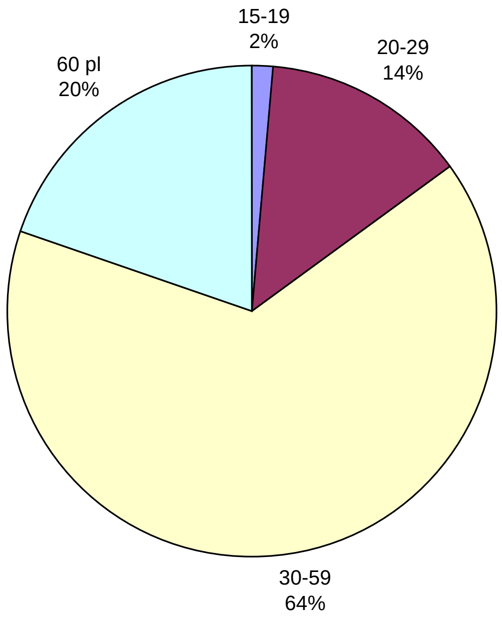


Figure 3 Distribution of the passenger vehicle fleet by owner age group: New Zealand 2005 and 2006 data.



4.3 NZ crash involvement risk patterns

The patterns of crash involvement by vehicle market group and owner location are also of interest. Table 4 shows New Zealand crude two-year crash involvement rates for licensed vehicles in 2005 and 2006 by the market group of the vehicle and the area of residence of the owner. The columns labelled '% of crash involved vehicles' present the proportion of vehicles within each market group and location that are involved in a crash over the 2005 and 2006 period.

Table 4 Classification of registered vehicles in NZ by market group and area of residence of vehicle owner – 2005 and 2006

	Auckland		Other Urban		Rural	
Market group	**n**	**% of crash involved vehicles**	**N**	**% of crash involved vehicles**	**n**	**% of crash involved vehicles**
Overall	664,505	0.92%	1,094,722	0.84%	669,401	0.77%
4WDC	28,041	0.86%	39,850	0.65%	23,454	0.66%
4WDL	11,971	0.69%	20,428	0.63%	21,063	0.49%
4WDM	31,042	0.73%	56,317	0.69%	50,171	0.67%
Van/ute	53,292	0.97%	105,187	0.75%	94,312	0.64%
Large	68,474	0.91%	113,047	0.83%	80,051	0.66%
Light	42,415	0.87%	75,814	0.83%	32,366	0.82%
Luxury	55,867	0.77%	76,336	0.80%	43,879	0.67%
Medium	124,563	0.97%	214,824	0.88%	127,886	0.79%
People mover	25,524	0.92%	29,746	0.81%	15,275	0.83%
Small	185,445	0.95%	309,383	0.91%	154,941	0.95%
Sport	37,871	1.05%	53,790	0.97%	26,003	0.98%

Table 4 shows that there are generally higher crash involvement rates in more urbanised areas, with the highest rates experienced by vehicles based in Auckland and the lowest experienced by vehicles based in rural NZ. In each of the areas considered, sports cars had the highest rate of crash involvement. However, as these vehicles are relatively rare, their overall contribution to road injury will be modest despite these elevated rates. It is noted that different rates of ownership by driver groups will also affect the crash rates. To enable comparisons with data from the Australian jurisdictions which have more limited data, the owner characteristics – apart from owner location – have not been examined separately here.

The results of the modelling of crash involvement risk, together with standard errors and measurements of statistical significance, are presented in Appendix One. The reference categories used as the comparison levels for the estimates were:

- age: "30-59"
- market group: "unknown"
- townclass: "rural"
- vehicle age: "0-8" years.

It is noted that owner gender was not included in the model as it had no significant explanatory effect on the estimated risk of crash involvement when the other variables were included in the model.

A number of interactions between variables were also found to be significant including:

- owner age group and vehicle market group (agegrp×marketgroup)
- vehicle market group and the owner's location (marketgroup×townclass)
- the owner's location and vehicle age (townclass×vage).

These significant interactions indicate that the model found that the risk estimated for one variable varied significantly according to the values of the other variable.

The results of the analysis are also presented in tabular form in Appendix One. Table 23, Table 24, Table 25, and Table 26 present the estimated crash involvement risk for the age groups 15 to 19, 20 to 29, 30 to 59 and 60 plus respectively. Where a cell is blank (e.g., for teenage owners of people movers), the data were too scarce to produce worthwhile estimates. This does not effect the testing of scenarios for changes in the fleet according to vehicle market groups as these empty cells represent very few vehicles.

The following series of figures present the risk of crash involvement for vehicles aged 14 to 17 years by vehicle market group and the level of urbanisation of the owner's address. Vehicles of different ages were estimated to have the same relativity between market groups. The only thing that varies for different years of manufacture is the vertical placement of the lines for Auckland, other urban and rural categories.

For vehicle owners aged 15 to 19, Figure 4 shows clearly a high crash risk per vehicle for large cars. Small cars were also relatively risky when owned in rural areas. For owners aged in their 20s, Figure 5 shows that large, luxury, people movers and sports cars had a high estimated risk. When considering scenarios for changes in the composition of the vehicle fleet that may reduce the number of crashes, the number of vehicles in the vehicle fleet and in each market group needs to be assessed to see whether a scenario is likely to have a large effect on crash numbers. For example, even though people movers present a high risk for owners in their 20s and owners aged 60 plus, their relatively low representation in the vehicle fleets owned by these age groups means that any interventions focused on these vehicles will have little effect on the overall crash rate.

Figure 4 **Risk of NZ crash involvement for 14-17 year old vehicles owned by 15-19 year olds by market group and level of urbanisation of home address**

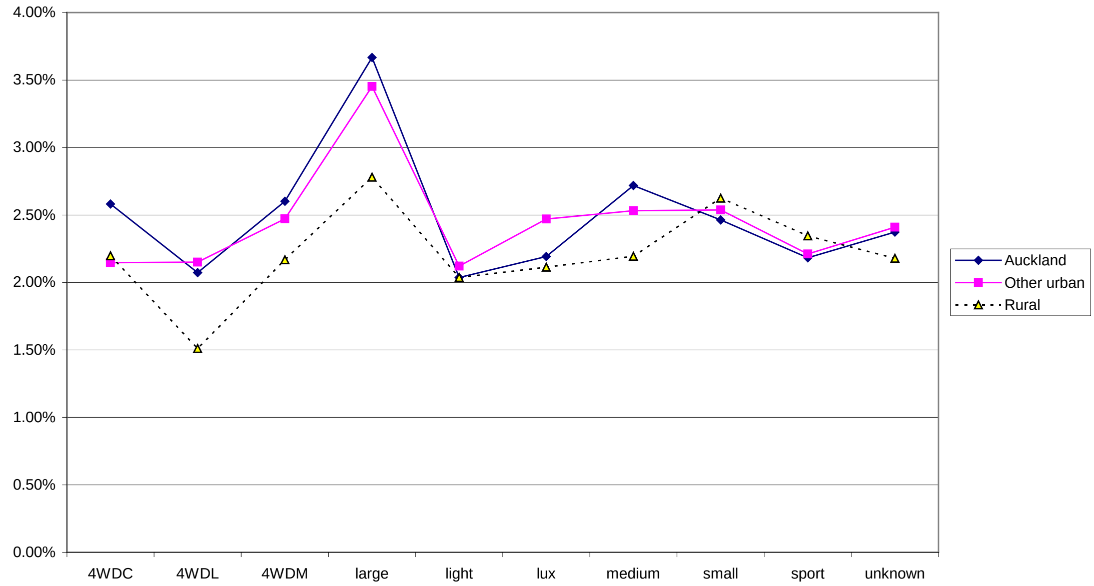


Figure 5 **Risk of NZ crash involvement for 14-17 year old vehicles owned by 20-29 year olds by market group and level of urbanisation of home address**

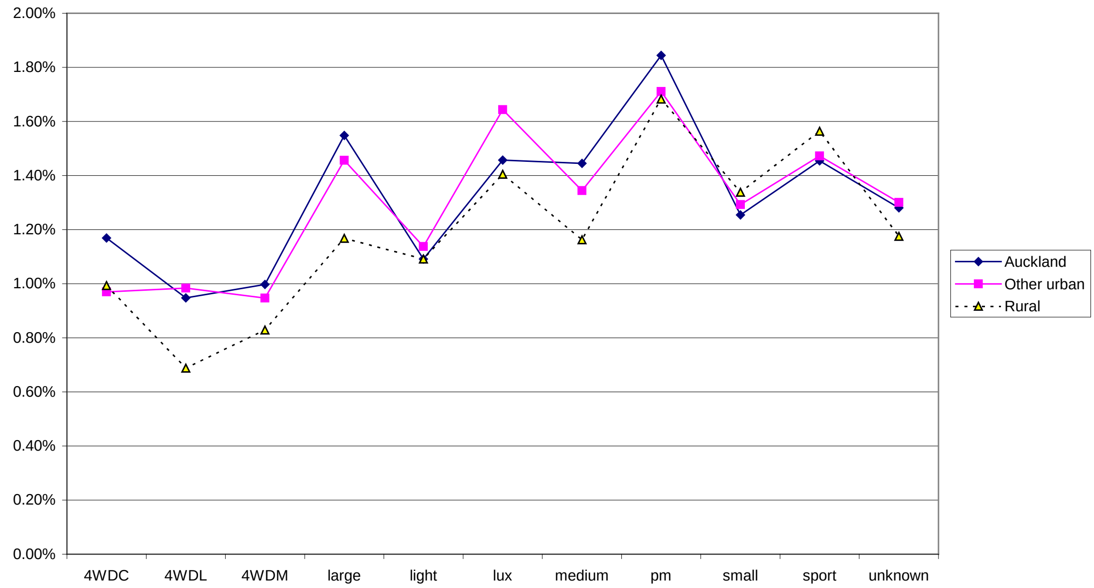


Figure 6 Risk of NZ crash involvement for 14-17 year old vehicles owned by 30-59 year olds by market group and level of urbanisation of home address

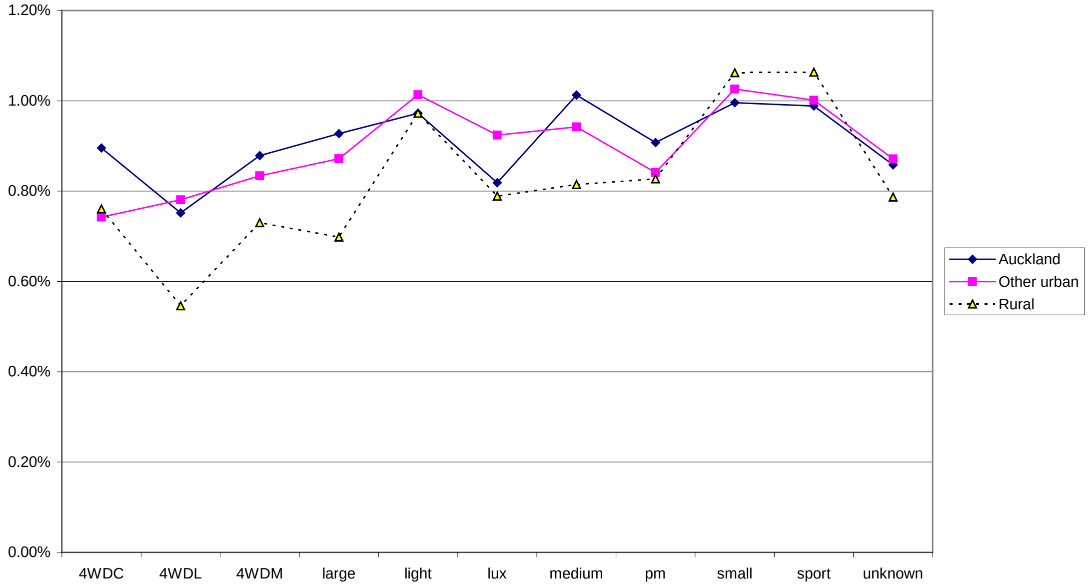


Figure 7 **Risk of NZ crash involvement for 14-17 year old vehicles of owners aged 60 plus by market group and level of urbanisation of home address**

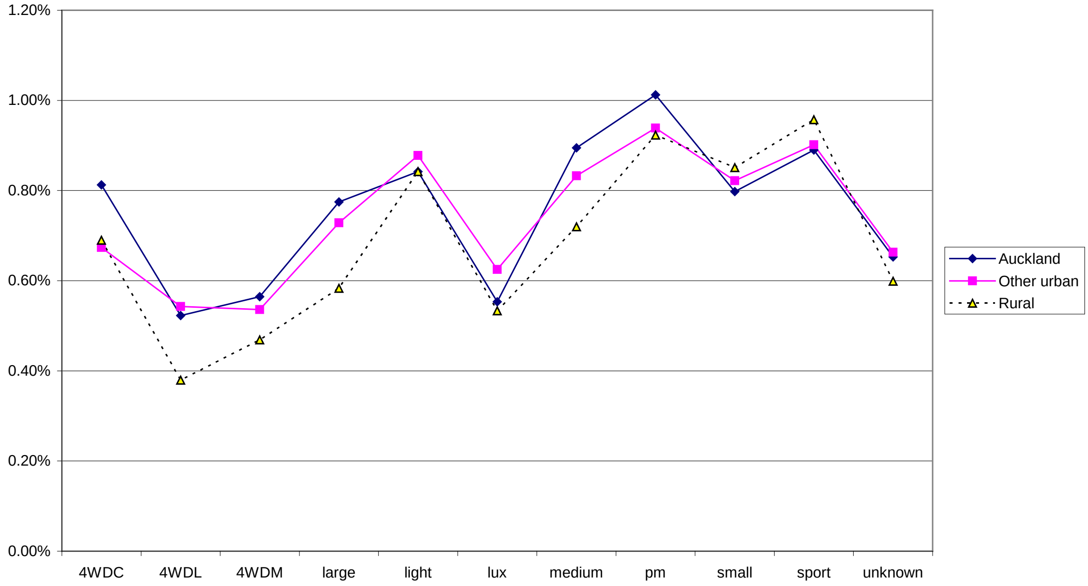
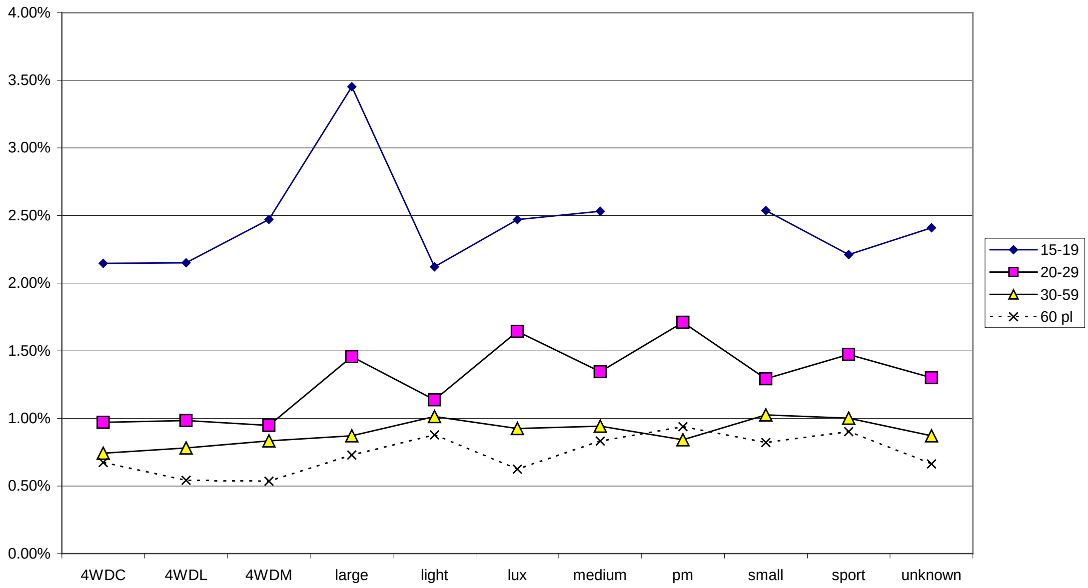


Figure 8 reproduces some of the information from the previous graphs, but the level of urbanisation and vehicle age are held constant (by showing only other urban-owned vehicles age between 14 and 17 years). This enables a comparison of the crash risks across the owner age groups, although this is obscured somewhat by the different vertical scales used in Figure 4 to Figure 7.

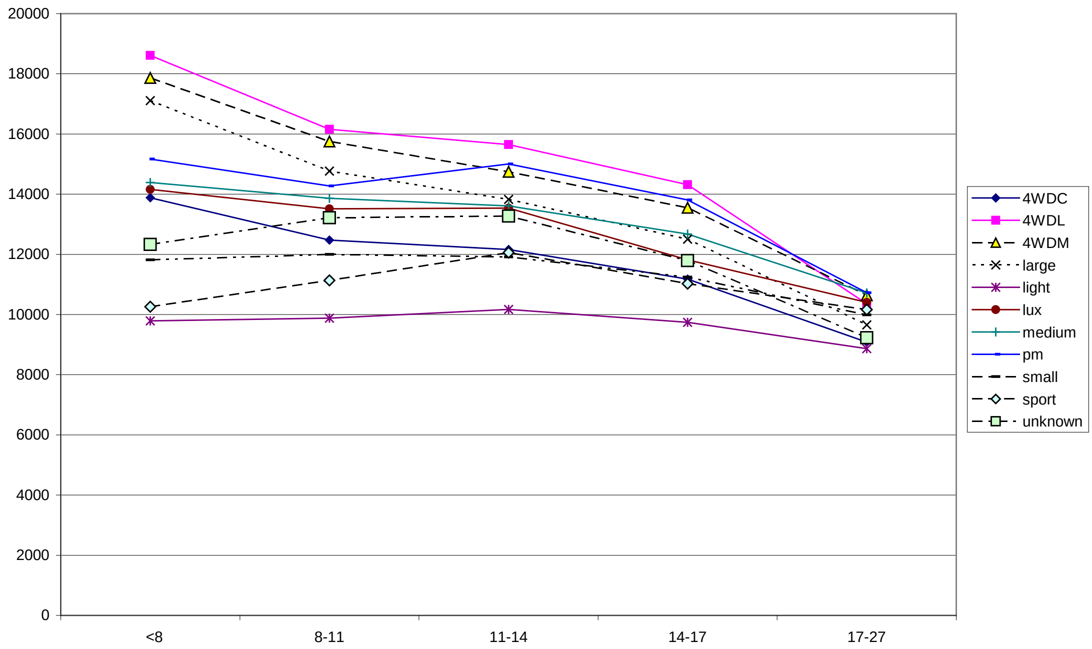
Figure 8 **NZ owner age group comparison of risk of crash involvement for 14-17 year old vehicles of owners in other urban locations by market group**



The most striking feature of Figure 8 is the far higher crash risk for vehicles owned by teenagers. The per-vehicle risks then generally fall with owner age, remaining elevated for owners in their 20s and reaching the lowest point for owners aged 60 plus, which is likely to be related to the way older owners use their vehicles. Figure 8 highlights the importance of having data on owner age for any vehicle risk estimation, which is unfortunately unavailable in the case of the NSW and Victorian motor vehicle registers.

Figure 9 shows some exposure information derived from the New Zealand motor vehicle licensing database. It shows that larger vehicles generally drove the highest annual distances. Newer vehicles also drove higher distances, although for many market groups, it was only for the oldest vehicles studied, those manufactured at least 17 years before the data were extracted, that the annual driving distances fell noticeably.

Figure 9 NZ average annual km driven by passenger vehicles in 2005/06 according to odometer readings by market group and age of vehicle



4.4 NSW vehicle fleet and ownership patterns

The crash involvement rates for each vehicle market group in NSW are presented in Table 5. It is clear from this data that there are higher crash involvement rates in Sydney than in Coastal Statistical Divisions, which were in turn higher than those in the Inland Statistical Divisions. These patterns are represented in Figure 10.

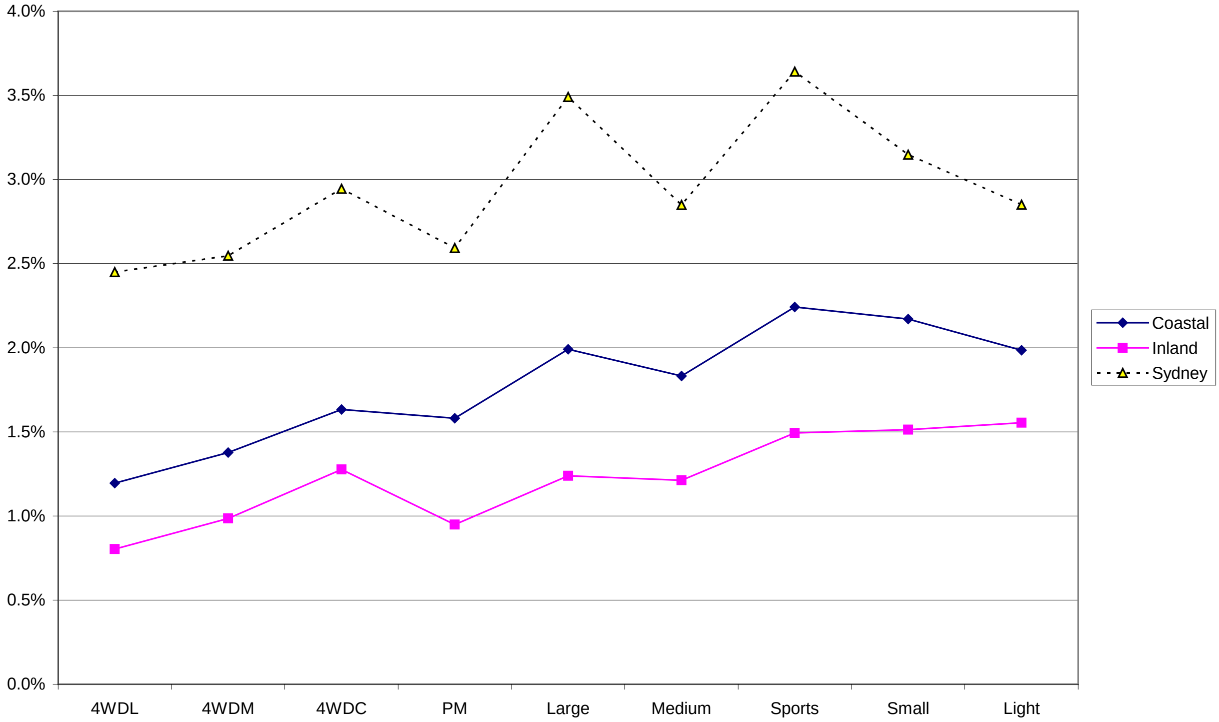
Table 5 Classification of registered vehicles in NSW by market group and area of residence of vehicle owner – registration data (2004); crash data (2004 and 2005)

	NSW		Coastal		Inland		Sydney	
Market group	**n**	**% of crash involved vehicles**	**n**	**% of crash involved vehicles**	**n**	**% of crash involved vehicles**	**n**	**% of crash involved vehicles**
Overall	3,640,368	2.4%	771,593	1.9%	884,211	1.3%	1,984,564	3.2%
4WDC	171,790	2.3%	36,625	1.6%	36,128	1.3%	99,037	2.9%
4WDL	146,298	1.6%	40,069	1.2%	44,181	0.8%	62,048	2.4%
4WDM	132,507	1.9%	32,034	1.4%	32,682	1.0%	67,791	2.5%
Ute	324,879	2.3%	87,033	1.9%	107,862	1.2%	129,984	3.5%
Van	77,692	2.7%	13,691	1.6%	15,146	1.2%	48,855	3.4%
Large	1,108,319	2.5%	236,248	2.0%	319,934	1.2%	552,137	3.5%
Medium	465,668	2.3%	87,266	1.8%	94,240	1.2%	284,162	2.8%
People mover	71,611	2.1%	11,829	1.6%	14,225	0.9%	45,557	2.6%
Small	830,727	2.6%	165,746	2.2%	155,960	1.5%	509,021	3.1%
Light	251,486	2.4%	53,605	2.0%	50,529	1.6%	147,352	2.8%
Sports	59,391	3.0%	7,447	2.2%	13,324	1.5%	38,620	3.6%

Not shown in Table 5 is the crash rate for those vehicles whose market group was unknown. There were 1,740,841 such vehicles with a crash involvement rate of 0.7%. This low calculated rate is likely to be related to factors that led to market group not being defined, such as missing data fields, rather than to actual low crash rates for these vehicles. These were generally also older vehicles that may not be driven as much as newer vehicles, as indicated by
Figure 9 for NZ vehicles.

The high rate of crash involvement for sports cars noted in the analysis of New Zealand data (Table 4) is also evident in Table 5. However, there is a significant difference between the NZ and NSW data overall. The estimated crash involvement rates are considerably higher in NSW than in NZ. This is largely an artefact of the types of crashes reported. NSW crash data include tow-away crashes in which no injury resulted. These are omitted from the NZ and Victorian data, which represent only injury crashes. As tow-away crashes are so much more common, NSW has a higher rate of crash involvement per vehicle.

Figure 10 Two-year crash involvement rates per registered vehicle in NSW by vehicle market group and area of owners' address

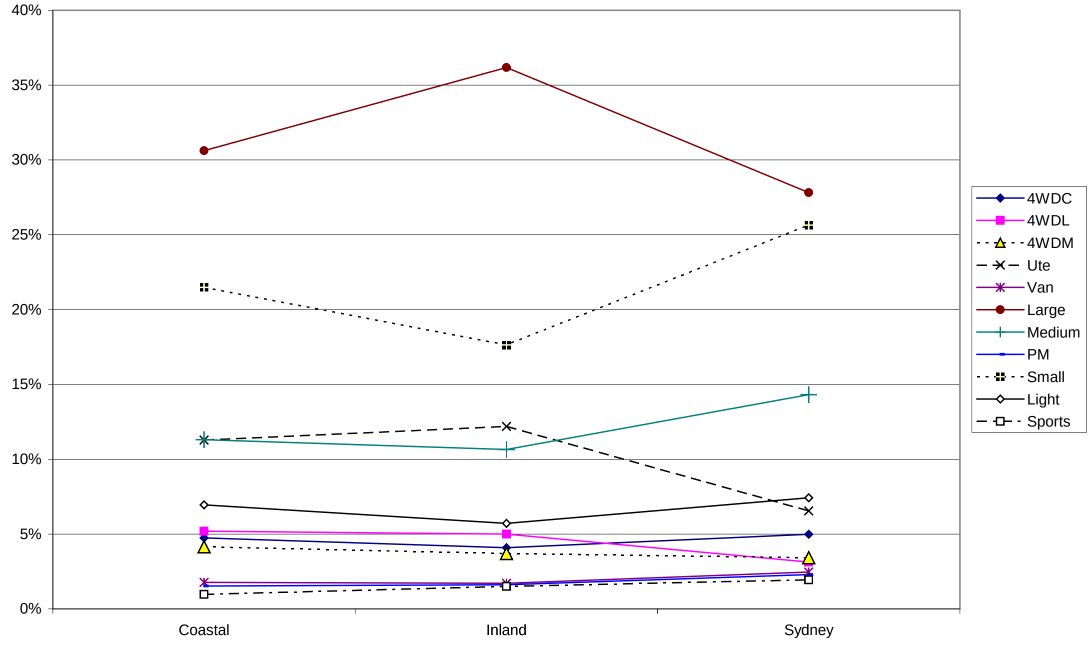


The distribution of registered vehicles by the location of the owners residence is shown in Table 6 and Figure 11. The data show little variation between areas in the composition of the licensed vehicle fleet for 4WDs (about 13% of the fleet in all areas). However, utes are much less common in urban city than in more rural areas. Large cars are also less common in Sydney than other areas of NSW but medium and small cars are more common in Sydney. This probably reflects the suitability of smaller cars for the urban setting.

Table 6 **Classification of registered vehicles in NSW by market group and area of residence of vehicle owners: registration data 2004**

	NSW		Coastal		Inland		Sydney	
Market group	**N**	**% of fleet**	**n**	**% of fleet**	**n**	**% of fleet**	**N**	**% of fleet**
Overall	3,640,368	100 %	771,593	100 %	884,211	100 %	1,984,564	100 %
4WDC	171,790	5%	36,625	5%	36,128	4%	99,037	5%
4WDL	146,298	4%	40,069	5%	44,181	5%	62,048	3%
4WDM	132,507	4%	32,034	4%	32,682	4%	67,791	3%
Ute	324,879	9%	87,033	11%	107,862	12%	129,984	7%
Van	77,692	2%	13,691	2%	15,146	2%	48,855	2%
Large	1,108,319	30%	236,248	31%	319,934	36%	552,137	28%
Medium	465,668	13%	87,266	11%	94,240	11%	284,162	14%
People mover	71,611	2%	11,829	2%	14,225	2%	45,557	2%
Small	830,727	23%	165,746	21%	155,960	18%	509,021	26%
Light	251,486	7%	53,605	7%	50,529	6%	147,352	7%
Sports	59,391	2%	7,447	1%	13,324	2%	38,620	2%

Figure 11 **Two-year crash involvement rates per registered vehicle in NSW by vehicle market group and by vehicle age**



To assess the potential effects of changes in the vehicle market fleet, it is useful to consider the proportion of the vehicle fleet comprised of younger vehicles. Table 7 shows the proportion of the NSW fleet in 2004 that was less than five years old. The analysis is restricted to those vehicles for which market group was able to be assigned, which excludes older vehicles.

Table 7 Proportion of the NSW vehicle fleet that was less than five years old by vehicle market group and area of owners' address: 2004 registration data

Market group	NSW	Coastal	Inland	Sydney
Overall	33%	28%	35%	35%
4WDC	59%	53%	64%	59%
4WDL	26%	19%	26%	31%
4WDM	52%	41%	55%	55%
Ute	38%	31%	39%	41%
Van	36%	28%	38%	37%
Large	29%	23%	28%	32%
Medium	27%	21%	31%	28%
People mover	33%	27%	38%	33%
Small	35%	31%	42%	35%
Light	31%	23%	38%	31%
Sports	28%	25%	26%	29%

Table 7 shows that, on average, large 4WDs are generally the oldest vehicles in the fleet, particularly in coastal areas. On average, the newer vehicles are compact 4WDs which reflects their more recent popularity and/or affordability. The vehicle fleet in coastal areas overall has a smaller percentage of newer vehicles than vehicle fleets elsewhere in NSW.

Figure 12 Two-year crash involvement rates per registered vehicle in NSW by vehicle market group and vehicle age

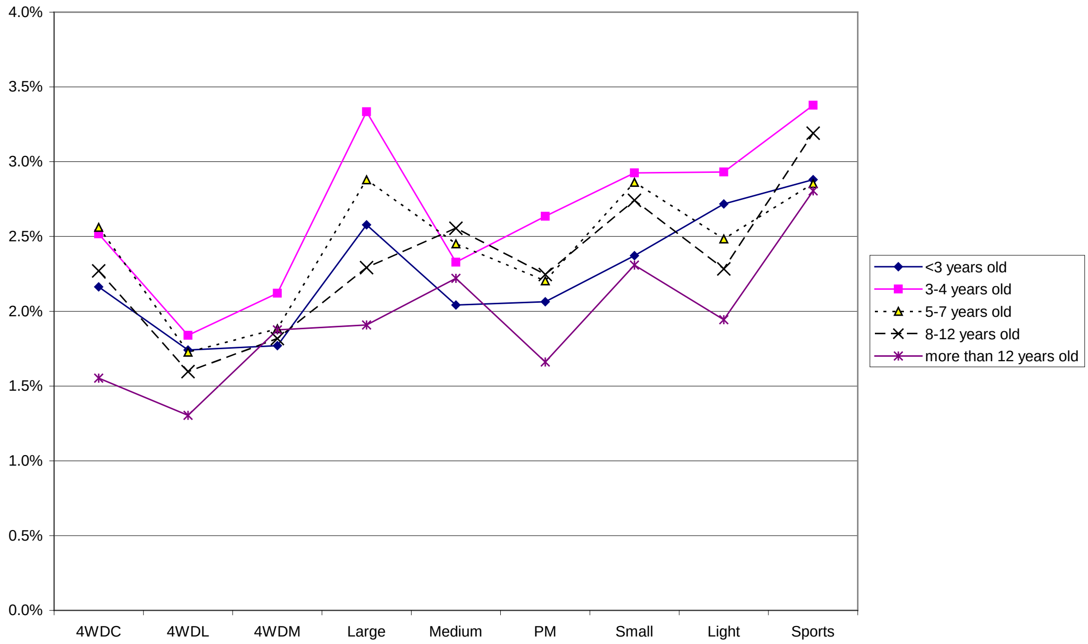


Figure 12 shows crash involvement rates for each market group by vehicle age. In general, vehicles aged between three and four years had the highest crash involvement rates and those aged more than 12 years had the lowest crash involvement rates. This last result is likely to be related to lower levels of exposure to crash risk for older vehicles as they may be driven less.

4.5 Victorian vehicle fleet and ownership patterns

Using Victorian registration data from 2005, it is possible to examine the composition of the vehicle fleet in terms of vehicle age and market group. This data is presented in Table 8 and Table 9. It should be noted that as the definition of market group is not reliable for older vehicles, the quintiles for analysis were different from the quintiles shown in the tables below.

Table 8 Classification of the Victorian vehicle fleet in 2005 for vehicles by vehicle age and market group: data excludes 2005 and 2006 model vehicles

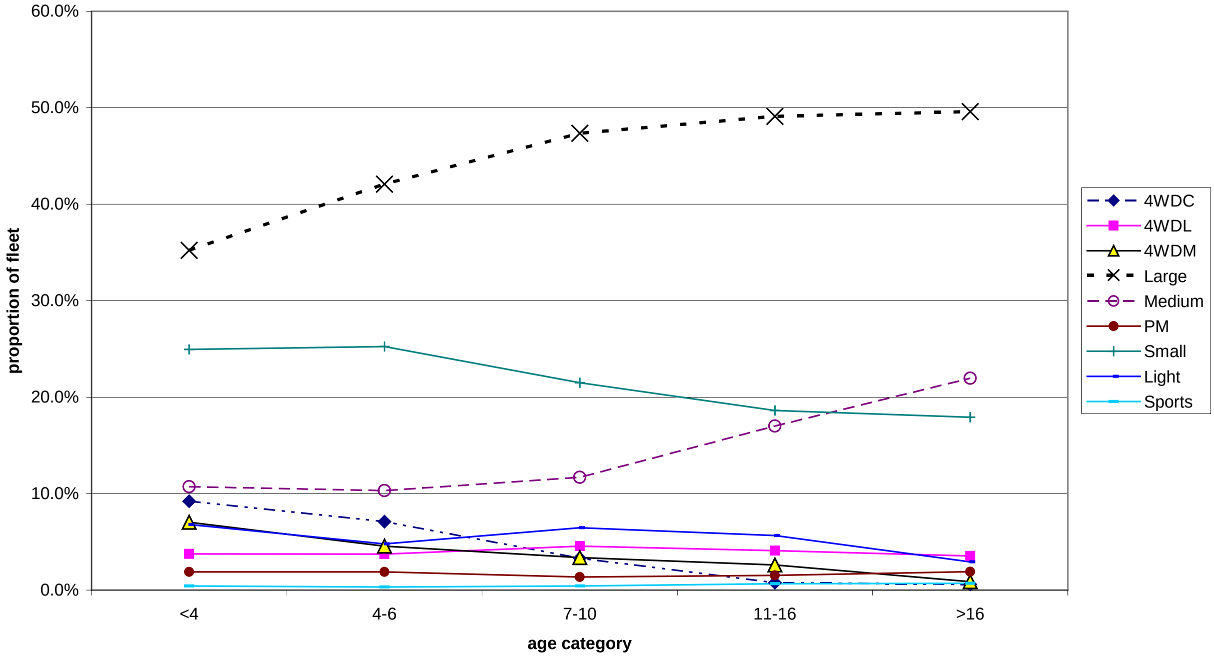
Market group	Vehicle age					Total
	<4	**4-6**	**7-10**	**11-16**	**>16**	**All ages**
Overall	452,035	620,092	689,194	608,314	627,248	2,996,883
4WDC	41,638	43,996	22,728	4,590	3,673	116,625
4WDL	16,932	23,089	31,367	24,849	22,158	118,395
4WDM	31,826	28,251	23,208	15,806	5,464	104,555
Large	159,242	260,986	326,374	298,805	311,139	1,356,546
Medium	48,461	63,944	80,539	103,393	137,804	434,141
PM	8,490	11,663	9,355	9,313	11,949	50,770
Small	112,765	156,524	148,161	113,202	112,340	642,992
Light	30,748	29,663	44,476	34,399	18,342	157,628
Sports	1,933	1,976	2,986	3,957	4,379	15,231

Table 9 Distribution of the Victorian vehicle fleet in 2005 by vehicle age and market group: data excludes 2005 and 2006 model vehicles

Market group	Vehicle age					Total
	<4	**4-6**	**7-10**	**11-16**	**>16**	**All ages**
4WDC	9.2%	7.1%	3.3%	0.8%	0.6%	3.9%
4WDL	3.7%	3.7%	4.6%	4.1%	3.5%	4.0%
4WDM	7.0%	4.6%	3.4%	2.6%	0.9%	3.5%
Large	35.2%	42.1%	47.4%	49.1%	49.6%	45.3%
Medium	10.7%	10.3%	11.7%	17.0%	22.0%	14.5%
PM	1.9%	1.9%	1.4%	1.5%	1.9%	1.7%
Small	24.9%	25.2%	21.5%	18.6%	17.9%	21.5%
Light	6.8%	4.8%	6.5%	5.7%	2.9%	5.3%
Sports	0.4%	0.3%	0.4%	0.7%	0.7%	0.5%
Total	100%	100%	100%	100%	100%	100%

The data from Table 9 is presented in graphical form in Figure 13. The data indicate that older vehicles in the Victorian fleet are less likely to be small vehicles or 4WDs than the more recent model vehicles. More recent vehicles are less likely to be classified as large or medium.

Figure 13 Victorian registration data from 2005 for vehicles for which market group was able to be assigned, excluding 2005 and 2006 model vehicles



When compared to data for NSW (Figure 12), Figure 14 shows a similar pattern of crash involvement rates in Victoria by vehicle market group and vehicle age. The Victorian fleet for which market group was able to be assigned was somewhat older than comparable vehicles in NSW and this is indicated by the older age ranges defined for the quintile groups.

Figure 14 Two-year crash involvement rates per registered vehicle in Victoria by vehicle market group and vehicle age

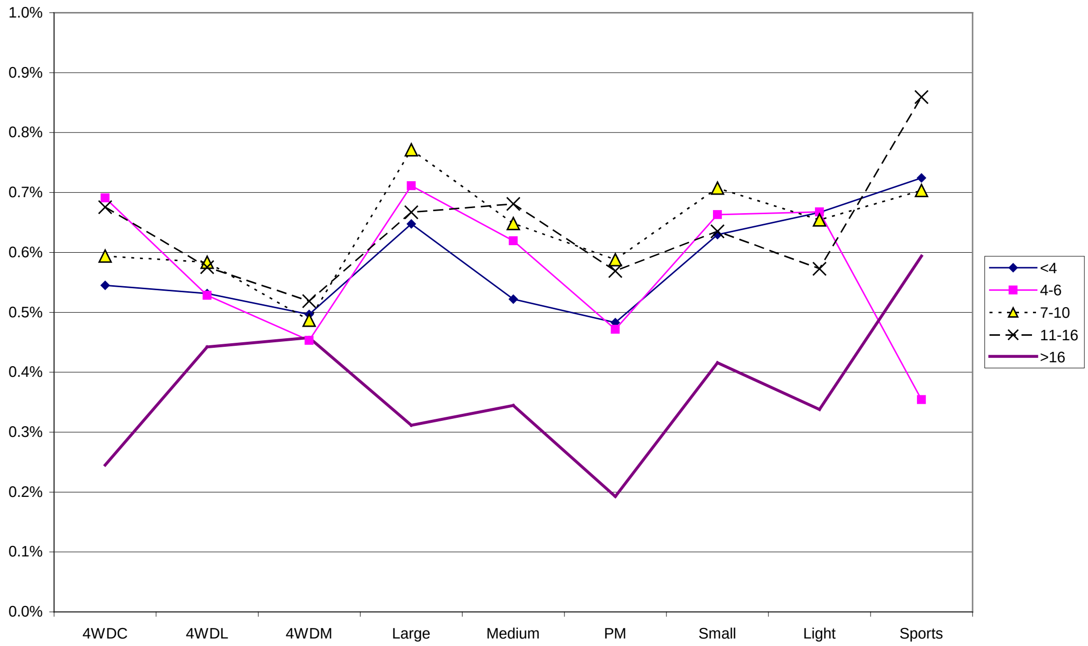


Table 10 shows Victorian fleet crash involvement rates by vehicle market group and vehicle age.

Table 10 Two year crash involvement rates per registered vehicle by vehicle market group and vehicle age: registration data 2005, crash data 2005 and 2006 rates per registered vehicle in NSW by vehicle

Market group	Vehicle age					Total
	<4	4-6	7-10	11-16	>16	
Overall	0.60%	0.66%	0.71%	0.65%	0.34%	0.59%
4WDC	0.55%	0.69%	0.59%	0.68%	0.25%	0.61%
4WDL	0.53%	0.53%	0.58%	0.58%	0.44%	0.54%
4WDM	0.50%	0.45%	0.49%	0.52%	0.46%	0.48%
Large	0.65%	0.71%	0.77%	0.67%	0.31%	0.62%
Medium	0.52%	0.62%	0.65%	0.68%	0.34%	0.54%
PM	0.48%	0.47%	0.59%	0.57%	0.19%	0.45%
Small	0.63%	0.66%	0.71%	0.64%	0.42%	0.62%
Light	0.67%	0.67%	0.65%	0.57%	0.34%	0.60%
Sports	0.72%	0.35%	0.70%	0.86%	0.59%	0.67%

As for NSW, the oldest quintile of Victorian vehicles studied was generally safest on a per-vehicle basis, which is likely to be an artefact of lower distances driven by these vehicles as shown for NZ vehicles in Figure 9. Large cars had quite a high risk of crash involvement per vehicle as were sports cars. The lower crash rates for Victoria compared to NSW are mainly due to the crash data collected as non-injury crashes are recorded in NSW, but not in Victoria.

4.6 Comparison of some fleet characteristics of NZ, NSW and VIC

Table 11 shows a comparison of the three registration data sets being analysed in this study. Note that the data used for the analyses excluded vehicles for which market group was not able to be defined, which were mainly older vehicles. This means that the age quintiles defined for the analysis were different from the quintiles shown in this table, which represents the entire fleets of the jurisdictions shown and provide a better basis for comparisons between fleets.

Table 11 Comparison of year of manufacture of cars, utes and vans for registration databases from NZ (2005/2006 data), NSW (2004 data) and VIC (2005 data)

	20^{th} percentile	40^{th} percentile	60^{th} percentile	80^{th} percentile	Total cars and vans
NSW	1984	1992	1997	2001	5,210,687
VIC	1985	1991	1997	2001	4,265,069
NZ	1987	1991	1994	1997	3,340,794

The 20^{th} percentile is interpreted as indicating that approximately 20% of the fleet in question had a year of manufacture earlier than the percentile calculated. Similarly, this was the case for the other percentiles. Note that NSW data were extracted for an earlier date than the other two jurisdictions, so a year or two should be subtracted from each percentile if we assume no major changes in the age of the NSW fleet from 2004 to 2005. This means that the NSW fleet is effectively slightly newer than the Victorian fleet by at least one year across all percentiles. NZ data are a combination of vehicles that were licensed as at the beginning of 2006 and/or in the middle of 2005. Although NZ has proportionately fewer older vehicles, the 60^{th} and 80^{th} percentiles for NZ are three years and four years older than the Victorian passenger fleet, indicating that there are fewer new vehicles in the NZ fleet. These differences are likely to be due to both the used car importation system in NZ as well as to other differences in vehicle markets and economies between the countries.

The vehicle fleets have also been compared on the basis of the proportion of vehicles crashed in speed zones over 75 km/h and the data is presented in Table 12.

Table 12 Percentage of crashed vehicles that crashed in higher speed limit areas (over 75km/h)

	% in higher speed limit areas		
Year	**NZ**	**NSW**	**VIC**
2001	41%	17%	28%
2002	39%	17%	30%
2003	40%	17%	29%
2004	40%	18%	28%
2005	40%	17%	30%
2006	38%	17%	-
Overall	39%	17%	29%

The comparisons in Table 12 are made using the crashworthiness datasets data for NSW and Victoria developed by MUARC (which exclude early models of vehicles, as described above). The data shows that a very low proportion of crashed vehicles in NSW were in higher speed limit areas. The principal reason for this is that tow-away crashes are included in the NSW data which most common in lower speed limit areas. The proportion of crashes in higher speed limit areas is lower in NSW as an artefact of the crash threshold used. A comparison of the NZ and Victoria data, which include only crashes involving injury, shows that New Zealand has a much higher proportion of crashes occurring in higher speed limit areas. This is likely an indication of the higher proportion of travel in New Zealand that occurs on such roads. Such differences in exposure may mean that the same vehicle may provide slightly different average levels of occupant protection in New Zealand compared to in Australia.

4.7 NZ scenarios for change in the vehicle fleet

Scenarios for changes in the vehicle fleet were first estimated by age group and by urbanisation level within age group when a particular risk pattern was apparent. The scenarios presented in Table 13 are preceded by the italicised "*situation as is*" that presents the crash involvement rate for owners in that age group under the fleet and ownership conditions of 2005/2006.

Lastly, some scenarios were estimated across all age groups equally. As there are some quite large differences between the risk patterns of the different owner age groups, such changes tend to be fairly blunt instruments, leading potentially to some increases in crash risk for some age groups. One such example is that large cars were estimated to be a relatively safe vehicle for owners aged 30-59 and 60 plus, but relatively risky for the younger owner age groups. Such differences in patterns need further research to identify the way that crash patterns may differ for different age groups and different market groups and how driving patterns may also differ for different market groups and driver age groups.

The scenarios tested and their estimated results are shown in Table 13.

Table 13 Scenarios for changes to vehicle market groups and the potential improvement in the rate of injury crash involvement and number of crashed vehicles

Scenario	Group targeted	Situation	Crash rate	Improvement from "as is"	Reduction in number of crashed vehicles
1	***15-19***	***Situation as is***	***2.126%***	-	-
2	15-19	to medium from small	2.090%	1.7%	11.7
3	15-19	switch to medium from small just in rural areas	2.071%	2.6%	17.8
4	15-19	to medium from large cars	2.090%	1.7%	11.9
5	15-19	scenarios 3 and 4 together	2.034%	4.3%	29.7
6	***20-29***	***Situation as is***	***1.185%***	-	-
7	20-29	to medium from large and sports	1.170%	1.2%	41.6
8	20-29	to medium from small just in rural	1.174%	0.9%	31.2
9	20-29	scenarios 7 and 8 together	1.159%	2.1%	72.8
10	***30-59***	***Situation as is***	***0.806%***	-	-
11	30-59	to large from sports	0.800%	0.7%	82.3
12	30-59	to medium from small just in rural areas	0.795%	1.4%	153.0
13	30-59	to large from medium, small and light	0.753%	6.6%	737.4
14	***60 plus***	***Situation as is***	***0.648%***	-	-
15	60 plus	to large from sports	0.644%	0.7%	18.3
16	60 plus	to medium from small just in rural areas	0.638%	1.5%	39.6
17	60 plus	to large from medium, small and light	0.586%	9.6%	259.5
18	60 plus	to large from medium, small, pm and light	0.582%	10.1%	272.6
19	***Overall***	***Situation as is***	***0.846%***	-	-
20	Overall	to large from sports	0.843%	0.4%	80.6
21	Overall	to medium from	0.835%	1.3%	241.7

Scenario	Group targeted	Situation	Crash rate	Improvement from “as is”	Reduction in number of crashed vehicles
		small just in rural areas			
22	Overall	to large from medium, small and light	0.815%	3.7%	666.9

The last three scenarios are applied across the entire fleet. Although large cars appear to present relatively high risk for young owners, nevertheless the wholesale switch to large cars from medium, small and light shown in the final scenario (Scenario 22) still generates a large improvement. This is because young owners are a small proportion of all owners (see Figure 3).

4.8 NSW scenarios for change in the vehicle fleet

Unlike NZ, the registration data from NSW had no data on vehicle owner age or gender, but did have information on the area of residence of vehicle owners. This meant that relatively simple scenarios could be tested such as those involving shifts in preference to a different vehicle market group. The lack of ability to disaggregate by owner characteristics meant that there was greater potential for confounding in the estimation of the effects of scenarios. Such confounding can arise, for example, when particular market groups are favoured by young owners, a group with known elevated driver risk, leading to apparently high rates for that market group.

Although Figure 10 shows clearly lower crash involvement risks per vehicle for people movers, for example, it was not considered a realistic scenario to test the effects of wholesale shifts to people movers from other market groups. Clearly, people movers are vehicles that people purchase for a particular purpose, generally to carry several passengers, and are therefore unlikely to be a realistic choice for other market group owners. Further, the sort of exposure of people movers when they are ferrying passengers may lead to different types of exposures and risks from other market groups. Such differences would violate the assumptions of the scenario modelling.

For similar reasons, there was no scenario modelling of vehicle age. Results for all three jurisdictions showed consistently lower risk for the oldest quintiles of vehicles studied, suggesting that such vehicles are driven differently compared to newer vehicles, probably with lower annual mileages. Again, the scenario modelling cannot account for such differences in exposure and no attempt was made to model the effects of changes in the age profiles of the fleets on crash involvement rates.

Table 14 shows four scenarios for change in the market group composition of the NSW fleet.

Table 14 Scenarios for changes to vehicle market groups and the potential improvement in the rate of injury crash involvement and number of crashed vehicles

Scenario	Situation	Crash rate	Improvement from "as is"	Reduction in number of crashed vehicles
1	***Situation as is***	2.44%		
2	to medium cars from large cars	2.31%	5.2%	4,077
3	to medium cars from sports cars	2.42%	0.5%	382
4	to medium from small and Light	2.35%	3.7%	2,912
5	to medium from large just in Sydney	2.32%	4.7%	3,677

Because large cars are a substantial part of the NSW vehicle fleet and they have quite a high crash risk relative to the other market groups, a wholesale shift to medium cars yields substantial benefits; a 5.2% reduction in the proportion of all crash-involved vehicles in NSW. Even though sports cars have a high crash rate, they are not common in the NSW fleet, so a shift from sports cars to medium cars was estimated to produce little overall benefit (Scenario 3). Scenario 4 shows that a shift from small and light cars to medium cars would result in an overall 3.7% reduction in the two-year crash involvement rate or almost 3,000 fewer crashed vehicles.

4.9 Victorian scenarios for changes in the vehicle fleet

Unlike NZ, the registration data from Victoria had no data on the age, gender or area of residence of vehicle owners. As a result, only simple scenarios involving shifts in preference to a different market group could be tested. Although Figure 14 shows clearly lower crash involvement risks per vehicle for people movers, for example, it was not considered a realistic scenario to test the effects of wholesale shifts to people movers from other market groups, as explained above for the NSW scenarios. Also as explained above, there was no scenario modelling of vehicle age.

Table 15 Scenarios for changes to vehicle market groups and the potential improvement in the rate of injury crash involvement and number of crashed vehicles

Scenario	Situation	Crash rate	Improvement from "as is"	Reduction in number of crashed vehicles
1	***Situation as is***	0.59%		
2	to medium cars from large cars	0.53%	10.3%	1830
3	to medium cars from sports cars	0.59%	0.1%	18
4	to medium cars from small and light cars	0.58%	1.8%	329

4.10 Effect on injury rates of changes in the aggressivity of the vehicle fleet

In order to quantify the effects on crash rates of the scenarios tested, it is necessary to identify the proportion of light vehicles involved in crashes where the aggressivity and/or the crashworthiness of the vehicle was important for injury outcomes for that vehicle's occupants. This information is shown for the NZ crash environment in Table 16. Corresponding data for tow-away crashes in NSW is shown in Table 17, derived from a previous report (Newstead et al, 2004). In the third column of Table 17 there are imputed numbers of vehicles involved in tow-away crashes, derived by multiplying the number of vehicle to vehicle crashes by two to get an approximation of the number of vehicles involved. Although the distribution of crash types was different for the NSW tow-away crashes compared to the NZ injury crashes, the total proportion of vehicles involved in crashes where the aggressivity of the vehicle could potentially influence the injury outcomes for other involved road users were identical.

Table 16 Crashed light passenger vehicles in NZ 2005/06 by crash type

Crash type involving light passenger vehicle according to crash partner	Proportion of light passenger vehicles involved in injury crashes	Crashed light vehicles involving injury risk to own vehicle occupants	Crashed light vehicles involving injury risk to other road users
Vehicle to vehicle	55%	55%	55%
Vehicle to heavy vehicle	5%	5%	0%
Single vehicle	26%	26%	0%
Unprotected road user	15%	0%	15%
Total	**100%**	**85%**	**69%**

Table 17 Percentage of tow-away crashes in NSW by crash type and imputed numbers of crashed light vehicles: adapted from (Newstead et al, 2004)

Crash type involving light passenger vehicle according to crash partner	% of tow-away crashes*	Imputed % of vehicles in tow-away crashes	Crashed light vehicles involving injury risk to occupants of own vehicle	Crashed light vehicles involving injury risk to other road users
Vehicle to vehicle	45%	62%	62%	62%
Vehicle to heavy vehicle	16%	11%	11%	0%
Single vehicle	29%	20%	20%	0%
Unprotected road user	10%	7%	0%	7%
Total	**100%**	**100%**	**93%**	**69%**

*These data are from (Newstead et al, 2004)

The effect of changes in the vehicle fleet on injury outcomes can then be calculated by combining information from the above tables with estimated aggressivity of the market groups being exchanged plus the prevalence of the original market group in the fleet.

Equation (1) is repeated here for reference:

$$p_{fs(other)}(Large) = p(riskother) \times p(Large) \times agg(Large) \quad (1)$$

Where

$p_{fs(other)}(Large)$ = estimated proportion of all tow-away crash involved vehicles that are large cars causing fatal or serious injury to another road user

p(riskother) = proportion of all tow-away crash involved vehicles that cause injury to other road users

p(Large) = proportion of the vehicle fleet that is large cars

agg(Large) = aggressivity of large cars (the risk that a crash involving a large car results in a serious/fatal injury to another road user)

Aggressivity has been estimated per market group in MUARC report 280 (Newstead et al, 2008). The average aggressivity was estimated to be about 3.7 for large cars and about 3.6 for medium cars. Putting all this information into equation (1) yields the estimates shown in Table 18, including the estimated improvement in fatal and serious injury rates that can be attributed to *fleet effects* of improved aggressivity (see equation (2)). Note that these are additional to the improvements in crash involvement rates estimated in the previous subsections. However, as shown in Table 18, the estimated improvements are quite modest, amounting to only 1 fatal or serious casualty saved per 1,000 such casualties in NZ, only 2 per 1,000 in NSW and 3 per 1,000 in Victoria.

Table 18 Fleet effects of replacing all large cars with medium cars

Jurisdiction	$p_{fs(other)}(Large)$	$p_{fs(other)}(\text{Medium replacing Large})$	**Estimated improvement in overall fatal/serious injury rate**
New Zealand	0.31%	0.30%	0.01%
NSW	0.77%	0.75%	0.02%
VIC	1.16%	1.13%	0.03%

5 DISCUSSION

Using the available registration and crash data from New Zealand, NSW and Victoria, it has been possible to develop an understanding of the licensed vehicle fleets as well as the crash vehicle fleets in these jurisdictions. The analysis has highlighted some notable differences that are relevant to the overall safety of the vehicle fleets. Large cars dominated the Australian vehicle fleets studied, making up 45% of the Victorian light passenger vehicle fleet and 30% of the NSW vehicle fleet. In contrast, only 11% of the NZ fleet were large cars. This situation was reversed for medium and small cars, which together made up almost half of the NZ fleet (19% and 27% respectively), but only 13% and 23% of the NSW fleet, and 14.5% and 21.5% of the Victorian fleet.

In terms of the age distribution of vehicles, NSW had the newest fleet, followed by Victoria and then New Zealand. The age distribution of the New Zealand fleet was somewhat unusual in that there were proportionately fewer older vehicles than the Australian fleets, but also proportionately fewer newer vehicles. The bulk of the New Zealand fleet could be described as "middle-aged", the fleet age distribution influenced by the widespread importation of used cars from Japan.

Given these differences in the vehicle fleets, it is necessary to consider potential scenarios for changes to the composition of the vehicle fleets separately for each jurisdiction. However, before discussing the results of the scenario modelling, it is useful to highlight the limitations of that modelling and, in particular, the assumption that replacing one vehicle market group with another will result in the change in crash rates estimated in this study.

First, there is an inherent assumption that the *amount* of exposure (e.g., the number of kilometres driven) is not determined by the characteristics of the vehicle. However, this is not consistent with data for the oldest quintile of vehicles studied. These vehicles were found to have a low crash involvement rate in all three vehicle fleets (see for example Table 10). It does not make sense that older vehicles without many of the modern safety features of more recent vehicles should have such distinctly lower crash risk unless they are driven substantially less than more modern vehicles. Older vehicles are driven lower distances per vehicle in New Zealand, as indicated by Figure 9, and this pattern is likely to be true of Australia (but we do not have the data to examine this currently). This lower exposure is likely to account for the lower crash involvement rates of older vehicles.

The second assumption in testing the scenarios is that the *type* of exposure (e.g., the proportion of driving on congested roads) does not depend on the characteristics of the vehicle. Again, this is almost certainly not true and is most obvious for the analysis of per-vehicle risk by the area of owners' residence. This analysis shows elevated risk in more urbanised areas of both NZ and NSW. The analysis was not possible in Victoria because the data provided were more limited. Further, the higher ownership levels of small cars in Sydney compared to other parts of NSW shown in Table 6 provide evidence that different market groups are preferred for different types of exposure (e.g., small cars are preferred for driving in congested city traffic). Because the patterns of exposure showed inconsistencies with the assumptions, the scenarios tested were generally restricted to changes between market groups that were likely to have similar types and degrees of exposure, such as shifts between large cars and medium cars. Despite their relatively low crash involvement risk, the larger 4WDs were not considered in the scenarios for two reasons: they are relatively rare in the fleet, meaning that their ownership is less likely to be representative of passenger vehicle owners more generally; and, they are substantially different vehicles that will often be used for different purposes to other passenger vehicles.

In addition to the above constraints, the crash involvement risks estimated for NZ and Victoria include aspects of both the primary and secondary safety of the vehicle market group. That is, the ability of the vehicle market group to avoid crash involvements in the first place, the protection provided by the vehicle market group in the event of a crash and the harm the vehicle market group does to the occupants of another vehicle into which it crashes. Using injury crash data alone, it is not possible to separate out the effects of these three factors. It is potentially the topic of further research to use tow-away crash involvement risks, such as can be computed using NSW data, to disentangle these effects. Reporting rates for crashes can be assumed to be related to the severity of the crash (Alsop, 2001), so even the analysis of tow-away crashes will include effects due to secondary safety as lower severity crashes have poorer reporting rates than higher severity crashes.

The scenarios used in the analysis replaced one vehicle market group with another vehicle market group with the effect of reducing crash involvement rates. Some of the scenarios presented showed quite substantial reductions in crash rates. For example, switching all large cars to medium cars in Victoria resulted in an estimated 10.3% reduction in crash involvement and the same change in the NSW vehicle fleet was associated with a 5.2% reduction in the crash rate. These results are also positive for carbon emissions policy and for reducing Australia's reliance on imported fuel, as the more fuel efficient vehicles (medium cars) also appear to be safer. However, small cars appear to have an elevated crash risk that should be taken into account if they are recommended as an option for reducing carbon emissions and petrol consumption. Further research is required to identify whether smaller cars have distinctly different exposure (e.g., whether they are used in congested traffic where the potential for collisions is higher) that contributes to their higher estimated crash rates. The consumer preference for small cars in urban areas such as Sydney compared to other areas of NSW hints that this may be the case. For the New Zealand fleet, the replacement of large cars with potentially more fuel-efficient medium cars was estimated to reduce safety overall. Again, further research is required to see whether differences in exposure patterns explain at least some of the lower risk estimated for large cars in New Zealand.

Table 12 shows that the crash patterns in New Zealand are quite different from the NSW and Victorian crash patterns, with a much larger proportion of crashes occurring in higher speed limit areas in New Zealand. Crash patterns provide an indication of driving patterns, but need to be confirmed by further research. In terms of achieving optimal safety levels, the driving environment in New Zealand may generally favour larger vehicles because of the higher proportion of driving that occurs on higher speed limit roads. However, examination of Table 23 to Table 26 shows that the area where the cars were owned (Auckland/other urban/rural) did not seem to affect the comparative safety of large and medium cars. This does not support the theory that the different road environment in New Zealand favours large cars in terms of safety. Auckland is a large urbanised area that should be similar in terms of road environment to the Australian cities.

The factor that did influence the comparative safety of large and medium cars in New Zealand (again, see Table 23 to Table 26), was the vehicle owner's age. For owners aged under 30, large cars had a higher risk than medium cars; this was reversed for owners aged 30 plus: medium cars had a higher risk than large cars. Such differences are consistent with exposure differences for younger and middle-aged owners, which again require further research.

The final and most significant qualification to the results presented in this report, is that the scenarios presented are an idealised situation where *all* vehicles of a given market group are immediately converted to a different vehicle market group. In reality, specific vehicle markets groups are unlikely to ever be entirely removed from the vehicle fleet and any changes are likely to occur over time. Therefore, the results of the scenario modelling should be seen as being an indication of the *direction* of the potential effects that could occur via policy changes or changes in consumer behaviour that may or may not be influenced by government information programmes, policy or legislation.

6 CONCLUSIONS

The study has found important differences between the New Zealand light passenger vehicle fleet and the vehicle fleets in NSW and Victoria. The New Zealand vehicle fleet, probably influenced by the widespread importation of used cars from Japan, is older on average than these two Australian fleets, but also has proportionately fewer older vehicles. There were also marked differences in crash patterns, with a much larger proportion of crashes in New Zealand occurring on higher speed limit roads than in either Victoria or NSW. This is likely to be a reflection of substantial differences in driving patterns, which may affect the composition of the vehicle fleet that achieves the lowest crash involvement rates. Passenger vehicle market groups were evaluated in terms of their crash rates per vehicle in the three fleets studied. In New Zealand, large cars were generally found to have lower crash involvement rates; in the Australian states, medium cars were found to be superior.

By modelling crash involvement rates using the available data on the vehicles and their owners, various scenarios were tested that involved shifts in market group preferences in each vehicle fleet. In particular, the effects on crash involvement rates were tested where entire market groups were removed from the fleet and replaced by market groups with lower crash involvement rates. These cannot be seen as realistic scenarios, but rather as extreme shifts that indicate the direction in which vehicle fleet safety could move, given shifts in market preference. These extreme shifts from large cars to medium cars were predicted to result in as much as a 10% injury crash involvement rate decrease for Victoria and a 5% reduction in tow-away crash involvement in NSW. For New Zealand, an overall switch from medium, small and light cars to large cars was predicted to yield an almost 4% decrease in injury crash involvement. Purely lowering the average *aggressivity* of the fleets, by switching from large cars to medium cars, was predicted to yield only a very modest reduction in road injury.

The main qualification to be applied to the results of the scenarios is that the scenarios present an idealised situation where *all* vehicles of a given market group are immediately converted to a different vehicle market group. Therefore, the effects should be seen as being an indication of the *direction* of potential effects that could occur via policy changes or changes in consumer behaviour that may or may not be influenced by government information programmes, policy or legislation.

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APPENDIX 1: DESCRIPTION AND ESTIMATED RISK PROFILE OF THE NZ VEHICLE FLEET

Table 19: Table of numbers of licensed vehicles in the NZ passenger fleet manufactured since 1979: 2005 and 2006 data for individual vehicle owners aged 15-19 (a * indicates <10)

Location	Auckland					Other urban					Rural				
Veh age	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27
4WDC	*	16	30	13	11	*	13	23	23	28	*	*	12	22	36
4WDL	*	*	*	*	*	*	*	*	*	14	*	*	*	*	18
4WDM	*	*	11	14	23	*	*	28	40	65	*	*	23	46	69
large	*	*	58	99	128	*	46	70	224	389	*	28	68	201	362
light	14	74	52	93	184	26	73	100	144	601	*	44	61	135	409
lux	13	35	46	62	134	*	41	83	156	407	*	24	55	98	280
medium	30	100	198	372	345	23	209	384	721	1020	21	143	321	663	863
pm	*	*	*	10	13	*	*	*	*	12	*	*	*	*	12
small	53	360	464	837	1204	55	441	642	1391	3451	57	366	564	1124	2707
sport	18	94	124	260	239	12	104	207	484	622	*	79	117	260	403
unknown	60	263	220	187	311	33	231	303	384	800	24	176	242	295	583

Table 20: Table of numbers of licensed vehicles in the NZ passenger fleet manufactured since 1979: 2005 and 2006 data for individual vehicle owners aged 20-29

Location	Auckland					Other urban					Rural				
Veh age	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27
4WDC	357	836	984	267	110	230	636	931	362	281	110	293	400	202	190
4WDL	39	101	99	68	74	43	133	65	134	228	37	82	75	148	260
4WDM	77	425	653	628	223	114	466	999	1067	752	118	354	789	803	740
large	488	987	1124	1336	982	752	1292	1553	2267	2863	678	875	1090	1363	2054
light	688	1227	772	795	1008	473	993	940	1191	2226	165	381	440	471	958
lux	472	1040	1376	888	979	224	828	1432	1257	2309	85	397	706	639	1173
medium	941	3891	4455	4550	2568	1106	4813	6613	7985	6542	682	2547	3595	4445	3848
pm	79	416	405	179	96	50	301	373	227	184	30	195	207	121	116
small	1805	7166	7226	6698	6120	1694	7327	8805	9493	13581	849	3224	4213	4516	7039
sport	370	1626	2200	3027	1643	207	1252	2277	3587	3099	45	420	811	1475	1405
unknown	1711	6886	5572	3079	2207	983	5721	5577	3933	4408	472	2612	2584	1998	2606

Table 21: Table of numbers of licensed vehicles in the NZ passenger fleet manufactured since 1979: 2005 and 2006 data for individual vehicle owners aged 30-59

Location	Auckland					Other urban					Rural				
Veh age	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27
4WDC	5231	5349	4712	1056	541	6121	6777	6483	2042	1674	3317	3378	3338	1404	1456
4WDL	1904	2017	1080	1294	919	2319	3185	1712	2481	2771	2160	2954	1846	2885	3371
4WDM	3162	4234	5557	4613	1909	4897	6693	9661	8938	5265	4299	5581	8529	7945	5628
Large	9919	7574	6877	5287	3410	17433	11760	10338	9035	10147	14595	8408	7451	6712	8430
Light	4994	4678	3138	2345	3247	7399	6032	5171	4431	8340	2739	2380	2264	2052	4374
Lux	7670	7271	7413	4920	4038	7222	7695	8551	6977	8968	3585	3971	4641	4268	6050
medium	7613	14309	18161	17381	9416	11769	21345	27107	28695	23955	6610	11646	15372	17299	16987
Pm	2702	6225	6489	2908	639	2714	6350	7355	4169	1275	1261	3048	3634	2146	808
Small	12054	19398	21611	17708	16286	16596	25971	28996	27896	38322	7573	11462	13766	14132	22987
Sport	1592	2604	4108	6566	3889	1624	3249	4752	8942	6997	708	1376	2239	4367	4022
unknown	13058	26638	26007	14981	10375	13728	27965	30519	20824	21815	6543	14659	17720	12425	14466

Table 22: Table of numbers of licensed vehicles in the NZ passenger fleet manufactured since 1979: 2005 and 2006 data for individual vehicle owners aged 60 plus

Location	Auckland					Other urban					Rural				
Veh age	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27
4WDC	1053	779	593	158	121	2557	1741	1434	526	423	2225	1453	1221	483	442
4WDL	188	177	110	159	108	383	388	223	344	389	509	464	299	453	579
4WDM	333	447	543	530	327	925	1113	1259	1299	937	1172	1234	1677	1616	1289
Large	1979	1379	1039	756	658	4790	2546	1959	1707	1927	4407	2163	1640	1424	1847
Light	3555	2132	1293	943	1207	9392	4858	2916	2514	3796	4014	2066	1331	1087	2047
Lux	2594	1608	1357	1068	1018	4252	2687	2378	2081	2722	3010	1795	1729	1555	2199
medium	2105	2444	2893	2986	2282	4927	5845	6057	6528	6943	3724	4232	4276	4848	5483
Pm	209	384	438	281	109	286	575	679	451	278	255	481	510	322	235
Small	5685	5485	5510	4911	4700	13806	12072	11231	10980	12625	7839	6433	6267	5967	7983
Sport	294	357	538	962	578	395	622	865	1416	1250	207	319	432	790	763
unknown	3803	4326	4044	2688	2706	6821	7810	7409	5239	6352	4054	4951	5323	3621	4825

Table 23: Table of NZ estimated risk of injury crash involvement over two years from model for vehicle owners aged 15-19. Empty cells indicate there were insufficient data on which to estimate risk.

Location	Auckland					Other urban					Rural				
Veh age	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27
4WDC	2.07%	2.60%	2.54%	2.58%	1.74%	1.45%	1.94%	2.09%	2.15%	1.64%	1.59%	2.04%	2.29%	2.20%	1.64%
4WDL	1.66%	2.09%		2.07%	1.39%	1.45%	1.94%	2.10%	2.15%	1.64%		1.40%	1.58%	1.51%	1.12%
4WDM	2.08%	2.62%	2.56%	2.60%	1.75%		2.24%	2.41%	2.47%	1.89%	1.57%	2.02%	2.26%	2.17%	1.62%
large	2.94%	3.70%	3.61%	3.67%	2.48%	2.34%	3.13%	3.37%	3.45%	2.65%	2.02%	2.59%	2.90%	2.78%	2.08%
light	1.63%	2.05%	2.00%	2.04%	1.37%	1.43%	1.92%	2.07%	2.12%	1.62%	1.48%	1.89%	2.13%	2.04%	1.52%
lux	1.75%	2.21%	2.16%	2.19%	1.47%	1.67%	2.23%	2.41%	2.47%	1.89%	1.53%	1.97%	2.21%	2.11%	1.58%
medium	2.18%	2.74%	2.67%	2.72%	1.83%	1.71%	2.29%	2.47%	2.53%	1.94%	1.59%	2.04%	2.29%	2.19%	1.64%
pm															
small	1.97%	2.48%	2.42%	2.46%	1.66%	1.71%	2.29%	2.47%	2.54%	1.94%	1.91%	2.44%	2.74%	2.62%	1.96%
sport	1.75%	2.20%	2.15%	2.18%	1.47%	1.49%	2.00%	2.16%	2.21%	1.69%	1.70%	2.18%	2.45%	2.35%	1.75%
unknown	1.90%	2.39%	2.33%	2.37%	1.60%	1.63%	2.18%	2.35%	2.41%	1.84%	1.58%	2.03%	2.27%	2.18%	1.63%

Table 24: Table of NZ estimated risk of injury crash involvement over two years from model for vehicle owners aged 20-29

Location	Auckland					Other urban					Rural				
Veh age	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27
4WDC	0.93%	1.18%	1.15%	1.17%	0.78%	0.65%	0.88%	0.95%	0.97%	0.74%	0.72%	0.92%	1.04%	0.99%	0.74%
4WDL	0.76%	0.96%	0.93%	0.95%	0.63%	0.66%	0.89%	0.96%	0.98%	0.75%	0.50%	0.64%	0.72%	0.69%	0.51%
4WDM	0.80%	1.01%	0.98%	1.00%	0.67%	0.64%	0.86%	0.92%	0.95%	0.72%	0.60%	0.77%	0.87%	0.83%	0.62%
large	1.24%	1.56%	1.52%	1.55%	1.04%	0.98%	1.32%	1.42%	1.46%	1.11%	0.84%	1.09%	1.22%	1.17%	0.87%
light	0.87%	1.10%	1.07%	1.09%	0.73%	0.76%	1.03%	1.11%	1.14%	0.87%	0.79%	1.01%	1.14%	1.09%	0.81%
lux	1.16%	1.47%	1.43%	1.46%	0.98%	1.11%	1.49%	1.60%	1.64%	1.25%	1.02%	1.31%	1.47%	1.40%	1.05%
medium	1.15%	1.46%	1.42%	1.44%	0.97%	0.90%	1.21%	1.31%	1.34%	1.03%	0.84%	1.08%	1.21%	1.16%	0.87%
pm	1.47%	1.86%	1.81%	1.84%	1.24%	1.15%	1.55%	1.67%	1.71%	1.31%	1.22%	1.57%	1.76%	1.68%	1.25%
small	1.00%	1.27%	1.23%	1.25%	0.84%	0.87%	1.17%	1.26%	1.29%	0.99%	0.97%	1.24%	1.40%	1.34%	1.00%
sport	1.16%	1.47%	1.43%	1.45%	0.98%	0.99%	1.33%	1.44%	1.47%	1.12%	1.13%	1.45%	1.63%	1.56%	1.17%
unknown	1.02%	1.29%	1.26%	1.28%	0.86%	0.88%	1.18%	1.27%	1.30%	0.99%	0.85%	1.09%	1.23%	1.17%	0.87%

Table 25: Table of NZ estimated risk of injury crash involvement over two years from model for vehicle owners aged 30-59

Location	Auckland					Other urban					Rural				
Veh age	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27
4WDC	0.71%	0.90%	0.88%	0.90%	0.60%	0.50%	0.67%	0.72%	0.74%	0.57%	0.55%	0.71%	0.79%	0.76%	0.57%
4WDL	0.60%	0.76%	0.74%	0.75%	0.50%	0.52%	0.70%	0.76%	0.78%	0.59%	0.39%	0.51%	0.57%	0.55%	0.41%
4WDM	0.70%	0.89%	0.86%	0.88%	0.59%	0.56%	0.75%	0.81%	0.83%	0.64%	0.53%	0.68%	0.76%	0.73%	0.54%
large	0.74%	0.94%	0.91%	0.93%	0.62%	0.59%	0.79%	0.85%	0.87%	0.66%	0.50%	0.65%	0.73%	0.70%	0.52%
light	0.78%	0.98%	0.96%	0.97%	0.65%	0.68%	0.92%	0.99%	1.01%	0.77%	0.70%	0.90%	1.02%	0.97%	0.72%
lux	0.65%	0.83%	0.80%	0.82%	0.55%	0.62%	0.83%	0.90%	0.92%	0.70%	0.57%	0.73%	0.82%	0.79%	0.59%
medium	0.81%	1.02%	1.00%	1.01%	0.68%	0.63%	0.85%	0.92%	0.94%	0.72%	0.59%	0.76%	0.85%	0.81%	0.61%
pm	0.72%	0.92%	0.89%	0.91%	0.61%	0.57%	0.76%	0.82%	0.84%	0.64%	0.60%	0.77%	0.86%	0.83%	0.62%
small	0.79%	1.00%	0.98%	1.00%	0.67%	0.69%	0.93%	1.00%	1.03%	0.78%	0.77%	0.99%	1.11%	1.06%	0.79%
sport	0.79%	1.00%	0.97%	0.99%	0.66%	0.67%	0.90%	0.98%	1.00%	0.76%	0.77%	0.99%	1.11%	1.06%	0.79%
unknown	0.68%	0.87%	0.84%	0.86%	0.57%	0.59%	0.79%	0.85%	0.87%	0.66%	0.57%	0.73%	0.82%	0.79%	0.59%

Table 26: Table of NZ estimated risk of injury crash involvement over two years from model for vehicle owners aged 60 plus

Location	Auckland					Other urban					Rural				
Veh age	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27	<8	8-11	11-14	14-17	17-27
4WDC	0.65%	0.82%	0.80%	0.81%	0.54%	0.45%	0.61%	0.66%	0.67%	0.51%	0.50%	0.64%	0.72%	0.69%	0.51%
4WDL	0.42%	0.53%	0.51%	0.52%	0.35%	0.36%	0.49%	0.53%	0.54%	0.41%	0.27%	0.35%	0.40%	0.38%	0.28%
4WDM	0.45%	0.57%	0.56%	0.56%	0.38%	0.36%	0.48%	0.52%	0.54%	0.41%	0.34%	0.44%	0.49%	0.47%	0.35%
large	0.62%	0.78%	0.76%	0.77%	0.52%	0.49%	0.66%	0.71%	0.73%	0.55%	0.42%	0.54%	0.61%	0.58%	0.43%
light	0.67%	0.85%	0.83%	0.84%	0.56%	0.59%	0.79%	0.86%	0.88%	0.67%	0.61%	0.78%	0.88%	0.84%	0.63%
lux	0.44%	0.56%	0.54%	0.55%	0.37%	0.42%	0.56%	0.61%	0.62%	0.48%	0.38%	0.50%	0.56%	0.53%	0.40%
medium	0.71%	0.90%	0.88%	0.89%	0.60%	0.56%	0.75%	0.81%	0.83%	0.63%	0.52%	0.67%	0.75%	0.72%	0.54%
pm	0.81%	1.02%	1.00%	1.01%	0.68%	0.63%	0.85%	0.92%	0.94%	0.71%	0.67%	0.86%	0.96%	0.92%	0.69%
small	0.64%	0.80%	0.78%	0.80%	0.53%	0.55%	0.74%	0.80%	0.82%	0.63%	0.62%	0.79%	0.89%	0.85%	0.63%
sport	0.71%	0.90%	0.87%	0.89%	0.60%	0.61%	0.81%	0.88%	0.90%	0.69%	0.69%	0.89%	1.00%	0.96%	0.71%
unknown	0.52%	0.66%	0.64%	0.65%	0.44%	0.45%	0.60%	0.65%	0.66%	0.50%	0.43%	0.56%	0.63%	0.60%	0.45%

APPENDIX 2: OUTPUT FROM PRIMARY RISK MODELS

8.1. NZ logistic model output for crash involvement risk per two vehicle years

The LOGISTIC Procedure

Model Information

Data Set	WORK.TOMODEL
Response Variable	crash
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	2125735
Number of Observations Used	2125713

Response Profile

Ordered Value	crash	Total Frequency
1	1	17993
2	0	2107720

Probability modeled is crash=1.

NOTE: 22 observations were deleted due to missing values for the response or explanatory variables.

Class Level Information

Class	Value	Design Variables									
agegrp	15-19	1	0	0							
	20-29	0	1	0							
	30-59	0	0	0							
	60 pl	0	0	1							
marketgroup	4WDC	1	0	0	0	0	0	0	0	0	0
	4WDL	0	1	0	0	0	0	0	0	0	0
	4WDM	0	0	1	0	0	0	0	0	0	0
	large	0	0	0	1	0	0	0	0	0	0
	light	0	0	0	0	1	0	0	0	0	0
	lux	0	0	0	0	0	1	0	0	0	0
	medium	0	0	0	0	0	0	1	0	0	0
	pm	0	0	0	0	0	0	0	1	0	0
	small	0	0	0	0	0	0	0	0	1	0
	sport	0	0	0	0	0	0	0	0	0	1
	unknown	0	0	0	0	0	0	0	0	0	0
townclass	0	1	0								
	1	0	1								
	3	0	0								

Class Level Information

Class	Value	Design Variables			
vage	<8	0	0	0	0
	8-11	1	0	0	0
	11-14	0	1	0	0
	14-17	0	0	1	0
	17-27	0	0	0	1

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	207556.13	206031.82
SC	207568.70	207012.25
-2 Log L	207554.13	205875.82

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	1678.3141	77	<.0001
Score	1873.9242	77	<.0001
Wald	1786.2761	77	<.0001

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
agegrp	3	199.8026	<.0001
marketgroup	10	103.2656	<.0001
agegrp*marketgroup	30	74.0443	<.0001
townclass	2	8.3512	0.0154
marketgrou*townclass	20	49.6545	0.0002
vage	4	96.3773	<.0001
townclass*vage	8	27.8430	0.0005

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Parameter			DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept			1	-5.1641	0.0597	7487.4734	<.0001
agegrp	15-19		1	1.0325	0.1126	84.0858	<.0001
agegrp	20-29		1	0.4049	0.0471	74.0565	<.0001
agegrp	60 pl		1	-0.2752	0.0540	25.9911	<.0001
marketgroup	4WDC		1	-0.0343	0.1015	0.1144	0.7351
marketgroup	4WDL		1	-0.3681	0.1260	8.5412	0.0035
marketgroup	4WDM		1	-0.0756	0.0754	1.0058	0.3159
marketgroup	large		1	-0.1205	0.0667	3.2598	0.0710
marketgroup	light		1	0.2137	0.0841	6.4545	0.0111
marketgroup	lux		1	0.00269	0.0787	0.0012	0.9727
marketgroup	medium		1	0.0349	0.0546	0.4081	0.5229
marketgroup	pm		1	0.0505	0.1067	0.2241	0.6360
marketgroup	small		1	0.3028	0.0508	35.5528	<.0001
marketgroup	sport		1	0.3041	0.0840	13.1125	0.0003
agegrp*marketgroup	15-19	4WDC	1	0.0429	0.4688	0.0084	0.9271
agegrp*marketgroup	15-19	4WDL	1	-0.00559	1.0170	0.0000	0.9956
agegrp*marketgroup	15-19	4WDM	1	0.0704	0.4003	0.0309	0.8605
agegrp*marketgroup	15-19	large	1	0.3703	0.1876	3.8968	0.0484
agegrp*marketgroup	15-19	light	1	-0.2828	0.2091	1.8305	0.1761
agegrp*marketgroup	15-19	lux	1	-0.0339	0.2250	0.0227	0.8804
agegrp*marketgroup	15-19	medium	1	-0.0281	0.1480	0.0360	0.8495
agegrp*marketgroup	15-19	pm	1	-7.9097	39.5581	0.0400	0.8415
agegrp*marketgroup	15-19	small	1	-0.1119	0.1283	0.7604	0.3832
agegrp*marketgroup	15-19	sport	1	-0.2286	0.1779	1.6515	0.1988
agegrp*marketgroup	20-29	4WDC	1	-0.1357	0.1468	0.8550	0.3551
agegrp*marketgroup	20-29	4WDL	1	-0.1717	0.3023	0.3227	0.5700
agegrp*marketgroup	20-29	4WDM	1	-0.2768	0.1350	4.2060	0.0403
agegrp*marketgroup	20-29	large	1	0.1142	0.0862	1.7541	0.1854
agegrp*marketgroup	20-29	light	1	-0.2885	0.1107	6.7954	0.0091
agegrp*marketgroup	20-29	lux	1	0.1780	0.0951	3.4999	0.0614
agegrp*marketgroup	20-29	medium	1	-0.0455	0.0642	0.5024	0.4784
agegrp*marketgroup	20-29	pm	1	0.3135	0.1594	3.8704	0.0491
agegrp*marketgroup	20-29	small	1	-0.1712	0.0597	8.2222	0.0041
agegrp*marketgroup	20-29	sport	1	-0.0144	0.0858	0.0283	0.8665
agegrp*marketgroup	60 pl	4WDC	1	0.1772	0.1297	1.8647	0.1721
agegrp*marketgroup	60 pl	4WDL	1	-0.0909	0.2471	0.1353	0.7130
agegrp*marketgroup	60 pl	4WDM	1	-0.1699	0.1399	1.4760	0.2244
agegrp*marketgroup	60 pl	large	1	0.0941	0.0987	0.9101	0.3401
agegrp*marketgroup	60 pl	light	1	0.1299	0.0899	2.0879	0.1485
agegrp*marketgroup	60 pl	lux	1	-0.1195	0.1037	1.3268	0.2494
agegrp*marketgroup	60 pl	medium	1	0.1501	0.0746	4.0464	0.0443
agegrp*marketgroup	60 pl	pm	1	0.3856	0.1629	5.6037	0.0179
agegrp*marketgroup	60 pl	small	1	0.0514	0.0668	0.5929	0.4413

agegrp*marketgroup	60 pl	sport	1	0.1690	0.1322	1.6343	0.2011
townclass	0		1	0.1866	0.0749	6.2126	0.0127
townclass	1		1	0.0295	0.0722	0.1664	0.6833
marketgrou*townclass	4WDC	0	1	0.0776	0.1248	0.3868	0.5340
marketgrou*townclass	4WDC	1	1	-0.1268	0.1209	1.1001	0.2942
marketgrou*townclass	4WDL	0	1	0.2352	0.1840	1.6331	0.2013
marketgrou*townclass	4WDL	1	1	0.2572	0.1611	2.5481	0.1104
marketgrou*townclass	4WDM	0	1	0.0994	0.1070	0.8637	0.3527
marketgrou*townclass	4WDM	1	1	0.0315	0.0951	0.1097	0.7405
marketgrou*townclass	large	0	1	0.1989	0.0863	5.3116	0.0212
marketgrou*townclass	large	1	1	0.1209	0.0792	2.3315	0.1268
marketgrou*townclass	light	0	1	-0.0875	0.1032	0.7194	0.3963
marketgrou*townclass	light	1	1	-0.0612	0.0934	0.4293	0.5123
marketgrou*townclass	lux	0	1	-0.0500	0.0972	0.2646	0.6070
marketgrou*townclass	lux	1	1	0.0567	0.0909	0.3898	0.5324
marketgrou*townclass	medium	0	1	0.1326	0.0678	3.8227	0.0506
marketgrou*townclass	medium	1	1	0.0442	0.0632	0.4887	0.4845
marketgrou*townclass	pm	0	1	0.00610	0.1290	0.0022	0.9623
marketgrou*townclass	pm	1	1	-0.0860	0.1274	0.4553	0.4998
marketgrou*townclass	small	0	1	-0.1526	0.0626	5.9392	0.0148
marketgrou*townclass	small	1	1	-0.1380	0.0584	5.5794	0.0182
marketgrou*townclass	sport	0	1	-0.1610	0.1011	2.5354	0.1113
marketgrou*townclass	sport	1	1	-0.1637	0.0957	2.9242	0.0873
vage	8-11		1	0.2538	0.0572	19.6814	<.0001
vage	11-14		1	0.3712	0.0549	45.6596	<.0001
vage	14-17		1	0.3271	0.0556	34.6060	<.0001
vage	17-27		1	0.0291	0.0560	0.2701	0.6032
townclass*vage	0	8-11	1	-0.0175	0.0735	0.0565	0.8121
townclass*vage	0	11-14	1	-0.1607	0.0717	5.0186	0.0251
townclass*vage	0	14-17	1	-0.0993	0.0734	1.8282	0.1763
townclass*vage	0	17-27	1	-0.2052	0.0790	6.7419	0.0094
townclass*vage	1	8-11	1	0.0439	0.0711	0.3816	0.5368
townclass*vage	1	11-14	1	0.00395	0.0687	0.0033	0.9542
townclass*vage	1	14-17	1	0.0735	0.0693	1.1245	0.2889
townclass*vage	1	17-27	1	0.0970	0.0700	1.9197	0.1659

Association of Predicted Probabilities and Observed Responses

Percent Concordant	45.7	Somers' D	0.151
Percent Discordant	30.6	Gamma	0.198
Percent Tied	23.7	Tau-a	0.003
Pairs	37924205960	c	0.576

The LOGISTIC Procedure

Partition for the Hosmer and Lemeshow Test

		crash = 1		crash = 0	
Group	Total	Observed	Expected	Observed	Expected
1	214239	1084	1072.96	213155	213166.0
2	212339	1245	1282.21	211094	211056.8
3	212697	1425	1427.86	211272	211269.1
4	204271	1574	1516.35	202697	202754.6
5	213620	1722	1692.08	211898	211927.9
6	204051	1674	1705.70	202377	202345.3
7	211093	1834	1852.63	209259	209240.4
8	201698	1891	1924.21	199807	199773.8
9	213149	2150	2167.61	210999	210981.4
10	238556	3394	3351.25	235162	235204.7

Hosmer and Lemeshow Goodness-of-Fit Test

Chi-Square	DF	Pr > ChiSq
6.0072	8	0.6464

8.2. NSW logistic model output for crash involvement risk per two vehicle years

The LOGISTIC Procedure

Model Information

Data Set	NSW.RTA2004WITHMKTGRPCRASH
Response Variable	crash
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	3237797
Number of Observations Used	3237797

Response Profile

Ordered Value	crash	Total Frequency
1	1	78892
2	0	3158905

Probability modeled is crash=1.

Class Level Information

Class	Value	Design Variables							
MKTGRP	4WDC	1	0	0	0	0	0	0	0
	4WDL	0	1	0	0	0	0	0	0
	4WDM	0	0	1	0	0	0	0	0
	L	0	0	0	1	0	0	0	0
	M	0	0	0	0	1	0	0	0
	PM	0	0	0	0	0	1	0	0
	S	0	0	0	0	0	0	1	0
	SL	0	0	0	0	0	0	0	1
	SP	0	0	0	0	0	0	0	0
owneraddress	Coastal	1	0						
	Inland	0	1						
	Sydney	0	0						
vage	a <3	0	0	0	0				
	b 5-7	1	0	0	0				
	c 3-4	0	1	0	0				
	d 8-12	0	0	1	0				
	e >12	0	0	0	1				

The LOGISTIC Procedure

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	741947.41	730662.81
SC	741960.40	732416.51
-2 Log L	741945.41	730392.81

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	11552.6015	134	<.0001
Score	10809.6251	134	<.0001
Wald	10028.2861	134	<.0001

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
MKTGRP	8	164.3397	<.0001
owneraddress	2	9.5781	0.0083
MKTGRP*owneraddress	16	34.0183	0.0054
vage	4	10.3242	0.0353
MKTGRP*vage	32	348.0074	<.0001
owneraddress*vage	8	29.8492	0.0002
MKTGRP*owneradd*vage	64	136.6784	<.0001

Analysis of Maximum Likelihood Estimates

Parameter			DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept			1	-3.3700	0.0758	1976.2466	<.0001
MKTGRP	4WDC		1	-0.1721	0.0834	4.2626	0.0390
MKTGRP	4WDL		1	-0.3417	0.0992	11.8634	0.0006
MKTGRP	4WDM		1	-0.3688	0.0880	17.5684	<.0001
MKTGRP	L		1	0.0303	0.0780	0.1512	0.6973
MKTGRP	M		1	-0.3049	0.0822	13.7749	0.0002
MKTGRP	PM		1	-0.2446	0.1046	5.4733	0.0193
MKTGRP	S		1	-0.1044	0.0784	1.7704	0.1833
MKTGRP	SL		1	0.00701	0.0825	0.0072	0.9323
owneraddress	Coastal		1	-0.4968	0.2439	4.1500	0.0416
owneraddress	Inland		1	-0.3955	0.1510	6.8601	0.0088
MKTGRP*owneraddress	4WDC	Coastal	1	-0.1088	0.2591	0.1764	0.6745
MKTGRP*owneraddress	4WDC	Inland	1	-0.2969	0.1669	3.1655	0.0752
MKTGRP*owneraddress	4WDL	Coastal	1	-0.1135	0.2876	0.1557	0.6932
MKTGRP*owneraddress	4WDL	Inland	1	-0.4098	0.1981	4.2815	0.0385
MKTGRP*owneraddress	4WDM	Coastal	1	0.0627	0.2662	0.0554	0.8139
MKTGRP*owneraddress	4WDM	Inland	1	-0.4347	0.1784	5.9402	0.0148
MKTGRP*owneraddress	L	Coastal	1	-0.1768	0.2494	0.5022	0.4786
MKTGRP*owneraddress	L	Inland	1	-0.3468	0.1553	4.9877	0.0255
MKTGRP*owneraddress	M	Coastal	1	0.1075	0.2588	0.1727	0.6777
MKTGRP*owneraddress	M	Inland	1	-0.1759	0.1641	1.1491	0.2837
MKTGRP*owneraddress	PM	Coastal	1	0.3245	0.3093	1.1007	0.2941
MKTGRP*owneraddress	PM	Inland	1	-0.5358	0.2235	5.7458	0.0165
MKTGRP*owneraddress	S	Coastal	1	-0.00981	0.2494	0.0015	0.9686
MKTGRP*owneraddress	S	Inland	1	-0.2533	0.1563	2.6269	0.1051
MKTGRP*owneraddress	SL	Coastal	1	0.0103	0.2584	0.0016	0.9682
MKTGRP*owneraddress	SL	Inland	1	-0.1683	0.1642	1.0500	0.3055
vage	b 5-7		1	-0.0166	0.0979	0.0288	0.8652
vage	c 3-4		1	0.1007	0.1032	0.9526	0.3290
vage	d 8-12		1	0.2232	0.0936	5.6808	0.0172
vage	e >12		1	0.1092	0.0913	1.4291	0.2319
MKTGRP*vage	4WDC	b 5-7	1	0.1118	0.1098	1.0380	0.3083
MKTGRP*vage	4WDC	c 3-4	1	-0.0479	0.1143	0.1757	0.6751
MKTGRP*vage	4WDC	d 8-12	1	-0.1002	0.1167	0.7376	0.3904
MKTGRP*vage	4WDC	e >12	1	-0.2568	0.1367	3.5281	0.0603
MKTGRP*vage	4WDL	b 5-7	1	0.0543	0.1258	0.1860	0.6663
MKTGRP*vage	4WDL	c 3-4	1	-0.0767	0.1399	0.3003	0.5837
MKTGRP*vage	4WDL	d 8-12	1	-0.1662	0.1269	1.7151	0.1903
MKTGRP*vage	4WDL	e >12	1	-0.1062	0.1278	0.6914	0.4057
MKTGRP*vage	4WDM	b 5-7	1	0.0883	0.1212	0.5312	0.4661
MKTGRP*vage	4WDM	c 3-4	1	0.0691	0.1229	0.3156	0.5743
MKTGRP*vage	4WDM	d 8-12	1	-0.1071	0.1193	0.8064	0.3692
MKTGRP*vage	4WDM	e >12	1	0.1161	0.1278	0.8262	0.3634
MKTGRP*vage	L	b 5-7	1	0.1350	0.1006	1.8025	0.1794
MKTGRP*vage	L	c 3-4	1	0.1253	0.1061	1.3941	0.2377
MKTGRP*vage	L	d 8-12	1	-0.3180	0.0967	10.8250	0.0010
MKTGRP*vage	L	e >12	1	-0.2799	0.0951	8.6697	0.0032

MKTGRP*vage	M	b 5-7		1	0.1476	0.1064	1.9253	0.1653
MKTGRP*vage	M	c 3-4		1	-0.0463	0.1125	0.1694	0.6806
MKTGRP*vage	M	d 8-12		1	0.0285	0.1010	0.0795	0.7780
MKTGRP*vage	M	e >12		1	0.0529	0.0990	0.2856	0.5930
MKTGRP*vage	PM	b 5-7		1	0.00913	0.1368	0.0045	0.9468
MKTGRP*vage	PM	c 3-4		1	0.0156	0.1429	0.0120	0.9129
MKTGRP*vage	PM	d 8-12		1	-0.1714	0.1341	1.6346	0.2011
MKTGRP*vage	PM	e >12		1	-0.2946	0.1332	4.8949	0.0269
MKTGRP*vage	S	b 5-7		1	0.0963	0.1012	0.9056	0.3413
MKTGRP*vage	S	c 3-4		1	-0.00087	0.1067	0.0001	0.9935
MKTGRP*vage	S	d 8-12		1	-0.1451	0.0973	2.2245	0.1358
MKTGRP*vage	S	e >12		1	-0.1635	0.0957	2.9216	0.0874
MKTGRP*vage	SL	b 5-7		1	-0.1577	0.1084	2.1151	0.1458
MKTGRP*vage	SL	c 3-4		1	-0.1036	0.1165	0.7906	0.3739
MKTGRP*vage	SL	d 8-12		1	-0.4800	0.1038	21.3652	<.0001
MKTGRP*vage	SL	e >12		1	-0.4456	0.1047	18.1068	<.0001
owneraddress*vage	Coastal	b 5-7		1	0.1168	0.3121	0.1401	0.7082
owneraddress*vage	Coastal	c 3-4		1	-0.0784	0.3437	0.0521	0.8195
owneraddress*vage	Coastal	d 8-12		1	0.0120	0.2930	0.0017	0.9673
owneraddress*vage	Coastal	e >12		1	-0.0690	0.2840	0.0591	0.8079
owneraddress*vage	Inland	b 5-7		1	-0.7039	0.2935	5.7530	0.0165
owneraddress*vage	Inland	c 3-4		1	0.1107	0.2691	0.1691	0.6809
owneraddress*vage	Inland	d 8-12		1	-1.0065	0.2376	17.9473	<.0001
owneraddress*vage	Inland	e >12		1	-0.6915	0.2018	11.7353	0.0006
MKTGRP*owneradd*vage	4WDC	Coastal	b 5-7	1	-0.1285	0.3361	0.1462	0.7022
MKTGRP*owneradd*vage	4WDC	Coastal	c 3-4	1	0.1000	0.3654	0.0749	0.7843
MKTGRP*owneradd*vage	4WDC	Coastal	d 8-12	1	-0.0232	0.3310	0.0049	0.9441
MKTGRP*owneradd*vage	4WDC	Coastal	e >12	1	0.1495	0.3438	0.1891	0.6637
MKTGRP*owneradd*vage	4WDC	Inland	b 5-7	1	0.5860	0.3264	3.2238	0.0726
MKTGRP*owneradd*vage	4WDC	Inland	c 3-4	1	-0.1128	0.3049	0.1369	0.7114
MKTGRP*owneradd*vage	4WDC	Inland	d 8-12	1	0.2480	0.3180	0.6082	0.4354
MKTGRP*owneradd*vage	4WDC	Inland	e >12	1	0.0248	0.3060	0.0066	0.9354
MKTGRP*owneradd*vage	4WDL	Coastal	b 5-7	1	-0.1822	0.3611	0.2546	0.6139
MKTGRP*owneradd*vage	4WDL	Coastal	c 3-4	1	-0.2740	0.4184	0.4290	0.5125
MKTGRP*owneradd*vage	4WDL	Coastal	d 8-12	1	-0.1325	0.3474	0.1455	0.7029
MKTGRP*owneradd*vage	4WDL	Coastal	e >12	1	-0.0778	0.3393	0.0526	0.8186
MKTGRP*owneradd*vage	4WDL	Inland	b 5-7	1	0.3213	0.3430	0.8776	0.3488
MKTGRP*owneradd*vage	4WDL	Inland	c 3-4	1	0.0726	0.3376	0.0463	0.8297
MKTGRP*owneradd*vage	4WDL	Inland	d 8-12	1	0.6380	0.2981	4.5805	0.0323
MKTGRP*owneradd*vage	4WDL	Inland	e >12	1	-0.0489	0.2762	0.0313	0.8595
MKTGRP*owneradd*vage	4WDM	Coastal	b 5-7	1	-0.3520	0.3517	1.0013	0.3170
MKTGRP*owneradd*vage	4WDM	Coastal	c 3-4	1	-0.3019	0.3812	0.6271	0.4284
MKTGRP*owneradd*vage	4WDM	Coastal	d 8-12	1	-0.2819	0.3348	0.7088	0.3999
MKTGRP*owneradd*vage	4WDM	Coastal	e >12	1	-0.1299	0.3323	0.1529	0.6958
MKTGRP*owneradd*vage	4WDM	Inland	b 5-7	1	0.5038	0.3533	2.0336	0.1539
MKTGRP*owneradd*vage	4WDM	Inland	c 3-4	1	-0.1998	0.3278	0.3717	0.5421
MKTGRP*owneradd*vage	4WDM	Inland	d 8-12	1	0.8028	0.2938	7.4657	0.0063
MKTGRP*owneradd*vage	4WDM	Inland	e >12	1	0.3155	0.2857	1.2194	0.2695
MKTGRP*owneradd*vage	L	Coastal	b 5-7	1	-0.0619	0.3181	0.0379	0.8457
MKTGRP*owneradd*vage	L	Coastal	c 3-4	1	-0.00024	0.3504	0.0000	0.9995
MKTGRP*owneradd*vage	L	Coastal	d 8-12	1	0.2363	0.2992	0.6235	0.4297
MKTGRP*owneradd*vage	L	Coastal	e >12	1	0.2768	0.2911	0.9040	0.3417
MKTGRP*owneradd*vage	L	Inland	b 5-7	1	0.2724	0.2985	0.8327	0.3615
MKTGRP*owneradd*vage	L	Inland	c 3-4	1	-0.1832	0.2756	0.4421	0.5061
MKTGRP*owneradd*vage	L	Inland	d 8-12	1	0.6412	0.2433	6.9446	0.0084
MKTGRP*owneradd*vage	L	Inland	e >12	1	0.2722	0.2087	1.7012	0.1921
MKTGRP*owneradd*vage	M	Coastal	b 5-7	1	-0.0165	0.3305	0.0025	0.9601
MKTGRP*owneradd*vage	M	Coastal	c 3-4	1	0.0291	0.3650	0.0064	0.9364
MKTGRP*owneradd*vage	M	Coastal	d 8-12	1	-0.1315	0.3099	0.1801	0.6713
MKTGRP*owneradd*vage	M	Coastal	e >12	1	-0.0696	0.3007	0.0536	0.8169
MKTGRP*owneradd*vage	M	Inland	b 5-7	1	0.2969	0.3170	0.8771	0.3490
MKTGRP*owneradd*vage	M	Inland	c 3-4	1	-0.1280	0.2989	0.1834	0.6684
MKTGRP*owneradd*vage	M	Inland	d 8-12	1	0.5065	0.2555	3.9303	0.0474
MKTGRP*owneradd*vage	M	Inland	e >12	1	0.3126	0.2189	2.0390	0.1533
MKTGRP*owneradd*vage	PM	Coastal	b 5-7	1	-0.5175	0.4103	1.5913	0.2071
MKTGRP*owneradd*vage	PM	Coastal	c 3-4	1	-0.1506	0.4346	0.1200	0.7290
MKTGRP*owneradd*vage	PM	Coastal	d 8-12	1	-0.4353	0.3908	1.2407	0.2653
MKTGRP*owneradd*vage	PM	Coastal	e >12	1	-0.3319	0.3764	0.7772	0.3780
MKTGRP*owneradd*vage	PM	Inland	b 5-7	1	0.6038	0.4163	2.1035	0.1470
MKTGRP*owneradd*vage	PM	Inland	c 3-4	1	0.1181	0.4145	0.0812	0.7756
MKTGRP*owneradd*vage	PM	Inland	d 8-12	1	0.8233	0.3683	4.9954	0.0254
MKTGRP*owneradd*vage	PM	Inland	e >12	1	0.5426	0.3176	2.9177	0.0876
MKTGRP*owneradd*vage	S	Coastal	b 5-7	1	0.0488	0.3185	0.0235	0.8782
MKTGRP*owneradd*vage	S	Coastal	c 3-4	1	0.1416	0.3506	0.1632	0.6862
MKTGRP*owneradd*vage	S	Coastal	d 8-12	1	0.1930	0.2999	0.4140	0.5199
MKTGRP*owneradd*vage	S	Coastal	e >12	1	0.1904	0.2920	0.4251	0.5144

MKTGRP*owneradd*vage	S	Inland	b 5-7	1	0.7307	0.3004	5.9159	0.0150
MKTGRP*owneradd*vage	S	Inland	c 3-4	1	-0.0336	0.2798	0.0145	0.9043
MKTGRP*owneradd*vage	S	Inland	d 8-12	1	0.7204	0.2468	8.5188	0.0035
MKTGRP*owneradd*vage	S	Inland	e >12	1	0.4872	0.2125	5.2545	0.0219
MKTGRP*owneradd*vage	SL	Coastal	b 5-7	1	0.0254	0.3320	0.0058	0.9391
MKTGRP*owneradd*vage	SL	Coastal	c 3-4	1	-0.0760	0.3749	0.0412	0.8392
MKTGRP*owneradd*vage	SL	Coastal	d 8-12	1	0.2828	0.3112	0.8262	0.3634
MKTGRP*owneradd*vage	SL	Coastal	e >12	1	0.2105	0.3067	0.4708	0.4926
MKTGRP*owneradd*vage	SL	Inland	b 5-7	1	0.6560	0.3185	4.2417	0.0394
MKTGRP*owneradd*vage	SL	Inland	c 3-4	1	-0.0641	0.3224	0.0396	0.8423
MKTGRP*owneradd*vage	SL	Inland	d 8-12	1	0.9146	0.2597	12.4062	0.0004
MKTGRP*owneradd*vage	SL	Inland	e >12	1	0.4986	0.2314	4.6431	0.0312

The LOGISTIC Procedure

Association of Predicted Probabilities and Observed Responses

Percent Concordant	56.7	Somers' D	0.213
Percent Discordant	35.3	Gamma	0.232
Percent Tied	8.0	Tau-a	0.010
Pairs	249212333260	c	0.607

Partition for the Hosmer and Lemeshow Test

		crash = 1		crash = 0	
Group	Total	Observed	Expected	Observed	Expected
1	319982	3081	3081.02	316901	316901.0
2	325821	4236	4236.00	321585	321585.0
3	340415	5857	5857.00	334558	334558.0
4	313672	6345	6345.00	307327	307327.0
5	324399	7710	7710.00	316689	316689.0
6	326385	9002	9002.00	317383	317383.0
7	329117	9701	9701.00	319416	319416.0
8	333964	10594	10594.00	323370	323370.0
9	281502	9248	9248.00	272254	272254.0
10	342540	13118	13118.00	329422	329422.0

Hosmer and Lemeshow Goodness-of-Fit Test

Chi-Square	DF	Pr > ChiSq
0.0000	8	1.0000

8.3. Victorian logistic model output for crash involvement risk per two vehicle years

The LOGISTIC Procedure

Model Information

Data Set	VIC.ORIGJUN2005WITHCRASH
Response Variable	crash
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	2996883
Number of Observations Used	2996883

Response Profile

Ordered Value	crash	Total Frequency
1	1	17828
2	0	2979055

Probability modeled is crash=1.

Class Level Information

Class	Value	Design Variables							
MKTGRP	4WDC	1	0	0	0	0	0	0	0
	4WDL	0	1	0	0	0	0	0	0
	4WDM	0	0	1	0	0	0	0	0
	L	0	0	0	1	0	0	0	0
	M	0	0	0	0	1	0	0	0
	PM	0	0	0	0	0	1	0	0
	S	0	0	0	0	0	0	1	0
	SL	0	0	0	0	0	0	0	1
	SP	0	0	0	0	0	0	0	0
vage	a <4	1	0	0	0				
	b 4-6	0	1	0	0				
	c 7-10	0	0	1	0				
	d 11-16	0	0	0	1				
	e >16	0	0	0	0				

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

The LOGISTIC Procedure

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	218272.96	217149.64
SC	218285.88	217730.73
-2 Log L	218270.96	217059.64

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	1211.3263	44	<.0001
Score	1091.0975	44	<.0001
Wald	1045.8687	44	<.0001

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
MKTGRP	8	50.9669	<.0001
vage	4	5.4106	0.2477
MKTGRP*vage	32	105.6061	<.0001

Analysis of Maximum Likelihood Estimates

Parameter			DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept			1	-5.1205	0.1967	677.6663	<.0001
MKTGRP	4WDC		1	-0.8878	0.3873	5.2546	0.0219
MKTGRP	4WDL		1	-0.2960	0.2212	1.7906	0.1809
MKTGRP	4WDM		1	-0.2620	0.2808	0.8700	0.3510
MKTGRP	L		1	-0.6480	0.1993	10.5697	0.0011
MKTGRP	M		1	-0.5463	0.2020	7.3133	0.0068
MKTGRP	PM		1	-1.1267	0.2865	15.4644	<.0001
MKTGRP	S		1	-0.3583	0.2021	3.1427	0.0763
MKTGRP	SL		1	-0.5659	0.2343	5.8353	0.0157
vage	a <4		1	0.2000	0.3326	0.3616	0.5476
vage	b 4-6		1	-0.5188	0.4267	1.4786	0.2240
vage	c 7-10		1	0.1704	0.2944	0.3352	0.5626
vage	d 11-16		1	0.3723	0.2615	2.0274	0.1545
MKTGRP*vage	4WDC	a <4	1	0.6019	0.4758	1.6005	0.2058
MKTGRP*vage	4WDC	b 4-6	1	1.5592	0.5447	8.1951	0.0042
MKTGRP*vage	4WDC	c 7-10	1	0.7178	0.4532	2.5082	0.1133
MKTGRP*vage	4WDC	d 11-16	1	0.6451	0.4606	1.9620	0.1613
MKTGRP*vage	4WDL	a <4	1	-0.0153	0.3634	0.0018	0.9664
MKTGRP*vage	4WDL	b 4-6	1	0.6976	0.4478	2.4266	0.1193
MKTGRP*vage	4WDL	c 7-10	1	0.1080	0.3200	0.1138	0.7358
MKTGRP*vage	4WDL	d 11-16	1	-0.1077	0.2926	0.1354	0.7129
MKTGRP*vage	4WDM	a <4	1	-0.1180	0.3965	0.0886	0.7660
MKTGRP*vage	4WDM	b 4-6	1	0.5090	0.4797	1.1260	0.2886
MKTGRP*vage	4WDM	c 7-10	1	-0.1079	0.3684	0.0858	0.7696
MKTGRP*vage	4WDM	d 11-16	1	-0.2460	0.3476	0.5011	0.4790
MKTGRP*vage	L	a <4	1	0.5351	0.3356	2.5417	0.1109
MKTGRP*vage	L	b 4-6	1	1.3484	0.4285	9.9019	0.0017
MKTGRP*vage	L	c 7-10	1	0.7409	0.2968	6.2315	0.0125
MKTGRP*vage	L	d 11-16	1	0.3928	0.2644	2.2072	0.1374
MKTGRP*vage	M	a <4	1	0.2169	0.3417	0.4030	0.5256
MKTGRP*vage	M	b 4-6	1	1.1075	0.4321	6.5692	0.0104
MKTGRP*vage	M	c 7-10	1	0.4641	0.3011	2.3745	0.1233
MKTGRP*vage	M	d 11-16	1	0.3118	0.2681	1.3524	0.2449
MKTGRP*vage	PM	a <4	1	0.7190	0.4226	2.8952	0.0888
MKTGRP*vage	PM	b 4-6	1	1.4140	0.4937	8.2031	0.0042
MKTGRP*vage	PM	c 7-10	1	0.9464	0.3851	6.0380	0.0140
MKTGRP*vage	PM	d 11-16	1	0.7118	0.3616	3.8755	0.0490
MKTGRP*vage	S	a <4	1	0.2173	0.3379	0.4134	0.5202
MKTGRP*vage	S	b 4-6	1	0.9884	0.4303	5.2753	0.0216

MKTGRP*vage S	c 7-10	1	0.3641	0.2996	1.4766	0.2243
MKTGRP*vage S	d 11-16	1	0.0538	0.2682	0.0403	0.8409
MKTGRP*vage SL	a <4	1	0.4825	0.3630	1.7672	0.1837
MKTGRP*vage SL	b 4-6	1	1.2025	0.4509	7.1123	0.0077
MKTGRP*vage SL	c 7-10	1	0.4932	0.3260	2.2882	0.1304
MKTGRP*vage SL	d 11-16	1	0.1573	0.2994	0.2759	0.5994

Association of Predicted Probabilities and Observed Responses

Percent Concordant	28.4	Somers' D	0.112
Percent Discordant	17.2	Gamma	0.245
Percent Tied	54.4	Tau-a	0.001
Pairs	53110592540	c	0.556

The LOGISTIC Procedure

Partition for the Hosmer and Lemeshow Test

Group	Total	crash = 1 Observed	crash = 1 Expected	crash = 0 Observed	crash = 0 Expected
1	326761	1001	1001.18	325760	325759.8
2	292620	1109	1109.02	291511	291511.0
3	298540	1544	1544.00	296996	296996.0
4	269387	1648	1648.00	267739	267739.0
5	272444	1750	1750.00	270694	270694.0
6	312287	2056	2056.00	310231	310231.0
7	298805	1993	1993.00	296812	296812.0
8	332789	2306	2306.00	330483	330483.0
9	262919	1870	1870.00	261049	261049.0
10	330331	2551	2551.00	327780	327780.0

Hosmer and Lemeshow Goodness-of-Fit Test

Chi-Square	DF	Pr > ChiSq
0.0000	8	1.0000