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FOUR-WHEEL DRIVE VEHICLE CRASH INVOLVEMENT RISK, ROLLOVER RISK AND INJURY RATE IN COMPARISON TO OTHER PASSENGER VEHICLES:

ESTIMATES BASED ON AUSTRALIAN AND NEW ZEALAND CRASH DATA AND ON NEW ZEALAND MOTOR VEHICLE REGISTER DATA

by

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Four-wheel Drive Vehicle Crash Involvement Risk, Rollover Risk and Injury Rate in Comparison to Other Passenger Vehicles: Estimates Based on Australian and New Zealand Crash Data and on New Zealand Motor Vehicle Register Data

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Abstract:

Recent analyses have established that 4WD vehicles are aggressive in crashes, causing comparatively more harm than other passenger vehicles when in collision with other road users, and have a high risk of rollover crashes. To assess the safety of these vehicles more completely, this study produced two analyses of risk: firstly, estimates of crash risk and injury rates using NZ data; and, secondly, induced exposure estimates of rollover risk using Australian and NZ crash data.

Crash risk and injury rates were estimated using NZ data, controlling for a number of relevant owner and vehicle characteristics. Nevertheless, within given locations, age bands and gender groups, drivers wanting to drive in a particular manner may choose types of vehicles to suit their driving style, leading to differences in risk between vehicle types. This is an explanation why Sports cars, which often have highly developed braking and handling systems, were found to have a high risk of crash involvement and a high rate of resultant injury. It is likely to be the manner in which these vehicles are driven that leads to these elevated rates. Similarly, despite previously estimated high rollover rates and high aggressivity for 4WDs, crash involvement risks estimated for 4WD vehicles were generally low, likely to be related to the manner in which they are driven. This estimated low crash involvement risk in combination with established generally good overall protection 4WD vehicles provide their own occupants in a crash meant that 4WD vehicles were estimated to impose relatively low injury risk on their own occupants, to other roads users and occupants of other vehicles per registered year adjusted for distance driven, despite their established high aggressivity. The one situation identified with unusually high risk for 4WDs compared to other passenger vehicle types was that of Large 4WDs owned by teenagers.

The induced exposure risk estimation involved two steps: identifying the most appropriate crash type to represent exposure (in terms of amount of driving, driving environment, and driver characteristics) using existing data on distance travelled in NZ; then fitting a model to crash data from Australia and NZ to estimate risk. The best set of comparison crashes was found to be multi-vehicle crashes in which the vehicle type analysed was damaged in the rear. Estimates of risk consistent with previous studies were generally obtained, showing higher rollover risk for those vehicles with a high centre of gravity compared to the width of the wheel track (4WDs and People Movers). As found in a previous study, higher rollover risk was found for young drivers. Higher rollover risk was also found for older vehicles: a 2% higher rollover risk (95% CI 1% to 3%) for a vehicle that is a year older than another vehicle. Female drivers were found to have a 35% lower rollover risk than male drivers (with 95% confidence interval 42% to 27%). The results overall warn that parents who are 4WD owners – and, to a lesser extent, owners of People Movers – need to be wary of allowing their novice family members to use such vehicles (keeping in mind that for young drivers, regular cars present significantly less rollover risk than 4WDs and people movers), and reinforce the importance of electronic stability technology as a highly desirable risk-reducing feature for these relatively unstable vehicles.

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

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EXECUTIVE SUMMARY

Recent analyses have found that four-wheel drive (4WD) vehicles are aggressive in crashes, creating a high chance of serious injury to other vehicle occupants or unprotected road users into which they crash. They are relatively unstable vehicles, with a high risk of rollover, which is a very serious crash type in terms of the potential for serious injury. This report addresses a gap in previous 4WD research, which is to control for the type and amount of driving of the vehicles (exposure) when assessing crash risk. Crash risk is assessed in two ways: *primary* risk estimates of overall crash risk and injury rates, both analyses controlling for exposure; and *induced exposure* estimates of rollover risk controlling for amount and type of driving via a proxy for measuring driving exposure. The proxy for measuring driving exposure is a count of involvements in a comparison crash type.

Primary safety of a vehicle is the ability of the vehicle to avoid a crash. 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. Primary safety estimates can potentially show whether a particular type of vehicle is safer to drive than another (taking into account the sorts of drivers who drive the vehicle, some account of the conditions under which it is driven and the number of kilometres driven). For example, is a 4WD vehicle safer or less safe than a large car? Are certain driver groups (e.g., young drivers) more or less safe in this type of vehicle? Are particular crash types a problem with certain types of vehicles? These are the sorts of questions that can theoretically be addressed by analysis of primary vehicle safety estimates.

The validity of primary safety estimation depends on the availability of good exposure data for vehicles and good information on who drives these vehicles. Good exposure data potentially enable the model to estimate risk as though each vehicle class considered was driven by the same sort of driver under similar conditions and for similar distances. With control over these potentially confounding factors, the estimates potentially provide invaluable information for vehicle buyers and government agencies that wish to minimise risk on the road without compromising mobility. It is likely that driver behaviour still has a strong effect on the risk estimates presented in this study as particular vehicle types can be expected to be chosen to fit particular driving styles. This report presents the estimation methodology and resulting estimates of crash involvement risk and injury rates derived from linking NZ crash and Motor Vehicle Register databases. Information on distances driven was derived from odometer readings recorded at the time of periodic vehicle inspections and extracted from the Motor Vehicle Register. Other information used to model risk included the location of the owner's address (rural vs. urban) as well as the age and gender of the owner.

Induced exposure methods have been used for a number of years to measure relative risks associated with different vehicles, drivers, or driving situations. The advantage of this approach is that it does not require an explicit exposure measure, which is often unavailable, but instead makes use of readily available data, forming exposure estimates from crash data where the comparison crash type is specially chosen to reflect the prevalence of the vehicle type / driver group / driving situation. The analysis described in this report identifies an appropriate set of comparison crashes from analysis of information on vehicle distance travelled for validating the choice of comparison crashes. It is rare that

such an opportunity is available to inform the choice of comparison crashes for this sort of analysis. Relative risk estimates were then able to be formed quite easily by comparing Australian and New Zealand crash frequencies of the crash type of interest (here, rollover crashes) with the comparison crashes, controlling for driver, vehicle and environmental variables by matching these variables of the rollover crashes with those of the comparison crashes.

Although the there were some situations where induced exposure estimates were likely to have some degree of bias, estimates of risk consistent with previous studies were generally obtained, showing higher rollover risk for those vehicles (4WDs and People Movers) with a relatively high centre of gravity compared to the width of the wheel track. As found in a previous study of Australian and NZ crash data, a situation of particularly high risk of rollover was found when teenagers either drive or own 4WD vehicles. This may be related to the fact that 4WD vehicles are more unstable and more difficult to control than cars and thus present greater risk for inexperienced drivers. Higher rollover risk was also found for older vehicles: a vehicle manufactured a year before another vehicle was estimated to have a 2% higher relative rollover risk, all other things being equal (vehicle market group, driver age and gender, speed limit area, jurisdiction, year of crash). Female drivers were found to have a 35% lower rollover risk than male drivers (with 95% confidence interval 42% to 27%).

Analysis of risk estimates for rollover crash involvement using NZ crash and motor vehicle registry data identified rural owner address as a significant risk factor for rollover, which is most likely related to the sorts of roads that non-urban drivers typically use. The higher speeds travelled on non-urban roads lead to greater instability of vehicles, particularly those vehicles that have a high centre of gravity relative to the width of their wheel track, such as most 4WDs, vans and utility vehicles. These risk estimates for rollover crash involvement showed elevated rollover risk for 4WD vehicles. Vans and Utilities were also estimated to have a consistently high rollover risk.

A model was also fitted that estimated average casualty rates controlling for exposure by vehicle market group for injury crashes of any type using NZ data. In this context, a casualty was defined as an injured person either in the focus vehicle (the focus vehicle being the vehicle for which risk was being estimated), or a casualty in a vehicle impacted by the focus vehicle, or an injured cyclist or pedestrian hit by the focus vehicle. Overall, Large 4WDs were clearly the safest vehicle market group in terms of casualty rate. This is despite previous research showing that 4WD vehicles pose a high risk to other vehicle drivers and unprotected road users when involved in a crash with a 4WD. It is likely that low 4WD crash involvement risk combined with generally good occupant protection performance by 4WD vehicles in a crash offset the high injury risk posed to other road users in a crash. This has resulted in a low estimated overall casualty rate for these vehicles in the way they are currently used. The market groups People Movers, Light, Small and Medium cars had relatively high casualty rates, on average, reflecting their average crash risk combined with often poor occupant protection performance in a crash, with Sport cars having clearly the highest injury rate of all the market groups reflecting their high estimated crash risks.

Despite their high rollover risk, 4WDs were found to have a relatively low crash risk overall compared to other vehicle classes. In comparison, sports cars had one of the highest estimated crash risks. Sports cars would be expected to have lower primary crash risks related to their low centre of gravity and design bias toward superior handling and braking. The high risks for sports cars estimated in the current study suggest that despite attempts to control for non-vehicle related factors in estimating crash risk by correcting for driver age, gender and location of residence, the risk estimates obtained still largely reflect aspects of driver behaviour that could not be measured in the available data. Whether these driver characteristics are inherent in the type of person buying a particular vehicle type or are induced by the characteristics of the vehicle driven remain unknown. There is therefore a need for caution in using the estimated crash risks presented in this study to formulate policies and recommendations aiming at directing consumers to particular vehicle types to minimise crash risk as the relatively low crash risk estimated for 4WD vehicles in this study may not be observed if a different cohort of drivers were substituted for those currently using these vehicles.

Another model estimated fatal and serious casualty rates for the vehicle market groups, with the rates averaged over the levels of the owner and vehicle characteristics considered. A proper assessment of safety should account for the seriousness of the injuries sustained, particularly as most minor injuries, while unpleasant, have few long-lasting effects. Here, the results of fitting a Poisson model to the counts of fatal and serious injuries resulting from crashes (including those where a pedestrian or cyclist is killed or seriously injured or occupants of another vehicle are killed or seriously injured in collision with the particular market group considered) showed that fatal and serious injury rates were relatively low for Large 4WDs and high for Sports cars. This is again likely to be largely associated with the crash risks of these two vehicle types rather than associated with secondary safety effects (crashworthiness and aggressivity characteristics) in the event of a crash. The estimates for this model had wider confidence intervals than for the previous models fitted, due to the fact that the data were relatively scarce, as fatal and serious injuries are much less numerous than minor injuries. For this reason, the other market groups cannot be very well distinguished in terms of their fatal and serious crash rates. A low fatal and serious injury rate estimated for Vans and Utilities is likely to be an artefact of the lower speed limit roads that are more often travelled on by such vehicles in mainly work-related driving. This is a limitation of this sort of modelling that exposure by road type can be accounted in only a limited way by the owner’s address. A further limitation is that within given locations, age bands and gender groups, drivers wanting to drive in a particular manner may choose types of vehicles to suit their driving style, leading to differences in risk between these vehicle types.

In summary, from models fitted to crash and Motor Vehicle Register data, the following conclusions can be made:

- In the way they are currently used in New Zealand, 4WD vehicles generally have a low estimated crash risk compared to other classes of vehicles.
- Previous studies from Australia and New Zealand have estimated that 4WD vehicles provide generally good levels of occupant protection in the event of a crash (crashworthiness). However these previous studies have also established that 4WD vehicles, particularly large and medium 4WD vehicles, pose a disproportionately high risk of serious injury to other road users with which they collide (aggressivity).
- Despite their established high aggressivity, 4WD vehicles appear to impose relatively low injury risk overall to their own occupants, to other roads users

and occupants of other vehicles per year of exposure on the road and adjusted for distance driven. This is a result of their estimated low crash involvement risk related to the way these vehicles are currently used, combined with good crashworthiness, offsetting the effects of high aggressivity.

- By far the least safe market group analysed in terms of crash risk was Sports cars. These vehicles consistently had a high risk compared to other market groups under the same circumstances modelled. For rural owners, these vehicles were particularly risky.
- Most vehicles with high annual kilometres driven were not found to have proportionately higher crash risk than low annual kilometre vehicles. This has been found in other studies, and is related – at least in part – to the sorts of driving and roads travelled on by drivers who drive large distances.

The original intent of the current study was to estimate risk associated primarily with vehicle design and handling. However, comparing the resultant risk estimates for 4WD vehicles to those for Sports cars in particular suggests the estimated risks are predominantly affected by driver behavioural factors that could not be measured in the available data rather than factors associated with vehicle design and handling. Whether these driver behavioural factors reflect behavioural adaptation to the type of vehicle being driven or are related to the type of driver buying a particular type of vehicle and the way that vehicle is used could only be determined through further research. Consequently, the relatively low crash risk estimated for 4WD vehicles in this study may not be observed if a different cohort of drivers were substituted for those currently using these vehicles.

Rollover crash risk was also estimated from Australian and NZ data using induced exposure risk estimation, controlling for driver and exposure factors. The main features of the analysis of rollover risk can be summarised as follows:

- Despite their low crash risk overall, the risk of rollover was found to be high for 4WD vehicles. Furthermore, previous studies have shown that 4WD vehicles have a higher relative fatality risk in rollover crashes than other classes of vehicle. The only other market group considered with a consistently high rollover risk was Vans and Utilities. This was consistent with results from previous studies that have also shown higher rollover risk for those vehicles (4WDs and People Movers) with a relatively high centre of gravity compared to the width of the wheel track.
- Analysis of primary risk estimates for rollover crash involvement from NZ data identified rural owner address as being a significant risk factor for vehicle rollover, which is most likely related to the sorts of roads that non-urban drivers typically use.
- As found in a previous study of Australian and NZ crash data, a situation of particularly high risk of rollover was found when teenagers either drove or owned 4WD vehicles. This may be related to the fact that 4WD vehicles are more unstable and more difficult to control than cars and thus present greater risk for inexperienced drivers.
- Higher rollover risk was found for older vehicles: a vehicle manufactured a year before another vehicle was estimated to have a 2% higher relative

rollover risk, all other things being equal (vehicle market group, driver age and gender, speed limit area, jurisdiction, year of crash).

- Female drivers were found to have a 35% lower relative rollover risk than male drivers (with 95% confidence interval 42% to 27%).

These results suggest that parents who are 4WD owners – and, to a lesser extent, owners of People Movers – need to be wary of allowing their novice family members to use such vehicles keeping in mind that cars present significantly less rollover risk for young drivers. The high 4WD rollover risk in general reinforces the importance of electronic stability technology as a highly desirable risk-reducing feature for these relatively unstable vehicles that are prone to rollover crashes.

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Estimates Based on Australian and New Zealand Crash Data and on New Zealand Motor Vehicle Register Data

1. Background

There are important safety concerns with four-wheel drive (4WD) vehicles, including their potential to cause harm to other vehicles and road users (White, 2004). In a recent report, Keall, Newstead and Watson (2006) compared crash patterns of types of 4WDs using Australian and New Zealand data. All three types of 4WDs considered (Compact, Medium and Large) were shown to be more likely to roll over and to provide relatively poor protection to their occupants in rollover crashes. However, there were a number of mitigating criteria in favour of 4WDs as a passenger vehicle, Firstly, despite the increasing size of the 4WD fleet, there did not appear to be a concomitant growing threat to car drivers. The reasons for this may be related to changes in the way that 4WDs are being used, and possibly to the growing number of smaller 4WDs in the fleet, gradually replacing the more aggressive Large 4WDs. Analysis of trends in 4WD crash patterns showed that crash-involved drivers were tending to be less young with proportionately more female drivers and that the crashes were becoming more urban in terms of speed limit area. These are driver groups and locations that tend to have lower rates of crash involvements that also tend to be less serious. The Monash University Accident Research Centre (MUARC) has also undertaken a number of studies into the *secondary safety* of vehicles, which is the ability of the vehicle to protect its occupants in the event of a crash (Newstead and Cameron, 2001; Newstead et al, 1998; Newstead et al, 2004a; Newstead et al, 2005; Newstead et al, 2003a; Newstead et al, 2004b; Newstead et al, 2003b; Newstead, 2004). There is very little information in the literature about the *primary safety* of 4WD vehicles, which is the ability of the vehicle to avoid a crash. 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.

Primary safety estimates can potentially show whether a particular type of vehicle is safer to drive than another (taking into account the sorts of drivers who drive the vehicle, some account of the conditions under which it is driven and the number of kilometres driven). For example, is a 4WD vehicle safer or less safe than a large car? Are certain driver groups (e.g., young drivers) more or less safe in this type of vehicle? Are particular crash types a problem with certain types of vehicles? These are the sorts of questions that can theoretically be addressed by analysis of primary vehicle safety estimates.

Care must be taken when assessing primary safety by vehicle type because of possible confounding due to the way different vehicles may be driven. Some recent studies (Keall and Frith, 2003; Keall and Frith, 2004; Keall et al, 2005) have shown that risks per km driven vary considerably by characteristics such as the age and gender of the driver, and also by the time and place of driving exposure. There remains a need to expand on that analysis by estimating risk while controlling for the exposure of the vehicle. One potential approach involves making use of data on vehicle distance driven combined with crash data to estimate primary risk. Such data are very uncommon internationally, meaning that few attempts have been made to produce such estimates. New Zealand Motor Vehicle Register data, which have odometer readings recorded periodically, are an ideal data source for this estimation approach.

Another approach uses the method of induced exposure for risk estimation. Induced exposure methods have been used for a number of years to measure relative risk of vehicles, drivers, or driving situations (e.g., Xuedong et al, 2005). The advantage of this approach is that it makes use of readily available data, forming exposure estimates from crash rates where the comparison crash type is specially chosen to reflect the prevalence of the vehicle type / driver group / driving situation. One recent example of this estimation was an assessment of the effectiveness of ABS braking systems in Australia (Delaney and Newstead, 2004).

1.1. Pilot study

Prior to this project, a pilot study done by Monash University Accident Research Centre for Land Transport New Zealand trialled a linking process between crash data and MVR data to find to what extent the crash-involved driver is the owner of the vehicle, or at least in the same age/gender group as the owner (Keall and Newstead, 2006a). For each crashed vehicle that had been successfully matched, comparisons were made between the location of the crash and the owner's address as well as between the age and gender of the driver who crashed and the owner's gender and age. The vast majority of crashed vehicles were being driven by someone in the same age range and of the same gender as the owner. There were two main exceptions to this: (i) vehicle types that are commonly company-owned, and (ii) a few makes and models of vehicle that are most commonly driven by young people. Both these classes of vehicles needed to be identified and treated specially to avoid biases in risk estimation when estimates of primary vehicle safety were being derived from these data. Vehicles crashed in similar types of locations (in terms of levels of urbanisation) as the places where their owners lived in about two thirds of cases. To the extent that the level of urbanisation presents different risk environments, as seems likely, the owner's address appears to be a very useful explanatory variable in analyses of risk.

To summarise, the pilot study's results indicated that it is valid to link the crash database and the Motor Vehicle Register in order to analyse risk per km driven by data such as owner age, gender and location. However, the capability of the models of primary vehicle safety to produce estimates for individual makes and models will be restricted to popular vehicles until more data become available.

1.2. Crash involvement patterns of 4WD vehicles

A recent report undertaken by the Monash University Accident Research Centre (MUARC) for the Royal Automobile Club of Victoria (RACV) (Keall et al, 2006) analysed 4WD crash involvement patterns in comparison to other passenger vehicles in Australia and New Zealand and reviewed recent work on estimating crashworthiness and aggressivity for 4WD and other vehicles. The main findings of this study were:

- On average, Large and Medium 4WDs had good crashworthiness.

- They have been shown to be aggressive vehicles, causing significantly higher risk of death and serious injury to other road users when in collision with other vehicles, cyclists and pedestrians. However, the feared increases in trauma to car drivers did not seem to have occurred at the same rate as sales had increased, perhaps indicating low km driven by 4WD vehicles. This possibility needed to be addressed by analyses that account for kilometres travelled.

- NSW data suggested that 4WD rollover rates were improving with time and the consequences for car drivers of a head-on crash with a 4WD may also be improving with time.

- Despite these positive points, 4WDs were more likely to roll over, a very serious crash type. Generally, 4WDs offered poor protection in this sort of crash and in single vehicle crashes generally.

- These rollover rates appeared to be higher for inexperienced 4WD drivers (high for young drivers; also indicative evidence that rates are high for older female drivers) and in higher speed limit areas. There was no evidence of differences in overall rollover rates between the three different size classes of 4WDs considered.

1.3. Components of the primary risk estimate

As discussed above, the *secondary safety* of vehicles is the ability of the vehicle to protect its occupants in the event of a crash and 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 crash reporting system only records injury crashes with consistent data, the primary risk estimates derived solely from NZ data of necessity include the *injury risk* component of crashworthiness, as represented below, and are hence not purely estimates of primary risk:

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

1.4. Purpose of the study

The current research attempts to address a limitation of previous analyses of 4WD risk, the desirability of accounting for distance driven and other relevant factors related to the owner/driver of the various passenger vehicle market groups considered to make more accurate comparisons of vehicle safety.

The purpose of the current study is twofold:

1. First, to use NZ data linking police reported crash data with Motor Vehicle Register (MVR) (exposure) data as input to sophisticated statistical models that estimate risk while controlling for confounding factors such as the sorts of drivers who drive the vehicle, the extent of driving undertaken by the vehicle and the conditions under which it is normally driven. These estimates would then show how safe (or dangerous) 4WD vehicles are compared to other passenger vehicle market groups.

2. Second, to use Australian and NZ data to estimate risk of rollover crash involvement of 4WD vehicles compared to other passenger vehicles. The analysis described in this report identifies an appropriate set of comparison crashes from analysis of New Zealand

data that had vehicle distance travelled available for validating the choice of comparison crashes. It is rare that such an opportunity is available to inform the choice of comparison crashes for this sort of analysis. Relative risk estimates are then able to be formed quite easily by comparing crash frequencies of the crash type of interest (here, rollover crashes) with the comparison crashes, controlling for driver, vehicle and environmental factors by matching these aspects of the rollover crashes with those of the comparison crashes.

2. DATA

2.1. 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 unroadworthy (e.g., with worn tyres etc) since its WoF/CoF inspection.

At the time of the WoF or CoF inspections, odometer readings are recorded by the inspecting mechanic. These data, along with the results of the vehicle inspection, are entered on-line and stored in a centralised database. Estimating vehicle distance driven is possible because two consecutive odometer readings for any vehicle inspected at least twice in New Zealand can be extracted from the database, along with the dates of the inspections. This provides an estimate for each vehicle of distance driven over the period between the WoF or CoF inspections. Such estimates can then be converted into estimates of annual distance driven by making the assumption that the vehicle is driven throughout the year at the same daily km rate as estimated for the period between the inspections considered.

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). This is because recent VKT data were not available to estimate distance driven for these vehicles. This is a desirable facet of the study of primary vehicle safety in that the vehicles studied were all maintained to a given minimum standard, so differences in maintenance levels of the vehicles studied should not bias estimates of the vehicle safety.

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 is a company.

Filters were used to ensure that invalid distance estimates were not included in the study, as described in an unpublished document from the New Zealand Ministry of Transport by Povey (2005). According to these filters, the following vehicles could not have a valid distance estimate calculated:

a) Those with at least one missing odometer reading.

b) The difference between consecutive odometer readings was less than 20 km. It was assumed that these vehicles had been under repair between inspection dates and that the distance travelled per day was therefore atypical.

c) The current odometer reading was less than the previous one.

d) Vehicles with fewer than 30 days between successive inspections. It was assumed that these vehicles had been under repair between inspection dates.

e) Vehicles with unreasonably large daily distances recorded. This was determined according to vehicle age (newer vehicles were allowed to have greater distances estimated and still be treated as valid). This was to avoid using data clearly affected by transcription errors or misrecording.

Market group was determined by using an Excel spreadsheet of makes and models of vehicles classified by market group based on analysis of the NZ vehicle fleet by MUARC. 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 for this classification. The classification “Unknown” was used for vehicles not identified by this process. Estimates were calculated for this group of vehicles as a check that the unclassifiable vehicles were not sufficiently atypical to skew (bias) estimates for the market groups able to be classified.

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). This was 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. For older vehicles, a distance unit (miles or kilometres) is required in order to estimate distance driven from the odometer readings. To obtain these, another file of MVR data from August 2004 was used, linked to both the data from March 2005 and from February 2006 by the vehicle identification number. Vehicle identification numbers are unique identifiers linked to the vehicle, unlike licence plates, which can sometimes be transferred from one vehicle to another. This August 2004 file contained the vast majority of older vehicles for which the distance unit information was important. For the relatively few vehicles that had a distance unit missing after this process, a unit was imputed by making use of information on the period of the year of manufacture of the vehicle and the most common distance unit used during that period. These were combined to form a file of 3,378,394 vehicles that were licensed during these two periods (March 2005 and February 2006), of which 2,995,906 were light passenger vehicles. The distance travelled was calculated in two different ways: (i) if only one distance estimate was valid, or the vehicle existed in one year’s file, but not the other’s, the distance estimate was taken to be whichever of the two distance driven estimates was valid; (ii) if there were two valid estimates, one for 2005 and one for 2006, the distance driven estimate for the vehicle was taken to be the 2006 distance estimate. The rationale for this process was that distance driven was a variable that was relatively frequently missing (due to transcription errors etc in recording odometer readings), so this practice of using all available valid data led to a higher proportion of vehicles having distance driven estimated. Only about 9% of the vehicles within the scope of this study had missing distance driven estimates. These were excluded from the analysis. 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, 2006b) 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.

2.2. Crash data used for primary risk estimation

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 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 in Section 2.1 above.

2.3. Crash data used for induced exposure models

Crash data from four Australian states, Victoria, New South Wales, Queensland and Western Australia, along with data from New Zealand, were used from the years 1993 to 2004. There were a number of key variables in the crash data defined for modelling vehicle rollover risk that were common to the five jurisdictions' crash data sets:

- Year of crash
- Speed limit at crash location (<80km/h, >=80km/h)
- Year of vehicle manufacture
- Vehicle market group
- Driver age (<26 years old; 26-59 years old; age 60 plus)
- Driver gender (male, female)

2.4. Defining rollovers

A rollover occurs when a vehicle impacts the ground or road surface with its side or top. To examine rollover rates and crashworthiness of vehicles given this crash outcome, it was necessary to identify crashes for which rollover was coded as the primary or first impact on the vehicle. Different crash datasets have different ways of coding rollovers, which lead to different definitions by jurisdiction. For Victoria and Queensland, a variable was available that coded for first impact type or major impact point on the vehicle: for Victoria, whether the top or roof of the vehicle was the point of *initial* impact and for Queensland, whether the top or roof of the vehicle was the point of *major* impact. For Western Australia a variable coded for non-collision accident type was used to identify a rollover. For New Zealand, a rollover was defined if there was damage to the top (roof) of the vehicle or the degree of damage was stated as due to the vehicle overturning.

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 12 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)
- Commercial vehicles (utilities and vans less than 3000 kg Gross Vehicle Mass)
  - Utility
  - Van

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 excluded from the induced exposure analysis, for reasons explained below. In this report, the market groups of vehicles are referred to be names with a capitalised first letter, viz. Small cars, Large 4WDs, etc.

3. ANALYSIS

The Analysis section describes the analytical approach used. Two analyses were performed: (i) estimation of primary vehicle risk from NZ data using six statistical models to investigate different perspectives of risk; (ii) estimation of rollover risk using induced exposure estimates. The description of the induced exposure estimation method also outlines the process used to identify the best comparison crash type to represent vehicle exposure.

3.1. Variables

All variables, apart from crash involvement, were derived from the owner details in the MVR. For crash-involved vehicles, Land Transport NZ found owner details from the MVR as at the date of the crash. This was to ensure that the owner current at the date of the crash was correctly identified and to avoid potential matching problems identified in the pilot study (Keall and Newstead, 2006a). Age group 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. The level of urbanisation of the owner's address was defined in four levels (Local Authorities were classified into: 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 vicinity of the owner's address can be expected to be the main area of driving exposure, these classifications provide a proxy for types of road, 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 plate numbers (which can be transferred from one vehicle to another vehicle in the case of personalised plates). As initial modelling showed that the two non-Auckland urban classifications had similar coefficients estimated, these were combined to form a single category for the analysis. The three urbanisation classifications for the owners' address were therefore: "Auckland"; "other urban"; "rural".

3.2. Primary risk modelling data

3.2.1. Models fitted to estimate primary risk

Six models were fitted to the data to estimate:

1. Overall risk of crash involvement by market group over the two years studied
2. Risk of rollover crash involvement by market group over the two years studied
3. Risk of multi-vehicle crash involvement by market group over the two years studied
4. Market group total safety (number of casualties resulting from crashes involving that market group controlling for distance driven and owner characteristics over the two years studied)
5. Market group *average* safety (number of casualties resulting from crashes involving that market group, averaged over the factors that interacted with the market group variable in Model 4) over the two years studied

6. Market group average *serious/fatal* safety (number of serious/fatal casualties resulting from crashes involving that market group, averaged over the factors that interacted with the market group variable) over the two years studied

3.2.2. Modelling continuous explanatory variables

Fractional polynomial analysis (Royston and Altman, 1994) was used to identify the most appropriate functional form for vehicle distance driven ("km_year", estimated from consecutive odometer readings on the MVR). In STATA (StataCorp, 2001), the appropriate polynomial form was determined for the regression that estimated the probability of crash involvement for Models 1 to 3, and estimated total casualties for Models 4 to 6, with the covariates owner gender (owner_gender), owner age group (agegrp), market group of the vehicle (marketgroup), level of urbanisation of the owner's address (townclass) and vehicle age (veh_age).

For Model 1 (overall crash involvement) and Model 3 (multi vehicle crash involvement), the most appropriate functional form for distance driven per year, was represented as two terms in the model, kmy1 and kmy2, where

$$\text{kmy1} = \log(x)+1.989913539$$
$$\text{kmy2} = x^{3}-0.0023518863 \quad (1)$$

where x = hundred thousands of vehicle km driven per year.

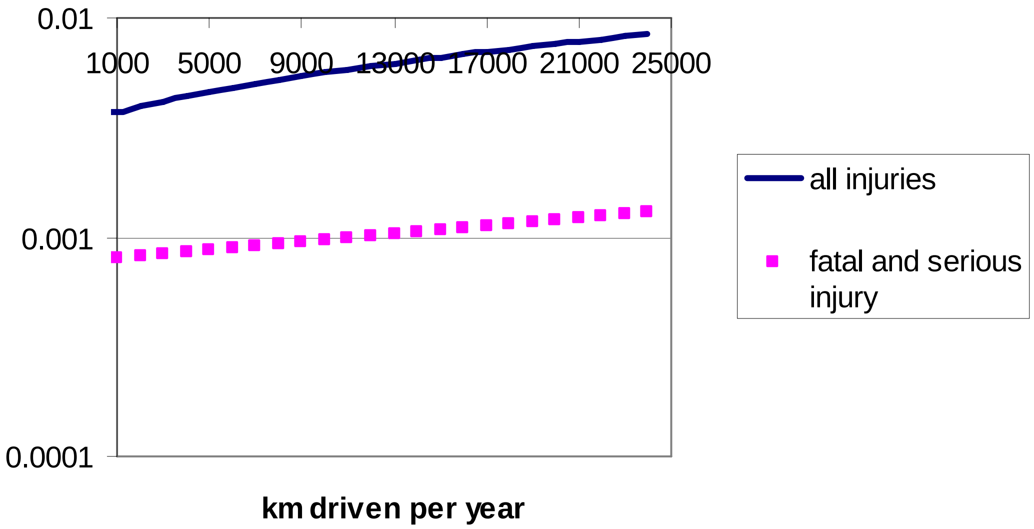

Figure 1: *Expected number of injuries per two vehicle years of driving by annual vehicle distance driven as modelled by fractional polynomial analysis*

For the rollover crash involvement model (Model 2), the more complex expressions involving annual distance driven were not statistically significantly superior to distance driven as a linear term in the logistic, so the simpler form was preferred. The shape of the resultant modelled relationship between km driven and risk for Models 1 and 3 is similar to the solid line presented in Figure 1, which is the relationship found for Model 4 (total safety). As for the rollover crash involvement model, and for the same statistical reasons, the fatal and serious injuries of Model 6 were modelled with a distance driven as a linear term in the logistic, represented by the dotted line of Figure 1.

Vehicle age was allowed to enter the regression as a continuous variable modelled as linear in the logistic space as this was considered to provide a proxy measurement for the crashworthiness of the vehicle. Previous work by Newstead and Watson (2005) has shown that the log of crashworthiness can be expected to change linearly against the variable vehicle age. Models 5 and 6 deliberately excluded all interactions with market group to estimate market group safety averaged over the levels of other variables modelled.

3.2.3. Modelling process for primary risk

Multivariate logistic regression models were used to estimate crash risk in Models 1-3. In order to avoid overly complex models, no third order interactions of terms entered into the model were allowed. For terms up to and including second order, 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). This process was carried out manually in the case of the Poisson regressions (Models 4, 5 and 6).

It was considered that each model fitted potentially represented different patterns of vehicle use leading to different risk patterns estimated, so variables included in one model were not automatically included in other models, but were subject to the selection criteria described above. As Model 2 involved relatively few cases of rollover crash involvement, there was less power available to detect significant terms, so a simpler model resulted. Terms included in the models, with estimated coefficients, are listed in the Appendix.

Unusual observations were identified during the modelling process, such as individual vehicles that had an unusually large effect on the estimated parameters. However, when the models were re-fitted without such observations, the effect on the estimated parameters was negligible, as may have been expected with such a large amount of data available. No data were omitted from the final analysis based on these criteria.

The Poisson regression models (Models 4, 5 and 6) were fitted to data that were clustered by crash for multi-vehicle crashes. Two vehicles crashing together may be expected to have a correlation in the number and severity of resultant casualties occurring in each vehicle. Negative binomial models, which could be expected to model this form of correlation adequately, failed to converge. GEE analysis, another approach suitable for clustered data, required too much computer memory for the analysis to be completed. The criteria often used for deciding on over or under-dispersion for Poisson models, the deviance divided by degrees of freedom and Pearson’s Chi-Square divided by degrees of freedom indicated a large degree of under-dispersion and modest over-dispersion respectively. Given these conflicting results, it is best to interpret the confidence intervals estimated by the Models 4 to 6 as being slight underestimates of the true confidence intervals.

3.3. Finding a crash type to represent exposure

The Analysis section now focuses on the process of estimating rollover risk using induced exposure measures combined with logistic models.

In order to produce induced exposure estimates of risk, a comparison set of crashes needs to be identified. The fundamental requirement of these comparison crashes is that the risk of crashes of this type is unaffected by the characteristics of the risk factor being evaluated. For example, if rollover risk is being evaluated for 4WDs in comparison with other passenger vehicle types, the comparison set of crashes should reflect the amount of driving undertaken by 4WDs in comparison to other vehicles, particularly under those conditions with increased or decreased rollover risk and when driven by driver groups with differences in rollover liability. This requirement of the comparison crashes can be represented analytically as follows:

Let c_{ij} be the number of crashes of type *i* under conditions/driver group/vehicle type *j*

Let e_j be the exposure under conditions/driver group/vehicle type *j*

Then $$\frac{c_{ij}}{\sum_j c_{ij}} \cong \frac{e_j}{\sum_j e_j} \qquad (2)$$

In other words, the ideal set of comparison crashes has the characteristic that the proportion of comparison crashes for driver/vehicle/condition is a good estimate of the proportion of driving undertaken by the driver/vehicle/condition combinations considered. The procedure used to identify a suitable group of comparison crashes sought to find such crash types whose rates *best* reflected exposure in terms of VKT for the conditions/driver group/vehicle type combinations available.

Given that an appropriate comparison set of crashes can be found, represented by the crashes *c* in equation (2), crude relative risk estimates can be formed from the ratio of the number crashes of interest under the conditions/driver group/vehicle type *j* to the number of comparison crashes for the conditions/driver group/vehicle type *j*.

Let the number of rollover crashes under conditions/driver group/vehicle type *j* be represented by r_j

Then, *crude estimate of risk for conditions/driver group/vehicle type j* $= \frac{r_j}{c_j}$ (3)

3.4. Comparison of crash rates with NZ exposure data

This section describes the analysis used to identify the most appropriate set of comparison crashes, by comparing NZ distance travelled estimates (derived from vehicle odometer readings) with the frequency of crashes of particular types. Candidates considered as comparison crash types were multi-vehicle crashes of the following sorts: rear-end crashes, in which damage occurs to the rear of the vehicle considered; side-on crashes, where damage occurs on a specified side (left or right) of the vehicle; combinations of these; all multi-vehicle crashes. The objective was to identify a crash type that most closely reflected the vehicle and driver's exposure, independent of the vehicle market group's primary crash risk and independent of the driver group's crash risk.

Figure 2 and Figure 3 show the proportion of crash-involved drivers in the age and gender group specified divided by the proportion of VKT driven by vehicles with owners in that age and gender group for three multi-vehicle crash types: damage on LHS of vehicle, damage on RHS of vehicle and damage on rear of vehicle, using New Zealand crash data from 2004/05 together with data on kilometres travelled derived from odometer readings of the NZ Motor Vehicle Register. The rationale behind such comparisons is that although the VKT estimates are based on *owner* data, the owner (or at least someone in the same age range and often the same gender as the owner) is the driver of the vehicle when it crashes (Keall and Newstead, 2006b).

The most appropriate set of comparison crashes is that which is represented by a line that is close to 1.0 throughout. In particular, there should be few extreme values where relative crash involvement rates are very poor estimates of relative exposure for particular groups or situations. Using these criteria, the "hitrear" crashes, in which recorded damage was to the rear of the vehicle, are evidently the best for the age and gender groups shown.

At an early stage in the analysis, it was apparent that the vans and utes were very dissimilar to the passenger vehicles in terms of multi-vehicle crash involvement compared to their distance driven. Their very high involvement in multi-vehicle crashes may be a result of their type of use, involving frequent manoeuvring in and out of traffic, or may be an artefact of the analysis method used. As only vehicles that were owned by individuals were considered in the estimation of distance travelled from the odometer readings, this approach may have missed many commercial vehicles that are owned by companies. This would mean that their distance driven overall was underestimated. For these reasons, and because vans and utes are often used for commercial reasons rather than as passenger vehicles, they were excluded from the induced exposure analysis of rollover risk.

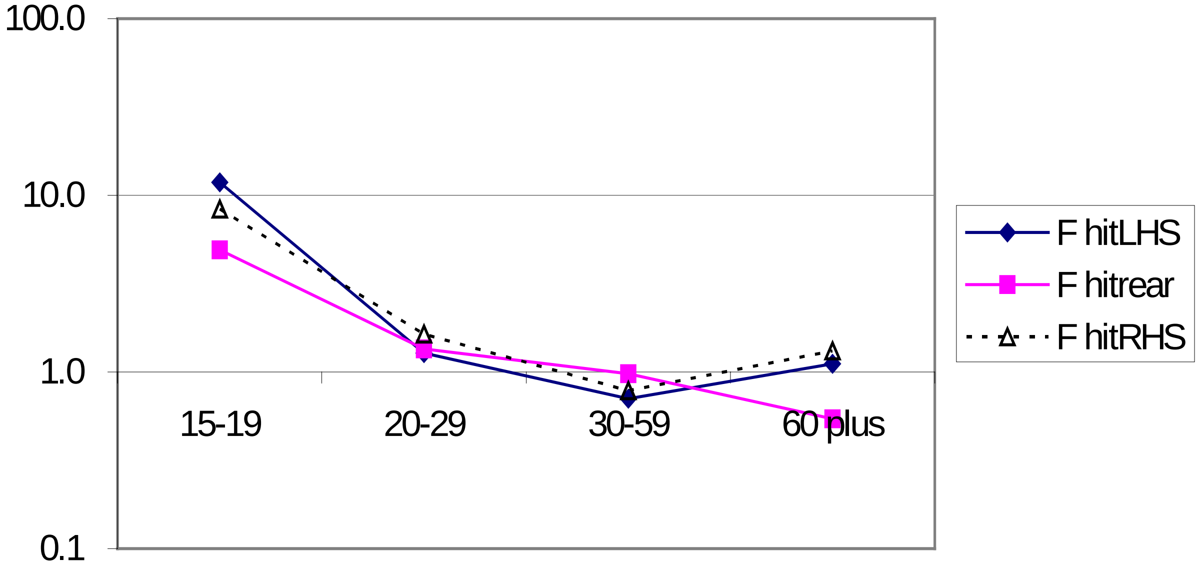

Figure 2: *For females, the proportion of crash-involved drivers in the age group specified divided by the proportion of VKT by vehicles with owners of that age and gender group for three multi-vehicle crash types: damage on LHS of vehicle, damage on RHS of vehicle and damage on rear of vehicle. Logarithmic vertical scale.*

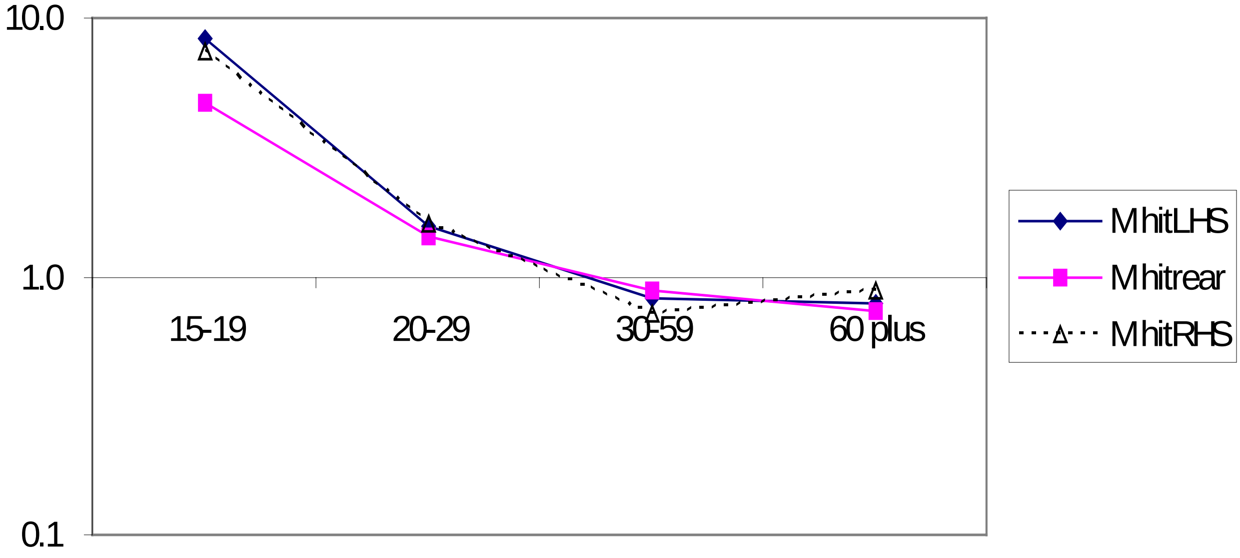

Figure 3: *For males, the proportion of crash-involved drivers in the age group specified divided by the proportion of VKT by vehicles with owners in that age and gender group for three multi-vehicle crash types: damage on LHS of vehicle, damage on RHS of vehicle and damage on rear of vehicle. Logarithmic vertical scale.*

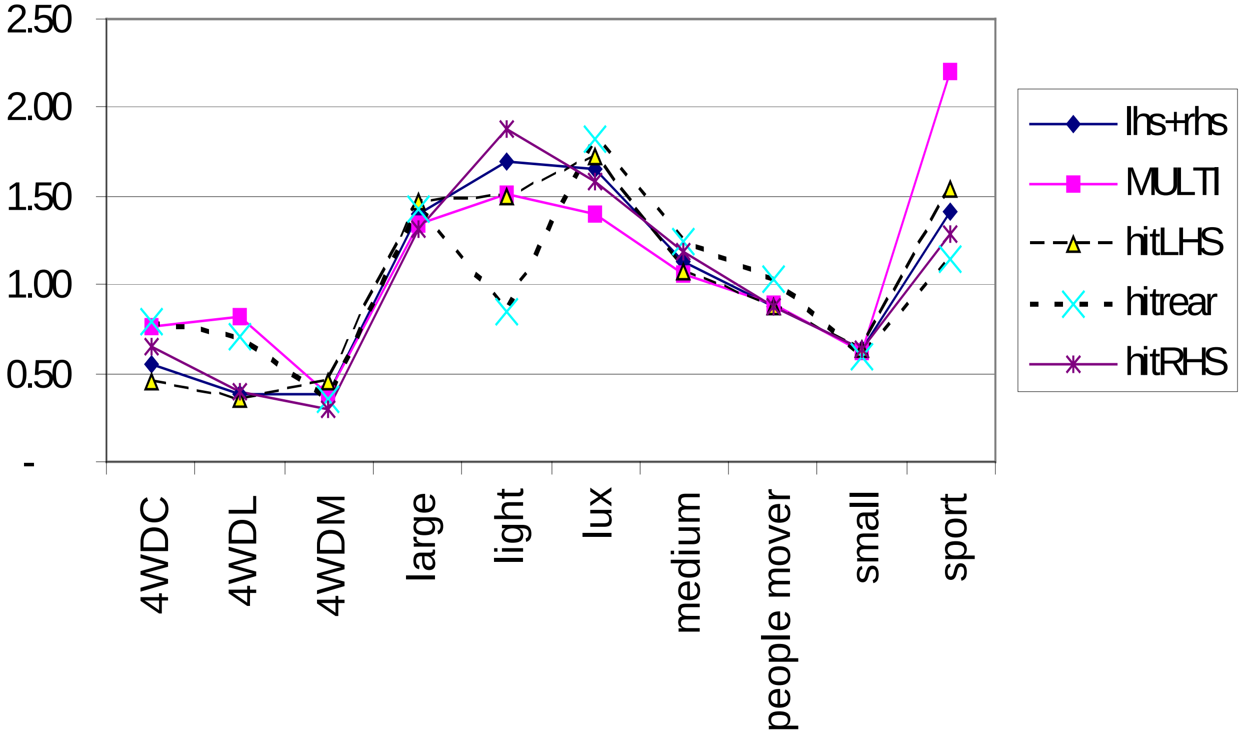

Figure 4: *By passenger vehicle market group, the proportion of crash-involved vehicles of the type specified divided by the proportion of VKT by these vehicle types for five multi-vehicle crash types or combination of crash types: damage on LHS of vehicle, damage on RHS of vehicle, damage on rear of vehicle, all multi-vehicle crashes combined and all crashed vehicles with damage to either side combined.*

Figure 4 shows the relative frequency of the crash types considered (which includes "MULTI", all multi-vehicle crashes and "lhs+rhs", all crashes where the vehicle is damaged on either side or both sides) compared to odometer readings-based distance driven estimates. Using whatever crash type featured, 4WD vehicles and Small cars are underrepresented. However, the best performing crash type, which is closer to the distance driven estimates in most cases, is (again) the "hitrear" crashes, where the vehicle is damaged in the rear. The under-representation of 4WD vehicles in crashes of this type (or in any of the crash types considered) means that any induced exposure estimates of risk will nevertheless be over-estimates for these vehicles.

There may be an effect where a large, robust vehicle is not recorded as having damage in the rear because such damage seems trivial compared to the damage to the front of the smaller vehicle that has rear-ended it, leading to the under-representation of 4WD vehicles relative to other vehicles. Both Light and Small cars are also under-represented, which is not consistent with such a mechanism. Some research has indicated that there may be differences in the way larger vehicles may be followed by another vehicle, leading to potential differences in rear-end crash rates for the followed vehicle. Specifically, larger vehicles were followed more closely, theoretically increasing the possibility that they may be hit from the rear (Sayer et al, 2000). Such research does not support the under-representation of 4WD rear-end damage compared to distance driven found in the current study.

3.5. Modelling rollover risk using induced exposure methods

Logistic regression models the odds of an event, which is defined here to be a rollover crash. The approach used to model risk involved creating a file that consisted of all rollover crashes and all comparison crashes. Then the odds estimated are of the form shown in equation (3), which conveniently estimates risk of rollover using the induced exposure measure.

As rollover is defined differently in each jurisdiction (see paragraph 2.4, above), it was necessary to estimate rollover risk *within* each jurisdiction, but ignore differences in risk *between* jurisdictions. Similarly, the comparison crash frequencies change according to speed limit zone, meaning that exposure comparisons (and the risk estimates that result from using these) are not meaningful *between* speed zones. Therefore, conditional logistic regression was used, where both jurisdiction and speed zone were conditioned out of the analysis.

The SAS procedure LOGISTIC (SAS Institute, 1998) was used to model the risk of rollover. Explanatory variables considered were: vehicle market group; vehicle year of manufacture; age of driver (in three groups); sex of driver. A comparison group was chosen for each factor considered. For vehicle market group, Large cars were chosen as the comparison group, as they are a logical alternative choice for many potential 4WD owners.

The variables:

- Year of crash
- Year of vehicle manufacture
- Vehicle market group
- Driver age (<26 years old; 26-59 years old; age 60 plus)
- Driver gender

were modelled as explanatory variables, as were meaningful interactions of these variables. Only terms significant at the 0.05 level were retained, which included all the above factors, but no interactions. One exception was the variable “year of crash”. This was retained as it was an apparent confounder of the effect of vehicle year of manufacture (as later years of crash also tend to involve vehicles with later years of manufacture), despite its lack of statistical significance at the 0.05 level. Pearson and Spearman correlation coefficients for these variables were both around 0.4. The degree of co-linearity implied was not considered to be high enough to be of concern to the interpretation of the results of the regression. As described above, the speed limit zone at crash location (<80km/h, >=80km/h) and jurisdiction (WA, QLD, VIC and NZ) were modelled as strata and were conditioned out of the analysis. With conditional logistic regression in PROC LOGISTIC provided in SAS 9.1, there is currently no output available regarding model fit or diagnostics.

4. Results

4.1. NZ Primary risk estimation: Crude crash rates

Crude rates of NZ crash involvement per licensed vehicle were calculated using the data obtained by matching crash data to the MVR data, excluding non-passenger vehicles or those whose odometer readings were identified as not useable, as described above. The estimates were calculated for risk of crash involvement overall, multi-vehicle crash involvement, rollover crash involvement and number of injuries per licensed vehicle over the period of two years. Table 2 shows that Large 4WDs (4WDL) had the lowest crude crash rate (0.57%) as well as the lowest multi-vehicle crash involvement rate (0.35%). Sports cars had the highest crude crash rate (0.98%). Medium 4WDs had the highest rollover rate (0.12%), followed by Vans/utilities (0.10%) and Compact 4WDs (0.07%), equal third with Sports cars (0.07%). The last column ("injury rate per vehicle") provides a crude (unadjusted) estimate of the total number of injuries sustained in crashes in which that vehicle type was involved, per licensed vehicle over the two years studied. This includes injuries to other vehicle occupants in multi-vehicle crashes in which the vehicle type was involved, including injuries to pedestrians and cyclists impacted by the market group. Sports cars stand out as being clearly the vehicle market group that was implicated in the most road injury. These estimates do not account for owner characteristics or for distance driven. Estimates of these rates adjusted for these other factors are presented below in Section 4.2.

Table 1: *NZ 2005/2006 data. Number of currently licensed passenger cars and vans analysed (n) and number matched to crash data (n crash) with crude two-year injury crash involvement rates per vehicle licensed during the two-year period: (i) overall; (ii) for crashes where more than one vehicle was involved; (iii) where the vehicle rolled over. "Injury rate per vehicle" shows crude numbers of injuries per two licensed vehicle years (including injuries to pedestrians and cyclists and occupants of other vehicles colliding with the market group considered)*

Market group	n licensed vehicles	Overall n crash	Overall crash rate*	Multi-vehicle crash rate*	Rollover crash rate*	Injury rate per vehicle
Overall	2,995,906	23,826	0.80%	0.48%	0.06%	1.15%
4WD Compact	91,345	640	0.70%	0.44%	0.07%	0.99%
4WD Large	53,462	304	0.57%	0.35%	0.06%	0.83%
4WD Medium	137,530	940	0.68%	0.41%	0.12%	1.02%
Large	261,572	2,041	0.78%	0.46%	0.04%	1.13%
Light	150,655	1,237	0.82%	0.50%	0.05%	1.14%
Luxury	177,151	1,298	0.73%	0.45%	0.04%	1.03%
Medium	467,273	4,003	0.86%	0.51%	0.05%	1.25%
People Mover	70,545	592	0.84%	0.54%	0.05%	1.32%
Small	649,779	5,910	0.91%	0.56%	0.06%	1.30%
Sport	115,690	1,136	0.98%	0.58%	0.07%	1.43%
Van/Ute	252,791	1,854	0.73%	0.43%	0.10%	1.07%
Unknown	568,113	3,871	0.68%	0.42%	0.05%	1.00%

*Rates are per licensed vehicle

Table 1 includes vehicles owned by companies or by more than one person. The models, however, were fitted to data excluding such vehicles and any vehicles with data on owner gender missing. This excluded 12% of eligible vehicles from the MVR. The reason for excluding these vehicles is that the exposure data by owner age, gender and home address were not available when the owner was not listed as an individual. A preliminary study that piloted this approach (Keall and Newstead, 2006a) found that the crashed driver was in the same age group and of the same gender as the owner in the vast majority of cases. This means that owner risk factors as analysed here can be regarded in a similar light to driver risk factors, which have been examined more extensively in the literature (e.g., Keall and Frith, 2004). Logistic regression was used to fit Models 1 (overall crash involvement risk), 2 (rollover crash involvement risk) and 3 (multi vehicle crash involvement risk) using the SAS procedure PROC LOGISTIC. Models 4, 5 and 6 were fitted using Poisson regression using the SAS procedure PROC GENMOD. Output generated by these procedures in SAS is provided in Appendix 1.

4.2. NZ Primary risk model estimates

The estimates from the models are presented here in the following order: estimates for variables that had no significant interaction with market group; estimates for market group within levels of interacting variables; estimates for market groups averaged over levels of other interacting variables. These last estimates are less able to be generalised as they represent the conditions, mix of traffic and drivers in New Zealand as in the years 2004-2005. However, they are the best overall estimates of average primary vehicle safety by market group.

4.2.1. NZ injury rates for owner variables not interacting with market group

As described above, no third order interactions of terms were included in order to avoid overly complex models. All the graphs presented show the same pattern or trend in risks for any levels of variables not represented on the graph. For example, Figure 5 shows estimated risk for the particular situation: other urban male owner, vehicle age at median (12 years) and market group being Medium car. Risk curves for other combinations of these variable levels will have same-shaped graphs that differ in terms of their vertical placement on the y-axis. In other words, the relativity of the estimates presented remains unchanged for any of the other situations modelled.

Figure 5 shows the way that risk of injury crash involvement changes according owner age and number of kms driven per year by the vehicle, set at three levels: “low” (6,000 km per year); “median” (11,000) and “high” (19,000). Figure 5 shows that lower km vehicles have consistently lower risk per year (as can be expected as the levels of exposure are lower). The differences in risk between high and low km vehicles owned by younger owners (aged under 30) are much smaller than those owned by older owners, indicating that there is an interaction estimated between the factors annual distance driven and age of the owner. This is likely to be related to the different way (type of exposure or manner of driving) that higher kilometre vehicles owned by young people are driven. It is a limitation of the current analysis (and of any published analysis known to the authors) that no further light can be shed on the reasons for this interaction. Analysis of the driving patterns of drivers who drive low annual distances has shown that such drivers have higher risks per km than drivers who drive greater distances per annum (Keall and Frith, 2006).

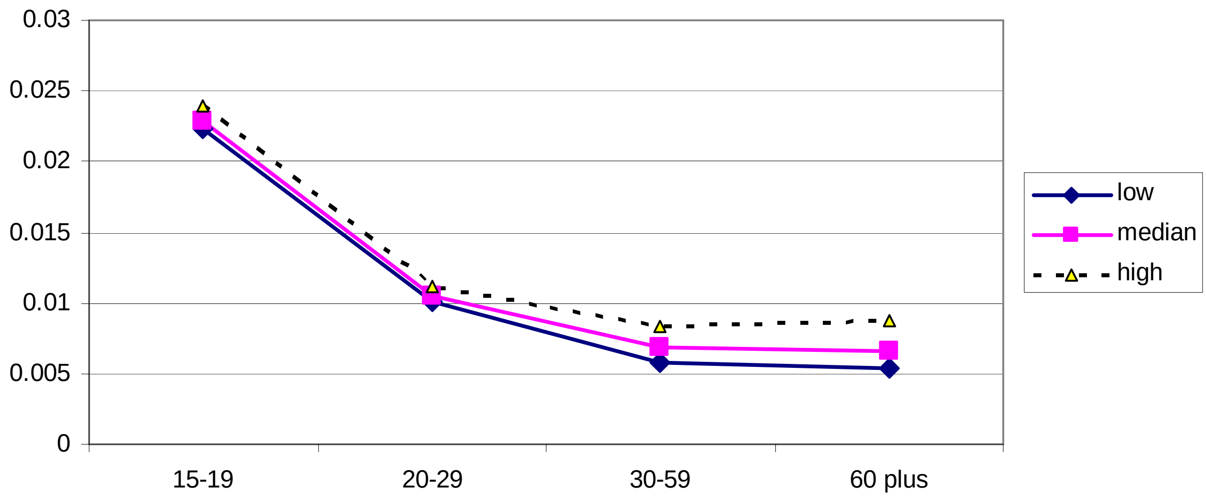

Figure 5: *Estimated probability of injury crash involvement by age of owner and km driven per year at three levels, "low", "median" and "high" (with male owner with other urban address, Medium car with age at median of 12 years). NZ data.*

No interaction such as shown in Figure 5 was estimated for the models of multi-vehicle crash involvement and rollover crash involvement (which had less power to detect significant interactions because of the sparse rollover crash data). The parameter estimates for all the models fitted are shown in Appendix 1.

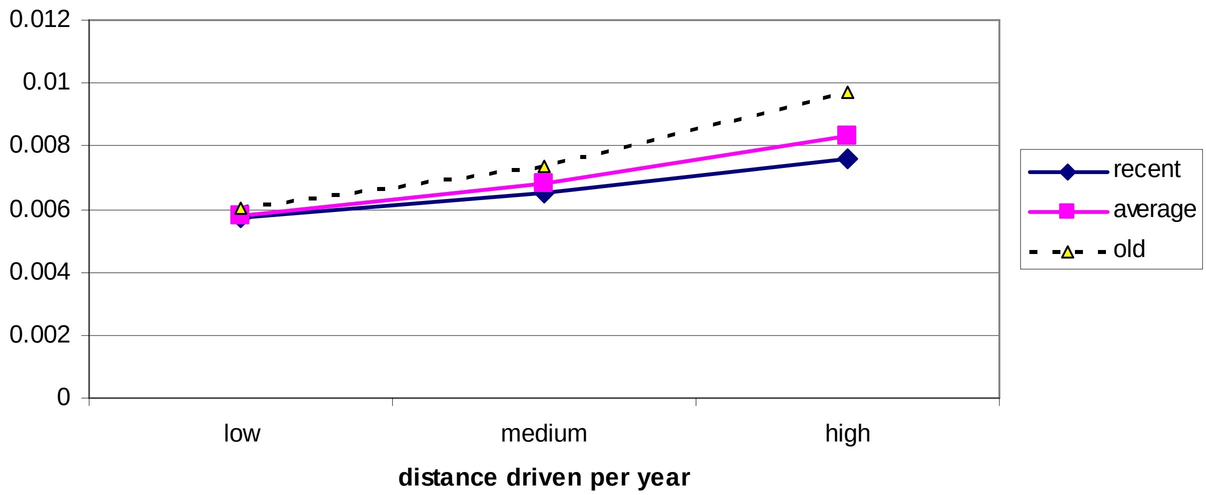

Figure 6: *Estimated probability of injury crash involvement by km driven per year at three levels, "low", "median" and "high" and age of vehicle at three levels (with other urban owner address, male owner aged 30-59, market group=Medium car). NZ data.*

Figure 6 shows that there was estimated to be a trend towards higher injury crash involvement risks for older vehicles when the vehicle had higher annual distance driven. The age of the vehicle appears to have little impact on risk when the vehicle is driven only small distances per year. This particular example is for a middle-aged urban-dwelling male driving a Medium car.

4.2.2. NZ Injury rates for owner variables interacting with market group

For Model 1 (injury crash involvement risk), statistically significant interactions with market group were for the variables owner age and level of urbanisation of owner address. Such interactions mean that the comparison of the safety between market groups changes for different levels of the interacting variable. Where a variable interacted significantly with the market group variable, a graph is generally presented to show how the market group estimates change at different levels of the interacting variable. Owner age has a large interaction estimated with the market group variable: Figure 7 presents age group estimates for different market groups. The most marked differences are for the highest risk owner group, owners aged under 20.

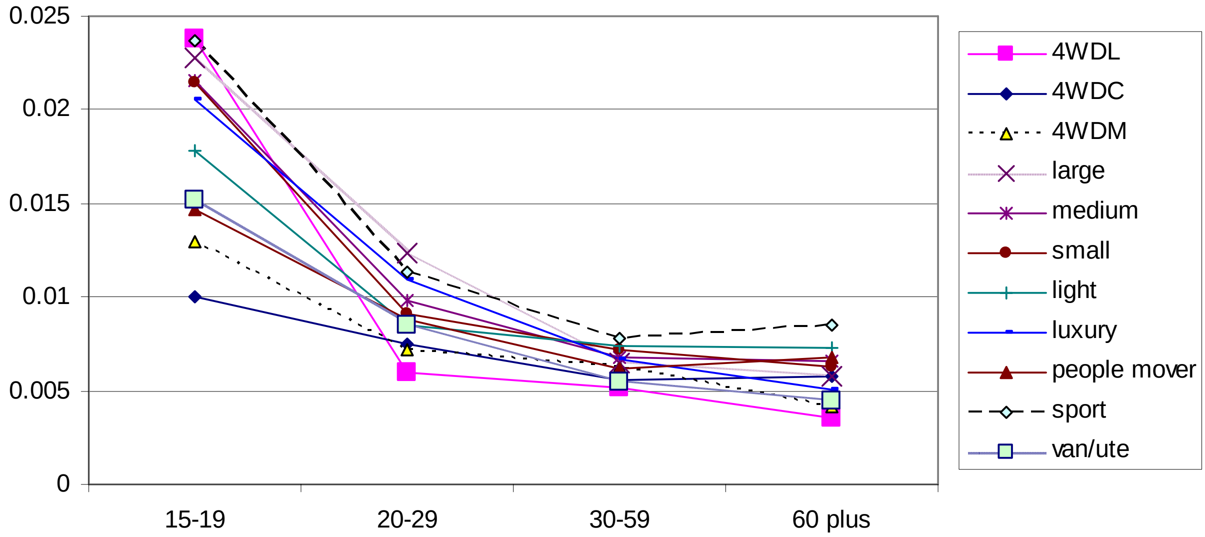

Figure 7: *Estimated probability of injury crash involvement by market group and age of owner (with owner sex=M, "other urban" owner address and km driven per year at median)*

In Figure 7, Large 4WDs are at low risk of injury crash involvement apart from those owned by teenagers, which have a very high risk. Once again, this is consistent with patterns found in an analysis of 4WD crash patterns in Australia and New Zealand for teenage drivers (Keall et al, 2006). Sports cars are the highest risk market group for most age groups. Confidence intervals are not shown to avoid a cluttered graph, but they are quite wide for vehicles within the less numerous owner groups, such as teenage owners.

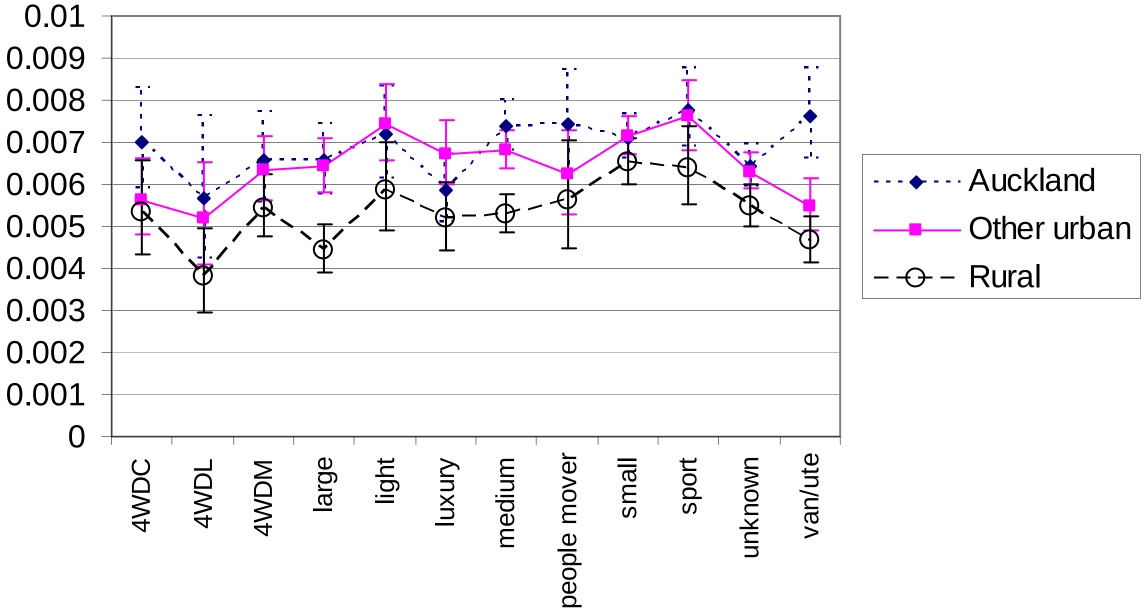

Figure 8: *Estimated probability of injury crash involvement by market group and level of urbanisation of owner's home (with owner sex=M, age=30-59 and km driven per year at median). 95% confidence intervals shown.*

Figure 8 shows how risk per market group changes according to the level of urbanisation of the owner's address. It shows that all vehicle market groups are estimated to have a lower crash risk when owned by a rural owner. This is because rural speed limit roads have lower rates of injury crash involvement (Keall and Frith, 2004), even though injuries on such roads are likely to be more severe because of higher vehicle speeds. Auckland owners generally have a higher estimated risk than other urban owners, likely to be related to the high traffic volumes on Auckland roads, leading to increased opportunities for injury crash involvement. In general, market groups that perform well or poorly when owned in a given urbanisation class perform similarly relative to the other market groups in other urbanisation classes. Large 4WDs are the lowest risk market group in each of the three urbanisation classes and Sports cars are high risk in all areas.

4.2.3. NZ estimates of rollover crash risk (Model 2)

As outlined above, rollover crashes were classified according to information in the Traffic Crash Reports if the vehicle had been recorded as having overturned or if there was significant damage identified for the top (roof) of the vehicle. As there were relatively few rollovers, a simpler model resulted from the modelling procedure, including fewer terms that were statistically significant than for the models of all crashes or multi-vehicle crashes. The risk of rollover (resulting in an injury) by market groups and level of urbanisation of the owner's address could therefore be presented in the one graph, Figure 9. Areas where vehicles drive at higher speeds, such as rural areas, can expect to have higher exposure to rollover risk than areas with higher levels of urbanisation and generally lower vehicle speeds. Figure 9 shows this theoretical higher exposure to rollover risk led to higher estimated rollover risk for most vehicle market groups apart from Large 4WDs with an Auckland owner. The large confidence interval associated with this last estimate shows that more data are needed to establish whether this effect is real or an artefact of variability in the data. Within each level of urbanisation, 4WDs have high rollover risk, as do vans and utes. The generally commercial use of vans and utes may be the explanation for the similar rollover risks estimated within each level of urbanisation. As has been mentioned above for 4WDs, vans and utes tend to have relatively high centres of gravity compared to the width of the wheel base, a combination that leads to greater instability.

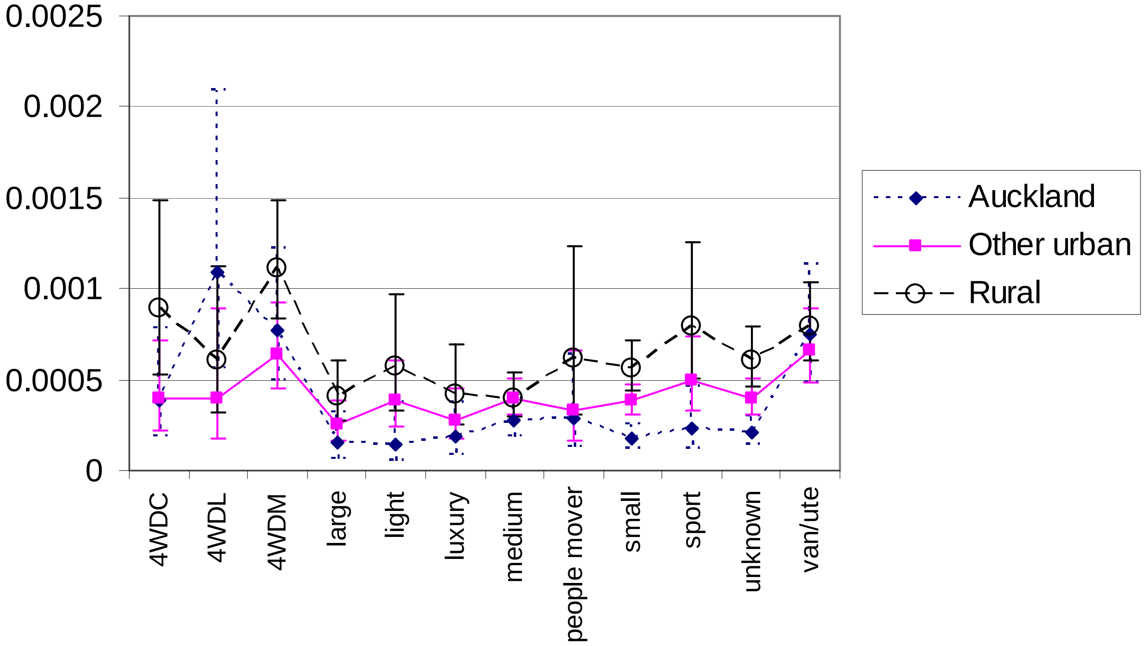

Figure 9: *Model 2: Estimated risk of rollover injury crash involvement by market group and level of urbanisation of owner's address (Auckland; other urban areas; rural areas) (with owner sex=M, age=30-59 and km driven per year and vehicle age at median). 95% confidence intervals shown. NZ data.*

4.2.4. NZ Estimates of multi-vehicle crash involvement (Model 3)

Model 3 estimated the probability of multi-vehicle crash involvement (in which the market group being considered crashes with another vehicle, and an injury occurs in either or both vehicles). Generally, the sorts of relationships estimated for Model 3 were similar to those of Model 1, so only one example of the estimates is graphed here: Figure 10, showing estimated risks of *multiple vehicle* injury crash involvement, has a similar risk pattern to Figure 8. In comparison with Figure 8, Figure 10 shows a somewhat higher multiple vehicle crash risk in Auckland, consistent with a more congested road network where vehicles frequently cross the paths of other vehicles, and a somewhat lower risk in rural areas, consistent with a less congested road network. Notable is the high risk of multi-vehicle crash involvement of Sports cars in all urbanisation areas and the relatively low risk of Large 4WDs. Compact and Medium 4WDs appear to have a multi-vehicle crash involvement risk similar to the better-performing cars. A full list of estimated parameters for Model 3 is given in Appendix 1, in Section 8 below.

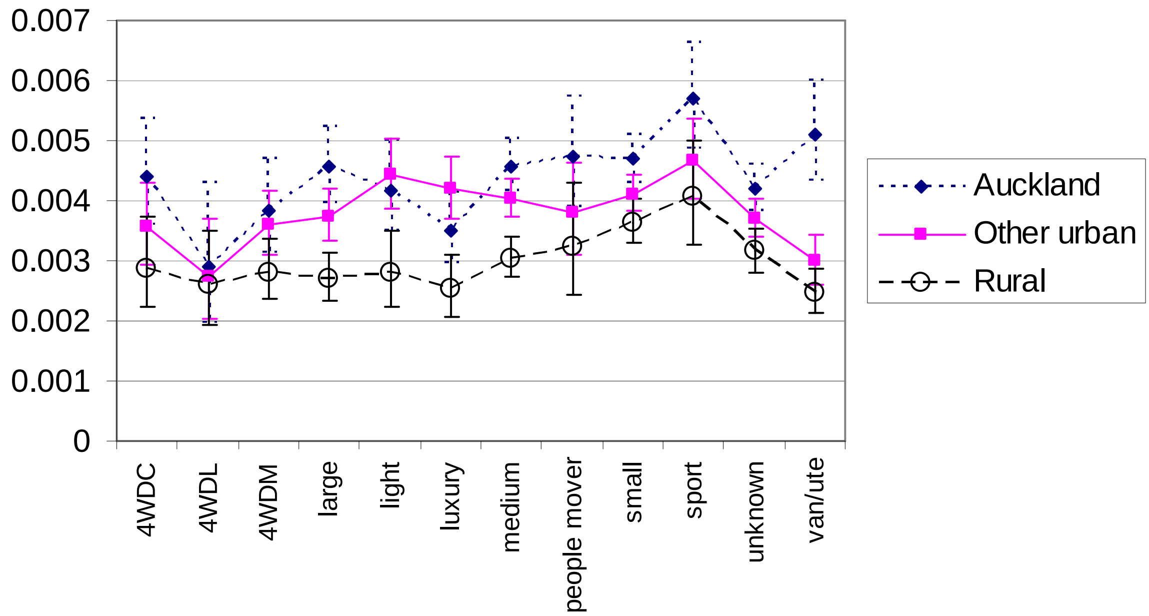

Figure 10: *Estimated probability of multiple vehicle injury crash involvement by market group and level of urbanisation of owner's home (with owner sex=M, age=30-59 and km driven per year and vehicle age at median) with 95% confidence intervals.*

4.2.5. NZ estimates of casualty rate per market group (Model 4)

This section described models estimating total numbers of casualties resulting from crashes involving the vehicle market groups and owner characteristics considered. Cyclists and pedestrians injured in collision with vehicles of the market group as well as injuries to occupants of the market group vehicle itself and to occupants of vehicles colliding with the market group vehicle are all included. The total casualty rate is affected by three components: primary safety (the ability of the vehicle to avoid a crash); secondary safety (the ability of the vehicle to protect the occupants in the event of a crash); and aggressivity (the amount of harm a vehicle does to other road users when colliding with them). A fourth component is the occupancy rate of the vehicles. Vehicles carrying larger numbers of passengers may have a higher casualty rate because more occupants are subject to the forces of the crash. This last factor is likely to increase the casualty rate of People Movers, for example.

Model 4 incorporates all statistically significant interactions in predicting the number of casualties, including any significant interactions with the market group variable. To simplify the presentation of these results, the last two models, Models 5 and 6 present estimates by market group of total primary safety averaged over the vehicle and owner characteristics that interact with the market group variable. The advantage of this approach is simplicity of presentation; the disadvantage is that the estimates are more specific to the time and place from which the data arose. Whereas the estimates from models that include the interacting variables with market group are more likely to be robust to changes in the vehicle fleet, and changes in types of vehicle owners, etc, the averaged estimates of Models 5 and 6 are more specific to NZ conditions in 2005/2006.

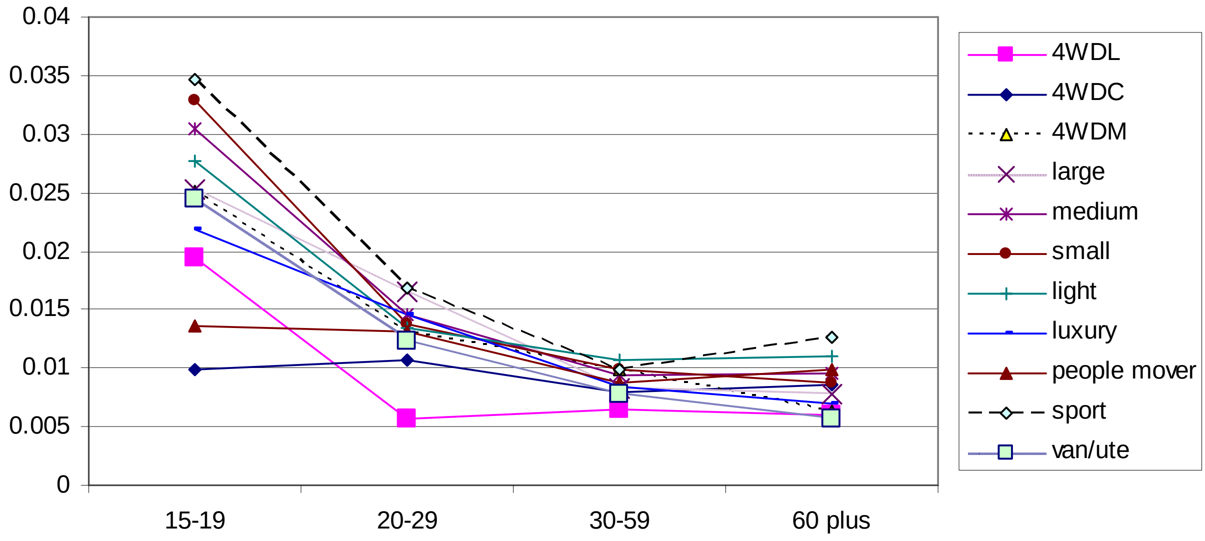

Figure 11: *Model 4: estimated number of casualties from crashes per two vehicle years by market group and age of owner (with owner sex=M, "other urban" owner address, vehicle age and km driven per year at median)*

Figure 11 shows that Sports cars have a very high casualty rate in crashes (injured occupants of Compact 4WDs, or of other vehicles or road users into which Sports cars crashed) for all age groups. Large 4WDs have a relatively high rate for teenage owners, but the lowest rate for owners in other age groups. As for the estimates of crash involvement risk of Model 1, the confidence intervals for young owners are large. The confidence intervals become tighter for estimates based on more data, particularly for the numerous 30-59-year-old owner group. For example, the lower bound for the 95% confidence interval for 30-59-year-old owners of Compact 4WDs is only just over 0.001 below the point estimate.

As Figure 12 has just three lines to present, 95% confidence intervals can be shown without too much clutter. This shows the same estimates (number of casualties resulting from crashes involving the given market group per vehicle year) for owners with Auckland, other urban and rural addresses. As discussed above, the location of the owners' address can be seen to some extent as a proxy for the sort of exposure of the vehicle: more urban for the urban-owned vehicles and more rural for the rural-owned vehicles. Figure 12 shows that Large 4WDs were estimated to have a low casualty rate in all areas. In rural areas, Sports cars were estimated to have the highest casualty rate.

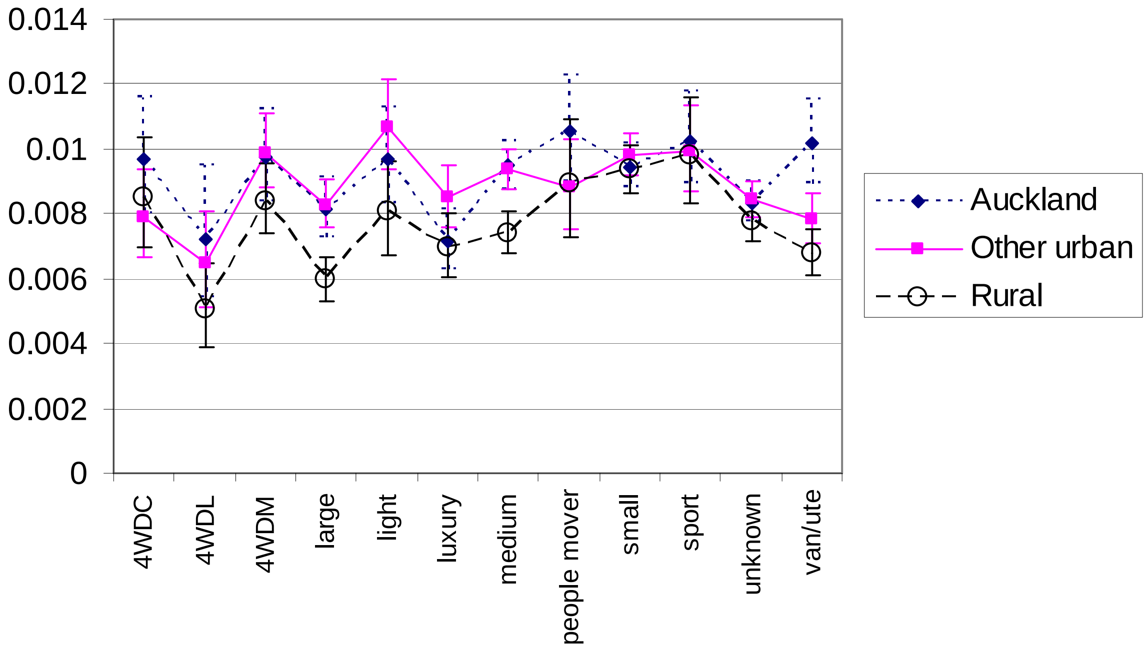

Figure 12: *Model 4: estimated number of casualties from crashes per two vehicles years by market group and level of urbanisation of residence of owner (with owner sex=M, aged 30-59, vehicle age and km driven per year at median). 95% confidence intervals shown.*

4.2.6. NZ Estimates of casualty rate averaged over variables interacting with market group (Model 5)

This section of the results presents estimated market group casualty rates averaged over the situations considered. As discussed above, such an approach has the advantage of simple presentation, where all market groups can be compared on the same graph. It has the disadvantage of not presenting insights into particular risky situations and of being less able to be generalised. For example, the way that urban and rural ownership interacts with casualty rates shown in Figure 12 is not estimated; instead, an average is presented in which the estimate for each market group is averaged over Auckland, other urban and rural ownership. As all vehicles are mainly urban-owned, the urban estimates are the ones that dominate the average estimated.

Figure 13 shows that on average Large 4WDs are clearly the safest vehicle market group in terms of the number of casualties resulting from their crashes, controlling for exposure. This reflects the low crash risk of large 4WDs together with their good crashworthiness, and despite their identified high aggressivity. The market groups Light, Small and Medium cars are relatively high risk on average due to relatively poor crashworthiness and high to average crash risk, with Sport cars being clearly the least safe market group primarily due to their extremely high crash risk. People Movers have a relatively wide confidence interval associated with a relatively high casualty rate, but their potentially high level of occupancy could be expected to increase their estimated casualty rate irrespective of their levels of primary and secondary safety.

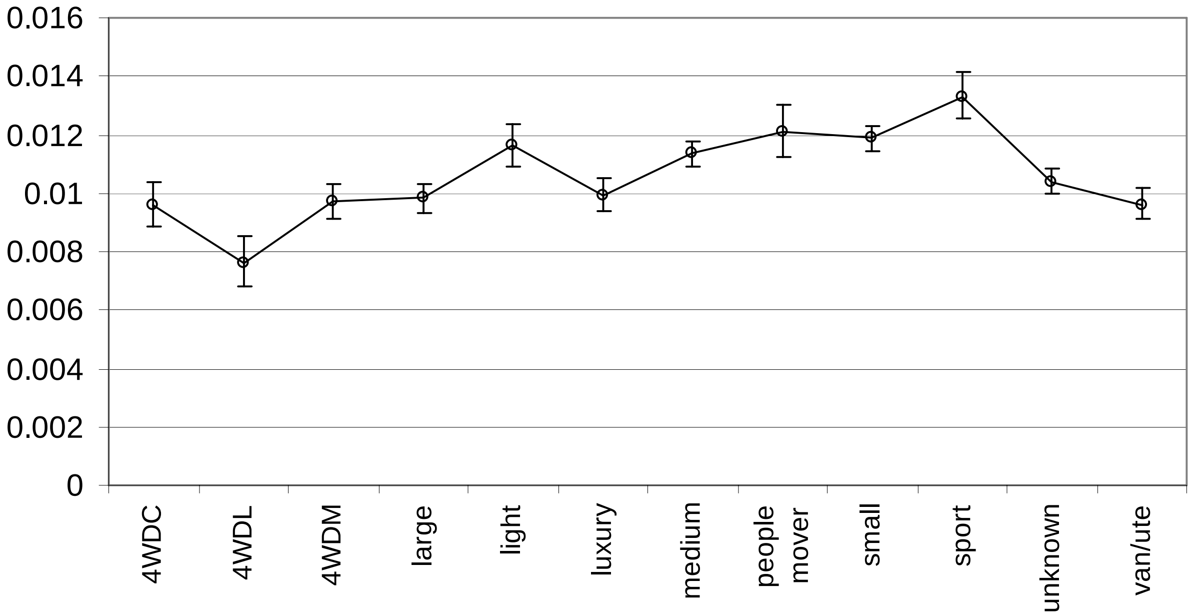

Figure 13: *Model 5: estimated number of casualties from crashes per two vehicle years by market group averaged over owner and vehicle characteristics interacting with market group (with owner sex=M, "other urban" owner address, owner aged 30-59, vehicle age and km driven per year at median). 95% confidence intervals shown.*

4.2.7. NZ Estimates of fatal and serious casualty rate averaged over variables interacting with market group (Model 6)

This section of the results presents a summary of *fatal and serious* casualty rates averaged over the situations considered for each market group. A proper assessment of safety should account for the seriousness of the injuries incurred, particularly as most minor injuries, while unpleasant, have few long-lasting effects. Here, the results of fitting a Poisson model to the counts of fatal and serious injuries resulting from crashes are presented (including counts of pedestrians or cyclists killed or seriously injured or occupants of another vehicle killed or seriously injured in collision with the particular market group considered).

Figure 14 shows estimates with quite wide confidence intervals, due to the fact that the data are now relatively scarce, as fatal and serious injuries are much less numerous than minor injuries. Nevertheless, Sports cars stand out as having a high fatal and serious injury rate. Large 4WDs have a relatively low rate estimated, but with a wide confidence interval that indicates that there is little evidence here to distinguish them from most other market groups. The low rate estimated for vans and utilities is likely to be an artefact of the lower speed limit roads that are more often travelled on by such vehicles in their work-related driving. This is an example of the limitations of this sort of modelling, that exposure by road type can be accounted in only a limited way by the owner's address.

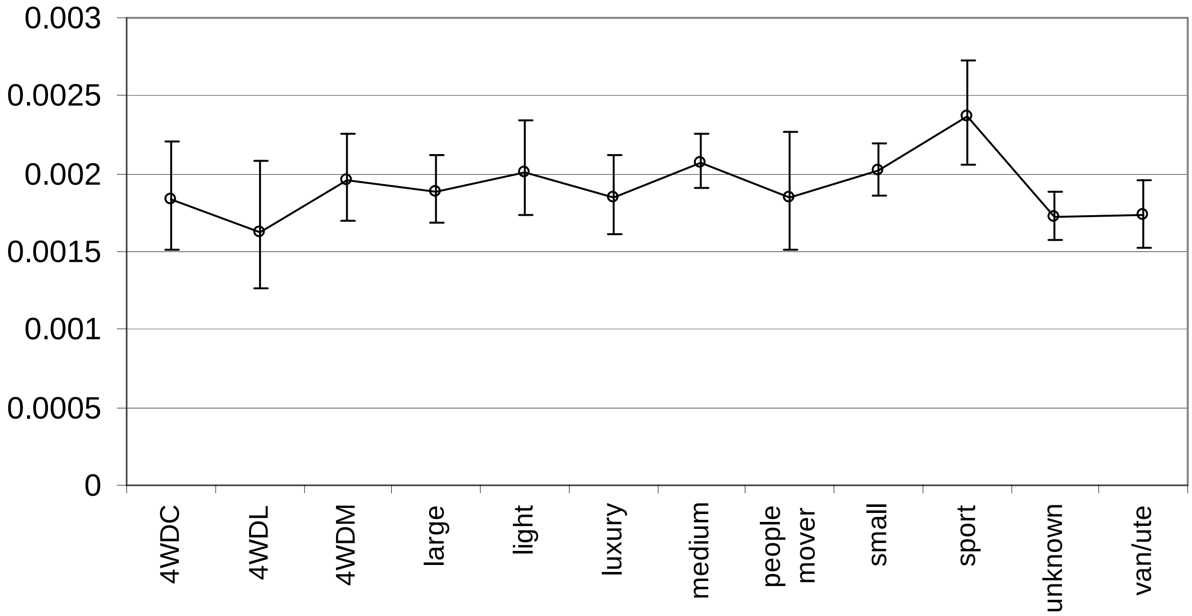

Figure 14: *Model 6: estimated number of fatal or serious casualties from crashes per two vehicle years by market group averaged over owner and vehicle characteristics interacting with market group (with owner sex=M, "other urban" owner address, owner aged 30-59, vehicle age and km driven per year at median). 95% confidence intervals shown.*

4.3. Crude crash rates (Australia and NZ)

The remainder of the Results section presents analysis from the induced exposure modelling of rollover risk, using Australian and NZ data.

Table 2 shows the numbers of crashes used in this analysis by vehicle market group. The last column shows crude risk estimates of the form represented by equation (3). These show elevated rollover risk for 4WDs, People Movers and Sports cars. These crude risk estimates do not take into account relevant driver and environmental factors. Logistic regression, described below, provides relative risk estimates adjusted for these factors.

Table 2: *1995 to 2005 crashed vehicle data by market group from VIC, QLD, WA, NZ. Number of crashed vehicles that rolled over and crashed vehicles with damage recorded in rear following a multi-vehicle crash. Australian and NZ data.*

Market group	n rollover	n rear-end damage	Rate of rollovers per rear-end
overall	**28,824**	**7,306**	**3.9**
Unknown	12,572	2,498	5.0
4WD - Compact	635	85	7.5
4WD - Large	1,564	118	13.3
4WD - Medium	565	57	9.9
Large	4,665	1,567	3.0
Luxury	802	232	3.5
Medium	1,849	582	3.2
People Mover	360	53	6.8
Small	3,412	1,257	2.7
Light	1,810	755	2.4
Sports	590	102	5.8

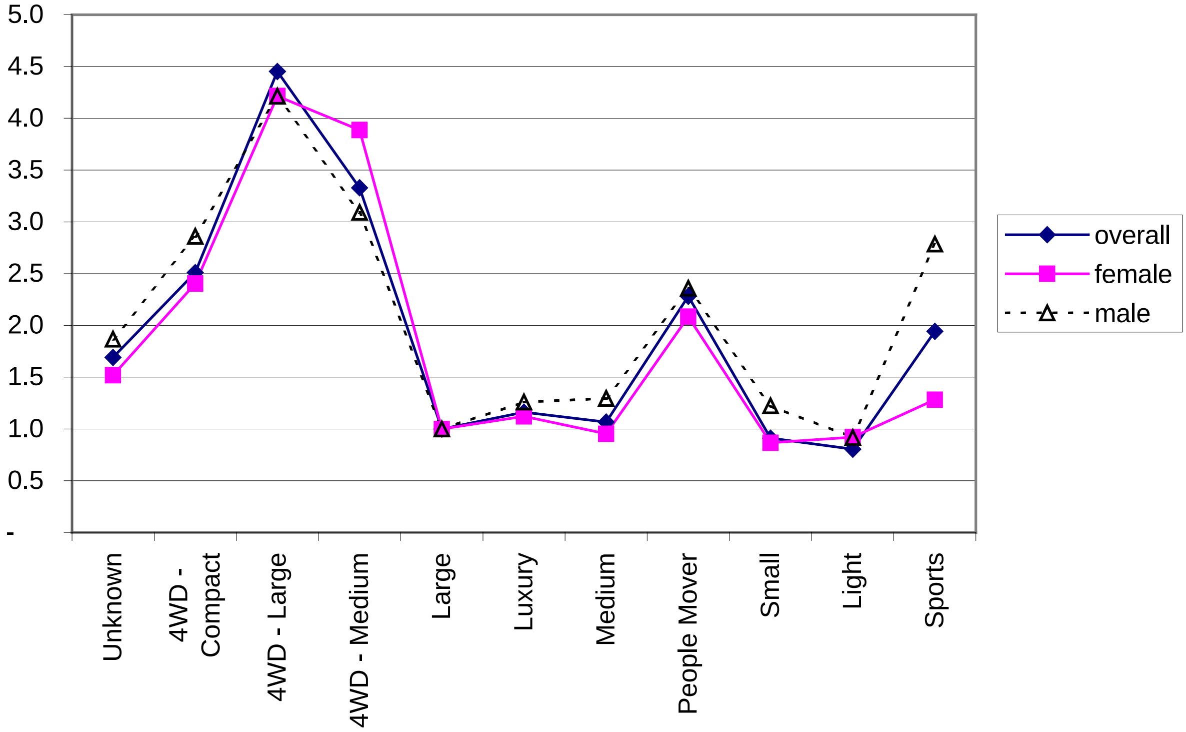

Figure 15: *Crude estimates of rollovers per rear-end overall and by sex of driver. Estimates given by each line are relative to Large cars for each group considered (set to equal 1).*

Figure 15 shows similar figures to the right-hand column of Table 2, but disaggregated by the sex of the driver. Only for the Sports cars is there a strong difference between the genders in terms of the vehicle type comparison. Male drivers are considerably more liable to rollover than female drivers in Sports cars according to these crude risk estimates.

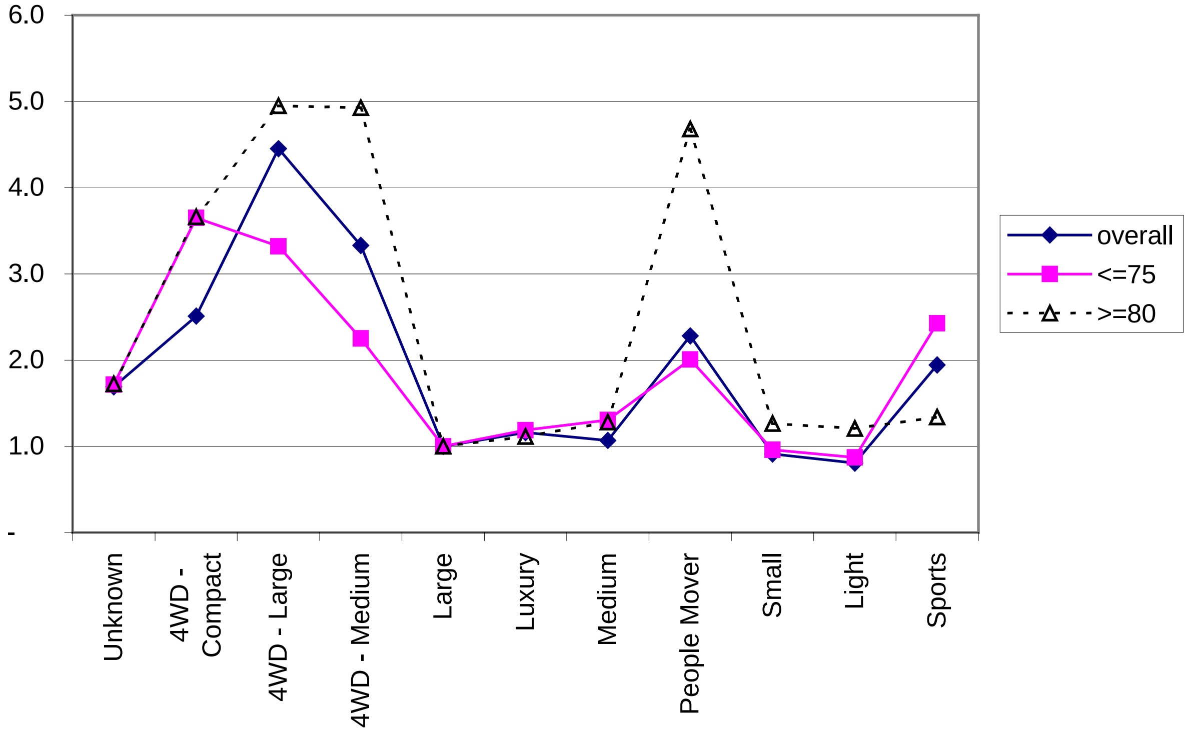

Figure 16: *Crude estimates of rollovers per rear-end overall and by speed limit area. Estimates given by each line are relative to Large cars for each group considered (set to equal 1).*

Figure 16 shows a much stronger effect of speed limit area on the rollover risk of certain vehicle types: Large and Medium 4WDs and People Movers. These vehicles may be less stable due to a higher centre of gravity compared to width of the wheel track, leading to even greater instability at higher speeds. A curious result for Sports cars shows a higher liability to rollover relative to Large cars in *lower* speed limit areas. This may reflect the way these vehicles are driven in urban speed limit areas rather than any inherent instability at low speeds.

Figure 17 shows a clear pattern of increased crude rollover risk (compared to Large cars) for older vehicles. It is possible that improvements have been made over the years in vehicle design, leading to greater stability. Note that Figure 17 shows crude rollover risk relative to Large cars, so any improvement for the market groups featured could be due to rollover risk *increasing* for Large cars with more recent year of manufacture, although this is an unlikely explanation. Crude estimates are also more liable to be confounded by other variables. For example, a higher rollover risk for older Sports cars could be estimated by crude risk estimates simply because a high proportion are driven by a driver group who are prone to rollover crashes, such as young male drivers.

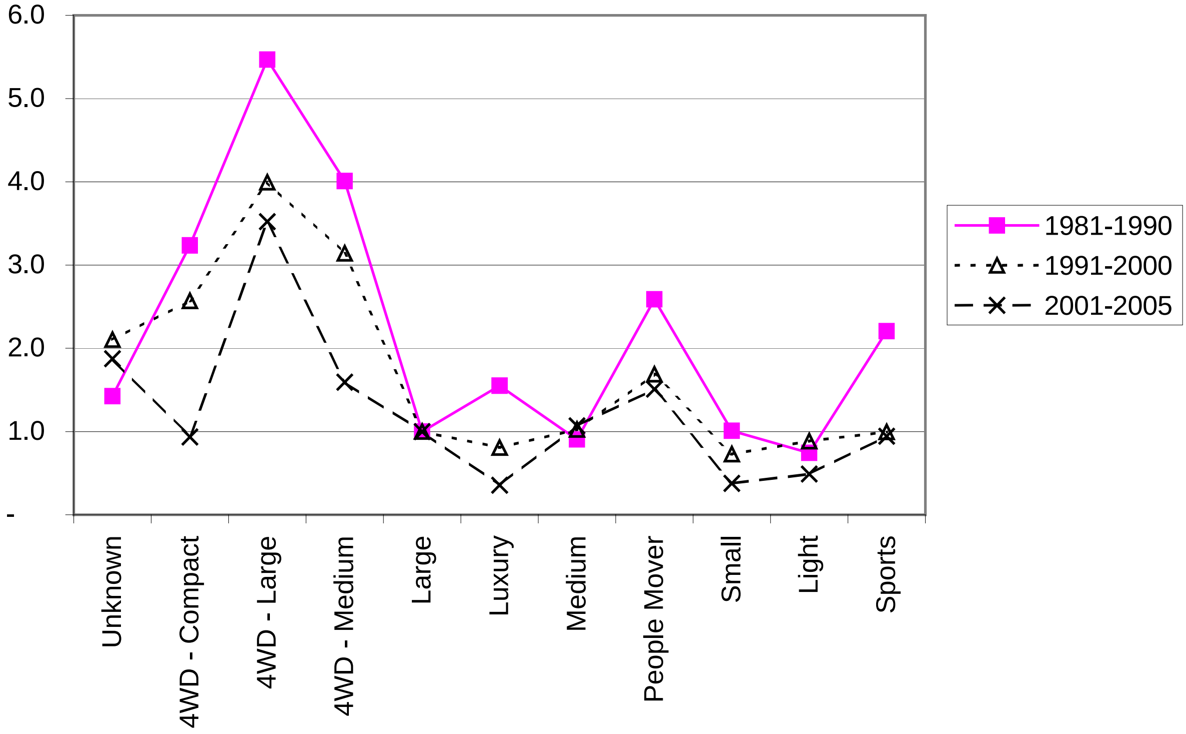

Figure 17: *Crude estimates of rollovers per rear-end overall and by vehicle year of manufacture. Estimates given by each line are relative to Large cars for each group considered (set to equal 1).*

4.4. Induced exposure model estimates (Australia and NZ): Rollover rates according to owner and vehicle factors

The remainder of the Results section presents induced exposure estimates of rollover risk from a model fitted to Australian and NZ crash data. This model estimates the effects of each variable (driver, vehicle, and speed limit variables) while controlling for the effects of the other variables.

Figure 18 shows adjusted odds ratio estimates from the model fitted to the data. These same estimates, plus the odds associated with vehicle year of manufacture, are shown in Table 3. The last row shows that there was a 2% estimated increase in rollover risk (95% CI 1% to 3%) associated with each additional manufacture year into the past. So, newer model vehicles were estimated to present lower risk of rollover, presumably reflecting improving technology with respect to vehicle stability. The second-to-last row shows that there was a non-significant decrease in risk for each additional year-of-crash. This factor was retained in the model, even though it failed to reach statistical significance, as it was a potential confounder of the year-of-manufacture term. This form of confounding can occur because vehicles with year of manufacture from 1981 to 1990, for example, were much more common on the roads in the older crash data analysed (crash data from 1994, for example), which may also represent a crash environment that was more susceptible to rollover crashes. A decrease in rollover risk can occur due to improvements in roads (improved surfacing, blackspot remediation, etc) and improvements in driver behaviour (e.g., reductions in average speeds).

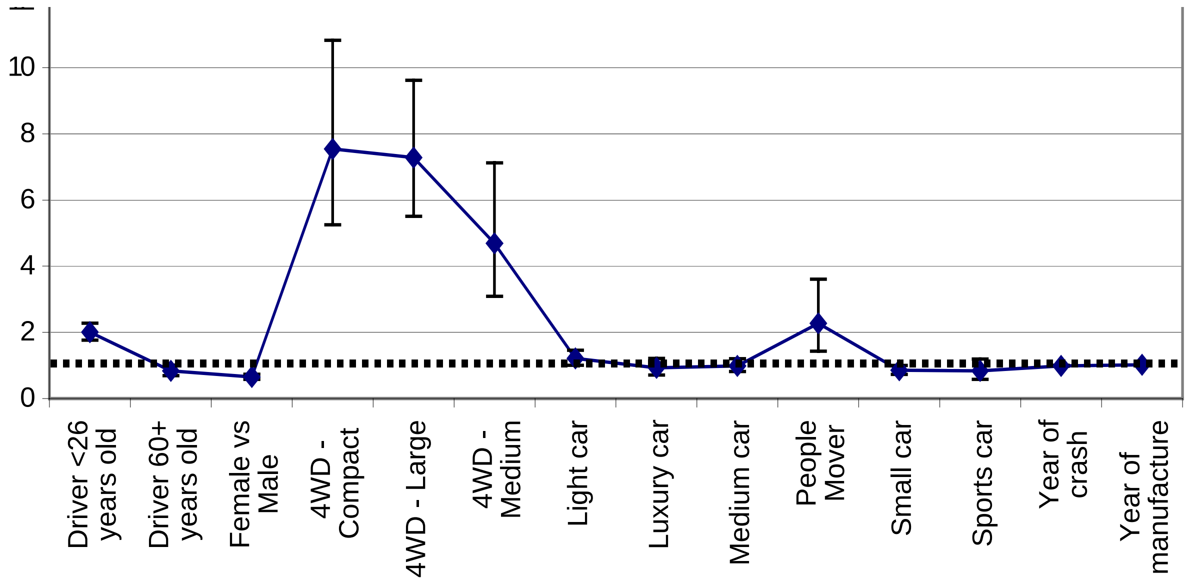

Figure 18: *Adjusted relative odds of rollover vs rear-end damage associated with the factors: driver age (compared to age 26-59), gender and passenger vehicle market group (compared to Large car), year of crash, with 95% confidence interval bars. Australian and NZ data.*

Table 3: *Adjusted relative odds of rollover vs rear-end damage associated with the factors: driver age (compared to age 26-59), gender and passenger vehicle market group (compared to Large car), year of crash, and year of manufacture (change in odds for one year older) with 95% confidence interval bars. Australian and NZ data. Estimates with confidence intervals that include 1 are not significantly different from the referent level.*

Effect vs comparison group	Point Estimate	95% Wald Confidence Limits	
AGE 25 years and under vs 26-59	2.01	1.77	2.28
AGE Greater than 60 years vs 26-59	0.84	0.69	1.02
SEX Female vs Male	0.65	0.58	0.73
4WD - Compact vs Large	7.54	5.25	10.83
4WD – Large vs Large	7.28	5.51	9.62
4WD - Medium vs Large	4.70	3.09	7.13
Light vs Large	1.21	1.01	1.46
Luxury vs Large	0.93	0.71	1.22
Medium vs Large	0.99	0.82	1.21
People Mover vs Large	2.27	1.43	3.61
Small vs Large	0.85	0.73	1.00
Sports vs Large	0.83	0.58	1.20
Year of crash (per year)	0.99	0.97	1.01
Year of manufacture (per single year older)	1.02	1.01	1.03

5. Discussion

The measures of crash risk presented here are not estimates per distance driven, although they do control for distance driven via the sorts of terms of equation (1) described in section 3.2.2 above. This is because the crash rate per vehicle was not found to increase proportionately to the distance driven per vehicle. Such non-linear associations between distance driven and risk have been found by studies such as Maycock and Lockwood (1993), in which risk increases less than proportionately to the amount of driving undertaken. Keall and Frith (2006) found that low km drivers, who are also likely to drive vehicles with low annual kms, tend to drive shorter trips in mainly urban areas, on roads where risk is highest per distance driven. Higher km drivers tend to drive more on rural speed limit roads.

The low crash risk of 4WDs overall was estimated despite their relatively high risk of rollover (as shown in Figure 9 and Figure 18). This high rollover risk was consistent with a prior study of crash patterns in Australia and New Zealand (Keall et al, 2006). That study also identified inexperienced drivers (or, more particularly, young drivers) on higher speed limit roads as having a particularly high 4WD rollover crash rate. As discussed in that paper, higher speeds lead to greater instability of vehicles, particularly those that have a high centre of gravity relative to the width of their wheel base, such as most 4WDs, vans and utilities. Using induced exposure risk estimation, Figure 9 identified rural owner address as being a significant risk factor for rollover, which is most likely related to the sorts of roads that drivers living in rural areas typically use. The induced exposure estimates represented in Figure 18 show a doubled risk of rollover for young drivers (here, defined as aged under 26). Induced exposure measures are susceptible to some biases and it is likely that young drivers' rollover risk is underestimated by the current analysis, according to Figure 2 and Figure 3.

A further important issue to note in interpreting the crash risk estimates derived from the New Zealand vehicle inspection data relates to the nature of the police reported crash data on which the estimates are based. Whilst police in New Zealand report both injury (casualty) and non-injury crashes, only the injury crash reports have sufficient detail to identify the make, model and market group of the crash involved vehicles. Because of the need to have vehicle market group identified for the analysis, the absolute crash risks estimated from the New Zealand data in this report is an estimate of the risk of a *casualty* crash per unit exposure, as discussed in Section 1.3. This is contributed to by both the primary and secondary safety of a vehicle since casualty crash risk is a product of absolute primary safety (risk of a crash of any severity per unit exposure) multiplied by the risk of a casualty being sustained given the crash has occurred. This second component is a secondary safety characteristic of the vehicle and is denoted as the injury risk component in the secondary safety crashworthiness ratings of Newstead et al (2005). Estimation of the injury risk component in the Australasian crashworthiness ratings system is only possible because of the availability of non-injury crash data sources in Australia.

Noting the crash risk estimates presented in this report are the risk of a *casualty* crash identifies an important contributor to the estimates for both Large 4WD vehicles and Sports cars. Large 4WD vehicles have the lowest injury risks of any class of vehicle in the crashworthiness ratings of Newstead et al (2005). In contrast, Sports cars have one of the highest injury risks of any market group, which would contribute to the high casualty crash risk estimated here. The differences between the market group secondary safety injury risk estimates are much smaller than the differences between the market group casualty crash risks estimated here. This suggests that the casualty crash risks estimated in this report are driven more by a combination of primary safety effects and driver behavioural effects than by secondary safety effects (the injury risk component) in the measure.

In theory, it would be possible to adjust the estimated casualty crash risks using the crashworthiness injury risk estimates to give estimates of vehicle primary safety performance unaffected by differences in secondary safety performance. Currently, secondary safety injury risk estimates only exist on a vehicle market group basis for all crash types combined (in Newstead et al, 2005) although estimates for specific crash types, such as vehicle rollover, could be produced to adjust all the estimates obtained in this study. Production of secondary safety adjustment factors for other crash types was beyond the scope of this study, hence all the estimates have been presented on a consistent, unadjusted basis.

The measures of total casualty rates provided in this study involved fitting Poisson regression models where any interactions of variables with the market group variable were excluded (Models 5 and 6). This effectively estimated an average expected injury rate for the market groups under NZ conditions in 2004/05, with the mix of driving conditions, vehicle types and drivers that existed in New Zealand at that time. This sort of analysis is important as it simplifies statements about the relative risks of the vehicle market groups considered. However, the analysis is more limited in its ability to be generalised than the analysis that considers interactions with the market group variable. These latter analyses allow for differences in risk between the market groups according to differences in other variables studied. For example, Model 1 found an interaction between vehicle owner age (which may generally be seen as a proxy for driver age) such that Large 4WDs were low risk vehicles for owners aged 20 and over, but high risk for teenage owners. This same pattern was found in Australian and NZ data for teenage drivers of 4WDs compared to drivers aged 20 plus (Keall et al, 2006). This implies that inexperience may play a greater role in the control of these larger and less stable vehicles than for the other vehicle types considered.

Currently, NZ data for primary risk estimation are only available for two years, meaning that only the most popular makes and models can be evaluated with any high degree of statistical accuracy. The confidence intervals shown in Figure 13 for Model 5 even for the least numerous market group ("4WDL", with approximately 1.8% of the fleet) are clearly small enough to justify this form of analysis. Shown in Table 4 are the most common makes and models on the New Zealand MVR, all of which have at least as many vehicles as the 4WDL market group. Primary risk estimates for these vehicles are currently viable. As more data become available, the scope of the analysis will obviously be able to be expanded.

Table 4: *NZ makes/models with at least 40,000 licensed vehicles*

MITSUBISHI GALANT
TOYOTA CAMRY
NISSAN PULSAR
HONDA CIVIC
FORD FALCON
MAZDA 323/FAMILIA
NISSAN BLUEBIRD
NISSAN PRIMERA
SUBARU LEGACY
TOYOTA COROLLA

Several qualifications are required for the interpretation of the primary risk estimates. To the authors' knowledge, these are the first estimates of primary vehicle safety produced in the literature that account for important factors such as the distance driven by the vehicles, the characteristics of the owners and, to some extent, where the vehicles are driven (proxied by the owners' address). Nevertheless, it is highly likely that these risk estimates are influenced by non-vehicle factors that cannot be measured by available data, such as the manner in which the vehicles are driven or risk-taking characteristics specific to drivers favouring particular vehicle types. To some extent this is inevitable, as the operator of any machine will change their behaviour in response to the characteristics of that machine. Even though it can be argued that the manner of driving is affected by the vehicle type and therefore validly should be included in the estimates of primary safety, the fact is that particularly Sports cars, vans and utilities, and 4WD vehicles may be driven in a different manner and may be purchased by drivers wishing to drive in this manner. Therefore, introducing policies that replace one type of vehicle with another may not necessarily reap the benefits in reduced crash risk expected from this analysis. For example, a Sports car owner who enjoys driving fast may still drive fast in a 4WD and have a correspondingly high crash risk, even though a naïve interpretation of the analysis described here predicts an improvement in crash risk. Clearly, Sports cars are presented and marketed as high-speed vehicles, which is likely to make them attractive to drivers who like driving fast. It is also likely that this manner of driving is a major factor making this market group clearly the highest crash risk passenger vehicle market group on New Zealand roads. In contrast, 4WDs have generally low to average crash risk, despite the possibility that they may be used more on relatively high-risk backcountry roads. It should be borne in mind that only crashes occurring on public roads in New Zealand were considered in the crash risk analysis, so some crashes occurring in characteristically 4WD terrain were not accounted for.

Further research, which looks at the patterns of crashes by type of crash and vehicle market group, can potentially identify whether there are differences in driving styles between market groups. Further research that evaluates induced exposure risk measures of vehicles in Australia and New Zealand could potentially address some of these issues of the influence of driving style on primary vehicle safety estimation. Questions that can be answered include: are there particular crash types that are a problem for vehicle type X; are there particular driver groups or situations associated with these crash problems and what advice can be given to the driving public to help mediate this risk? Some differences in driving style can already be derived from other data sources. For example, 4WD vehicles in New Zealand are used proportionally more on rural speed limit roads (compared to urban speed limit roads) than other passenger vehicles according to NZ travel survey estimates. Despite some methodological limitations of induced exposure estimates, they provide a very convenient means of illuminating patterns in crash data that cannot usually be achieved by other means.

It is likely that data on vehicle distance driven collected as part of annual vehicle roadworthiness inspections in New South Wales in Australia will allow similar analyses of primary risk estimation to be undertaken, as were done here for NZ data. Further research is required to evaluate the utility of these data sources to produce primary risk estimates based on matched NSW crash and motor vehicle register data. Added value could be obtained from New South Wales data by obtaining estimates of the risk of a tow-away or greater severity crashes, as non-injury crashes are reported by police in New South Wales. This is in contrast to the ratings based on New Zealand data presented here that measure casualty crash risk only, with some corresponding limitations discussed above.

Figure 9 shows estimated risk of rollover by vehicle type (and also by speed limit area), controlling for distance driven according to odometer readings from New Zealand data. Generally these estimates are consistent with the estimates shown above in Figure 18 and Table 3, derived from induced exposure risk estimates using Australian and NZ crash data. Although the induced exposure estimates of Table 3 show a much higher relative risk of rollover for the 4WD vehicles, it must be borne in mind firstly that we are looking at Australian data as well as NZ data in that analysis, and driving conditions etc may differ between countries. Secondly, the induced exposure method of estimating risk has its limitations. Note that Figure 4, above, shows that 4WD vehicles' exposure was underestimated compared to data on distance driven. This means that risk estimates are likely to be somewhat overestimated (as the induced exposure risk estimator has exposure as a denominator, as shown in equation (3)). We cannot be sure of the level of this overestimation as there are only NZ data available for making the comparison shown in Figure 4. Nevertheless, if we use adjustment factors based on the data from Figure 4, the relative rollover risks of Compact, Large and Medium 4WDs are generally consistent with the confidence intervals shown in Figure 9. Nevertheless, it is worth emphasising that the New Zealand based crash risk estimates are measuring the risk of a casualty crash whereas the Australian crash data include both injury and non-injury crashes. This could explain at least some of the differences between the absolute crash risk estimates and those derived from the induced exposure methodology.

There has recently been a very promising development in technology, called Electronic Stability Control (amongst other names). This technology, which has been available from the late 1990s, corrects for loss of steering control by applying brakes to individual wheels. A recent report suggests major benefits of this technology in terms of single vehicle crashes (of which rollover is a dominant crash outcome), with reductions in such crashes of about 67% for 4WDs and 35% for passenger cars (Dang, 2004). Clearly, 4WD vehicles have the most to benefit from this technology and prospective owners of 4WDs should consider this as a very desirable feature of any new purchase.

6. Conclusions

From models fitted to crash and Motor Vehicle Register data, estimates were made of the primary safety of NZ passenger vehicle market groups, controlling for owner characteristics (age, gender, place of residence) and vehicle characteristics (vehicle age, distance driven). The main features of these estimates can be summarised as follows:

- In the way they are currently used in New Zealand, 4WD vehicles generally have a low estimated crash risk compared to other classes of vehicles.
- Previous studies from Australia and New Zealand have estimated that 4WD vehicles provide generally good levels of occupant protection in the event of a crash (crashworthiness). However these previous studies have also established that 4WD vehicles, particularly large and medium 4WD vehicles, pose a disproportionately high risk of serious injury to other road users with which they collide (aggressivity).
- Despite their established high aggressivity, 4WD vehicles appear to impose relatively low injury risk overall to their own occupants, to other roads users and occupants of other vehicles per year of exposure on the road and adjusted for distance driven. This is a result of their estimated low crash involvement risk related to the way these vehicles are currently used, combined with good crashworthiness, offsetting the effects of high aggressivity.
- By far the least safe market group analysed in terms of crash risk was Sports cars. These vehicles consistently had a high risk compared to other market groups under the same circumstances modelled. For rural owners, these vehicles were particularly risky.
- Most vehicles with high annual kilometres driven were not found to have proportionately higher crash risk than low annual kilometre vehicles. This has been found in other studies, and is related – at least in part – to the sorts of driving and roads travelled on by drivers who drive large distances.

The original intent of the current study was to estimate risk associated primarily with vehicle design and handling. However, comparing the resultant risk estimates for 4WD vehicles to those for Sports cars in particular suggests the estimated risks are predominantly affected by driver behavioural factors that could not be measured in the available data rather than factors associated with vehicle design and handling. Whether these driver behavioural factors reflect behavioural adaptation to the type of vehicle being driven or are related to the type of driver buying a particular type of vehicle and the way that vehicle is used could only be determined through further research. Consequently, the relatively low crash risk estimated for 4WD vehicles in this study may not be observed if a different cohort of drivers were substituted for those currently using these vehicles.

Rollover crash risk was also estimated from Australian and NZ data using induced exposure risk estimation, controlling for driver and exposure factors. The main features of the analysis of rollover risk can be summarised as follows:

- Despite their low crash risk overall, the risk of rollover was found to be high for 4WD vehicles. Furthermore, previous studies have shown that 4WD vehicles have a higher relative fatality risk in rollover crashes than other classes of vehicle. The only other market group considered with a consistently high rollover risk was Vans and Utilities. This was consistent with results from previous studies that have also shown higher rollover risk for those vehicles (4WDs and People Movers) with a relatively high centre of gravity compared to the width of the wheel track.

- Analysis of primary risk estimates for rollover crash involvement from NZ data identified rural owner address as being a significant risk factor for vehicle rollover, which is most likely related to the sorts of roads that non-urban drivers typically use.
- As found in a previous study of Australian and NZ crash data, a situation of particularly high risk of rollover was found when teenagers either drove or owned 4WD vehicles. This may be related to the fact that 4WD vehicles are more unstable and more difficult to control than cars and thus present greater risk for inexperienced drivers.
- Higher rollover risk was found for older vehicles: a vehicle manufactured a year before another vehicle was estimated to have a 2% higher relative rollover risk, all other things being equal (vehicle market group, driver age and gender, speed limit area, jurisdiction, year of crash).
- Female drivers were found to have a 35% lower relative rollover risk than male drivers (with 95% confidence interval 42% to 27%).

These results suggest that parents who are 4WD owners – and, to a lesser extent, owners of People Movers – need to be wary of allowing their novice family members to use such vehicles keeping in mind that cars present significantly less rollover risk for young drivers. The high 4WD rollover risk in general reinforces the importance of electronic stability technology as a highly desirable risk-reducing feature for these relatively unstable vehicles that are prone to rollover crashes.

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8. Appendix 1: output from primary risk models

8.1. Model 1: Logistic model of crash involvement risk per vehicle year

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Parameter			DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept			1	-5.6917	0.1184	2309.2398	<.0001
OWNER_GENDER	FEMALE		1	0.0465	0.0171	7.3636	0.0067
agegrp	15-19		1	1.9811	0.3316	35.7026	<.0001
agegrp	20-29		1	1.0261	0.1600	41.1038	<.0001
agegrp	30-59		1	0.2016	0.1236	2.6608	0.1029
marketgroup	4WDC		1	0.4169	0.1663	6.2827	0.0122
marketgroup	4WDL		1	-0.3999	0.2864	1.9490	0.1627
marketgroup	4WDM		1	-0.0696	0.1714	0.1650	0.6846
marketgroup	large		1	0.0706	0.1386	0.2595	0.6105
marketgroup	light		1	0.4841	0.1413	11.7339	0.0006
marketgroup	lux		1	0.0457	0.1458	0.0982	0.7539
marketgroup	medium		1	0.3025	0.1190	6.4644	0.0110
marketgroup	pm		1	0.4936	0.2088	5.5910	0.0181
marketgroup	small		1	0.4644	0.1136	16.7081	<.0001
marketgroup	sport		1	0.7363	0.1694	18.8825	<.0001
marketgroup	unknown		1	0.2093	0.1210	2.9919	0.0837
townclass	0		1	0.4680	0.1042	20.1630	<.0001
townclass	1		1	0.1602	0.0892	3.2261	0.0725
veh_age			1	0.0162	0.00436	13.7997	0.0002
kmy1			1	1.1204	0.2974	14.1913	0.0002
kmy2			1	6.1285	1.3381	20.9772	<.0001
agegrp*marketgroup	15-19	4WDC	1	-0.7847	0.7716	1.0341	0.3092
agegrp*marketgroup	15-19	4WDL	1	0.6793	1.0791	0.3963	0.5290
agegrp*marketgroup	15-19	4WDM	1	-0.1203	0.5892	0.0417	0.8382
agegrp*marketgroup	15-19	large	1	0.1034	0.3431	0.0909	0.7631
agegrp*marketgroup	15-19	light	1	-0.4411	0.3439	1.6451	0.1996
agegrp*marketgroup	15-19	lux	1	0.1186	0.3517	0.1137	0.7359
agegrp*marketgroup	15-19	medium	1	-0.0802	0.2995	0.0718	0.7887
agegrp*marketgroup	15-19	pm	1	-0.5224	1.0583	0.2437	0.6216
agegrp*marketgroup	15-19	small	1	-0.0923	0.2876	0.1030	0.7483
agegrp*marketgroup	15-19	sport	1	-0.2842	0.3282	0.7498	0.3865
agegrp*marketgroup	15-19	unknown	1	0.0610	0.3069	0.0395	0.8424
agegrp*marketgroup	20-29	4WDC	1	-0.4555	0.2244	4.1185	0.0424
agegrp*marketgroup	20-29	4WDL	1	-0.1430	0.4377	0.1067	0.7440
agegrp*marketgroup	20-29	4WDM	1	-0.1184	0.2246	0.2777	0.5982
agegrp*marketgroup	20-29	large	1	0.0844	0.1677	0.2534	0.6147
agegrp*marketgroup	20-29	light	1	-0.6056	0.1781	11.5572	0.0007
agegrp*marketgroup	20-29	lux	1	0.0774	0.1776	0.1899	0.6630
agegrp*marketgroup	20-29	medium	1	-0.2749	0.1458	3.5554	0.0594
agegrp*marketgroup	20-29	pm	1	-0.4276	0.2850	2.2513	0.1335
agegrp*marketgroup	20-29	small	1	-0.3438	0.1404	5.9924	0.0144
agegrp*marketgroup	20-29	sport	1	-0.4444	0.1867	5.6681	0.0173
agegrp*marketgroup	20-29	unknown	1	-0.1458	0.1487	0.9609	0.3270
agegrp*marketgroup	30-59	4WDC	1	-0.2805	0.1618	3.0035	0.0831
agegrp*marketgroup	30-59	4WDL	1	0.1814	0.2822	0.4130	0.5204
agegrp*marketgroup	30-59	4WDM	1	0.2126	0.1707	1.5518	0.2129
agegrp*marketgroup	30-59	large	1	-0.1039	0.1356	0.5865	0.4438
agegrp*marketgroup	30-59	light	1	-0.2536	0.1325	3.6641	0.0556
agegrp*marketgroup	30-59	lux	1	0.0500	0.1404	0.1271	0.7215

Parameter			DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
agegrp*marketgroup	30-59	medium	1	-0.1856	0.1172	2.5049	0.1135
agegrp*marketgroup	30-59	pm	1	-0.3183	0.1972	2.6049	0.1065
agegrp*marketgroup	30-59	small	1	-0.1335	0.1124	1.4123	0.2347
agegrp*marketgroup	30-59	sport	1	-0.3197	0.1639	3.8080	0.0510
agegrp*marketgroup	30-59	unknown	1	-0.0662	0.1187	0.3108	0.5772
agegrp*townclass	15-19	0	1	-0.3539	0.1328	7.1020	0.0077
agegrp*townclass	15-19	1	1	-0.2944	0.1056	7.7694	0.0053
agegrp*townclass	20-29	0	1	-0.1372	0.0787	3.0380	0.0813
agegrp*townclass	20-29	1	1	-0.1906	0.0696	7.5077	0.0061
agegrp*townclass	30-59	0	1	0.0180	0.0657	0.0752	0.7840
agegrp*townclass	30-59	1	1	-0.0124	0.0562	0.0487	0.8254
marketgrou*townclass	4WDC	0	1	-0.2097	0.1550	1.8313	0.1760
marketgrou*townclass	4WDC	1	1	-0.1140	0.1451	0.6173	0.4321
marketgrou*townclass	4WDL	0	1	-0.0742	0.2126	0.1217	0.7272
marketgrou*townclass	4WDL	1	1	0.1677	0.1870	0.8041	0.3699
marketgrou*townclass	4WDM	0	1	-0.3013	0.1364	4.8807	0.0272
marketgrou*townclass	4WDM	1	1	0.0105	0.1169	0.0080	0.9286
marketgrou*townclass	large	0	1	-0.0912	0.1176	0.6011	0.4382
marketgrou*townclass	large	1	1	0.2006	0.1030	3.7962	0.0514
marketgrou*townclass	light	0	1	-0.2974	0.1382	4.6330	0.0314
marketgrou*townclass	light	1	1	0.0803	0.1213	0.4378	0.5082
marketgrou*townclass	lux	0	1	-0.3511	0.1300	7.2915	0.0069
marketgrou*townclass	lux	1	1	0.1130	0.1160	0.9481	0.3302
marketgrou*townclass	medium	0	1	-0.1532	0.1027	2.2279	0.1355
marketgrou*townclass	medium	1	1	0.1158	0.0898	1.6620	0.1973
marketgrou*townclass	pm	0	1	-0.1968	0.1620	1.4751	0.2245
marketgrou*townclass	pm	1	1	-0.0425	0.1560	0.0742	0.7854
marketgrou*townclass	small	0	1	-0.4014	0.0989	16.4891	<.0001
marketgrou*townclass	small	1	1	-0.0625	0.0862	0.5251	0.4687
marketgrou*townclass	sport	0	1	-0.3993	0.1331	9.0072	0.0027
marketgrou*townclass	sport	1	1	-0.0371	0.1209	0.0940	0.7591
marketgrou*townclass	unknown	0	1	-0.3021	0.1032	8.5660	0.0034
marketgrou*townclass	unknown	1	1	0.0137	0.0919	0.0223	0.8814
kmy1*agegrp	15-19		1	-2.1893	0.4730	21.4223	<.0001
kmy1*agegrp	20-29		1	-2.0753	0.2791	55.2738	<.0001
kmy1*agegrp	30-59		1	-0.6783	0.2310	8.6238	0.0033
kmy2*agegrp	15-19		1	1.7833	1.5081	1.3982	0.2370
kmy2*agegrp	20-29		1	1.5865	0.6547	5.8720	0.0154
kmy2*agegrp	30-59		1	0.6611	0.5388	1.5055	0.2198
veh_age*kmy1			1	0.1093	0.0170	41.0750	<.0001
veh_age*kmy2			1	-0.2346	0.0486	23.3170	<.0001
veh_age*agegrp	15-19		1	-0.0354	0.0115	9.5133	0.0020
veh_age*agegrp	20-29		1	-0.0143	0.00637	5.0111	0.0252
veh_age*agegrp	30-59		1	0.000199	0.00491	0.0016	0.9677
kmy1*kmy2			1	-7.2719	1.6007	20.6383	<.0001

8.2. Model 2: Logistic model of rollover crash involvement risk per vehicle year

Analysis of Maximum Likelihood Estimates

Parameter			DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept			1	-8.8057	0.2413	1331.4017	<.0001
OWNER_GENDER	FEMALE		1	-0.3684	0.2329	2.5009	0.1138
agegrp	15-19		1	1.9406	0.2037	90.7649	<.0001
agegrp	20-29		1	1.3668	0.1429	91.4942	<.0001
agegrp	30-59		1	0.5107	0.1278	15.9644	<.0001
OWNER_GENDER*agegrp	FEMALE	15-19	1	0.4666	0.3610	1.6711	0.1961
OWNER_GENDER*agegrp	FEMALE	20-29	1	-0.1164	0.2727	0.1821	0.6696
OWNER_GENDER*agegrp	FEMALE	30-59	1	0.3439	0.2463	1.9487	0.1627
marketgroup	4WDC		1	0.7730	0.3226	5.7396	0.0166
marketgroup	4WDL		1	0.3681	0.3709	0.9852	0.3209
marketgroup	4WDM		1	0.9925	0.2402	17.0779	<.0001
marketgroup	light		1	0.3271	0.3310	0.9764	0.3231
marketgroup	lux		1	0.0126	0.3225	0.0015	0.9689
marketgroup	medium		1	-0.0341	0.2414	0.0199	0.8878
marketgroup	pm		1	0.3893	0.4029	0.9333	0.3340
marketgroup	small		1	0.3125	0.2240	1.9454	0.1631
marketgroup	sport		1	0.6506	0.2969	4.8037	0.0284
marketgroup	unknown		1	0.3838	0.2317	2.7435	0.0976
marketgroup	vanute		1	0.6602	0.2341	7.9562	0.0048
townclass	0		1	-1.0088	0.4243	5.6536	0.0174
townclass	1		1	-0.5088	0.2911	3.0557	0.0805
marketgrou*townclass	4WDC	0	1	0.1744	0.6098	0.0818	0.7749
marketgrou*townclass	4WDC	1	1	-0.3178	0.4924	0.4166	0.5186
marketgrou*townclass	4WDL	0	1	1.6085	0.6257	6.6087	0.0101
marketgrou*townclass	4WDL	1	1	0.1059	0.5929	0.0319	0.8583
marketgrou*townclass	4WDM	0	1	0.6412	0.5031	1.6243	0.2025
marketgrou*townclass	4WDM	1	1	-0.0419	0.3722	0.0127	0.9104
marketgrou*townclass	light	0	1	-0.3966	0.7083	0.3135	0.5755
marketgrou*townclass	light	1	1	0.1113	0.4542	0.0600	0.8064
marketgrou*townclass	lux	0	1	0.2026	0.6098	0.1104	0.7396
marketgrou*townclass	lux	1	1	0.1074	0.4586	0.0549	0.8148
marketgrou*townclass	medium	0	1	0.6215	0.4851	1.6414	0.2001
marketgrou*townclass	medium	1	1	0.5049	0.3446	2.1468	0.1429
marketgrou*townclass	pm	0	1	0.2619	0.6869	0.1454	0.7030
marketgrou*townclass	pm	1	1	-0.1050	0.5787	0.0330	0.8560
marketgrou*townclass	small	0	1	-0.1607	0.4775	0.1132	0.7365
marketgrou*townclass	small	1	1	0.1082	0.3271	0.1095	0.7407
marketgrou*townclass	sport	0	1	-0.2100	0.5843	0.1292	0.7192
marketgrou*townclass	sport	1	1	0.0518	0.4163	0.0155	0.9009
marketgrou*townclass	unknown	0	1	-0.0732	0.4832	0.0230	0.8795
marketgrou*townclass	unknown	1	1	0.0890	0.3404	0.0684	0.7937
marketgrou*townclass	vanute	0	1	0.9385	0.4930	3.6235	0.0570
marketgrou*townclass	vanute	1	1	0.3092	0.3522	0.7710	0.3799
veh_age			1	0.0254	0.00709	12.8105	0.0003
X			1	1.8047	0.2990	36.4217	<.0001

8.3. Model 3: Logistic model of multi-vehicle crash involvement risk per vehicle year

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Parameter			DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept			1	-5.8347	0.1085	2890.0459	<.0001
OWNER_GENDER	FEMALE		1	0.0603	0.0220	7.5000	0.0062
agegrp	15-19		1	1.7993	0.2536	50.3557	<.0001
agegrp	20-29		1	0.6221	0.1260	24.3691	<.0001
agegrp	30-59		1	-0.0446	0.0891	0.2507	0.6166
marketgroup	4WDC		1	0.0594	0.1483	0.1605	0.6887
marketgroup	4WDL		1	-0.0614	0.1662	0.1365	0.7118
marketgroup	4WDM		1	0.0254	0.1141	0.0494	0.8242
marketgroup	light		1	0.0265	0.1349	0.0386	0.8442
marketgroup	lux		1	-0.0633	0.1240	0.2609	0.6095
marketgroup	medium		1	0.1032	0.0899	1.3185	0.2509
marketgroup	pm		1	0.1582	0.1632	0.9395	0.3324
marketgroup	small		1	0.2960	0.0857	11.9185	0.0006
marketgroup	sport		1	0.3838	0.1290	8.8578	0.0029
marketgroup	unknown		1	0.1330	0.0913	2.1242	0.1450
marketgroup	vanute		1	-0.0866	0.1032	0.7047	0.4012
townclass	0		1	0.3001	0.1352	4.9260	0.0265
townclass	1		1	0.1004	0.1210	0.6883	0.4067
agegrp*townclass	15-19	0	1	-0.1902	0.1712	1.2341	0.2666
agegrp*townclass	15-19	1	1	-0.2949	0.1439	4.2019	0.0404
agegrp*townclass	20-29	0	1	-0.0142	0.1004	0.0200	0.8874
agegrp*townclass	20-29	1	1	-0.1349	0.0906	2.2148	0.1367
agegrp*townclass	30-59	0	1	0.1295	0.0812	2.5455	0.1106
agegrp*townclass	30-59	1	1	0.0218	0.0701	0.0967	0.7559
marketgrou*townclass	4WDC	0	1	-0.0839	0.1918	0.1916	0.6616
marketgrou*townclass	4WDC	1	1	-0.1110	0.1854	0.3585	0.5493
marketgrou*townclass	4WDL	0	1	-0.3918	0.2693	2.1163	0.1457
marketgrou*townclass	4WDL	1	1	-0.2430	0.2341	1.0773	0.2993
marketgrou*townclass	4WDM	0	1	-0.2058	0.1688	1.4862	0.2228
marketgrou*townclass	4WDM	1	1	-0.0535	0.1491	0.1289	0.7196
marketgrou*townclass	light	0	1	-0.1185	0.1755	0.4560	0.4995
marketgrou*townclass	light	1	1	0.1523	0.1592	0.9146	0.3389
marketgrou*townclass	lux	0	1	-0.1982	0.1635	1.4698	0.2254
marketgrou*townclass	lux	1	1	0.1848	0.1503	1.5135	0.2186
marketgrou*townclass	medium	0	1	-0.1013	0.1227	0.6821	0.4089
marketgrou*townclass	medium	1	1	-0.0114	0.1127	0.0103	0.9192
marketgrou*townclass	pm	0	1	-0.1171	0.2027	0.3340	0.5633
marketgrou*townclass	pm	1	1	-0.1329	0.2004	0.4402	0.5070
marketgrou*townclass	small	0	1	-0.2607	0.1165	5.0070	0.0252
marketgrou*townclass	small	1	1	-0.1999	0.1077	3.4450	0.0634
marketgrou*townclass	sport	0	1	-0.1736	0.1649	1.1086	0.2924
marketgrou*townclass	sport	1	1	-0.1405	0.1577	0.7939	0.3729
marketgrou*townclass	unknown	0	1	-0.2001	0.1221	2.6846	0.1013
marketgrou*townclass	unknown	1	1	-0.1230	0.1147	1.1486	0.2838
marketgrou*townclass	vanute	0	1	0.2003	0.1496	1.7941	0.1804
marketgrou*townclass	vanute	1	1	-0.1334	0.1372	0.9455	0.3309
veh_age			1	0.00225	0.00651	0.1191	0.7300
veh_age*agegrp	15-19		1	-0.0375	0.0151	6.1804	0.0129
veh_age*agegrp	20-29		1	-0.0153	0.00811	3.5728	0.0587
veh_age*agegrp	30-59		1	0.00210	0.00594	0.1246	0.7241
veh_age*townclass	0		1	0.00679	0.00652	1.0846	0.2977
veh_age*townclass	1		1	0.0150	0.00575	6.8164	0.0090
kmy1			1	-0.4951	0.0825	35.9745	<.0001
veh_age*kmy1			1	0.0341	0.00740	21.2577	<.0001
veh_age*kmy2			1	-0.1388	0.0487	8.1411	0.0043
kmy2			1	4.0357	0.5408	55.6967	<.0001

8.4. Model 4: Total safety: Poisson model of number of injuries per vehicle year

The GENMOD Procedure

Algorithm converged.

Analysis Of Parameter Estimates

Parameter			DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square
Intercept			1	-5.2311	0.1154	-5.4573	-5.0048	2053.86
OWNER_GENDER	FEMALE		1	0.0541	0.0807	-0.1040	0.2122	0.45
agegrp	15-19		1	1.7726	0.2219	1.3377	2.2075	63.81
agegrp	20-29		1	0.9280	0.1174	0.6980	1.1581	62.50
agegrp	30-59		1	0.3265	0.0930	0.1442	0.5089	12.32
OWNER_GENDER*agegrp	FEMALE	15-19	1	-0.1087	0.0834	-0.2722	0.0547	1.70
OWNER_GENDER*agegrp	FEMALE	20-29	1	-0.0513	0.0507	-0.1506	0.0480	1.02
OWNER_GENDER*agegrp	FEMALE	30-59	1	0.0558	0.0430	-0.0284	0.1401	1.69
marketgroup	4WDC		1	0.4005	0.1859	0.0361	0.7648	4.64
marketgroup	4WDL		1	-0.3385	0.2881	-0.9031	0.2261	1.38
marketgroup	4WDM		1	-0.1000	0.1890	-0.4704	0.2704	0.28
marketgroup	large		1	-0.0237	0.1459	-0.3096	0.2623	0.03
marketgroup	light		1	0.5935	0.1585	0.2829	0.9040	14.03
marketgroup	lux		1	-0.0362	0.1594	-0.3486	0.2762	0.05
marketgroup	medium		1	0.3429	0.1331	0.0820	0.6037	6.64
marketgroup	pm		1	0.6230	0.2360	0.1604	1.0856	6.97
marketgroup	small		1	0.5439	0.1261	0.2968	0.7911	18.61
marketgroup	sport		1	0.8405	0.1978	0.4529	1.2280	18.06
marketgroup	unknown		1	0.3725	0.1338	0.1103	0.6347	7.75

Analysis Of Parameter Estimates

Parameter			Pr > ChiSq
Intercept			<.0001
OWNER_GENDER	FEMALE		0.5025
agegrp	15-19		<.0001
agegrp	20-29		<.0001
agegrp	30-59		0.0004
OWNER_GENDER*agegrp	FEMALE	15-19	0.1922
OWNER_GENDER*agegrp	FEMALE	20-29	0.3115
OWNER_GENDER*agegrp	FEMALE	30-59	0.1937
marketgroup	4WDC		0.0312
marketgroup	4WDL		0.2399
marketgroup	4WDM		0.5968
marketgroup	large		0.8712
marketgroup	light		0.0002
marketgroup	lux		0.8203
marketgroup	medium		0.0100
marketgroup	pm		0.0083
marketgroup	small		<.0001
marketgroup	sport		<.0001
marketgroup	unknown		0.0054

The GENMOD Procedure

Analysis Of Parameter Estimates

Parameter			DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square
OWNER_GEN*marketgrou	FEMALE	4WDC	1	-0.1940	0.1085	-0.4067	0.0186	3.20
OWNER_GEN*marketgrou	FEMALE	4WDL	1	0.0619	0.1693	-0.2699	0.3938	0.13
OWNER_GEN*marketgrou	FEMALE	4WDM	1	-0.2303	0.1034	-0.4330	-0.0276	4.96
OWNER_GEN*marketgrou	FEMALE	large	1	0.0263	0.0867	-0.1435	0.1962	0.09
OWNER_GEN*marketgrou	FEMALE	light	1	-0.2283	0.0932	-0.4110	-0.0456	6.00
OWNER_GEN*marketgrou	FEMALE	lux	1	0.0371	0.0917	-0.1426	0.2167	0.16
OWNER_GEN*marketgrou	FEMALE	medium	1	-0.0965	0.0760	-0.2455	0.0525	1.61
OWNER_GEN*marketgrou	FEMALE	pm	1	-0.0875	0.1084	-0.2999	0.1250	0.65
OWNER_GEN*marketgrou	FEMALE	small	1	-0.1151	0.0739	-0.2599	0.0297	2.43
OWNER_GEN*marketgrou	FEMALE	sport	1	-0.0919	0.0920	-0.2722	0.0884	1.00
OWNER_GEN*marketgrou	FEMALE	unknown	1	-0.0211	0.0764	-0.1709	0.1287	0.08
agegrp*marketgroup	15-19	4WDC	1	-1.3414	0.7476	-2.8066	0.1239	3.22
agegrp*marketgroup	15-19	4WDL	1	-0.3015	1.0430	-2.3457	1.7426	0.08
agegrp*marketgroup	15-19	4WDM	1	-0.1021	0.4299	-0.9446	0.7404	0.06
agegrp*marketgroup	15-19	large	1	-0.2946	0.2806	-0.8446	0.2553	1.10
agegrp*marketgroup	15-19	light	1	-0.5434	0.2801	-1.0924	0.0057	3.76
agegrp*marketgroup	15-19	lux	1	-0.3395	0.2901	-0.9082	0.2291	1.37
agegrp*marketgroup	15-19	medium	1	-0.3214	0.2370	-0.7859	0.1430	1.84
agegrp*marketgroup	15-19	pm	1	-1.1734	1.0337	-3.1994	0.8525	1.29
agegrp*marketgroup	15-19	small	1	-0.1508	0.2276	-0.5968	0.2952	0.44
agegrp*marketgroup	15-19	sport	1	-0.4641	0.2609	-0.9754	0.0472	3.17
agegrp*marketgroup	15-19	unknown	1	-0.2401	0.2459	-0.7221	0.2419	0.95
agegrp*marketgroup	20-29	4WDC	1	-0.5605	0.1990	-0.9506	-0.1704	7.93
agegrp*marketgroup	20-29	4WDL	1	-0.8352	0.4013	-1.6217	-0.0486	4.33
agegrp*marketgroup	20-29	4WDM	1	-0.0569	0.1864	-0.4223	0.3086	0.09
agegrp*marketgroup	20-29	large	1	-0.0088	0.1443	-0.2916	0.2740	0.00
agegrp*marketgroup	20-29	light	1	-0.5751	0.1573	-0.8833	-0.2668	13.37
agegrp*marketgroup	20-29	lux	1	-0.0391	0.1533	-0.3396	0.2613	0.07
agegrp*marketgroup	20-29	medium	1	-0.3525	0.1256	-0.5987	-0.1063	7.88
agegrp*marketgroup	20-29	pm	1	-0.5026	0.2375	-0.9681	-0.0371	4.48
agegrp*marketgroup	20-29	small	1	-0.3113	0.1226	-0.5517	-0.0710	6.45
agegrp*marketgroup	20-29	sport	1	-0.4844	0.1587	-0.7953	-0.1734	9.32
agegrp*marketgroup	20-29	unknown	1	-0.2028	0.1279	-0.4536	0.0479	2.51
agegrp*marketgroup	30-59	4WDC	1	-0.4183	0.1404	-0.6934	-0.1433	8.88
agegrp*marketgroup	30-59	4WDL	1	-0.2490	0.2218	-0.6837	0.1857	1.26
agegrp*marketgroup	30-59	4WDM	1	0.1233	0.1447	-0.1603	0.4070	0.73
agegrp*marketgroup	30-59	large	1	-0.2587	0.1166	-0.4873	-0.0302	4.93
agegrp*marketgroup	30-59	light	1	-0.3449	0.1173	-0.5747	-0.1150	8.65
agegrp*marketgroup	30-59	lux	1	-0.1251	0.1213	-0.3629	0.1127	1.06
agegrp*marketgroup	30-59	medium	1	-0.3403	0.1017	-0.5396	-0.1409	11.19
agegrp*marketgroup	30-59	pm	1	-0.4489	0.1644	-0.7712	-0.1267	7.45
agegrp*marketgroup	30-59	small	1	-0.2095	0.0990	-0.4036	-0.0154	4.48
agegrp*marketgroup	30-59	sport	1	-0.5387	0.1399	-0.8129	-0.2646	14.83
agegrp*marketgroup	30-59	unknown	1	-0.2076	0.1028	-0.4091	-0.0062	4.08
townclass	0		1	0.3472	0.1008	0.1497	0.5447	11.87
townclass	1		1	0.0249	0.0848	-0.1413	0.1911	0.09
OWNER_GEND*townclass	FEMALE	0	1	0.0820	0.0393	0.0050	0.1589	4.36
OWNER_GEND*townclass	FEMALE	1	1	0.0653	0.0356	-0.0045	0.1351	3.37
agegrp*townclass	15-19	0	1	-0.3825	0.1107	-0.5995	-0.1655	11.93

The GENMOD Procedure

Analysis Of Parameter Estimates

Parameter			Pr > ChiSq
OWNER_GEN*marketgrou	FEMALE	4WDC	0.0737
OWNER_GEN*marketgrou	FEMALE	4WDL	0.7146
OWNER_GEN*marketgrou	FEMALE	4WDM	0.0260
OWNER_GEN*marketgrou	FEMALE	large	0.7612
OWNER_GEN*marketgrou	FEMALE	light	0.0143
OWNER_GEN*marketgrou	FEMALE	lux	0.6860
OWNER_GEN*marketgrou	FEMALE	medium	0.2044
OWNER_GEN*marketgrou	FEMALE	pm	0.4197
OWNER_GEN*marketgrou	FEMALE	small	0.1193
OWNER_GEN*marketgrou	FEMALE	sport	0.3177
OWNER_GEN*marketgrou	FEMALE	unknown	0.7827
agegrp*marketgroup	15-19	4WDC	0.0728
agegrp*marketgroup	15-19	4WDL	0.7725
agegrp*marketgroup	15-19	4WDM	0.8122
agegrp*marketgroup	15-19	large	0.2937
agegrp*marketgroup	15-19	light	0.0524
agegrp*marketgroup	15-19	lux	0.2419
agegrp*marketgroup	15-19	medium	0.1749
agegrp*marketgroup	15-19	pm	0.2563
agegrp*marketgroup	15-19	small	0.5074
agegrp*marketgroup	15-19	sport	0.0752
agegrp*marketgroup	15-19	unknown	0.3289
agegrp*marketgroup	20-29	4WDC	0.0049
agegrp*marketgroup	20-29	4WDL	0.0374
agegrp*marketgroup	20-29	4WDM	0.7603
agegrp*marketgroup	20-29	large	0.9515
agegrp*marketgroup	20-29	light	0.0003
agegrp*marketgroup	20-29	lux	0.7986
agegrp*marketgroup	20-29	medium	0.0050
agegrp*marketgroup	20-29	pm	0.0343
agegrp*marketgroup	20-29	small	0.0111
agegrp*marketgroup	20-29	sport	0.0023
agegrp*marketgroup	20-29	unknown	0.1129
agegrp*marketgroup	30-59	4WDC	0.0029
agegrp*marketgroup	30-59	4WDL	0.2616
agegrp*marketgroup	30-59	4WDM	0.3940
agegrp*marketgroup	30-59	large	0.0265
agegrp*marketgroup	30-59	light	0.0033
agegrp*marketgroup	30-59	lux	0.3025
agegrp*marketgroup	30-59	medium	0.0008
agegrp*marketgroup	30-59	pm	0.0063
agegrp*marketgroup	30-59	small	0.0344
agegrp*marketgroup	30-59	sport	0.0001
agegrp*marketgroup	30-59	unknown	0.0434
townclass	0		0.0006
townclass	1		0.7693
OWNER_GEND*townclass	FEMALE	0	0.0368
OWNER_GEND*townclass	FEMALE	1	0.0666
agegrp*townclass	15-19	0	0.0006

The GENMOD Procedure

Analysis Of Parameter Estimates

Parameter			DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square
agegrp*townclass	15-19	1	1	-0.3582	0.0873	-0.5293	-0.1871	16.84
agegrp*townclass	20-29	0	1	-0.1136	0.0666	-0.2441	0.0168	2.91
agegrp*townclass	20-29	1	1	-0.2071	0.0588	-0.3223	-0.0919	12.42
agegrp*townclass	30-59	0	1	0.0125	0.0558	-0.0968	0.1217	0.05
agegrp*townclass	30-59	1	1	-0.0226	0.0474	-0.1154	0.0702	0.23
marketgrou*townclass	4WDC	0	1	-0.2651	0.1320	-0.5238	-0.0065	4.04
marketgrou*townclass	4WDC	1	1	-0.2182	0.1223	-0.4578	0.0214	3.19
marketgrou*townclass	4WDL	0	1	-0.0252	0.1844	-0.3866	0.3363	0.02
marketgrou*townclass	4WDL	1	1	0.1320	0.1602	-0.1820	0.4459	0.68
marketgrou*townclass	4WDM	0	1	-0.2551	0.1144	-0.4794	-0.0308	4.97
marketgrou*townclass	4WDM	1	1	0.0404	0.0965	-0.1489	0.2296	0.17
marketgrou*townclass	large	0	1	-0.1010	0.0990	-0.2950	0.0929	1.04
marketgrou*townclass	large	1	1	0.1701	0.0854	0.0028	0.3374	3.97
marketgrou*townclass	light	0	1	-0.2217	0.1205	-0.4578	0.0144	3.39
marketgrou*townclass	light	1	1	0.1514	0.1051	-0.0545	0.3573	2.08
marketgrou*townclass	lux	0	1	-0.3761	0.1102	-0.5921	-0.1601	11.64
marketgrou*townclass	lux	1	1	0.0583	0.0965	-0.1308	0.2475	0.37

marketgrou*townclass	medium	0	1	-0.1551	0.0868	-0.3252	0.0151	3.19
marketgrou*townclass	medium	1	1	0.1135	0.0749	-0.0332	0.2602	2.30
marketgrou*townclass	pm	0	1	-0.2188	0.1318	-0.4772	0.0395	2.76
marketgrou*townclass	pm	1	1	-0.1300	0.1262	-0.3774	0.1175	1.06
marketgrou*townclass	small	0	1	-0.3864	0.0842	-0.5515	-0.2213	21.04
marketgrou*townclass	small	1	1	-0.0956	0.0728	-0.2382	0.0470	1.73
marketgrou*townclass	sport	0	1	-0.3531	0.1124	-0.5734	-0.1328	9.87
marketgrou*townclass	sport	1	1	-0.0852	0.1016	-0.2842	0.1139	0.70
marketgrou*townclass	unknown	0	1	-0.3034	0.0870	-0.4739	-0.1329	12.17
marketgrou*townclass	unknown	1	1	-0.0262	0.0764	-0.1760	0.1236	0.12
veh_age			1	-0.0005	0.0060	-0.0123	0.0113	0.01
veh_age*marketgroup	4WDC		1	0.0199	0.0120	-0.0036	0.0434	2.76
veh_age*marketgroup	4WDL		1	0.0225	0.0142	-0.0053	0.0503	2.53
veh_age*marketgroup	4WDM		1	0.0126	0.0099	-0.0068	0.0321	1.63
veh_age*marketgroup	large		1	0.0156	0.0078	0.0004	0.0308	4.03
veh_age*marketgroup	light		1	-0.0084	0.0082	-0.0244	0.0077	1.04
veh_age*marketgroup	lux		1	0.0170	0.0085	0.0003	0.0337	4.00
veh_age*marketgroup	medium		1	0.0074	0.0070	-0.0064	0.0211	1.11
veh_age*marketgroup	pm		1	0.0079	0.0135	-0.0186	0.0344	0.34
veh_age*marketgroup	small		1	-0.0009	0.0065	-0.0137	0.0118	0.02
veh_age*marketgroup	sport		1	0.0050	0.0099	-0.0143	0.0244	0.26
veh_age*marketgroup	unknown		1	-0.0037	0.0071	-0.0176	0.0101	0.28
veh_age*townclass	0		1	0.0030	0.0043	-0.0054	0.0113	0.49
veh_age*townclass	1		1	0.0102	0.0036	0.0031	0.0173	7.90
kmy1			1	0.0169	0.0147	-0.0119	0.0457	1.32
kmy1*agegrp	15-19		1	-0.0401	0.0244	-0.0878	0.0076	2.71
kmy1*agegrp	20-29		1	0.0051	0.0106	-0.0157	0.0259	0.23
kmy1*agegrp	30-59		1	0.0081	0.0096	-0.0108	0.0269	0.70
kmy1*marketgroup	4WDC		1	-0.0300	0.0250	-0.0790	0.0191	1.44
kmy1*marketgroup	4WDL		1	-0.0528	0.0519	-0.1545	0.0488	1.04
kmy1*marketgroup	4WDM		1	-0.0179	0.0211	-0.0592	0.0235	0.72
kmy1*marketgroup	large		1	0.0104	0.0154	-0.0197	0.0405	0.46

The GENMOD Procedure

Analysis Of Parameter Estimates

Parameter			Pr > ChiSq
agegrp*townclass	15-19	1	<.0001
agegrp*townclass	20-29	0	0.0878
agegrp*townclass	20-29	1	0.0004
agegrp*townclass	30-59	0	0.8233
agegrp*townclass	30-59	1	0.6332
marketgrou*townclass	4WDC	0	0.0445
marketgrou*townclass	4WDC	1	0.0743
marketgrou*townclass	4WDL	0	0.8915
marketgrou*townclass	4WDL	1	0.4101
marketgrou*townclass	4WDM	0	0.0258
marketgrou*townclass	4WDM	1	0.6759
marketgrou*townclass	large	0	0.3073
marketgrou*townclass	large	1	0.0463
marketgrou*townclass	light	0	0.0657
marketgrou*townclass	light	1	0.1496
marketgrou*townclass	lux	0	0.0006
marketgrou*townclass	lux	1	0.5456
marketgrou*townclass	medium	0	0.0741
marketgrou*townclass	medium	1	0.1295
marketgrou*townclass	pm	0	0.0969
marketgrou*townclass	pm	1	0.3033
marketgrou*townclass	small	0	<.0001
marketgrou*townclass	small	1	0.1888
marketgrou*townclass	sport	0	0.0017
marketgrou*townclass	sport	1	0.4018
marketgrou*townclass	unknown	0	0.0005
marketgrou*townclass	unknown	1	0.7317
veh_age			0.9361
veh_age*marketgroup	4WDC		0.0969
veh_age*marketgroup	4WDL		0.1120
veh_age*marketgroup	4WDM		0.2018
veh_age*marketgroup	large		0.0448
veh_age*marketgroup	light		0.3082
veh_age*marketgroup	lux		0.0456
veh_age*marketgroup	medium		0.2923
veh_age*marketgroup	pm		0.5581
veh_age*marketgroup	small		0.8855
veh_age*marketgroup	sport		0.6107
veh_age*marketgroup	unknown		0.5995
veh_age*townclass	0		0.4862
veh_age*townclass	1		0.0050
kmy1			0.2511

Parameter		Pr > ChiSq
kmy1*agegrp	15-19	0.0995
kmy1*agegrp	20-29	0.6317
kmy1*agegrp	30-59	0.4035
kmy1*marketgroup	4WDC	0.2309
kmy1*marketgroup	4WDL	0.3082
kmy1*marketgroup	4WDM	0.3969
kmy1*marketgroup	large	0.4971

The GENMOD Procedure

Analysis Of Parameter Estimates

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square
kmy1*marketgroup	light	1	0.0074	0.0169	-0.0257	0.0406	0.19
kmy1*marketgroup	lux	1	-0.0032	0.0202	-0.0427	0.0363	0.03
kmy1*marketgroup	medium	1	0.0030	0.0149	-0.0262	0.0322	0.04
kmy1*marketgroup	pm	1	-0.0144	0.0216	-0.0567	0.0279	0.45
kmy1*marketgroup	small	1	-0.0006	0.0141	-0.0282	0.0271	0.00
kmy1*marketgroup	sport	1	0.0035	0.0179	-0.0315	0.0385	0.04
kmy1*marketgroup	unknown	1	0.0014	0.0135	-0.0251	0.0279	0.01
kmy2		1	2.4113	0.2979	1.8274	2.9951	65.51
kmy2*agegrp	15-19	1	-1.8259	0.4761	-2.7591	-0.8926	14.70
kmy2*agegrp	20-29	1	-1.3266	0.2567	-1.8297	-0.8236	26.71
kmy2*agegrp	30-59	1	-0.2456	0.2073	-0.6520	0.1608	1.40
kmy2*marketgroup	4WDC	1	-0.3538	0.5252	-1.3833	0.6756	0.45
kmy2*marketgroup	4WDL	1	-0.3644	0.7754	-1.8841	1.1553	0.22
kmy2*marketgroup	4WDM	1	-0.9299	0.4388	-1.7900	-0.0699	4.49
kmy2*marketgroup	large	1	0.7524	0.3163	0.1325	1.3724	5.66
kmy2*marketgroup	light	1	-0.4763	0.4190	-1.2975	0.3449	1.29
kmy2*marketgroup	lux	1	0.3129	0.3914	-0.4542	1.0799	0.64
kmy2*marketgroup	medium	1	0.3248	0.3023	-0.2677	0.9173	1.15
kmy2*marketgroup	pm	1	0.2246	0.4856	-0.7271	1.1763	0.21
kmy2*marketgroup	small	1	0.0620	0.2897	-0.5058	0.6297	0.05
kmy2*marketgroup	sport	1	0.4266	0.4247	-0.4058	1.2589	1.01
kmy2*marketgroup	unknown	1	0.0593	0.2968	-0.5223	0.6409	0.04
Scale		0	1.0000	0.0000	1.0000	1.0000	

Analysis Of Parameter Estimates

Parameter		Pr > ChiSq
kmy1*marketgroup	light	0.6603
kmy1*marketgroup	lux	0.8739
kmy1*marketgroup	medium	0.8408
kmy1*marketgroup	pm	0.5042
kmy1*marketgroup	small	0.9675
kmy1*marketgroup	sport	0.8443
kmy1*marketgroup	unknown	0.9192
kmy2		<.0001
kmy2*agegrp	15-19	0.0001
kmy2*agegrp	20-29	<.0001
kmy2*agegrp	30-59	0.2362
kmy2*marketgroup	4WDC	0.5005
kmy2*marketgroup	4WDL	0.6384
kmy2*marketgroup	4WDM	0.0341
kmy2*marketgroup	large	0.0174
kmy2*marketgroup	light	0.2556
kmy2*marketgroup	lux	0.4240
kmy2*marketgroup	medium	0.2826
kmy2*marketgroup	pm	0.6437
kmy2*marketgroup	small	0.8306
kmy2*marketgroup	sport	0.3152
kmy2*marketgroup	unknown	0.8416
Scale		

NOTE: The scale parameter was held fixed.

8.5. Model 5: Market group average total safety: Poisson model of number of injuries per vehicle year averaged over driving conditions etc

The GENMOD Procedure

Algorithm converged.

Analysis Of Parameter Estimates

Parameter			DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square
Intercept			1	-4.8616	0.0495	-4.9585	-4.7646	9652.03
owner_gender	FEMALE		1	0.1153	0.0337	0.0493	0.1813	11.72
agegrp	15-19		1	1.2158	0.0683	1.0820	1.3497	316.99
agegrp	20-29		1	0.5925	0.0460	0.5023	0.6827	165.63
agegrp	30-59		1	0.1226	0.0363	0.0515	0.1937	11.41
owner_gender*agegrp	FEMALE	15-19	1	-0.2191	0.0764	-0.3687	-0.0694	8.23
owner_gender*agegrp	FEMALE	20-29	1	-0.1849	0.0445	-0.2722	-0.0976	17.23
owner_gender*agegrp	FEMALE	30-59	1	-0.0569	0.0371	-0.1297	0.0158	2.35
marketgroup	4WDC		1	0.0089	0.0460	-0.0813	0.0990	0.04
marketgroup	4WDL		1	-0.2376	0.0627	-0.3604	-0.1147	14.36
marketgroup	4WDM		1	0.0152	0.0392	-0.0616	0.0920	0.15
marketgroup	large		1	0.0338	0.0341	-0.0331	0.1007	0.98
marketgroup	light		1	0.1768	0.0385	0.1013	0.2522	21.10
marketgroup	lux		1	0.0427	0.0369	-0.0296	0.1149	1.34
marketgroup	medium		1	0.1671	0.0295	0.1093	0.2250	32.06
marketgroup	pm		1	0.2163	0.0448	0.1285	0.3040	23.33
marketgroup	small		1	0.2211	0.0288	0.1647	0.2776	58.91
marketgroup	sport		1	0.3322	0.0376	0.2584	0.4059	77.95
marketgroup	unknown		1	0.0796	0.0299	0.0209	0.1382	7.07

Analysis Of Parameter Estimates

Parameter			Pr > ChiSq
Intercept			<.0001
owner_gender	FEMALE		0.0006
agegrp	15-19		<.0001
agegrp	20-29		<.0001
agegrp	30-59		0.0007
owner_gender*agegrp	FEMALE	15-19	0.0041
owner_gender*agegrp	FEMALE	20-29	<.0001
owner_gender*agegrp	FEMALE	30-59	0.1249
marketgroup	4WDC		0.8473
marketgroup	4WDL		0.0002
marketgroup	4WDM		0.6983
marketgroup	large		0.3217
marketgroup	light		<.0001
marketgroup	lux		0.2469
marketgroup	medium		<.0001
marketgroup	pm		<.0001
marketgroup	small		<.0001
marketgroup	sport		<.0001
marketgroup	unknown		0.0078

The GENMOD Procedure

Analysis Of Parameter Estimates

Parameter			DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square
townclass	0		1	0.1014	0.0632	-0.0224	0.2252	2.58
townclass	1		1	0.0615	0.0532	-0.0428	0.1659	1.34
agegrp*townclass	15-19	0	1	-0.2232	0.1042	-0.4274	-0.0191	4.59
agegrp*townclass	15-19	1	1	-0.1773	0.0826	-0.3392	-0.0154	4.61
agegrp*townclass	20-29	0	1	-0.0859	0.0608	-0.2051	0.0332	2.00
agegrp*townclass	20-29	1	1	-0.1295	0.0530	-0.2333	-0.0257	5.98
agegrp*townclass	30-59	0	1	0.0428	0.0505	-0.0561	0.1417	0.72
agegrp*townclass	30-59	1	1	-0.0587	0.0422	-0.1413	0.0239	1.94
veh_age			1	0.0073	0.0025	0.0023	0.0123	8.26
veh_age*townclass	0		1	-0.0020	0.0038	-0.0094	0.0053	0.29
veh_age*townclass	1		1	0.0068	0.0032	0.0005	0.0130	4.48
kmy1			1	0.0238	0.0062	0.0118	0.0359	14.96
kmy1*agegrp	15-19		1	-0.0164	0.0152	-0.0461	0.0133	1.17
kmy1*agegrp	20-29		1	0.0113	0.0075	-0.0035	0.0261	2.25
kmy1*agegrp	30-59		1	0.0017	0.0069	-0.0118	0.0152	0.06
kmy2			1	2.5927	0.1571	2.2849	2.9006	272.43
kmy2*agegrp	15-19		1	-1.6504	0.3717	-2.3789	-0.9220	19.72
kmy2*agegrp	20-29		1	-0.9716	0.2119	-1.3869	-0.5563	21.03
kmy2*agegrp	30-59		1	-0.3832	0.1734	-0.7231	-0.0433	4.88
Scale			0	1.0000	0.0000	1.0000	1.0000	

Analysis Of Parameter Estimates

Parameter			Pr > ChiSq
townclass	0		0.1085
townclass	1		0.2478
agegrp*townclass	15-19	0	0.0321
agegrp*townclass	15-19	1	0.0319
agegrp*townclass	20-29	0	0.1576
agegrp*townclass	20-29	1	0.0145
agegrp*townclass	30-59	0	0.3966
agegrp*townclass	30-59	1	0.1637
veh_age			0.0040
veh_age*townclass	0		0.5877
veh_age*townclass	1		0.0344
kmy1			0.0001
kmy1*agegrp	15-19		0.2789
kmy1*agegrp	20-29		0.1335
kmy1*agegrp	30-59		0.8065
kmy2			<.0001
kmy2*agegrp	15-19		<.0001
kmy2*agegrp	20-29		<.0001
kmy2*agegrp	30-59		0.0271
Scale			

NOTE: The scale parameter was held fixed.

8.6. Model 6: Market group average fatal/serious safety: Poisson model of number of fatal/serious injuries per vehicle year averaged over driving conditions etc

The GENMOD Procedure

Algorithm converged.

Analysis Of Parameter Estimates

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept		1	-6.8327	0.0881	-7.0054	-6.6599	6008.62	<.0001
owner_gender	FEMALE	1	-0.1063	0.0330	-0.1710	-0.0415	10.36	0.0013
agegrp	15-19	1	1.2591	0.0834	1.0956	1.4225	228.05	<.0001
agegrp	20-29	1	0.5132	0.0549	0.4057	0.6207	87.53	<.0001
agegrp	30-59	1	0.1211	0.0450	0.0329	0.2093	7.24	0.0071
marketgroup	4WDC	1	0.0641	0.1118	-0.1551	0.2833	0.33	0.5663
marketgroup	4WDL	1	-0.0684	0.1405	-0.3438	0.2070	0.24	0.6263
marketgroup	4WDM	1	0.1285	0.0911	-0.0501	0.3071	1.99	0.1585
marketgroup	large	1	0.0948	0.0810	-0.0640	0.2537	1.37	0.2419
marketgroup	light	1	0.1430	0.0945	-0.0422	0.3283	2.29	0.1302
marketgroup	lux	1	0.0735	0.0888	-0.1005	0.2475	0.69	0.4076
marketgroup	medium	1	0.1833	0.0706	0.0449	0.3216	6.74	0.0094
marketgroup	pm	1	0.0581	0.1180	-0.1731	0.2894	0.24	0.6223
marketgroup	small	1	0.1615	0.0695	0.0253	0.2976	5.40	0.0202
marketgroup	sport	1	0.3185	0.0916	0.1390	0.4980	12.10	0.0005
marketgroup	unknown	1	-0.0060	0.0729	-0.1489	0.1370	0.01	0.9347
townclass	0	1	-0.3706	0.0440	-0.4568	-0.2843	70.95	<.0001
townclass	1	1	-0.0577	0.0358	-0.1278	0.0124	2.61	0.1065
veh_age		1	0.0155	0.0034	0.0087	0.0222	20.26	<.0001
X		1	2.0396	0.1309	1.7830	2.2963	242.63	<.0001
Scale		0	1.0000	0.0000	1.0000	1.0000		

NOTE: The scale parameter was held fixed.

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
owner_gender	1	10.44	0.0012
agegrp	3	258.50	<.0001
marketgroup	11	29.72	0.0018
townclass	2	84.04	<.0001
veh_age	1	20.23	<.0001
X	1	189.67	<.0001

9. Appendix 2: induced exposure model: output from SAS

The LOGISTIC Procedure

Conditional Analysis

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
AGE3	25 years and under	1	0.6972	0.0651	114.7345	<.0001
AGE3	Greater than 60 years	1	-0.1791	0.0988	3.2864	0.0699
SEX1	Female	1	-0.4262	0.0591	52.0693	<.0001
MKTGRP	4WD - Compact	1	2.0202	0.1846	119.8059	<.0001
MKTGRP	4WD - Large	1	1.9853	0.1421	195.0801	<.0001
MKTGRP	4WD - Medium	1	1.5465	0.2130	52.7207	<.0001
MKTGRP	Light	1	0.1938	0.0954	4.1268	0.0422
MKTGRP	Luxury	1	-0.0723	0.1375	0.2765	0.5990
MKTGRP	Medium	1	-0.00924	0.0999	0.0086	0.9263
MKTGRP	People Mover	1	0.8201	0.2366	12.0193	0.0005
MKTGRP	Small	1	-0.1575	0.0800	3.8775	0.0489
MKTGRP	Sports	1	-0.1832	0.1849	0.9818	0.3217
YEARMAN		1	0.0195	0.00645	9.1579	0.0025
year		1	-0.00897	0.00884	1.0289	0.3104

Odds Ratio Estimates

Effect		Point Estimate	95% Wald Confidence Limits	
AGE3	25 years and under vs 26 - 59 years	2.008	1.768	2.281
AGE3	Greater than 60 years vs 26 - 59 years	0.836	0.689	1.015
SEX1	Female vs Male	0.653	0.582	0.733
MKTGRP	4WD - Compact vs Large	7.540	5.251	10.827
MKTGRP	4WD - Large vs Large	7.281	5.511	9.621
MKTGRP	4WD - Medium vs Large	4.695	3.093	7.127
MKTGRP	Light vs Large	1.214	1.007	1.463
MKTGRP	Luxury vs Large	0.930	0.711	1.218
MKTGRP	Medium vs Large	0.991	0.815	1.205
MKTGRP	People Mover vs Large	2.271	1.428	3.610
MKTGRP	Small vs Large	0.854	0.730	0.999
MKTGRP	Sports vs Large	0.833	0.580	1.196
YEARMAN		1.020	1.007	1.033
year		0.991	0.974	1.008

10. Appendix 3: NZ makes and models with market groups

Make	Model	Year of manufacture	NZ Market Group
Daihatsu	Feroza / Rocky	89-97	4WD - Compact
Daihatsu	Rocky / Rugger	85-98	4WD - Compact
Daihatsu	Terios	97-03	4WD - Compact
Holden	Cruze	02-03	4WD - Compact
Mitsubishi	Pajero iO	99-03	4WD - Compact
Mitsubishi	Outlander	03-03	4WD - Compact
Kia	Sportage	98-03	4WD - Compact
Kia	Sorento	03-03	4WD - Compact
Ford / Mazda	Escape / Tribute	01-03	4WD - Compact
Nissan	X-Trail	01-03	4WD - Compact
Lada	Niva	84-99	4WD - Compact
Honda	CR-V	97-01	4WD - Compact
Honda	CR-V	02-03	4WD - Compact
Honda	HR-V	99-02	4WD - Compact
Landrover	Freelander	98-03	4WD - Compact
Subaru	Forester	97-02	4WD - Compact
Subaru	Forester	02-03	4WD - Compact
Suzuki	Vitara / Escudo	88-98	4WD - Compact
Suzuki	Grand Vitara	99-03	4WD - Compact
Holden / Suzuki	Drover / Sierra / Samurai / SJ410 / SJ413	82-99	4WD - Compact
Suzuki	Jimny	98-03	4WD - Compact
Toyota	RAV4	94-00	4WD - Compact
Toyota	RAV4	01-03	4WD - Compact
Volkswagen	Touareg	03-03	4WD - Large
Ford	Bronco	82-87	4WD - Large
Ford	Explorer	00-01	4WD - Large
Ford	Explorer	01-03	4WD - Large
Holden	Suburban	98-00	4WD - Large
Jeep	Grand Cherokee	96-99	4WD - Large
Jeep	Grand Cherokee	99-03	4WD - Large
Mercedes Benz	M-Class W163	98-03	4WD - Large
Mercedes Benz	G-Class	83-88	4WD - Large
Nissan	Patrol / Safari	82-87	4WD - Large
Nissan / Ford	Patrol / Maverick / Safari	88-97	4WD - Large
Nissan	Patrol / Safari	98-02	4WD - Large
Porsche	Cayenne	03-03	4WD - Large
Land Rover	Range Rover	82-94	4WD - Large
Land Rover	Range Rover	95-02	4WD - Large
Land Rover	Range Rover	02-03	4WD - Large
Toyota	Landcruiser	82-89	4WD - Large
Toyota	Landcruiser	90-97	4WD - Large
Toyota	Landcruiser	98-03	4WD - Large
Daewoo / Ssangong	Musso	98-02	4WD - Medium
Ssangyong	Rexton	03-03	4WD - Medium
Holden / Isuzu	Jackaroo / Bighorn	82-91	4WD - Medium

Make	Model	Year of manufacture	NZ Market Group
Holden / Isuzu	Jackaroo / Bighorn	92-97	4WD - Medium
Holden / Isuzu	Jackaroo / Bighorn	98-02	4WD - Medium
Holden	Frontera / Mu	95-03	4WD - Medium
Holden	Adventra	03-03	4WD - Medium
Hyundai	Terracan	01-03	4WD - Medium
Hyundai	Santa Fe	00-03	4WD - Medium
Mitsubishi	Pajero	82-90	4WD - Medium
Mitsubishi	Pajero	92-99	4WD - Medium
Mitsubishi	Pajero NM / NP	00-03	4WD - Medium
Mitsubishi	Challenger	98-03	4WD - Medium
Jeep	Cherokee XJ	96-00	4WD - Medium
Jeep	Wrangler	96-03	4WD - Medium
Jeep	Cherokee KJ	01-03	4WD - Medium
Land Rover	Defender	92-03	4WD - Medium
Land Rover	Discovery	91-02	4WD - Medium
Land Rover	Discovery	02-03	4WD - Medium
Nissan	Pathfinder / Terrano	88-94	4WD - Medium
Nissan	Pathfinder / Terrano	95-02	4WD - Medium
Nissan	Terrano II	97-00	4WD - Medium
Honda	MDX	03-03	4WD - Medium
Toyota	Kluger	03-03	4WD - Medium
Toyota	Landcruiser Prado	96-03	4WD - Medium
Toyota	Landcruiser Prado	03-03	4WD - Medium
Volvo	XC 90	03-03	4WD - Medium
Ford / Nissan	Falcon Ute / XFN Ute	82-95	Commercial - Ute
Ford	Falcon Ute	96-99	Commercial - Ute
Ford	Falcon Ute AU	00-02	Commercial - Ute
Ford	Falcon Ute BA	03-03	Commercial - Ute
Ford	Ford F-Series	82-92	Commercial - Ute
Ford	F-Series	01-03	Commercial - Ute
Holden	Commodore Ute VG/VP	90-93	Commercial - Ute
Holden / Isuzu	Rodeo / Pickup	82-85	Commercial - Ute
Holden / Isuzu	Rodeo / Pickup	86-88	Commercial - Ute
Holden / Isuzu	Rodeo / Pickup	89-95	Commercial - Ute
Holden	Rodeo	96-98	Commercial - Ute
Holden	Rodeo	99-02	Commercial - Ute
Holden	WB Series	82-85	Commercial - Ute
Holden	Commodore Ute VR/VS	94-00	Commercial - Ute
Holden	Commodore VU Ute	00-02	Commercial - Ute
Holden	Commodore VY Ute	02-03	Commercial - Ute
Holden	Rodeo	03-03	Commercial - Ute
Kia	Ceres	92-00	Commercial - Ute
Kia	K2700	02-03	Commercial - Ute
Ford / Mazda	Courier / B-Series / Bounty	98-02	Commercial - Ute
Ford / Mazda	Courier / Bravo / Bounty	03-03	Commercial - Ute
Nissan	720 Ute	82-85	Commercial - Ute
Nissan	Navara	86-91	Commercial - Ute

Make	Model	Year of manufacture	NZ Market Group
Nissan	Navara	92-96	Commercial - Ute
Nissan	Navara	97-03	Commercial - Ute
Subaru	Brumby	82-92	Commercial - Ute
Suzuki	Mighty Boy	85-88	Commercial - Ute
Toyota	4Runner/Hilux	82-85	Commercial - Ute
Toyota	4Runner/Hilux	86-88	Commercial - Ute
Toyota	4Runner/Hilux	89-97	Commercial - Ute
Toyota	Hilux	98-02	Commercial - Ute
Toyota	Hilux	03-03	Commercial - Ute
Volkswagen	LT	03-03	Commercial - Van
Citroen	Berlingo	99-03	Commercial - Van
Daihatsu	Handivan	82-90	Commercial - Van
Daihatsu	Hi-Jet	82-90	Commercial - Van
Daihatsu	Handivan / Cuore	99-03	Commercial - Van
Ford	Falcon Panel Van	82-95	Commercial - Van
Ford	Falcon Panel Van	96-99	Commercial - Van
Ford	Transit	95-00	Commercial - Van
Ford	Transit	01-03	Commercial - Van
Fiat	Ducato	02-03	Commercial - Van
Holden	Shuttle / WFR Van	82-87	Commercial - Van
Kia	Pregio	02-03	Commercial - Van
Mercedes Benz	MB100 / MB140	99-03	Commercial - Van
Mercedes Benz	Vito	99-03	Commercial - Van
Mercedes Benz	Sprinter	98-03	Commercial - Van
Honda	Acty	83-86	Commercial - Van
Holden / Suzuki	Scurry / Carry	82-00	Commercial - Van
Suzuki	Carry	99-03	Commercial - Van
Toyota	Hiace/Liteace	82-86	Commercial - Van
Toyota	Hiace/Liteace	87-89	Commercial - Van
Toyota	Hiace/Liteace	90-95	Commercial - Van
Toyota	Hiace/Liteace	96-03	Commercial - Van
Volkswagen	Caravelle / Transporter	88-94	Commercial - Van
Volkswagen	Caravelle / Transporter	95-03	Commercial - Van
Proton	Jumbuck	03-03	Commercial -Ute
Ford	Falcon XE/XF	82-88	Large
Ford	Falcon EA / Falcon EB Series I	88-Mar 92	Large
Ford	Falcon EB Series II / Falcon ED	Apr 92-94	Large
Ford	Falcon EF/EL	94-98	Large
Ford	Falcon AU	98-02	Large
Ford	Taurus	96-98	Large
Ford	Falcon BA	02-03	Large
Holden / Toyota	Commodore VN/VP / Lexcen	89-93	Large
Holden / Toyota	Commodore VR/VS / Lexcen	93-97	Large
Holden	Commodore VT/VX	97-02	Large
Holden	Commodore VY	02-03	Large
Holden	Commodore VB-VL	82-88	Large
Hyundai	Sonata	98-01	Large
Hyundai	Sonata	02-03	Large
Hyundai	Sonata	89-97	Large

Make	Model	Year of manufacture	NZ Market Group
Hyundai	Grandeaur / XG	99-00	Large
Mitsubishi	Magna TM/TN/TP / Sigma / V3000	85-90	Large
Mitsubishi	Magna TE/TF/TH/TJ / Verada KE/KF/KH/KJ / Diamante	96-03	Large
Mitsubishi	Magna TR/TS / Verada KR/KS / V3000 / Diamante	91-96	Large
Mitsubishi	Magna TL / Verada KL	03-03	Large
Kia	Optima	01-03	Large
Nissan	Skyline	83-88	Large
Holden / Toyota	Apollo JM/JP / Camry / Sceptor	93-97	Large
Toyota	Camry	98-02	Large
Toyota	Avalon	00-03	Large
Toyota	Camry	02-03	Large
Volkswagen	Polo	02-03	Light
Daihatsu	Charade	82-86	Light
Daihatsu	Charade	88-92	Light
Daihatsu	Charade	93-00	Light
Daihatsu	Pyzar	97-01	Light
Daihatsu	Move	97-99	Light
Daihatsu	Sirion / Storia	98-03	Light
Daihatsu	YRV	01-03	Light
Daihatsu	Mira	90-96	Light
Daihatsu	Charade	03-03	Light
Daewoo	1.5i	94-95	Light
Daewoo	Cielo	95-97	Light
Daewoo	Lanos	97-03	Light
Daewoo	Matiz	99-03	Light
Daewoo	Kalos	03-03	Light
Ford	Festiva WD/WH/WF	94-01	Light
Ford	Ka	99-03	Light
Holden	Barina XC	01-03	Light
Holden	Barina SB	95-00	Light
Hyundai	Excel	86-90	Light
Hyundai	Excel	90-94	Light
Hyundai	Excel / Accent	95-00	Light
Hyundai	Accent	00-03	Light
Hyundai	Getz	02-03	Light
Mitsubishi	Mirage / Colt	82-88	Light
Kia	Rio	00-03	Light
Ford / Mazda	Festiva WA / 121	87-90	Light
Mazda	121 / Autozam Review	94-96	Light
Mazda	121 Metro / Demio	97-02	Light
Mazda	2	02-03	Light
Nissan	Micra	95-97	Light
Honda	Jazz	01-03	Light
Honda	Insight	01-03	Light
Honda	City	83-86	Light
Peugoet	205	87-94	Light
Peugeot	206	99-03	Light
Proton	Satria	97-03	Light

Make	Model	Year of manufacture	NZ Market Group
Renault	Clio	02-03	Light
Lada	Samara	88-90	Light
Seat	Ibiza	95-99	Light
Smart	City-Coupe		Light
Subaru	Sherpa / Fiori / 700 / Rex	89-92	Light
Suzuki	Swift	82-85	Light
Holden / Suzuki	Barina / Swift / Cultus	86-88	Light
Holden / Suzuki	Barina / Swift / Cultus	89-99	Light
Suzuki	Hatch / Alto	82-84	Light
Suzuki	Alto	85-00	Light
Suzuki	Ignis	00-02	Light
Toyota	Starlet	96-99	Light
Toyota	Echo	99-03	Light
Toyota	Prius	01-02	Light
Volkswagen	Polo	96-00	Light
Volkswagen	Polo	01-02	Light
Volkswagen	New Beetle	00-03	Luxury
Alfa Romeo	164	89-92	Luxury
Alfa Romeo	75	86-92	Luxury
Alfa Romeo	90	85-88	Luxury
Alfa Romeo	156	99-03	Luxury
Alfa Romeo	166	99-03	Luxury
Alfa Romeo	147	01-03	Luxury
Audi	A6/S6/AllRoad	95-03	Luxury
Audi	A8	95-03	Luxury
Audi	A4	95-01	Luxury
Audi	A3/S3	97-03	Luxury
Audi	A4	01-03	Luxury
Audi	A8	03-03	Luxury
Audi	Cabriolet	02-03	Luxury
BMW	3 Series E30	82-91	Luxury
BMW	3 Series E36	92-98	Luxury
BMW	3 Series E46	99-03	Luxury
BMW	5 Series E28	82-88	Luxury
BMW	5 Series E34	89-95	Luxury
BMW	5 Series E39	96-03	Luxury
BMW	6 Series E24	86-89	Luxury
BMW	7 Series E23	82-88	Luxury
BMW	7 Series E32	89-94	Luxury
BMW	7 Series E38	95-01	Luxury
BMW	7 Series E65/66	02-03	Luxury
BMW	8 Series E31	90-99	Luxury
Mini	Mini Cooper	02-03	Luxury
BMW	5 Series E60	03-03	Luxury
Citroen	BX	86-94	Luxury
Citroen	Xanitia	94-00	Luxury
Citroen	XM	91-00	Luxury
Citroen	C5	01-03	Luxury
Ford	Fairlane Z & LTD F	82-87	Luxury

Make	Model	Year of manufacture	NZ Market Group
Ford	Fairlane N & LTD D	88-94	Luxury
Ford	Fairlane N & LTD D	95-98	Luxury
Ford	Fairlane & LTD AU	99-02	Luxury
Ford	Fairlane & LTD BA	03-03	Luxury
Holden	Statesman/Caprice WB	82-85	Luxury
Holden	Stateman/Caprice VQ	90-93	Luxury
Holden	Stateman/Caprice VR/VS	94-98	Luxury
Holden	Statesman/Caprice WH	99-03	Luxury
Holden	Statesman/Caprice WK	03-03	Luxury
Jaguar	XJ6	82-86	Luxury
Jaguar	XJ6	87-94	Luxury
Jaguar	XJ6	95-97	Luxury
Jaguar	XJ8	98-03	Luxury
Jaguar	XJS	82-96	Luxury
Jaguar	XJR	95-03	Luxury
Jaguar	XK8 / XKR	97-03	Luxury
Jaguar	S-Type	99-02	Luxury
Jaguar	X-Type	02-03	Luxury
Jaguar	XJ	03-03	Luxury
Mazda	929 / Luce	82-90	Luxury
Mazda	929 / Sentia / Efini MS-9	92-96	Luxury
Mazda	Eunos 500	93-99	Luxury
Mazda	Eunos 800	94-00	Luxury
Mercedes Benz	C-Class W201	87-93	Luxury
Mercedes Benz	C-Class W202	95-00	Luxury
Mercedes Benz	CLK C208	97-03	Luxury
Mercedes Benz	E-Class W123	82-85	Luxury
Mercedes Benz	E-Class W124	86-94	Luxury
Mercedes Benz	E-Class W210	96-02	Luxury
Mercedes Benz	S-Class W126	82-92	Luxury
Mercedes Benz	S-Class R129	93-02	Luxury
Mercedes Benz	S-Class C140	93-98	Luxury
Mercedes Benz	A-Class W168	98-03	Luxury
Mercedes Benz	S-Class W220	99-03	Luxury
Mercedes Benz	CL500/600 C215	98-00	Luxury
Mercedes Benz	C-Class W203	00-03	Luxury
Mercedes Benz	CLK C209	03-03	Luxury
Mercedes Benz	E-Class W211	02-03	Luxury
Mercedes Benz	S-Class R230	02-03	Luxury
Nissan	280C / Laurel	82-84	Luxury
Nissan	Maxima	90-94	Luxury
Nissan	Maxima / Cefiro	95-99	Luxury
Nissan	Maxima	00-02	Luxury
Nissan	300C / Laurel	85-87	Luxury
Nissan	Infiniti	93-97	Luxury
Nissan	Maxima	03-03	Luxury
Honda	Accord Euro	03-03	Luxury
Honda	Accord	03-03	Luxury

Make	Model	Year of manufacture	NZ Market Group
Honda	Legend	82-85	Luxury
Honda	Legend	86-95	Luxury
Honda	Legend	96-98	Luxury
Honda	Legend	99-03	Luxury
Honda	Accord	82-85	Luxury
Honda	Accord	86-90	Luxury
Honda	Accord	91-93	Luxury
Honda	Accord	94-98	Luxury
Honda	Accord	99-02	Luxury
Peugeot	405	89-97	Luxury
Peugeot	505	82-93	Luxury
Peugeot	605	94-96	Luxury
Peugeot	406	96-03	Luxury
Peugeot	607	01-03	Luxury
Renault	20	82-83	Luxury
Renault	25	85-91	Luxury
Renault	Laguna	95-96	Luxury
Renault	Laguna	02-03	Luxury
Rover	3500	82-87	Luxury
Rover	825	87-88	Luxury
Rover	MG ZT	02-03	Luxury
Rover	75	01-03	Luxury
Saab	900 Series	82-92	Luxury
Saab	900/9-3	94-02	Luxury
Saab	9000	86-97	Luxury
Saab	9-5	98-02	Luxury
Saab	9-3	03-03	Luxury
Toyota	Crown / Cressida / Mark II	82-85	Luxury
Toyota	Crown / Cressida / Mark II	86-88	Luxury
Toyota	Cressida / Mark II	89-93	Luxury
Lexus	ES300 / Windom	92-01	Luxury
Lexus	LS400 / Celsior	90-00	Luxury
Lexus	IS200 / IS300	99-03	Luxury
Lexus	GS300	97-03	Luxury
Lexus	LS430	00-03	Luxury
Lexus	ES300	01-03	Luxury
Volvo	850/S70/V70/C70	92-03	Luxury
Volvo	200 Series	82-93	Luxury
Volvo	300 Series	84-88	Luxury
Volvo	700/900 Series	84-92	Luxury
Volvo	960/S90/V90	90-98	Luxury
Volvo	S80	98-03	Luxury
Volvo	S60	01-03	Luxury
Volvo	S40/V40	97-03	Luxury
Volkswagen	Passat	95-97	Luxury
Volkswagen	Passat	98-03	Luxury
Chrysler	PT Cruiser	00-03	Medium
Daewoo	Espero	95-97	Medium
Daewoo	Leganza	97-03	Medium

Make	Model	Year of manufacture	NZ Market Group
Daewoo	Tacuma	00-03	Medium
Ford	Cortina	82-82	Medium
Ford	Mondeo	95-01	Medium
Fiat	Argenta	83-85	Medium
Fiat	Croma	88-89	Medium
Fiat	Superbrava	82-85	Medium
Holden	Camira	82-89	Medium
Holden	Vectra	97-03	Medium
Holden	Vectra ZC	03-03	Medium
Mitsubishi	Sigma / Galant / Sapporo / Lambda	82-84	Medium
Mitsubishi	Galant	89-93	Medium
Mitsubishi	Galant	95-96	Medium
Kia	Credos	98-01	Medium
Ford / Mazda	Telstar / 626 / MX6 / Capella	83-86	Medium
Ford / Mazda	Telstar / 626 / MX6 / Capella	88-91	Medium
Ford / Mazda	Telstar / 626 / MX6 / Capella / Cronos	92-97	Medium
Mazda	626	98-02	Medium
Mazda	6	02-03	Medium
Nissan	Pintara	86-88	Medium
Nissan / Ford	Pintara / Corsair / Bluebird	89-92	Medium
Nissan	Bluebird	82-86	Medium
Nissan	Bluebird	93-97	Medium
Renault	18	82-83	Medium
Renault	21	87-91	Medium
Renault	Scenic	01-03	Medium
Subaru	1800 / Leone / Omega / 4WD Wagon	82-93	Medium
Subaru	Liberty / Legacy	89-93	Medium
Subaru	Liberty / Legacy / Outback	94-98	Medium
Subaru	Liberty / Legacy / Outback	99-03	Medium
Subaru	Liberty / Legacy / Outback	03-03	Medium
Toyota	Corona	82-88	Medium
Toyota	Camry	83-86	Medium
Holden / Toyota	Apollo JK/JL / Camry / Vista	88-92	Medium
Chrysler	Voyager	97-03	People Mover
Ford	Spectron	86-90	People Mover
Holden	Zafira TT	01-03	People Mover
Hyundai	Trajet	00-03	People Mover
Mitsubishi	Nimbus / Chariot / Spacewagon	85-91	People Mover
Mitsubishi	Nimbus / Chariot	92-98	People Mover
Mitsubishi	Nimbus	99-03	People Mover
Mitsubishi	Starwagon / L300	83-86	People Mover
Mitsubishi	Starwagon / Delica Starwagon	87-93	People Mover
Mitsubishi	Starwagon / Delica Spacegear	95-98	People Mover
Mitsubishi	Starwagon / Delica Spacegear	98-03	People Mover
Kia	Carens	00-02	People Mover
Kia	Carnival	99-03	People Mover
Mazda	MPV	94-99	People Mover
Mazda	MPV	00-03	People Mover
Nissan	Prairie	84-86	People Mover

Make	Model	Year of manufacture	NZ Market Group
Nissan	Serena	92-95	People Mover
Honda	Odyssey	95-00	People Mover
Honda	Odyssey	00-02	People Mover
Toyota	Tarago	83-89	People Mover
Toyota	Tarago / Previa / Estima	91-99	People Mover
Toyota	Tarago / Previa / Estima	00-03	People Mover
Toyota	Spacia	93-00	People Mover
Toyota	Spacia	01-02	People Mover
Toyota	Avensis	01-03	People Mover
Alfa Romeo	33	83-92	Small
Alfa Romeo	Alfetta	82-88	Small
Alfa Romeo	Guilietta	82-86	Small
Alfa Romeo	Alfasud	82-84	Small
Chrysler	Neon	96-99	Small
Chrysler	Neon	00-02	Small
Citroen	AX	91-93	Small
Citroen	Xsara	00-03	Small
Citroen	C3	02-03	Small
Daihatsu	Applause	89-99	Small
Daewoo	Nubira	97-03	Small
Daewoo	Lacetti	03-03	Small
Ford	Laser	91-94	Small
Ford	Laser	95-97	Small
Ford	Escort	82-82	Small
Ford	Focus	02-03	Small
Fiat	Regata	84-88	Small
Holden	Gemini	82-84	Small
Holden	Gemini RB	86-87	Small
Holden	Astra TR	96-98	Small
Holden	Astra TS	98-03	Small
Hyundai	Elantra Lavita	01-03	Small
Hyundai	S Coupe	90-96	Small
Hyundai	Lantra	91-95	Small
Hyundai	Lantra	96-00	Small
Hyundai	Elantra	00-03	Small
Mitsubishi	Lancer / Mirage CA	89-90	Small
Mitsubishi	Lancer / Mirage CB	91-92	Small
Mitsubishi	Lancer / Mirage CC	93-95	Small
Mitsubishi	Lancer / Mirage CE	96-03	Small
Mitsubishi	Cordia	83-87	Small
Mitsubishi	Lancer CG	02-03	Small
Mitsubishi	Lancer CG / CH	03-03	Small
Kia	Mentor	97-00	Small
Kia	Spectra	01-03	Small
Ford / Mazda	Laser / 323 / Familia	82-88	Small
Mazda	323 / Familia / Lantis	90-93	Small
Mazda	323 / Familia / Lantis	95-98	Small
Ford / Mazda	Laser / 323	99-03	Small
Mazda	Premacy	01-03	Small

Make	Model	Year of manufacture	NZ Market Group
Holden / Nissan	Astra / Pulsar / Langley	84-86	Small
Holden / Nissan	Astra / Pulsar / Vector / Sentra	88-90	Small
Nissan	Pulsar / Vector / Sentra	92-95	Small
Nissan	Pulsar / Vector / Sentra	96-99	Small
Nissan	Stanza	82-83	Small
Nissan	Pulsar	00-03	Small
Honda	Civic	82-83	Small
Honda	Civic / Ballade / Shuttle	84-87	Small
Honda	Civic / Shuttle	88-91	Small
Honda	Civic	92-95	Small
Honda	Civic	96-00	Small
Honda	Civic	01-03	Small
Honda	Concerto	89-93	Small
Peugeot	306	94-01	Small
Peugeot	307	01-03	Small
Proton	Wira	95-96	Small
Proton	Waja	01-03	Small
Renault	19	91-96	Small
Renault	Megane II	03-03	Small
Rover	Quintet	82-86	Small
Seat	Cordoba	95-99	Small
Subaru	Impreza	93-00	Small
Subaru	Impreza	01-03	Small
Suzuki	Baleno / Cultus Crescent	95-02	Small
Suzuki	Liana	01-03	Small
Toyota	Corolla	82-84	Small
Toyota	Corolla	86-88	Small
Toyota / Holden	Corolla / Nova	89-93	Small
Toyota / Holden	Corolla / Nova	94-97	Small
Toyota	Corolla	98-01	Small
Toyota	Corolla	02-03	Small
Toyota	Tercel	83-88	Small
Toyota	Corolla 4WD Wagon	92-96	Small
Toyota	Prius	03-03	Small
Volkswagen	Golf	82-94	Small
Volkswagen	Golf	95-98	Small
Volkswagen	Golf / Bora	99-03	Small
Alfa Romeo	Sprint	82-88	Sports
Alfa Romeo	GTV	82-84	Sports
Alfa Romeo	GTV / Spider	98-03	Sports
Audi	TT	99-03	Sports
BMW	Z3 E36	97-03	Sports
BMW	Z4	03-03	Sports
Chrysler	Viper	02-03	Sports
Chrysler	Crossfire	03-03	Sports
Daihatsu	Copen	03-03	Sports
Ford	Capri	89-94	Sports
Ford	Probe	94-98	Sports
Ford	Cougar	99-03	Sports

Make	Model	Year of manufacture	NZ Market Group
Ford	Mustang	01-03	Sports
Fiat	X-1/9	82-85	Sports
Holden	Calibra	94-97	Sports
Holden / Isuzu	Piazza	86-88	Sports
Holden	Monaro	01-03	Sports
Hyundai	Tiburon	02-03	Sports
Hyundai	Coupe	96-00	Sports
Mitsubishi	Starion	82-87	Sports
Mitsubishi	3000GT	92-97	Sports
Mazda	RX7	82-85	Sports
Mazda	RX7	86-91	Sports
Mazda	RX7	92-98	Sports
Mazda	MX5 / Eunos Roadster	89-97	Sports
Mazda	MX5 / Eunos Roadster	98-03	Sports
Mazda	Eunos 30X / Presso / MX-3 / Autozam AZ-3	90-97	Sports
Mazda	RX8	03-03	Sports
Mercedes Benz	SLK R170	97-03	Sports
Nissan	300ZX / Fairlady Z	90-95	Sports
Nissan	Gazelle / Silvia	84-86	Sports
Nissan	280ZX	82-84	Sports
Nissan	Exa	83-86	Sports
Nissan	Exa	87-91	Sports
Nissan	NX/NX-R	91-96	Sports
Nissan	200SX / Silvia	94-02	Sports
Nissan	350Z	03-03	Sports
Honda	CRX	87-91	Sports
Honda	CRX	92-98	Sports
Honda	S2000	99-03	Sports
Honda	Prelude	82-82	Sports
Honda	Prelude	83-91	Sports
Honda	Prelude	92-96	Sports
Honda	Prelude	97-02	Sports
Honda	Integra	86-88	Sports
Honda	Integra	90-92	Sports
Honda	Integra	93-01	Sports
Honda	Integra	02-03	Sports
Honda	NSX	91-02	Sports
Porsche	944	82-91	Sports
Porsche	911	82-03	Sports
Porsche	928	82-95	Sports
Porsche	968	92-95	Sports
Porsche	Boxter	97-03	Sports
Renault	Feugo	82-87	Sports
Renault	Megane Cabriolet	01-03	Sports
Rover	MGF / MG TF	99-02	Sports
Smart	Roadster		Sports
Subaru	Vortex	85-89	Sports
Subaru	SVX / Alcyone	92-95	Sports
Toyota	Celica	81-85	Sports

Make	Model	Year of manufacture	NZ Market Group
Toyota	Celica	86-89	Sports
Toyota	Celica	90-93	Sports
Toyota	Celica	94-99	Sports
Toyota	Celica	00-03	Sports
Toyota	Supra	82-90	Sports
Toyota	MR2	87-90	Sports
Toyota	MR2	91-00	Sports
Toyota	Paseo / Cynos	91-99	Sports
Toyota	MR2	00-03	Sports
Lexus	SC430	01-03	Sports