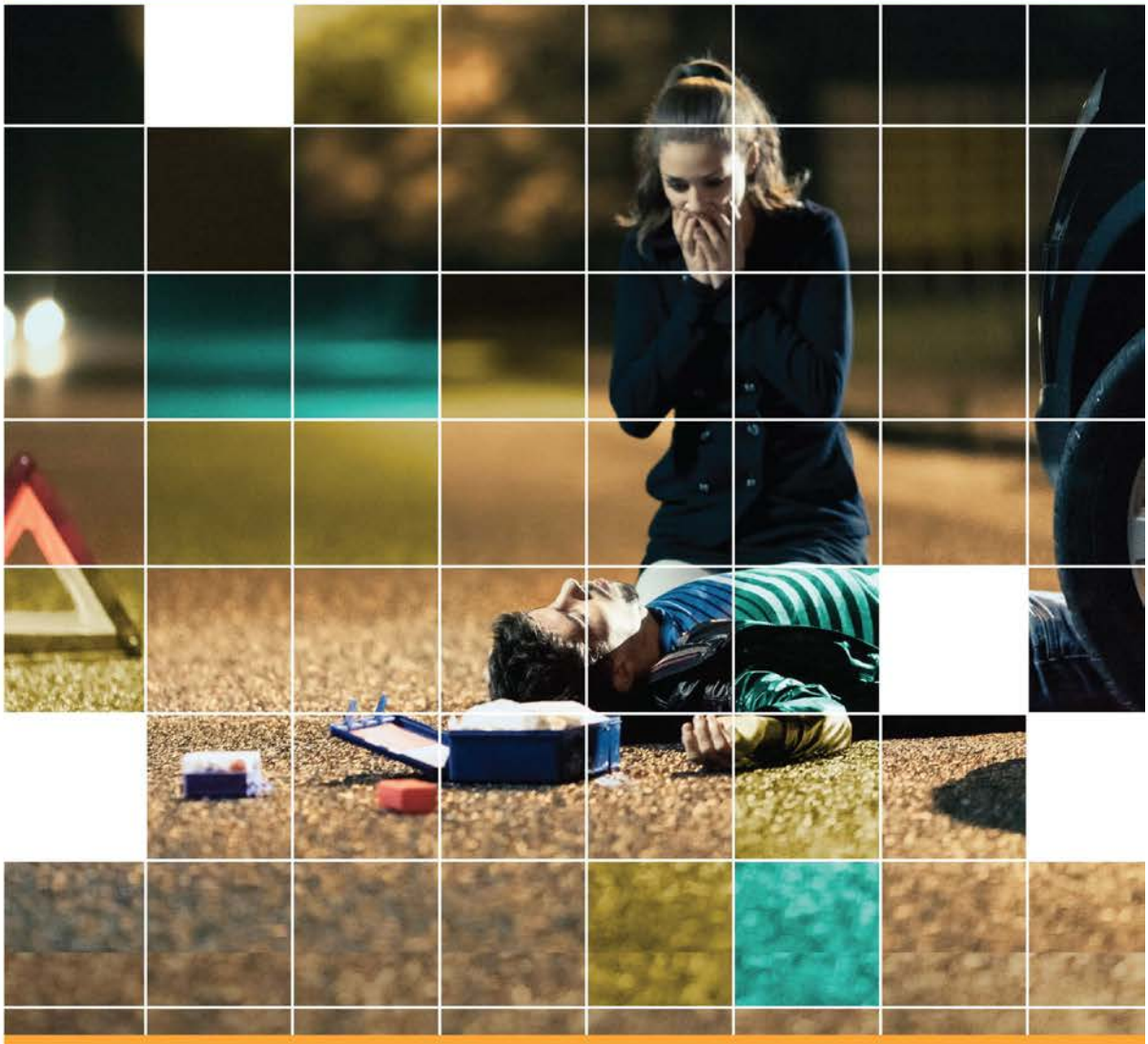
TRANSPORT

Factors causing serious road trauma in each district of the Otago and Southland regions: Results and statistical analyses

Interim report



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Overview

This report provides information for setting road-safety priorities in each district in the Otago and Southland regions. This is the second of two reports prepared to assist those working on road safety in southern New Zealand: the regional transport committees of Otago and Southland, the NZ Transport Agency (NZTA), territorial local authorities (TLA), NZ Police and the Accident Compensation Corporation (ACC). The first report looked at regional priorities and identified the 'Top 5' as being motorcyclists, pedestrians, cyclists, driving under the influence of alcohol and driving on high-speed roads (those with a speed limit of 80kph or higher). This second report looks at priorities for addressing fatal and serious injuries at the district level.

Findings from 12 months of statistical analysis of crash, hospitalisation and ACC data add detail about the patterns and causes of, and factors contributing to, serious road trauma in the eight districts of the two regions: Central Otago District, Clutha District, Waitaki District, Queenstown Lakes District, Dunedin City and Invercargill City, Gore and Southland districts. The report includes recommendations for action, along with some further investigations needed to understand causes so that effective interventions can be designed.

The number of fatal or serious crashes in southern New Zealand has been stable for the past few years, declining only in Southland and Gore districts. The findings set out in this report will assist those organisations involved with road safety to determine where and how to focus interventions to reduce the level of serious road trauma substantially.

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1. Introduction

The aim of this report is to provide scientifically robust information for setting road-safety priorities in each district in the Otago and Southland regions when undertaking strategic or asset management planning, and for designing effective intervention programmes. To that end, the report sets out the findings drawn from analyses of crash, hospitalisation and Accident Compensation Corporation (ACC) data, but explains the evidence upon which each finding is based. The intended audience for this report are those working in territorial local authorities (TLAs), NZ Transport Agency (NZTA), the NZ Police and ACC, all of whom are engaged in planning and prioritising work directed at, or affecting road, road safety.

This is the second of two reports examining the issues associated with serious and fatal crashes in the Otago and Southland regions to establish intervention priorities. The first report, *Road safety in Otago and Southland regions: The top priorities for action,* identified regional road-safety priorities, based on analysis of crash, accident compensation and hospitalisation data. This report looks at priorities at the district level. It describes the patterns and causes of road trauma in the Central Otago District, the Clutha District, the Waitaki District, Queenstown Lakes District, Dunedin City, Invercargill City, Gore and Southland Districts.

The recommendations in this report do not supersede the conclusions in the first report about the Top 5 priorities for action in Otago and Southland; rather they complement them. Both reports derive from the same body of work undertaken at Otago Regional Council (ORC) in 2014, and funded by ORC, Environment Southland and NZTA.

Statistical analyses encompassing entire local government regions (such as the Otago or Southland regions, either singularly or combined) can be problematic from a statistical perspective. For example, analysing the whole of Otago is problematic if serious and fatal crashes are mostly clustered in the Queenstown Lakes District (while minor crashes are mostly clustered in Dunedin City); the analyst fundamentally ends up comparing Dunedin crashes versus Queenstown Lakes crashes, rather than serious/fatal versus minor crashes. This is not particularly helpful to policymakers. To avoid this problem, we looked at districts individually (comparing, for example, serious and fatal crashes in Queenstown Lakes with minor crashes only within Queenstown Lakes, and not with crashes throughout Otago).

Most of the report concentrates on fatal and serious trauma because this is what gives rise to the greatest proportion of social cost. (We have estimated that 33% of total-social cost in Otago and Southland arises from fatalities and 45% from serious, non-fatal injuries, with the remainder from minor injuries.)

For each district, the results cover these matters:

- the factors associated with serious and fatal crashes in each district
- the main themes (issues) that emerged from the analyses of crash, ACC and hospitalisation data
- those crash factors (whether timing, environmental conditions, demographic factors, infrastructure factors or crash characteristics) found to be associated with, or causing, serious and fatal crashes in each district.

- factors common in injury crashes in each district that are associated only with the local roads in the district, or with the state highways (rather than with both)
- the insights gained into the root causes of crashes in each district from factor analysis, a statistical technique.

The themes identified for each district are those that tended to be associated with very high statistical significance levels, thus representing a strong pattern, and which are actionable (meaning each represents an issue that can be targeted for intervention by road-controlling authorities or other relevant stakeholders). These themes give a clear steer to policymakers and decision makers about what they should be addressing. The conclusion puts these district-level results into the context of the overall priorities for the Otago and Southland regions that are set out in *Road safety in Otago and Southland regions: The top priorities for action.*

In each district, the transport network is a mix of local roads and state highways. Identifying the factors common in injury crashes in each district that are associated (solely or principally) with either local roads or state highways (rather than with the roading network as a whole) is important Local roads and state highways serve different purposes and have different management and funding mechanisms. Hence, any action plan to address priorities for intervention identified through statistical analysis needs to factor in these different management regimes.

The statistical techniques used to undertake the analyses from which the results in this report are based are described briefly in the Methodology section (following). The Results section first summarises the number of crashes in each district, and their projected trend for the next few years, then sets out detailed results for each district. (Gore and Southland districts crash-data results are combined for the reason explained in the Methodology section.) A summary at the start of the results for each district lists the main findings for that district and recommendations for the TLAs and NZTA to consider.

The conclusion lists the main themes found for each district. It then examines the relationship between the road-safety priorities for action identified for Otago and Southland regions, and for each of the regions' district, with those in the national road-safety strategy *Safer Journeys,* *New Zealand's road safety strategy 2010-2020* (*Safer Journeys*).

2. Methodology

2.1. Sources of data

This section summarises the methods used and describes issues which readers should be aware of when interpreting the results of the statistical analyses presented here. The method used to identify the priorities for action on road safety in Otago and Southland involved statistically analysing data from three different sources: NZTA's Crash Analysis System (CAS), hospital records and ACC data[1]. Each dataset has strengths and weaknesses when used for this purpose (described in the first report, *Road safety in Otago and Southland region: The top priorities for action).* Analysing all three datasets provides more insight into what is causing or exacerbating road trauma, than does using one of these datasets alone.

The most commonly used source of data available on crashes in New Zealand is from the CAS database (used by the Police to record crashes). This report uses CAS crash records from Otago and Southland over the 2010-2013 period, inclusive. This period was chosen to ensure a reasonably sized dataset that is relevant to the present day (i.e. to ensure that enforcement and reporting rates remain stable throughout the dataset). Using data from earlier (e.g. 2000) could inadvertently bias results due to different patterns of police reporting; using data from later (e.g. 2013 only) does not provide a large enough dataset for detailed analysis.

The Otago dataset contained all reported injury crashes between 2010 and 2013. The Southland dataset did not, however. Specifically, the number of 2013 crashes in the Southland dataset used to produce this report is artificially low, given that the dataset was obtained in mid-January 2014 while unfiled police reports from November and December were still being processed. Using less than 12 months data for 2013 should not have affected the results of the statistical analysis because data from November and December were available for 2010, 2011 and 2012, and only very few crashes, relative to the size of the total dataset, were excluded in late-2013.

Two sources of hospitalisation data were used during the analysis. The hospitalisation data initially used was obtained from the National Injury Query System run by the University of Otago's Injury Prevention Research Unit (IPRU)[2]. This dataset provides demographic information on the individuals discharged from public hospitals following various incidents, including motor-vehicle traffic accidents. IPRU's hospitalisation data is available by TLA, which enables comparisons within each region. All analyses performed on these data were filtered by 'motor-vehicle traffic crash' as the primary cause of injury. The data include all patients involved with motor-vehicle crashes; thus, passengers, cyclists, pedestrians and other road users are included, as well as drivers/riders.

Analysis was also undertaken of the Ministry of Health's data on all public hospital discharges in the Southern District Health Board (covering the Otago and Southland local government regions), which were caused by a 'land-transport accident'. This data covered all publicly funded hospital discharges, from 1st July 2000 to 30th June 2013, with a land-transport accident-external cause code (ICD-10-AM-I codes V01-V89) where the agency

[1] Further detail on the statistical methodology used in contained in unpublished reports held by ORC.

[2] See http://ipru3.otago.ac.nz/niqs/ .

code is Southern District Health Board (4160). The dataset included discharges from a number of agencies in the greater Otago region that do not report under the Southern District Health Board (e.g. Dunstan Charitable Trust)[3].

ACC records are the third major source of information on motor-vehicle crashes. Many motor-vehicle crash victims will lay claims with ACC at some stage during their treatment or rehabilitation phase, and these claims can provide another perspective on motor-vehicle crash records.

While police records examine the contributing factors to the crash (what came before), and hospital records provide information on how the patient fared directly after the crash (what came during and slightly after), ACC records provide an insight into the longer-term effects of crash victims (what comes several months or years later). ACC records also include information on patients' injury and diagnosis, which helps to corroborate information gained from hospitalisation records. If there is a discrepancy between injury types typically sustained in motor-vehicle crashes (obtained from hospital records) and types recorded by ACC, information can be provided on what sorts of patients are most likely to make claims. Furthermore, ACC records provide an insight into other sorts of injuries sustained on public roads in New Zealand (e.g. slips and falls sustained during running, walking, recreational sport or other activities). These types of injuries are rarely examined by local government authorities, but research carried out by Opus Central Laboratories suggests that falls, slips, knocks and other non-motor-vehicle accidents are a major contributor to road-network trauma[4].

2.2. Analyses undertaken

This greater part of the analysis compares serious and fatal injury crashes in each district with minor injury crashes. For each district, two crash types should shed light on what factors tend to be associated with serious and fatal crashes in each district. These two crash types were defined formally as:

- injury crashes occurring in the district between 2010 and 2013 inclusive that were serious or fatal (i.e. at least one road user in the crash suffered a serious injury, including but not limited to broken bones, concussions, etc., and/or died from their injuries)[5]
- injury crashes occurring in the district between 2010 and 2013 inclusive that were minor (i.e. at least one road user in the crash had minor injuries requiring a degree of medical attention, such as cuts and bruises, but no road users in the crash suffered serious injury or died from their injuries).

In this report, only statistically significant differences between the two groups are mentioned. However, all variables provided by the Police in the traffic-crash report were tested for

[3] *Pers. comm*., Chris Lewis, Information Analyst (Analytical Services – Ministry of Health). 3rd December 2013.

[4] Frith, W. & Thomas, J. (2010). The mechanisms and types of non-motor-vehicle injuries to pedestrians in the transport system and indicated infrastructure implications. *New Zealand Transport Agency Research Report 431*.

[5] For more information on police definitions of 'minor', 'serious' and 'fatal', see NZTA's *Guide for the Interpretation of Coded Crash Reports from the Crash Analysis System (CAS),* January 2014, http://www.nzta.govt.nz/resources/guide-to-coded-crash-reports/index.html .

statistical significance. If a variable of interest does not appear in this report, it indicates that there was no statistically significant difference between the two groups.

A judgement is given, based on a chi-squared test, about whether each issue is more of a problem on local roads or on state highways (or both). Where differences are reported between serious trauma on state highways and that on local roads in a district, then each of the factors listed has been determined to be statistically significant at the 95% level or higher. (That is, we can be at least 95% confident that the factors listed do represent a systematic difference between local-road crashes and state-highway crashes in that district, as opposed to random, chance variation.)

The National Injury Query System hospitalisation data was analysed using correspondence analysis, a technique that is used in the early stages of an investigation to visualise data and identify any unusual patterns, which can then be examined in more detail with other statistical methods. Correspondence analysis was used to produce association graphs, which showed whether the patterns were statistically significant or not.

This analysis of ACC data focused on comparing the claims filed for incidents that have occurred in a district. The analysis comprised two separate parts: One analysing claims associated with motor-vehicle crashes that took place on a public road ('motor-vehicle crash claims'), and the other analysing claims associated with non-motor-vehicle accidents (e.g. slipping, falling, tripping and incidents involving individuals getting on/off or in/out of vehicles, etc.). The ACC dataset examined in the preparation of this report was inclusive of all claims involving accidents that took place in the Otago and Southland local-government regions from 1st January 2010 to 31st December 2013, which were paid from the Motor Vehicle Account (i.e. injury was associated with a motor vehicle on a public road[6]), and/or were marked as 'road accident', and/or the scene of the accident was stated as 'road'[7].

This analysis focuses on comparing the claims filed for incidents that have occurred in each of Otago and Southland's eight districts: Dunedin City, Central Otago, Clutha, Queenstown-Lakes, Waitaki, Invercargill, Gore and Southland. (The latter two districts were analysed separately rather than combined as done when analysing CAS data.) Because ACC is an injury-insurance provider, it is fair to assume that all clients who have filed a claim with ACC were injured in the relevant incident.

The analysis of ACC data comprised of two separate parts: One analysing claims associated with motor-vehicle crashes that took place on a public road ('motor-vehicle crash claims'), and the other analysing claims associated with non-motor-vehicle accidents (e.g. slipping, falling, tripping, incidents involving individuals getting on/off or in/out of vehicles, etc.). The number of non-motor-vehicle accident claims far outnumbers the number of motor-vehicle crash claims:

- 8760 claims have been filed for motor-vehicle crash events in Otago and Southland over the 2010-13 period, of which 90 were associated with a fatal crash (1.0%)
- 25442 non-motor-vehicle accident claims have been filed in Otago and Southland over the same period (2010-13), of which eight were associated with a fatal accident (0.03%).

[6] See ACC's website: http://www.acc.co.nz/about-acc/overview-of-acc/how-were-funded/index.htm

[7] *Pers. comm.,* Zeeman Van Der Merwe, ACC Manager for Information Integrity and Analysis. 11th July 2014.

In general, there are about three times as many ACC claims filed for a motor-vehicle crash as there are crashes recorded in the CAS database (although this varies slightly by district). There are two major reasons for this:

- Each crash event is only recorded once in the CAS database, but may involve multiple claims to ACC (e.g. a crash involving two vehicles will only be recorded as a single 'injury crash' in the CAS database, but may result in two separate ACC claims for each vehicle's driver). In addition, passengers may file claims that contribute to the number of claims recorded for each 'injury-crash' event in CAS.
- Under reporting is a known issue; many injury crashes are not recorded in the CAS database[8]. (Table 2 examines this for Otago and Southland data.)

ACC claims are filed by injured individuals, and the CAS data examined involves 'injury crashes', so the two are directly comparable in this regard (as property-damage-only incidents are not included in either dataset).

Two more types of analyses of CAS data were undertaken for the five districts in Otago: Factor analysis and logistic regression. 'Factor analysis' was used to determine the major factors playing a role in crashes in the five Otago districts. It is a statistical technique used to describe variability among a number of observed variables in terms of a smaller number of latent factors that are unobservable[9]. It can provide a clear picture of what needs to be done for each district. The results of the factor analyses for a district are reported under the sub-heading 'Additional insights into the root causes of crashes in … District'. The crash statistics serve as the observed variables; factor analysis can produce a number of unobserved, latent factors that can then be targeted for intervention.

Logistic regression of CAS data was then performed for the five Otago districts, using relevant predictor variables. Logistic regression aims to develop a probabilistic model, relating the likelihood of an event occurring (e.g. a fatal injury) with a number of predictor variables (e.g. daylight, time of day, etc.). This kind of analysis can produce very useful information; for example, knowing that, relative to a serious crash, a fatal crash is twice as likely to occur after midnight can help to prioritise budgeting and spending. The technique yielded a few further insights, reported as part of the findings.

A detailed explanation of the theory behind the statistical techniques used to project the trends shown in the summary of results (Table 4) is beyond the scope of this report. But it is worth noting that all projections in the first sub-section of Results have been generated using seasonal autoregressive integrated moving average (SARIMA/ARIMA) modelling techniques[10].

[8] Alsop, J. & Langley, J. (2001). Under-reporting of motor vehicle traffic crash victims in New Zealand. *Accident Analysis & Prevention, 33,* 353-359. doi: 10.1016/S0001-4575(00)00049-X

[9] See UCLA's article on the subject: http://www.ats.ucla.edu/stat/spss/output/factor1.htm .

[10] For information on this technique, see a reference volume such as Yaffee, R.A. & McGee, M. (2000). *An Introduction to Time-Series and Forecasting.* Massachusetts, USA: Elsevier Academic Press (or the Wikipedia entry http://en.wikipedia.org/wiki/Autoregressive_integrated_moving_average).

2.3. Categorisation of crashes

In this analysis, crashes have been categorised into 'minor' or 'serious/fatal', based on the most severe injury sustained in the crash, which, in turn, is based on the standard convention in New Zealand.

'Fatal crashes' are those in which a crash casualty died at the scene or within 30 days of the crash as a result of injuries sustained in that crash; 'serious crashes' involve broken bones, concussions, etc. and are frequently associated with an overnight stay in hospital; 'minor crashes' involve cuts, sprains, bruises, etc. and do not usually require detention in hospital. Police officers assess the severity of the crash upon arrival at the crash scene, as follows:

- If one or more fatal injuries were sustained, the crash was classed as '*serious or fatal'*.
- If one or more serious injuries were sustained, the crash was classed as '*serious or fatal'*.
- If no serious injuries were sustained, the crash was classed as '*minor'*.

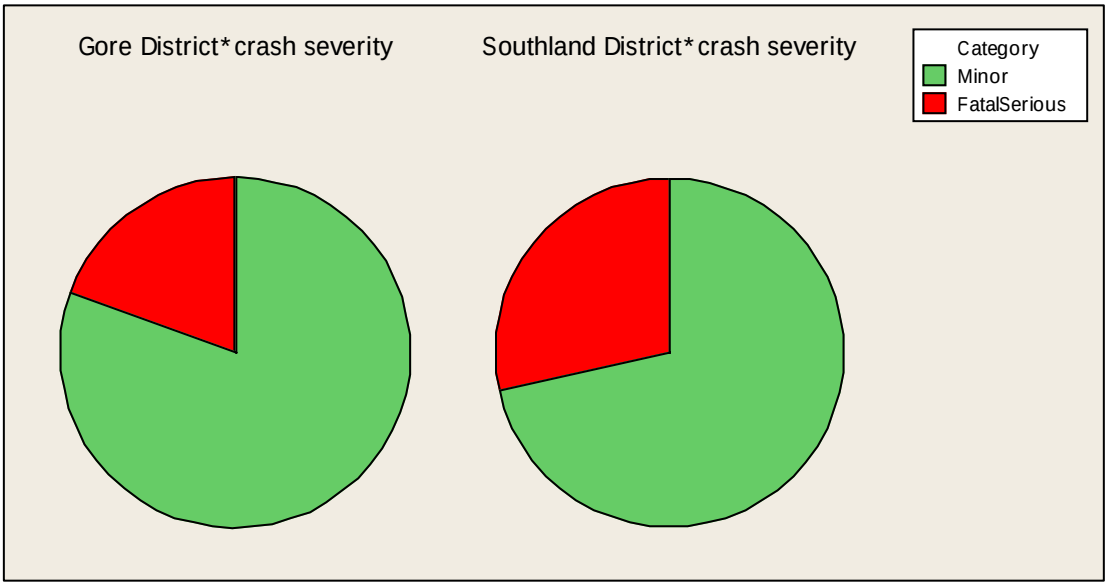
Analysis presented in this report compares '*serious or fatal'* crashes with '*minor'* crashes in each district.

Other than a single situation where we might have expected to see a difference between 'serious/fatal' and 'minor' crashes, we saw no trends over time. Situations where no systematic differences were observed between '*serious or fatal'* and *'minor'* crashes are not discussed here.

2.4. Analysis of data by local government district

Data for each local-government district in the Otago and Southland regions was analysed separately with the exception of Gore District and Southland District. Gore and Southland districts were combined because Gore was too small to analyse individually (apart from the ACC data). There is no statistically significant difference in crash distribution of fatal, serious and minor crashes in Gore and Southland districts (i.e. crashes involving serious road trauma make up about the same proportion of the overall crash profile in both districts). Overall, 19.4% of injury crashes in Gore District between 2010 and 2013 have been classed as '*serious or fatal'*; 28.5% of injury crashes in Southland District have been classed as *fatal or serious*. Serious and fatal crashes make up about the same proportion of the overall crash record in Gore and Southland districts, and there is no statistical evidence ($\chi^2 = 3.601$, *p*-value > 0.05) that serious and fatal crashes are apportioned differently between Gore and Southland districts, compared with minor crashes. Any apparent difference in fatal and serious crash proportions between the two graphs in Figure 1 below can be attributed to random chance, given the high *p*-value quoted above.

Figure 1 **Comparing the severity of injury crashes in Gore and Southland districts, 2010-2013**



2.5. Methodological issues and the interpretation of results

2.5.1. A note concerning interpretation of statistically significant results

Statistical analysis enables us to determine whether patterns are real or false. It eliminates the human tendency to assume most patterns are real and uses mathematics to determine whether, for example, a coin or die is weighted. The usefulness of statistical analysis in a road-safety context cannot be understated. Is speeding truly associated with young people, or is that assumption related to the bias of road-safety specialists? (That is, they know that young people tend to crash more and are risk-takers, so they will tend to interpret ambiguous results as indicating that young people tend to speed.) The only fair way to determine whether young people really are over represented in speeding crashes (for example) is to use mathematics, specifically, statistical analysis.

When an issue is statistically significant, this indicates that the observed pattern is very unlikely to be due to chance. Different researchers have different thresholds for 'significance'; a common threshold in scientific research is 95% (i.e. a result is reported to be systematic and not due to chance when we are 95% sure, statistically, that the pattern is systematic).

2.5.2. Sampling of crashes

One of the most prominent issues with the CAS database is the common tendency, regionally, nationally and internationally, for crashes to be under reported; that is, there are many crashes that take place which do not ever enter the database. This has been well established in both the national[11] and international[12] literature. The Ministry of Transport

[11] Alsop, J. & Langley, J. (2001). Under-reporting of motor vehicle traffic crash victims in New Zealand. *Accident Analysis & Prevention, 33,* 353-359. doi: 10.1016/S0001-4575(00)00049-X

[12] Amoros, E., Martin, J.-L. & Laumon, B. (2006). Under-reporting of road crash casualties in France. *Accident Analysis & Prevention, 38,* 627-635. doi: 10.1016/j.aap.2005.11.006

attempts to take this under reporting into account when calculating the social cost of road trauma in New Zealand[13].

Under reporting would not be a major issue if crashes were under reported equally; that is, if the crashes in the CAS database were a representative sample of the actual population of all crashes in a particular region or district. However, this is not the case; research indicates that some crashes are more likely to be reported than others. In particular, fatal and serious crashes are more likely to be reported than minor crashes, which, in turn, are more likely to be reported than property-damage-only crashes. Other factors influencing whether or not a crash will be reported include[1]: the number of vehicles involved, the age of the road users involved in the crash, the month and the geographic region in which the crash occurred[1].

Clearly, this is a major issue, as it means that the sample of crashes recorded in the CAS database is not a representative sample of all crashes occurring in New Zealand. For this reason, generalising statistics and results obtained from the database to the overall crash population in a particular region is theoretically problematic, and should be executed with caution. At the very least, the limitations of the database should be made clear, such that readers interpret the report with this in mind.

2.5.3. Subjective assessment of causal or contributing factors

Many of the results reported in the CAS database are the result of judgements made by the Police officer(s) at the crash scene. As an example, with respect to road curvature, the Police officer attending the crash notes whether the crash occurred on a straight section of road, or an easy, moderate or severe curve (one example of the many factors on which subjective assessments are made). Some factors are left to the discretion of officers more than others. For example, simple facts of the crash, such as the time of day it occurred, the vehicles involved, and the drivers' demographic details (age, sex and licence type) should not differ strongly between officers. By contrast, other variables, such as whether the officer believes speed was a factor in the crash, are likely to be subjective and vary according to the officers' individual beliefs, preferences and (often unintentional) biases.

Such judgements, which are the discretion of the attending officer, introduce a subjective element into the database. Potentially, an individual crash may be coded differently by different officers. This comment is not intended as a criticism of Police officers attending crashes, rather an observation on the need for adequate training of those attending crashes and of systems to minimise variation arising from subjective assessments.

This subjectivity in data inputted to CAS as a causal or contributing factor in crashes is a fundamental methodological issue. This limitation in the database must be considered when determining how to interpret the findings from this report. All findings in this report based on police judgement are noted as such.

On the other end of the scale, when multiple statistical analyses are undertaken, the risk of detecting a false association (i.e. believing that there is a statistically significant effect when in reality there is none, and the association is random chance) increases[14]. To counter this

[13] See the Ministry of Transport's website: http://www.transport.govt.nz/research/roadcrashstatistics/thesocialcostofroadcrashesandinjuries/ .

[14] For more information on this phenomenon, see further information on the 'multiple comparisons problem' in

effect, patterns in this analysis are only reported with a *p*-value of 0.01 or lower (i.e. 99.0% significance or higher).

Wikipedia: http://en.wikipedia.org/wiki/Multiple_comparisons.

3. Results

3.1. Number of injuries and crashes, with trend over time in each district

Table 1 below shows the number of serious, fatal and all injury crashes in each district for the period 2010-13, inclusive. The data are for crashes reported through the CAS system. It is worth noting that the reporting rates for types of crash varies by travel mode, and are relatively low for some modes (see Table 2). The figures in Table 2 are derived by comparing ACC and CAS data and do not take into account crashes not reported in either database. (The estimate for motor vehicles is based on the number of people in crashes to remove the potential for double counting, when more than one person is injured in a crash.)

Note that reference to a district or city refers to all that district or city's local roads and state highways, not just to the roads managed by a district or city council.

Table 1 **Number of injury crashes in each district, 2010-13, inclusive**

District	No. of serious injury crashes	No. of fatal injury crashes	Total no. of serious or fatal injury crashes	% of injury crashes that are fatal or serious
Central Otago District	65	7	72	36.0
Clutha District	78	9	87	25.8
Dunedin City	274	20	294	19.9
Gore & Southland districts	151	20	171	27.0
Invercargill City	79	6	85	18.1
Queenstown Lakes District	78	8	86	26.6
Waitaki District	52	14	66	25.7

Table 2 **Estimate of the percentage of Otago and Southland injury crashes on roadways not captured in CAS, 2010-13**

Type of road user (mode)	Percentage of injury crashes (or accidents) not captured in CAS
Motorcyclists	74% or more
Pedestrians	**57% or more**
Cyclists	43% or more
Motor vehicles (excludes motorcycles)	**27% or more**

Examination of the cost of ACC claims for each mode suggests that CAS probably captures most of the serious crashes and all of the fatal crashes, but under reports minor crashes. The percentage of pedestrians in CAS, for example, is roughly the same as the percentage of ACC claims that are most serious ((the latter indicated by the magnitude of treatment costs). A similar pattern exists for motorcyclists).

In looking at comparative degree of road trauma in each district, the number of fatal, serious and minor injuries in each district only gives part of the picture. Another indication of the degree of serious road trauma in each district can be obtained by examining ACC pay-outs: The percentage of pay-outs that are expensive or low cost.

Table 3 summarises the number of injuries and size of pay-outs for motor-vehicle crashes in each district, 2010-2103, inclusive. The data are from ACC claims on ACC's Motor Vehicle Account. This shows that Central Otago and Clutha districts experience a higher proportion of expensive ACC pay-outs compared to other districts in Otago and Southland.

The average or range of costs of an ACC claim is a good proxy for injury severity. It is completely independent of subjective opinion, unlike subjective assessments at/after a crash scene of injury of whether an injury is serious or minor.

Table 3 **Number of injuries and size of payouts, for motor-vehicle crashes in each district, 2010-2103, inclusive (Source: ACC claims, Motor Vehicle Account)**

District	Number of injuries suffered by client (on average)	Relative level of compensation provided by ACC
Central Otago District	Majority of ACC claims filed involve clients with multiple injuries. On average, clients experiencing a crash in this district experience more injuries than clients involved in a crash in any other district in Otago or Southland.	High pay-outs: 72.0% of its motor-vehicle crash-related claims involve relatively low pay-outs of $999.99, or less.
Clutha District	Majority of ACC claims filed involve clients with multiple injuries	High pay-outs: 69.4% of its motor-vehicle crash-related claims involve relatively low pay-outs of $999.99, or less.
Dunedin City	Majority of ACC claims filed involve clients with only single injuries	Low pay-outs: 83.8% of its crash-related claims involve relatively low pay-outs ($999.99, or less).
Gore District	Majority of ACC claims filed involve clients with only single injuries	Low pay-outs: 81.0% of its motor-vehicle crash-related claims involve relatively low pay-outs of $999.99, or less.
Invercargill City	Majority of ACC claims filed involve clients with only single injuries	Low pay-outs: 83.2% of its motor-vehicle crash-related claims involve relatively low pay-outs of $999.99, or less.
Queenstown Lakes District	Majority of ACC claims filed involve clients with only single injuries	Moderate pay-outs: 78.5% of its motor-vehicle crash-related claims involve relatively low pay-outs of $999.99, or less.
Southland District	Majority of ACC claims filed involve clients with only single injuries	Moderate pay-outs: 78.9% of its motor-vehicle crash-related claims involve relatively low pay-outs of $999.99, or less.
Waitaki District	Majority of ACC claims filed involve clients with only single injuries	Moderate pay-outs: 77.0% of its motor-vehicle crash-related claims involve relatively low pay-outs of $999.99, or less.

3.2. Projected trend in road injuries for each district

The number of serious and fatal crashes in southern New Zealand has not increased over the past few years, and is staying stable in each district, with the exception of Gore and Southland districts, where it is decreasing sharply[15]. Table 4 summarises the projected trend for each district for all injury levels (fatal, serious and minor) for the next three or so years. This is based on CAS data only and does not take the under reporting in CAS into account.

Table 4 **Projected trend in road injuries by district and region, Otago and Southland, estimated on data to 2013, inclusive**

Area	Projected trend in road trauma (all injuries)
OTAGO REGION	Slight increase
Dunedin City	Slight increase
Clutha	Stable
Waitaki	Stable
Central Otago	Stable
Queenstown Lakes	Slight decrease
SOUTHLAND REGION	Stable
Invercargill City	Stable
Gore and Southland districts	Decrease

Note that crash numbers are too small to project the level of serious injuries or fatalities for all districts; hence Table 4 examines all injuries, including minor ones.

3.3. Important note regarding the results for each district

The next sections summarise the findings for each district. These are principally based on analysis of CAS data, but they also incorporate findings from the analysis of hospital and ACC data for each district. Note that reference to a district or city refers to all of that district or city's local roads and state highways, not just to the roads managed by a district or city council.

The two tables in the Appendix list the factors common in motor-vehicle crashes, and non-motor-vehicle crashes and accidents in each district for 2010-2013, inclusive, identified from analysis of ACC claims.

[15] Unpublished analyses undertaken by Elle Flinn, ORC, 2014.

3.4. Central Otago District results

3.4.1. Findings and recommendations, summarised

Five themes emerged from analysis of data for Central Otago District:

- Local roads tend to host a high proportion of fatal and serious crashes.
- The district has a very high number of serious injuries for its population size (and relative to other districts in Otago and Southland, a higher proportion of expensive ACC claims).
- There is a serious road-safety issue associated with motorcycles.
- Many of the serious and fatal crashes happen on the weekend, particularly on a Saturday.
- Serious and fatal crashes disproportionately involve blood alcohol in excess of the legal limit.

Other findings:

- Weekend holidaymakers visiting Central Otago are a primary cause of road deaths and injuries in the region. These holidaymakers are frequently vulnerable road users (especially motorcyclists), and any crash they experience is likely to have a serious outcome.
- Cutting corners (and swinging wide) in the Central Otago District is nearly always coupled with inadequate signage, invisible-road markings or the absence of street lights.
- Relative to minor crashes, serious and fatal crashes in Central Otago District:
  - are closely associated with weekends / Saturdays and typically do not take place on Wednesdays
  - are closely associated with evenings and typically do not take place in the mornings
  - are closely associated with one or more parties recording a blood alcohol level over the legal limit
  - are closely associated with motorcycles in the key-vehicle role.
- Compared to state highways, local roads have a high proportion of serious injuries and a low proportion of minor injuries.
- Local roads in have a high proportion of crashes involving animals, relative to state highways.

Recommendations for the Central Otago District Council and/or NZTA to consider:

1. Initiate some kind of weekend-protection programme for tourists to the region, which would assist in increasing safety on local roads and for vulnerable motorcyclists. Police may wish to focus most of their Central Otago speed and alcohol operations on local roads during the weekend.

1. Increase public awareness about the issues surrounding following distance in the region. Because many roads have sudden or sharp turns, it is crucial for the public to understand that following too closely can lead to a crash quite easily.

2. On roads where vehicles are known to cut corners or swing wide, investigate whether changing the road markings in the area would reduce the incidence of drivers deliberately cutting corners.

3. Investigate the extent to which under reporting of local-road crashes (particularly minor crashes) is understood in Central Otago and liaise with Police and the community to improve reporting rates in the area.

4. Investigate how to lower the rate of animal-induced crashes in the district. Better protection of household pets may also merit investigation, given the high rate of pet-induced injuries in the region relative to a location like Dunedin City, which should have the highest frequency of pet-induced injuries simply based on sheer volume of pets.

3.4.2. Themes found in the analysis of serious and fatal crashes

Theme 1: Local roads in the Central Otago District tend to host a high proportion of fatal and serious crashes.

51.4% of serious- and fatal-injury crashes in the Central Otago District have taken place on local roads (2010-2013); in contrast, 25.8% of minor-injury crashes have taken place on local roads (see figures 2 and 3).

Figure 2 **Comparative severity of injury crashes in Central Otago District, 2010-2013, on state highways and local roads**

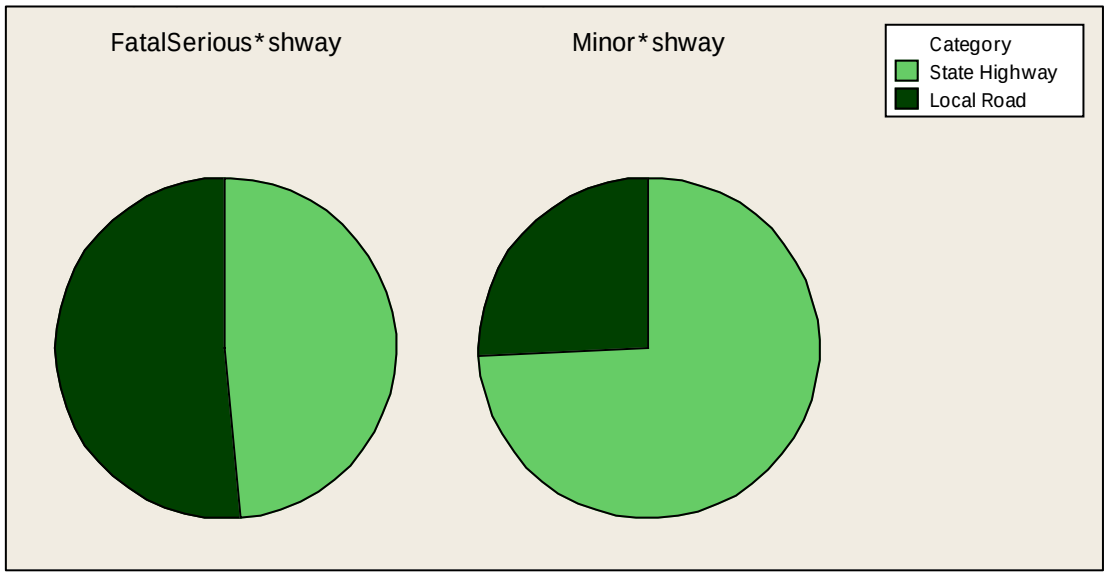
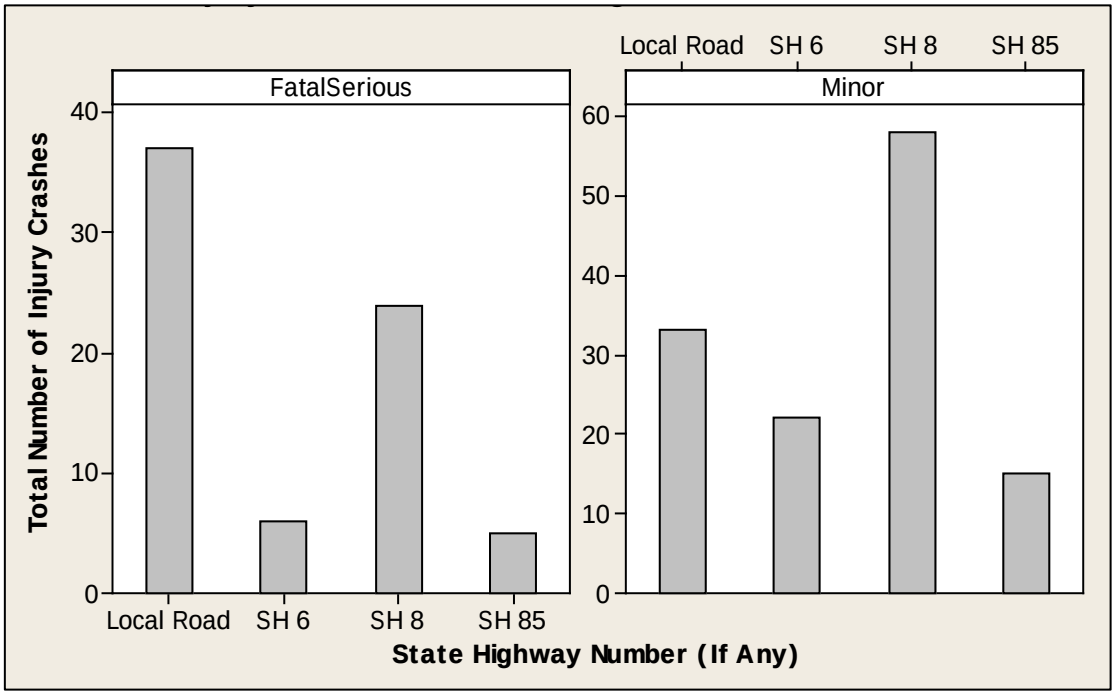


Figure 3 **Number of injury crashes on each state highway in the Central Otago District, 2010-2013**



Compared to state highways in the Central Otago District, local roads have a high proportion of serious injuries and a low proportion of minor injuries. There is strong evidence (99.9%) to suggest that fatal and serious crashes in the Central Otago District are closely associated with the area's local-road network, compared with minor crashes.

While 51.4% of serious and fatal injury crashes have taken place on local roads (2010-2013), 25.8% of minor-injury crashes have taken place on local roads (2010-2013). Moreover, 52.9% of reported-injury crashes taking place on local roads have been classed as '*fatal or serious'*. This means that over half of all reported-injury crashes taking place on local roads resulted in a serious injury to at least one road user (and some of those injuries may have proved fatal).

Clearly, the two pie charts in Figure 2 show a very different pattern. The panel on the left, describing fatal- and serious-injury crashes in Central Otago, indicates an even split across state highways and local roads; by contrast, the panel on the right, describing minor-injury crashes in Central Otago, is closely associated with state highways, with only a few minor crashes taking place on local roads.

These two graphs in Figure 3 hold a similar shape, with the exception of the 'local road' category; most of fatal- and serious-injury crashes have taken place on local roads, while minor crashes are more likely to take place on the state-highway network.

Figure 4 **Comparative severity of injury crashes on state highways and local roads in Central Otago, 2010-2013**

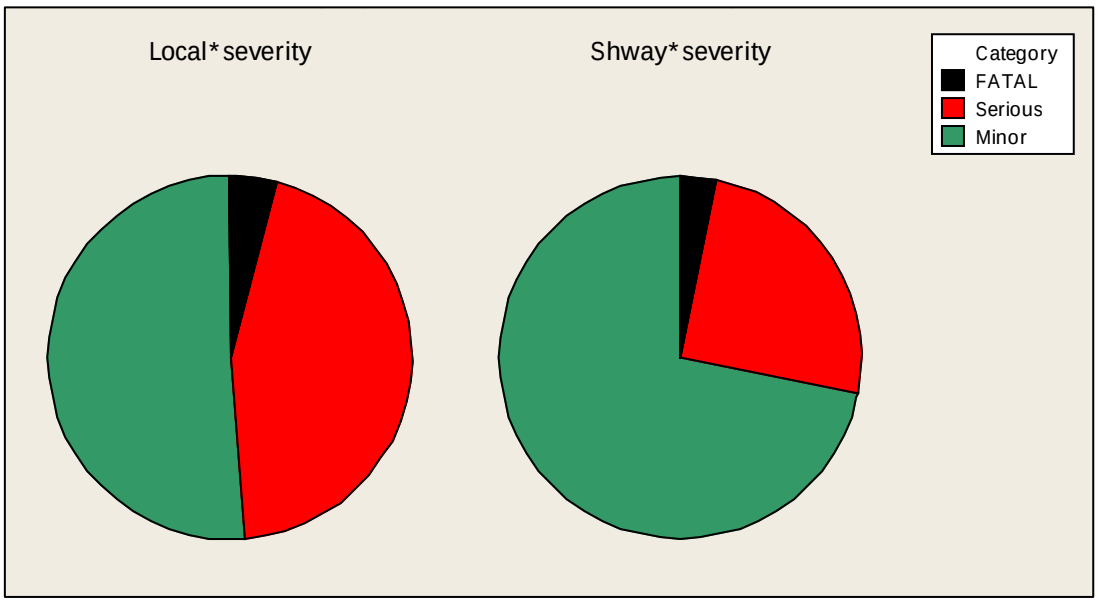


Figure 4 shows this discrepancy clearly. The left pie chart shows the distribution of injury severity on local roads in Central Otago, and the right pie chart shows the distribution of injury severity on state highways in Central Otago.

The state-highway network shows the expected distribution based on international literature: 72% of its crashes are minor, 25% serious and 3% fatal. By contrast, the local-road network shows a much more deadly distribution: 51% of its crashes are minor, while 44% are serious and 4% are fatal. Half of all reported crashes on Central Otago's local-road network are either fatal or serious, requiring hospitalisation overnight. There are (at least) two possible explanations for this phenomenon. Either police reporting of minor crashes on local roads is extremely low, or else local roads are of poorer quality, resulting in more serious crashes than on state highways (which often have protective barriers or other safety features). In all likelihood, both situations apply: Under reporting of minor crashes on Central Otago's local roads is likely to be a problem, and state highways are likely to have higher safety standards, resulting in fewer serious and fatal crashes (by proportion).

Areas requiring further investigation if these findings are to be explained are:

1. whether local roads in Central Otago are inherently more dangerous than state highways, resulting in a higher proportion of serious and fatal crashes (taking into consideration such matters as road configuration, maintenance levels, signage and the speed limit)

2. whether local roads are associated with riskier driving behaviours than state highways

3. whether there is an under reporting issue where minor crashes are reported far less often than serious or fatal crashes. If this were the case, and if under reporting were more prevalent on local roads (perhaps due to their remoteness from police headquarters and the lack of traffic on these roads, relative to state highways), then the local-road graph may appear quite skewed, with a high proportion of fatal and serious

crashes, not because fewer minor crashes occur, as the above two suggestions hypothesise, but because fewer minor crashes are reported.

Theme 2: Central Otago District has a high number of serious injuries for its population size.

Analysis of crashes reported to the police-crash data shows that Central Otago hosts a high number of serious crashes, relative to other districts in Otago and Southland. The district only makes up a small proportion of total reported injury crashes (7.9%) in Otago, but a significantly higher proportion of all serious reported injury crashes (12.2%) for the region. This crash data, as well as the ACC data, suggests that crashes in Central Otago tend to be more serious (on average) than crashes in other parts of Otago and Southland.

Moreover, ACC clients who experienced a motor-vehicle crash in Central Otago District suffer more injuries, on average, than clients who experienced a crash in any other district in Otago or Southland. Furthermore, relative to other districts in Otago and Southland, Central Otago District has a higher proportion of expensive ACC claims.

54.1% of ACC claims filed for motor-vehicle crashes occurring in Central Otago (2010-13) are filed by clients who suffered multiple injuries during the crash event. This is a higher proportion of multiple-injury claims than any other district in Otago or Southland. Presuming that the claims data are representative of all crashes in the district (i.e. all crashes are equally likely to result in an ACC claim on behalf of the crash victim), this indicates that – in general – crashes in Central Otago tend to result in more injuries than crashes in any other district.

Theme 3: There is a serious road-safety issue associated with motorcycles in Central Otago District.

There is powerful evidence (99.5%) that fatal and serious crashes in the Central Otago District tend to involve different key vehicles, when compared to minor crashes. The Police categorise key vehicles[16] into: '*Car'* (or station wagon), '*SUV'* (or 4x4), '*Van'* (or Ute), '*Truck'*, '*Bus'*, '*Motorcycle'*, '*Moped'* and '*Cyclist'*.

75.0% of all injury crashes involving a motorcycle in the key-vehicle role resulted in a serious injury to at least one road user (and some of those injuries proved fatal). In comparison, 36.0% of all injury crashes in the district were classed as '*serious or fatal'*.

Relative to minor crashes, serious and fatal crashes are closely associated with motorcycles in the key-vehicle role. The high rate of motorcycle crashes is a problem, both on local roads and state highways. There is no evidence that the high rate of motorcycle crashes can be attributed mostly to crashes on the local-road or state-highway networks. Any apparent

[16] See NZTA's *Guide for the Interpretation of Coded Crash Reports from the Crash Analysis System (CAS),* January 2014, http://www.nzta.govt.nz/resources/guide-to-coded-crash-reports/index.html . The '*key vehicle'* is defined by the Police as 'the vehicle exhibiting the bolded movement on the police-movement coding sheet[16]'. Note that this does not necessarily indicate fault.

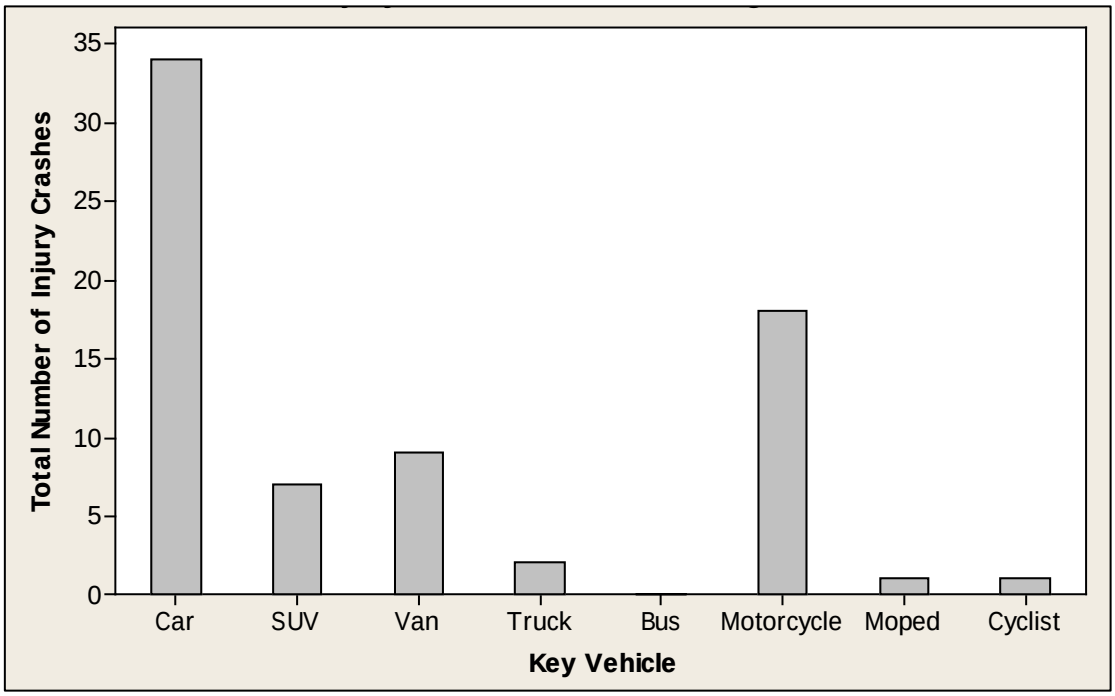
variation in the proportion of motorcycle crashes between the state-highway and local-road networks is not systematic, and can be attributed to random chance.

Clearly, the biggest difference between figures 5 and 6 is the '*Motorcycle*' category. Motorcycle riders are at a much higher risk of death or serious injury when compared with other road users in the Central Otago District. Three-quarters of all injury crashes involving a motorcycle in the key-vehicle role resulted in a serious injury to at least one road user (and some of those injuries may have proved fatal).

Motorcycles feature prominently in the fatal- and serious-injury graph, but, in contrast, barely feature at all in the '*Minor'* graph, with fewer crashes than key-vehicle '*SUVs'* and key-vehicle '*Vans'*. Clearly, most crashes involving a '*Motorcycle'* in the key-vehicle role do have serious outcomes for at least one road user in the crash (probably the motorcyclist).

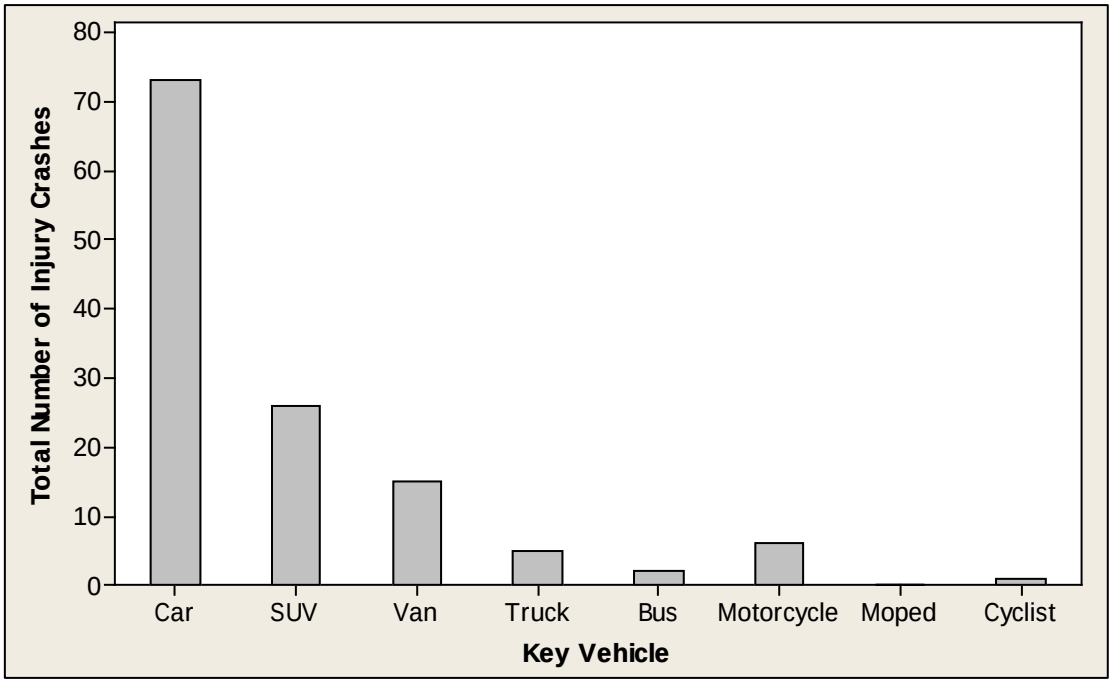
This finding is not surprising, as academic research has long indicated that motorcycles are over-represented in traffic accidents, including serious-traffic accidents (i.e. serious- and fatal-injury accidents). This means that not only are motorcyclists more likely to be involved in a crash than other road users, but that crash is more likely to be serious or fatal. Singaporean data, for example, indicate that motorcycle crashes comprise about 40% of all fatalities, but only comprise 19% of motorised vehicles in Singapore[17]. This finding raises the question of whether there is something about the district that makes it particularly susceptible to serious traffic crashes involving motorcycles.

Figure 5 **Fatal and serious injury crashes in the Central Otago District, 2010-2013, by vehicle type**



[17] Quddus, M.A., Noland, R.B. & Chin, H.C. (2002). An analysis of motorcycle injury and vehicle damage severity using ordered probit models. *Journal of Safety Research, 33,* 445-462. doi: 10.1016/S0022-4375(02)00051-8

Figure 6 **Minor injury crashes in the Central Otago District, 2010-2013, by vehicle type**



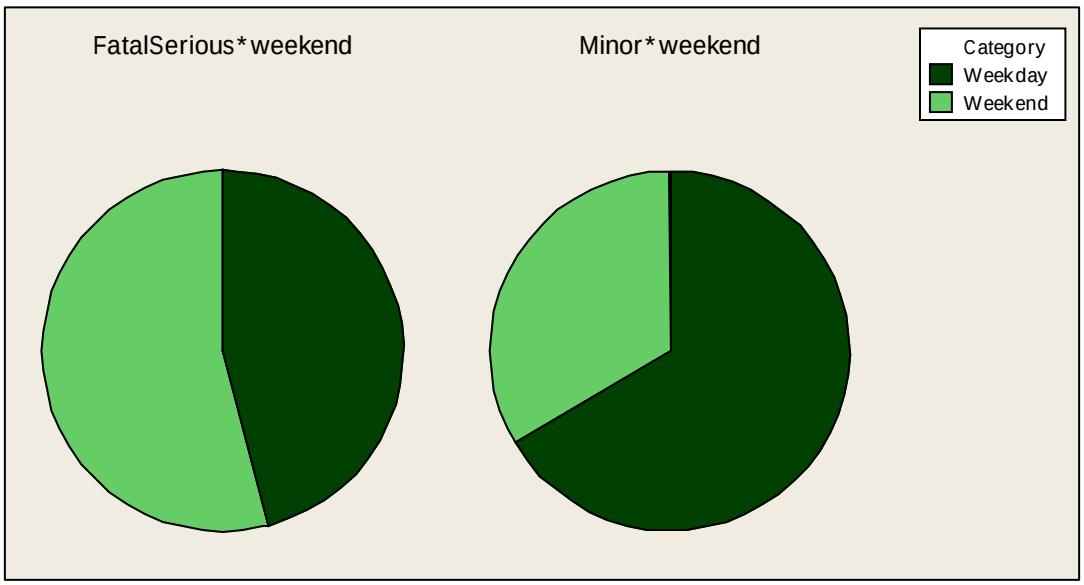
Theme 4: Serious and fatal crashes in Central Otago happen on the weekend (particularly Saturdays).

As shown in Figure 7, fatal and serious crashes in tend to occur during the weekend, particularly on Saturday. There is powerful evidence (99.5%) that serious and fatal crashes tend to occur during the weekend, compared with minor crashes. '*Weekend*' indicates that the crash occurred between 6 pm on Friday and 5:59 am on Monday on ordinary weekends, or between 4 pm on the first day and 5:59 am on the final day of holiday weekends. All other crashes are classed as '*Weekday*'.

Clearly, the two pie charts in Figure 7 show a different pattern. Most fatal and serious crashes in Central Otago over the 2010-2013 period have occurred during the weekend; by contrast, most minor crashes occur during the working week. Overall, 54.2**%** of serious- and fatal-injury crashes have taken place over the weekend; by contrast, 33.6% of minor crashes have taken place over the weekend.

Moreover, as Figure 8 shows, fatal and serious crashes are strongly associated with Saturdays (relative to minor crashes); over half of all injury crashes taking place on a Saturday in Central Otago (2010-2013) resulted in a serious injury to at least one road user (and some of those injuries proved fatal). Figure 9 shows the comparative data for minor-injury crashes, where the number of injuries is more evenly spread across the days of the week (with a drop occurring on Mondays).

Figure 7 Comparative timing of injury crashes in the Central Otago District, 2010-2013, by weekend or weekday



This poses the question of whether weekends are inherently risky in the Central Otago District (e.g. more traffic on the road during the weekend), or whether certain 'risky' driving behaviours are associated with the weekend. Both recreational motorcycling and alcohol intoxication, for example, are likely to be more common over the weekend, and both tend to be associated with fatal/serious crashes, thus causing weekends to have a more severe-crash record compared with weekdays).

Figure 8 **Fatal- and serious-injury crashes in the Central Otago District, 2010-2013, by day of the week**

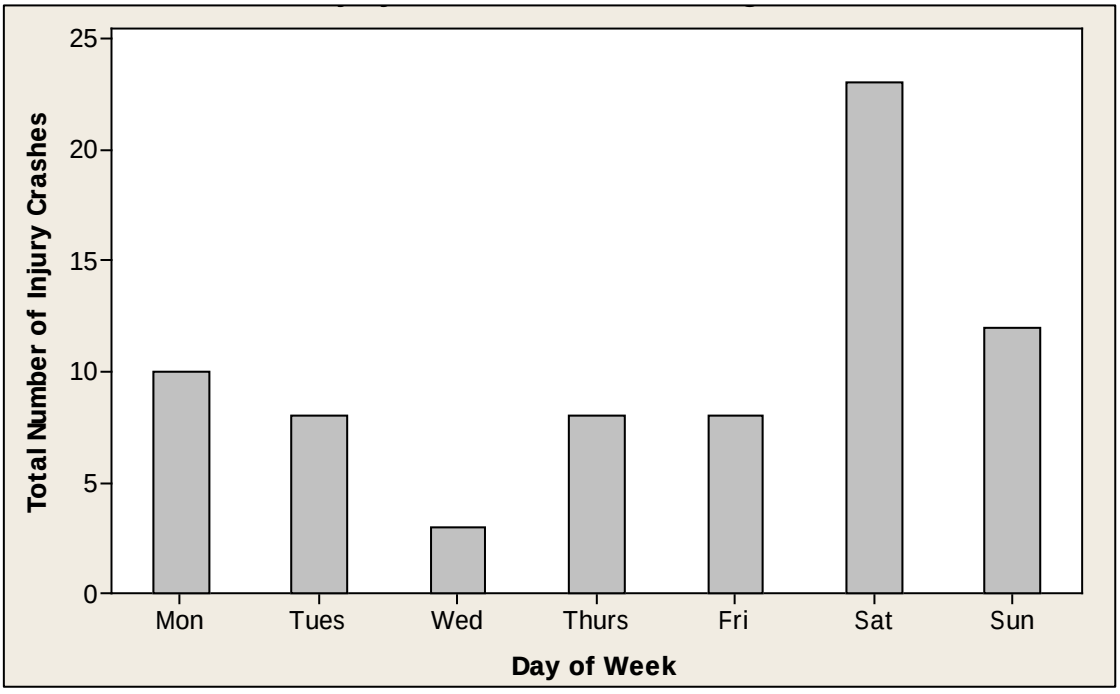
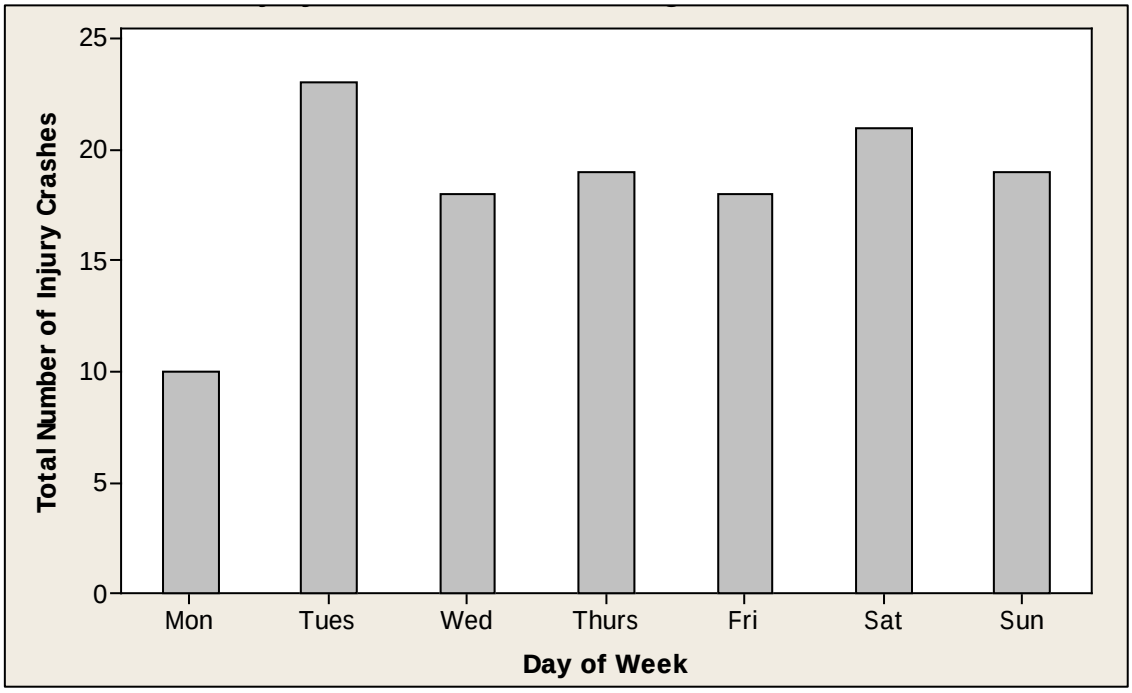


Figure 9 **Minor-injury crashes in the Central Otago District, 2010-2013, by day of the week**



The high number of weekend crashes in the Central Otago District, relative to the other Otago districts, can be largely attributed to Central Otago's local-road network. Local Central Otago roads have a high proportion of crashes on weekends, relative to state highways. State highways have a high proportion of crashes on weekdays, relative to local roads. The evidence that the distribution of weekend crashes is not equal across the state-highway and local-road networks is strong (99%). Specifically, 66% of state-highway crashes occur during the working week (Monday-Friday), while 34% occur during the weekend. By contrast, 46% of local-road crashes occur during the working week; 54% occur during the weekend. The fact that more than half of local-road crashes take place during the weekend (a two-day period, as opposed to the five days taken up by the working week) indicates that weekend crashes are over represented.

The reason for the high rate of local-road crashes during the weekend is unclear. Police reporting may possibly have an impact. However, no information is available on Southern District police-reporting rates during the weekend, making speculation difficult. In addition, police under reporting alone is unlikely to explain the huge discrepancy shown above. One potential reason may be that Dunedinites and other visitors often visit Central Otago during the weekend for a brief holiday getaway, and use local roads to travel around and view the countryside. Unlike locals, however, visitors are not necessarily familiar with Central Otago's roading system.

Theme 5: Serious and fatal crashes in the Central Otago District disproportionately involve blood alcohol in excess of the legal limit.

Relative to minor crashes, serious and fatal crashes in the Central Otago District are closely associated with one or more parties recording a blood alcohol level over the legal limit.

A crash was categorised as '*AboveBAC Limit*' if one or more parties in the crash were noted to be above the legal limit for alcohol and/or refusing to take the test (crash code 103). According to the Police, refusing the test is very rare; most of the 103-coded crashes involve road users who were above the legal alcohol limit[18]. There is strong evidence (99.0%) that fatal and serious crashes in Central Otago are more likely to involve one or more drivers over the legal blood alcohol limit, compared with minor crashes.

Figure 10 **Comparative severity of injury crashes where driver is above the BAC limit, or not, in Central Otago District, 2010-2013**

The pie charts in Figure 10 above show that excess blood alcohol is a factor in a sizeable proportion of fatal and serious crashes, but is a much smaller factor in minor crashes.

Overall, 15.3% of fatal and serious crashes involved one or more parties in the crash recording an alcohol level over the legal limit; by contrast, 4.7% of minor crashes in the district involved one or more parties in the crash recording an alcohol level over the legal limit.

This is not a surprising finding, as international research indicates that blood alcohol levels in excess of the legal limit are associated with more severe-crash outcomes. Excess blood alcohol has long been linked to negative outcomes in road safety, including both an increased incidence (drivers are more likely to crash when under the influence of excess blood alcohol) and crash severity (crashes involving intoxicated drivers tend to be serious or fatal, rather than minor incidents)[19].

[18] *Pers. comm.*, Steve Larking, Acting Road Policing Manager for the Southern District. 13th Nov., 2013.

[19] Kim, K., Nitz, L., Richardson, J., & Li, L. (1995). Personal and behavioral predictors of automobile crash and injury severity. *Accident Analysis & Prevention, 27,* 469-481.doi: 10.1016/0001-4575(95)00001-G

3.4.3. Factors associated with serious and fatal crashes

Crash characteristics and causes

Time of day

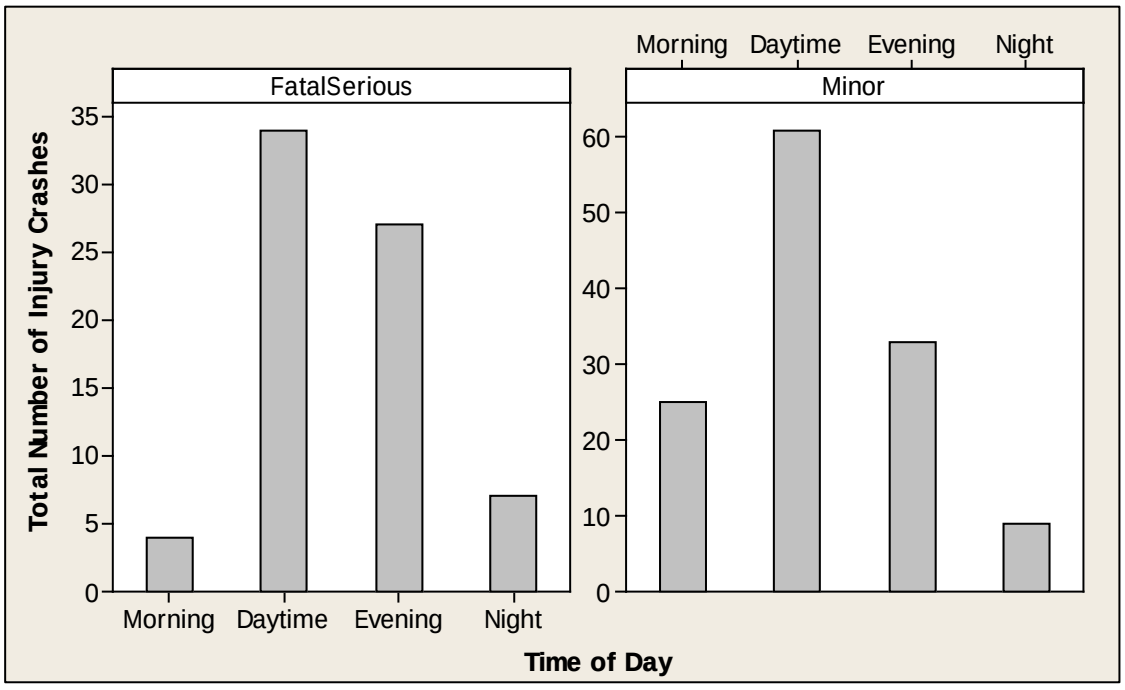
Finding:

Relative to minor crashes, serious and fatal crashes in Central Otago District are closely associated with evenings and typically do not take place in the mornings.

There is evidence (95.0%) that serious and fatal crashes tend to occur at different times of the day, compared with minor crashes. 13.8% of injury crashes occurring in the morning (4 am-9:59 am) in Central Otago (2010-2013) were classed as '*serious or fatal'*. By contrast, 45.0% of injury crashes occurring during the evening (4 pm – 9:59 pm) were classed as '*serious or fatal'*. This means that almost half of all injury crashes taking place during the evening period (4 pm-9:59 pm) resulted in a serious injury to at least one road user – and some of those injuries may have proved fatal.

Both graphs in Figure 11 show the same overall pattern: A peak in the daytime (10 am-3:59 pm), with fewer crashes at other times of the day (i.e. few crashes occur between the hours of 10 pm and 10 am). There are two major points of difference, however. One is that almost as many fatal and serious crashes have occurred in the evening (4 pm-9:59 pm) as during the daytime (10 am-3:59 pm) over the 2010-2013 period. By contrast, the '*Minor'* graph shows a much more defined peak at '*Daytime*', with relatively few crashes occurring in the evening. The other point of difference is '*Morning*', which barely features in the '*Fatal/Serious'* graph, indicating that few fatal and serious crashes occur then. By contrast, minor crashes are relatively common in the morning.

Figure 11 **Comparative severity of injury crashes in the Central Otago District, 2010-2013, by time of day**



It is also worth noting that the Central Otago District experiences a high number of ACC claims for crashes that took place during the day, but a very low number of ACC claims for crashes that took place at night.

3.4.4. *Areas where serious and fatal crashes perform better than minor crashes*

Compared with minor crashes, serious/fatal crashes in the Central Otago District are less likely to:

- occur on a Wednesday
- take place in the morning (i.e. between 4 am and 9:59 am).

Each of the factors listed have been determined to be statistically significant at the 95% level or higher. (That is, we can be at least 95% confident that the factors listed do represent a systematic difference between serious/fatal crashes and minor crashes in the Central Otago District, as opposed to random, chance variation). The list should be interpreted to indicate that serious/fatal crashes are very rare in the district under the conditions listed above. For example, serious/fatal crashes are very rare on Wednesdays.

3.4.5. Additional insights into the root causes of crashes

Crashes involving vulnerable road users and the holidaymakers in the Central Otago District

There is a particular *type* of crash that occurs often in Central Otago District: Vulnerable road users experiencing serious crashes on the weekend, usually riding on local roads (particularly motorcycles but also mopeds, cyclists and pedestrians). Weekend holidaymakers visiting Central Otago is a major cause of road deaths and injuries in the region. These holidaymakers are frequently vulnerable road users (especially motorcyclists), and any crash they experience is likely to have a serious outcome.

The factors that are shown to be associated are: Motorcycle crashes, serious crashes, weekend crashes and local-road crashes. This factor is extremely informative in providing information about issues that are particularly problematic in the Central Otago District.

This scenario is quite common: Many motorcyclists (and cyclists) visit Central Otago for a weekend's relaxation away from coastal Otago. In addition, much of the sightseeing on local roads. The fact that these factors are linked indicates that many local-road crashes occur on weekends when visitors to the region, particularly motorcyclists, are enjoying the scenery and relaxing ride. The serious nature of the injuries is a consequence of most motorcycle crashes.

Visibility and safe driving in the Central Otago District

Deliberately failing to keep left (i.e. cutting corners or swinging wide) is associated with poor information being imparted to the driver. In other words, cutting corners (and swinging wide) in the Central Otago District is nearly always coupled with inadequate signage, invisible-road markings or the absence of street lights.

Crashes in the Central Otago District caused by sudden braking are associated with following distance.

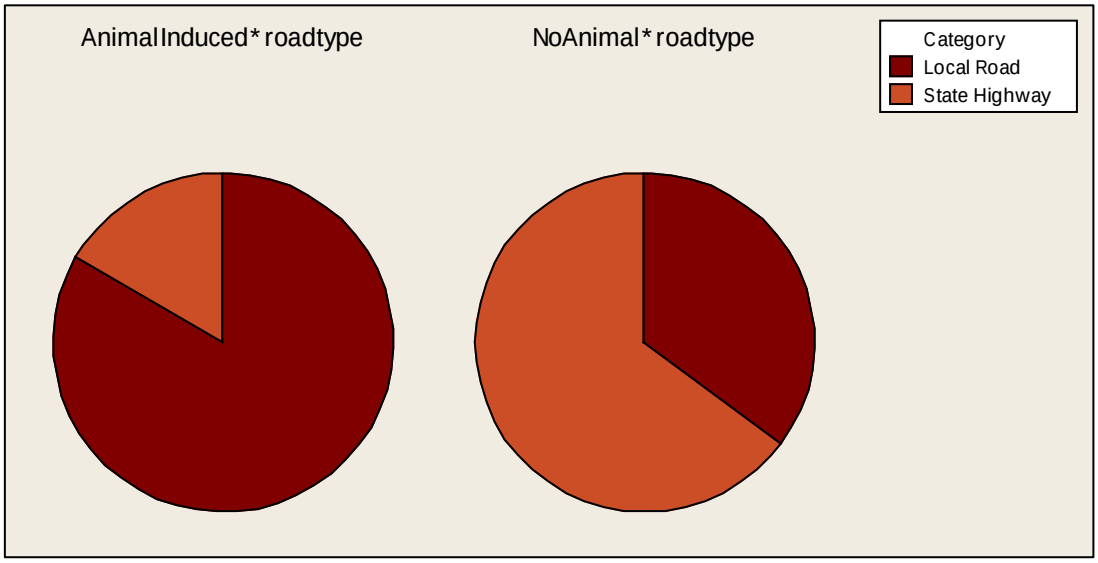
This factor indicates that crashes involving sudden braking are nearly always associated with close-following distance or incorrect-merging procedure. The usefulness of this factor is in determining that sudden braking is not generally an issue (e.g. when coming across an animal in the road) unless the braking vehicle is attempting to avoid a crash with the car in front.

The high rate of animal-induced crashes in Central Otago can largely be attributed to local roads.

Relative to state highways, local roads have a high proportion of crashes involving animals. The high number of animal-induced crashes in Central Otago relative to the other Otago districts, suggests the underlying cause of this finding is associated in some way with Central Otago's local-road network. Five of the six animal-induced crashes in 2010-2013 have occurred on local roads, with just one animal-induced crash taking place on a state highway.

The evidence that the distribution of animal-induced crashes in Central Otago is not equal across the state-highway and local-road networks is significant (97.5%). In Figure 12, the pie chart on the left shows crashes that have involved an animal on the road surface; the right pie chart indicates crashes that have not involved an animal on the road surface (i.e. all other crashes). Specifically, 83% of all animal-induced crashes have occurred on Central Otago Distict's local-road network. By contrast, only 35% of non-animal-related crashes have occurred on the local-road network.

Figure 12 **Comparative incidence of anmal-induced injury crashes on state highways and local roads in Central Otago, 2010-2013**



It is not surprising that the majority of animal-induced crashes occur on local roads; fencing and other barriers are usually better-maintained adjacent to state highways. In addition, most of the farms in Central Otago are accessed through the local-road network, and not through

the state-highway network. This means that there are simply more opportunities for animals to wander onto the road surface on local roads.

Examining the six animal-induced crashes in detail reveals that three involved a household pet rushing out in front of the vehicle or playing on the road; two involved a farm animal straying; and one involved a farm animal attended by the farmer, but there was inadequate warning or the accident occurred in an unexpected location.

Animal-induced crashes in the Central Otago District are usually on slight curves or straight sections of road.

Crashes involving animals on the road are usually associated with slight curves or straight sections of road. Intuitively, this makes sense. On bendy sections of road, drivers will probably be travelling more slowly and are thus able to stop or avoid animals. In addition, roads travelling through or past farms are not typically bendy, due to the need for most farm animals to be on large, flat pastures.

3.4.6. Issues involving high numbers of crashes on both state highways and local roads in the Central Otago District

These issues are:

- the high rate of crashes during the Central Otago summer (December-January)
- the high rate of wind- and snow-induced crashes
- the high rate of 'tourist inexperience' crashes.

3.5. Clutha District results

3.5.1. Findings and recommendations, summarised

Two themes emerged from analyses of data for the Clutha District:

- There is a serious road-safety issue associated with motorcycles.
- Certain crash-movement types tend to be much more serious than others, particularly head-on collisions.

Other findings:

- Analysis of hospitalisation data shows that the district has a serious problem with two demographics in particular: young drivers (aged 10-19) and men.
- The district experiences a high proportion of expensive ACC claims, second only, in Otago and Southland, to those in the Central Otago District.
- Relative to minor crashes, serious and fatal crashes in the district are:
  - closely associated with pedestrians who are not crossing the road (i.e. are walking adjacent to traffic, or entering/leaving a parked vehicle)
  - closely associated with vehicles turning in front of, or next to, each other (typically at an intersection)
  - closely associated with one or more parties recording a blood alcohol level over the legal limit
  - closely associated with bright sunlight at the crash site and only weakly associated with overcast conditions at the crash site.
- Almost all swerving-related crashes in the Clutha District involve pedestrians not animals.
- Failing to give way in Balclutha occurs mainly at night.
- Losing control on bends involves excessive speed.
- The high rate of crashes caused by road-quality problems in Clutha is mainly associated with the local-road network.
- Relative to state highways, local Clutha roads have a high proportion of crashes on sections of road with no markings.
- The high rate of icy-road crashes, including slipping on ice, is mainly associated with the state-highway network.
- Relative to local roads, state highways have a high proportion of crashes on sections of road with no-passing lines.

Recommendations for the Clutha District Council and/or NZTA to consider:

1. Investigate which local roads are most susceptible to issues causing or contributing to serious road trauma, the root causes of the issues, and what actions might reduce serious road trauma on these roads.

2. Investigate which stretches of the state-highway network are particularly prone to icy-road crashes and whether ice treatments such as gritting the road surface may be effective (or other options such as driver education through signage and warnings).

3. Investigate which sections of the state-highway network are most prone to 'no-passing' line crashes and the most suitable action (e.g. police enforcement).

4. Review how many crashes in the Clutha District have involved pedestrians, and the most suitable interventions (e.g. raising community awareness of the dangers associated with stepping out from behind parked vehicles, or waiting on the roadway for moving traffic, and driver awareness of the dangers associated with unsupervised children on the roadway).

5. Investigate whether drivers are failing to see or simply ignoring give-way signs at night; identify which give-way signs are problematic for this behaviour, and ascertain which interventions would be most suitable.

6. Tightly enforcing the speed limit in the Clutha District may be advisable, in combination with advertising and media initiatives. It seems that speeding is more dangerous than in other parts of Otago; the tight bends and high number of roadside objects mean that losing control on Clutha roads can be disastrous.

3.5.2. Themes found in the analysis of serious and fatal crashes

Theme 1: There is a serious road-safety issue associated with motorcycles in Clutha District.

Figure 13 **Fatal and serious injury crashes in the Clutha District, 2010-2013, by vehicle type**

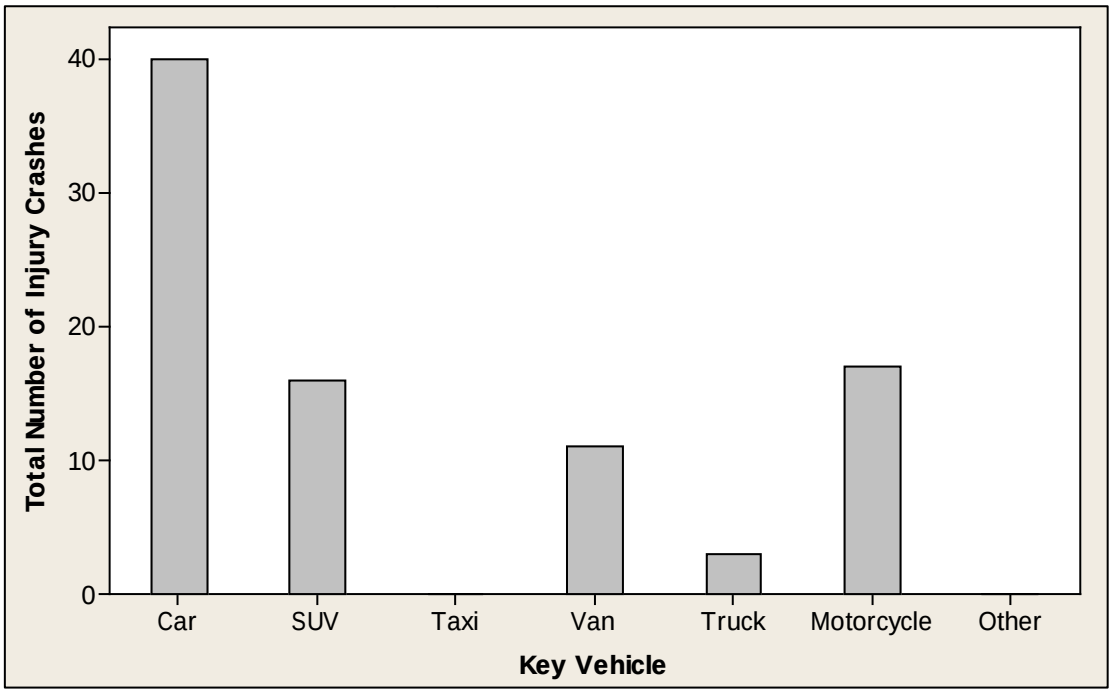
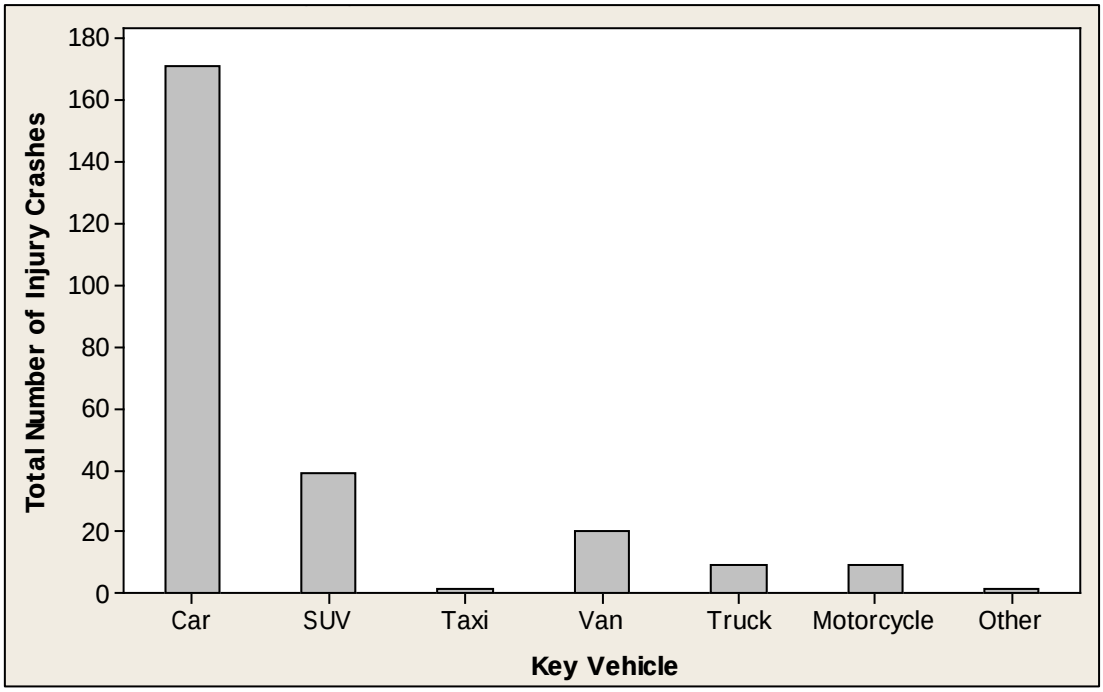


Figure 14 Minor injury crashes in the Clutha District, 2010-2013, by vehicle type



Relative to minor crashes, serious and fatal crashes in the Clutha District are closely associated with motorcycles in the key-vehicle role. The biggest difference between figures 13 and 14 is the '*Motorcycle*' category. Motorcycles feature prominently in the fatal and serious injury graph; a significant proportion of fatal and serious crashes have involved motorcycles in the key-vehicle position. By contrast, key-vehicle motorcycles barely feature in the '*Minor'* graph, having fewer crashes than both key-vehicle SUVs and vans. Most crashes involving a motorcycle in the key-vehicle role have serious outcomes for at least one road user in the crash (probably the motorcyclist).

65.4% of all injury crashes involving a motorcycle in the key-vehicle role in the Clutha District (2010-2013) were classed as '*serious or fatal'*. This means that almost two-thirds of all injury crashes involving a motorcycle in the key-vehicle role resulted in a serious injury to at least one road user (and some of those injuries may have proved fatal). (By contrast, 25.8% of all injury crashes were classed as '*serious or fatal'*.)

As figures 13 and 14 show, motorcycle riders are at a much higher risk of death or serious injury (as opposed to minor injury) when compared with other road users in the Clutha District. This is not surprising; academic research has long indicated that motorcycles are over represented in traffic accidents, including serious-traffic accidents (i.e. serious and fatal injury accidents). This means that not only are motorcyclists more likely to be involved in a crash than other road users, but that a crash is more likely to be serious or fatal. Singaporean data, for example, indicate that motorcycle crashes comprise about 40% of all fatalities, but only comprise 19% of motorised vehicles in Singapore[20]. This raises the question of whether there is something about the Clutha District that makes it particularly susceptible to serious traffic crashes.

[20] Quddus, M.A., Noland, R.B. & Chin, H.C. (2002). An analysis of motorcycle injury and vehicle damage severity using ordered probit models. *Journal of Safety Research, 33,* 445-462. doi: 10.1016/S0022-4375(02)00051-8

There is strong evidence (99.9%) that fatal and serious crashes in the Clutha District tend to involve different key vehicles, when compared to minor crashes (see footnote 16 for explanation of the term key vehicle).

Theme 2: Certain crash-movement types in Clutha tend to be much more serious than others, particularly head-on collisions.

There is powerful evidence (99.5%) that serious and fatal crashes in the Clutha District tend to involve different crash-movement types, when compared with minor crashes. Relative to minor crashes, serious and fatal crashes are:

- closely associated with head-on collisions
- closely associated with pedestrians who are not crossing the road (i.e. are walking adjacent to traffic, or entering/leaving a parked vehicle)
- closely associated with vehicles turning in front of, or adjacent to, each other (typically at an intersection)
- only weakly associated with crashes involving a collision with a road-surface obstruction (e.g. parked vehicle, workman's vehicle, etc.).

Note that there are 15 crash types identified by the Police. These are '*Overtaking*' (and lane change), '*Head-on'*, lost control (on a straight section), '*Cornering'* (on a bend), '*Collision'* (with obstruction of some kind), rear-end, '*Turning versus same direction'* (i.e. crash involved two vehicles on the same side of the road, with one or both attempting to turn, often resulting in a sideswipe crash), '*Crossing'* (no turns (i.e. side-impact crash)), '*Crossing'* (vehicle turning (i.e. crash involved at least one vehicle turning, usually at an intersection)), '*Merging'*, '*Right-turn against'* (i.e. making a right turn against the flow of through traffic),*'Manoeuvring'* (crash during complex manoeuvre (e.g. parking, U-turn)), '*Pedestrian crossing road'*, '*Pedestrian other'* (crash involved pedestrian not crossing the road (e.g. on footpath or leaving vehicle)) and '*Miscellaneous'*.

There are several noticeable differences between figures 15 and 16, the most prominent being the '*Head-on'* category. 43.5% of all head-on-injury crashes in Clutha (2010-2013) were fatal or serious. By contrast, 25.8% of all injury crashes were classed as '*serious or fatal'*.

International research has shown that head-on collisions are often much more serious than other crash types[21]. This is particularly true for head-on collisions involving elderly drivers (defined as those drivers aged 65 or over)[22]. There is still a question of whether this research finding is sufficient to explain the association of head-on crashes with severe road trauma in Clutha, or whether Clutha particularly susceptible to dangerous head-on collisions (through a lack of median barriers, excessively narrow roads, etc.) The key point to note is that few

[21] Singleton, M., Qin, H. & Luan, J. (2004). Factors associated with higher levels of injury severity in occupants of motor vehicles that were severely damaged in traffic crashes in Kentucky, 2000-2001. *Traffic Injury Prevention, 5,* 144-150. doi: 10.1080/15389580490435169

[22] Zhang, J., Lindsay, J., Clarke, K., Robbins, G. & Mao, Y. (2000). Factors affecting the severity of motor vehicle traffic crashes involving elderly drivers in Ontario. *Accident Analysis & Prevention, 32*, 117-125. doi: 10.1016/S0001-4575(99)00039-1

other districts in the Otago or Southland regions have had a statistically significant increase in crash severity associated with head-on collisions. As a result, it is reasonable to hypothesise that Clutha is particularly susceptible to severe head-on collisions, perhaps through a lack of available median barriers or an abundance of excessively narrow roads.

Figure 15 **Fatal and serious-injury crashes in the Clutha District, 2010-2013, by crash-movement type**

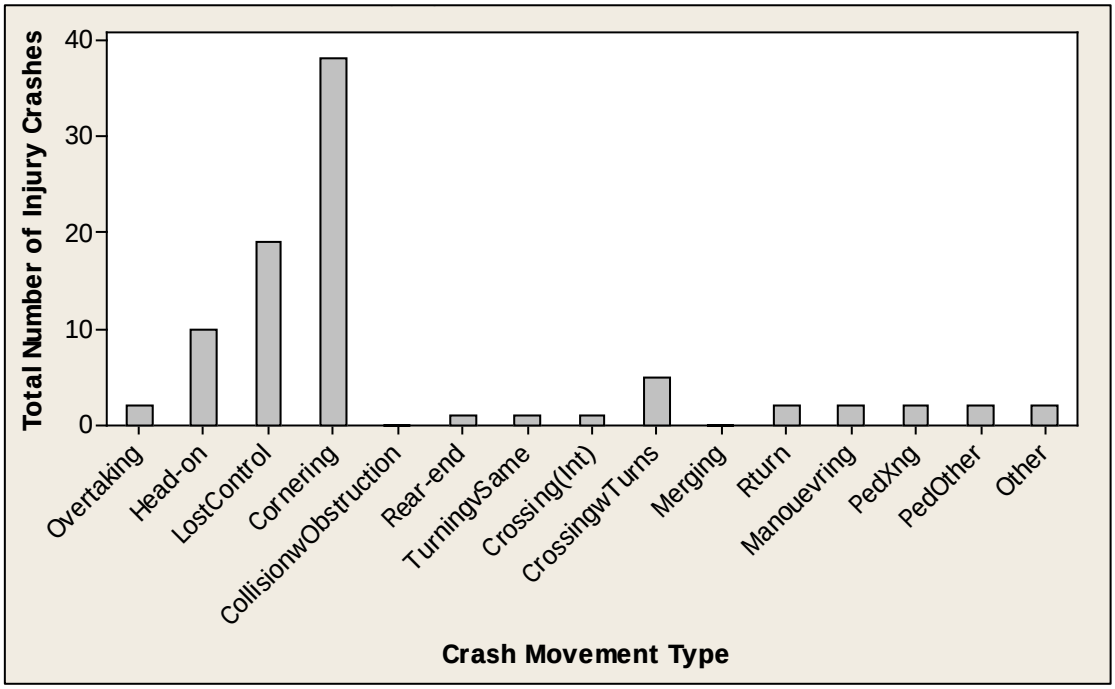
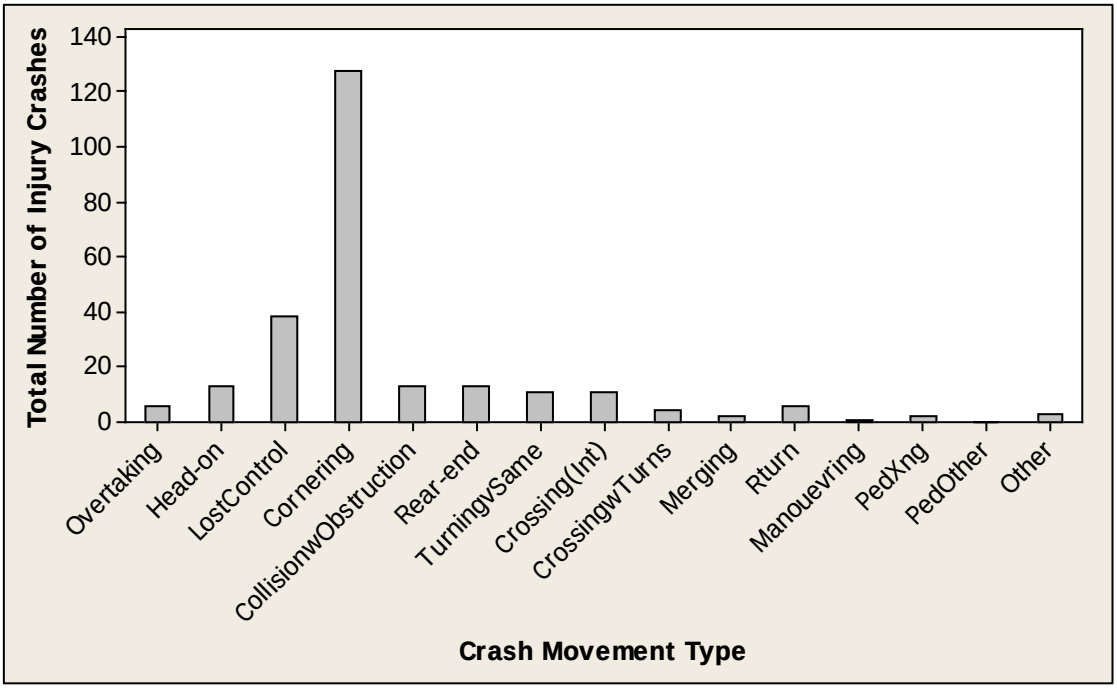


Figure 16 **Minor-injury crashes in the Clutha District, 2010-2013, by crash-movement type**



Other differences between figures 15 and 16 are '*PedOther'*, '*CrossingwTurns'*, '*Head-on'* and '*CollisionwObstruction'*. '*PedOther'*, '*CrossingwTurns'* and '*Head-on'*, which are all much larger in the serious and fatal chart (figure 15), relative to the '*Minor'* chart (figure 16). By contrast, '*CollisionwObstruction'* is significantly lower, with no serious or fatal crashes involving this movement type at all (despite a sizeable minority of minor crashes involving a collision with a road-surface obstruction such as a parked vehicle).

100.0% of all injury crashes in Clutha (2010-2013) involving a pedestrian who was not crossing the road (i.e. pedestrian walking with traffic, entering/leaving vehicle, etc.) were fatal or serious. Note that while this category comprises only two injury crashes, both were associated with serious road trauma.

55.6% of all injury crashes in Clutha (2010-2013) involving vehicles turning adjacent or in front of each other, typically at an intersection, were fatal or serious. 43.5% of all head-on injury crashes in Clutha (2010-2013) were fatal or serious. By contrast, 0.0% of the 13 injury crashes that involved a collision with a road-surface obstruction of some kind (e.g. parked vehicle, broken-down vehicle, workman's vehicle, etc.) were fatal or serious.

3.5.3. Factors associated with serious and fatal crashes

Demographics / gender

Young drivers and male drivers are over represented in hospital statistics in the Clutha District. Analysis of hospitalisation data shows that the district has a serious problem involving two groups in particular: young drivers (aged 10-19) and men. Focusing efforts on Clutha to bring its injury rate in line with the rest of Otago is likely to be fruitful and cost effective, as it has appeared in a number of separate analyses showing elevated crash rates (particularly for young men).

Crash characteristics and causes

Above the legal BAC limit

Finding:

Relative to minor crashes, serious and fatal crashes in the Clutha District are closely associated with one or more parties recording a blood alcohol level over the legal limit.

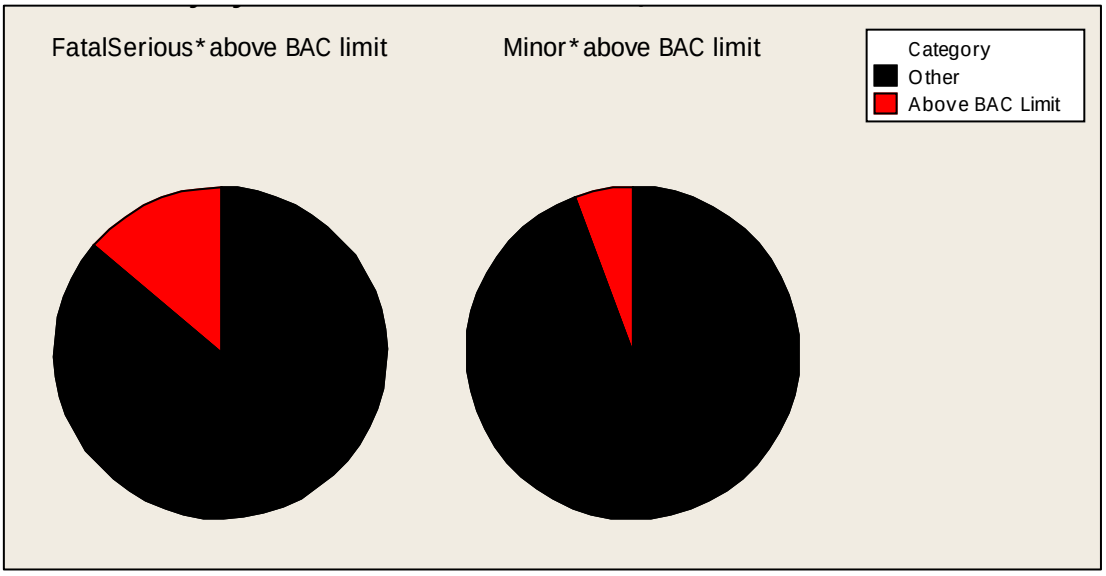
A crash was categorised as '*Above BAC Limit*' if one or more parties in the crash were noted to be above the legal limit for alcohol and/or refusing to take the test (crash code 103). According to the Police, refusing to take the test is very rare; the majority of 103-coded crashes involve road users who were above the legal alcohol limit[23]. There is significant evidence (97.5%) that fatal and serious crashes in Clutha are more likely to involve one or more drivers over the legal blood alcohol limit, compared with minor crashes.

Overall, as Figure 17 shows, 3.8% of fatal and serious crashes in the Clutha District involved one or more parties in the crash recording an alcohol level over the legal limit; by contrast,

[23] *Pers. comm.*, Steve Larking, Acting Road Policing Manager for the Southern District. 13th Nov., 2013.

5.6% of minor crashes involved one or more parties in the crash recording an alcohol level over the legal limit.

Figure 17 **Comparative severity of injury crashes in Clutha District where a driver is over the BAC limit, or not, 2010-2013**



Infrastructure

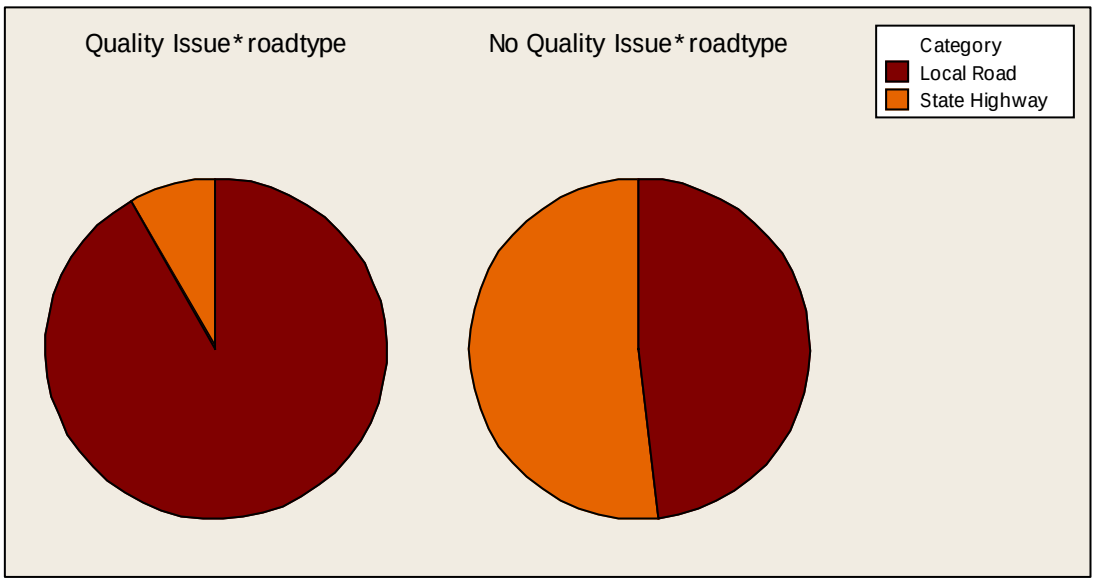
Road quality

Finding:

The high rate of crashes caused by road-quality problems in Clutha is mainly associated with the local-road network.

There is strong evidence (99.9%) that the distribution of crashes caused by road-quality problems in Clutha is not equal across the state-highway and local-road networks. Overall, 13.4% of Clutha's local-road crashes have been attributed, partly or wholly, to road-quality problems.

Figure 18 **Comparative incidence of injury crashes in the Clutha District in which road quality is cited as an issue, 2010-2013, by state highway or local road**



In Figure 18, the pie chart on the left shows crashes that were caused (wholly or in part) by a road-quality issue, such as potholes, an uneven road surface, gravel road, extremely narrow road, etc. Given that only four local-road crashes were caused partly by slipping on a gravel road, as determined by the Police, it seems likely that the most common road-quality issues in Clutha are potholes, an uneven road surface and unsuitable width (i.e. too narrow).

Specifically, 48.3% of crashes that did not involve a road-quality problem occurred on local roads, with 51.7% taking place on state highways. By contrast, 91.7% of road-quality-related crashes occurred on local roads, with 8.3% taking place on state highways.

This is not particularly surprising since state highways are built to a different standard and to suit a different purpose than local roads. Furthermore, the Clutha District Council has highlighted on occasion how milk tankers and stock trucks wear down the road surface quickly in the district. Growth in the dairying industry over the past few years has resulted in trucks travelling Clutha's local roads, often many times a day, to collect milk from farms in the area. This can also contribute to the weathering of the road surface. In addition, stock trucks often dump effluent on the road, which may be contributing to road-surface degradation.

No-passing lines

Finding:

The high rate of 'no-passing-line' crashes in Clutha is primarily associated with the state-highway network.

This analysis aims to investigate whether the high rate of crashes on no-passing sections of road is associated with the state-highway or local-road network. There is strong evidence (99.9%) that the distribution of no-passing-lane crashes is not equal across the state-highway and local-road networks.

Overall:

- Relative to state highways, local Clutha roads have a high proportion of crashes on sections of road with no markings.
- Relative to local roads, Clutha state highways have a high proportion of crashes on sections of road with no-passing lines.

These findings indicate that the high proportion of crashes on no-passing lines can be attributed mainly to the state=highway network.

Figure 19 **Comparative incidence of injury crashes on state highways and local roads in the Clutha District involving no road markings and no-passing line, 2010-2013**

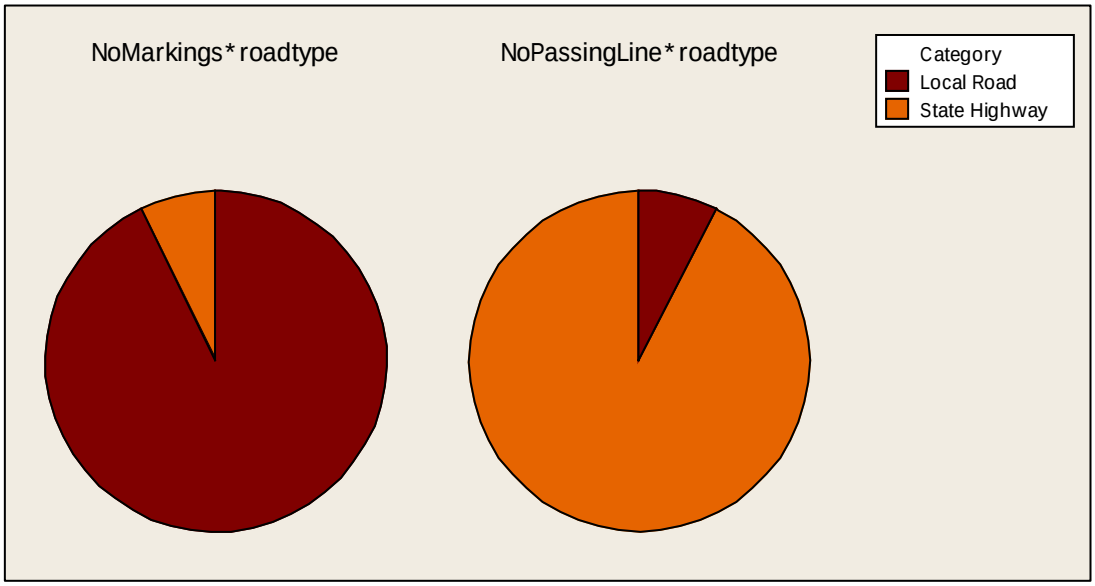


Figure 19 (the left pie chart) shows that the majority of crashes occurring on roads with no road markings occur on local roads, and the majority of crashes occurring on sections of road with no-passing lines occur on state highways.

Specifically, 92.8% of no-markings crashes occurred on local roads, with 7.2% taking place on state highways. By contrast, 7.4% of no-passing-line crashes occurred on local roads, with 92.6% taking place on state highways, as depicted in the right pie chart in Figure 19.

This is not particularly surprising as local roads are built for a different purpose and to a different standard than NZTA-administered state highways. Throughout the country, many local roads do not have road markings. This is usually not problematic, given that local roads have a much smaller volume of traffic. Drifting across the absent centre line is less of a concern than on higher-trafficked networks of road, like state highways.

It is equally unsurprising that most crashes on no-passing sections of road occur on state highways. As mentioned above, state highways are built for a different purpose, and tend to have specially designed overtaking lanes spaced throughout the route so that faster traffic can overtake slower vehicles in safe locations, in a section of road built for the purpose. No-passing lines are usually employed when it would be unsafe for a vehicle to overtake, such as before a tight bend, or in an area with poor visibility (e.g. with trees or another object obstructing the overtaking motorist's view).

Environmental conditions

Lighting conditions

Findings:

Relative to minor crashes, serious and fatal crashes in the Clutha District:

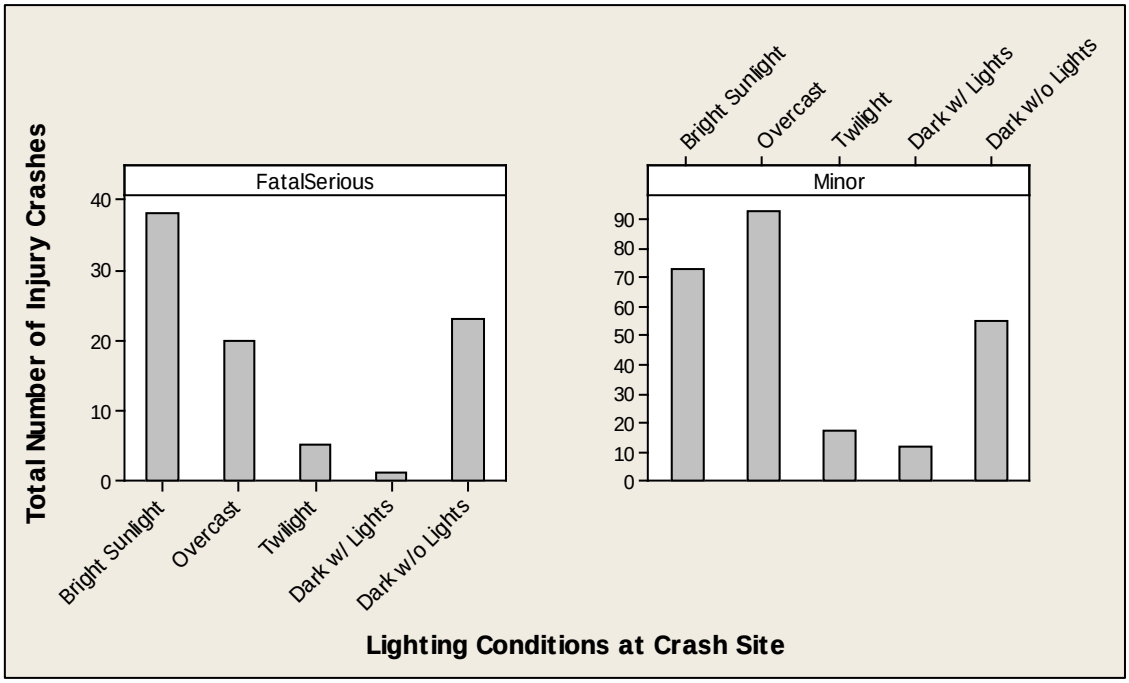
- are closely associated with bright sunlight at the crash site
- are only weakly associated with overcast conditions at the crash site.

Crashes have been divided into five categories: '*BrightSunlight'*, '*Overcast'*, '*Twilight'*, '*Dark w/ Lights'* (dark conditions, but with working streetlights present at the crash scene),\ and '*Dark w/o Lights'* (dark conditions, and with no streetlights in the vicinity of the crash). There is evidence (95.0%) that fatal and serious crashes in the Clutha District tend to take place in different lighting conditions, compared to minor crashes.

A high proportion of crashes occurring in bright sunlight tend to be classed as '*fatal or serious*'. In contrast, as for crashes occurring in overcast conditions, a low proportion is classed as '*fatal or serious'*.

Specifically, 34.2% of injury crashes occurring in bright sunlight in the Clutha District (2010-2013) were classed as '*fatal or serious'*. By contrast, 17.7% of injury crashes occurring in overcast conditions were classed as '*fatal or serious'*. This means that about one-third of all injury crashes taking place in bright sunlight resulted in a serious injury to at least one road user (and some of those injuries may have proved fatal).

Figure 20 Injury crashes in the Clutha District, 2010-2013, by lighting condition



The two graphs in Figure 20 show a similar pattern for '*Twilight', 'Dark w/Lights'* and '*Dark w/oLights'*. The points of difference are clearly '*BrightSunlight'* and '*Overcast'*. The '*Fatal/Serious'* graph, on the left-hand side, is dominated by '*BrightSunlight'*. '*Overcast'* is less prominent, with more fatal and serious crashes taking place in darkness than in overcast conditions. By contrast, while '*BrightSunlight'* does feature in the '*Minor'* graph, here '*Overcast'* is clearly dominant; a high proportion of minor-injury crashes have occurred in overcast conditions.

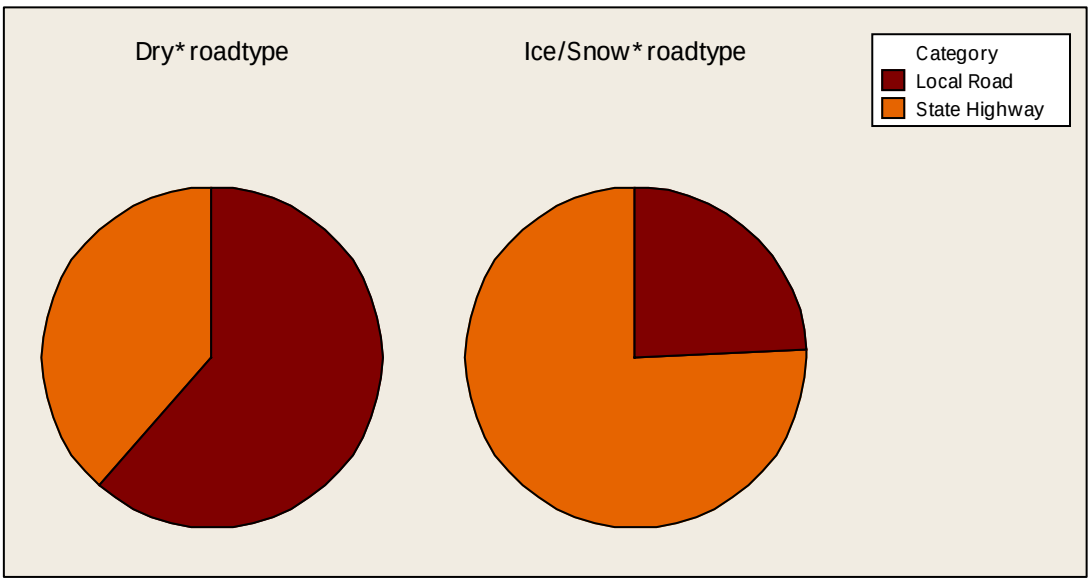
Icy or snowy roads / conditions

Finding:

The high rate of icy-road crashes in the Clutha District is mainly associated with the state-highway network. Furthermore, crashes caused by slipping on ice are far more common on the state-highway network than the local-road network.

There is strong evidence (99.9%) that the distribution of icy-road crashes is not equal across the state-highway and local-road networks. Overall, relative to state highways, local roads have a high proportion of dry-road crashes, wet-road crashes and icy-road crashes.

Figure 21 **Comparative incidence of injury crashes on dry and icy/snowy local roads and state highways in Clutha District, 2010-2013**



The pie charts in Figure 21 show that most of the dry-road injury crashes have occurred on local roads; however, icy-road injury crashes have occurred mainly on the state-highway network.

Specifically:

- 61.5% of all dry-road crashes have occurred on local roads, with 38.5% occurring on state highways
- 40.7% of all wet-road crashes have occurred on local roads, with 59.3% occurring on state highways
- 24.3% of all icy-road crashes have occurred on local roads, with 75.7% occurring on state highways**.**

It is difficult to speculate about the causes of the imbalance in icy-road crashes. It may be that motorists travelling on narrow local roads are already travelling quite slowly, and slow down further when they notice ice; however, on state highways, average speeds are higher and motorists may fail to slow appropriately.

It is also possible that motorists travelling on local roads are probably locals themselves, or are familiar with the area. They are probably aware of the dangers of ice in the Clutha District and take precautionary steps to prevent a crash. By contrast, motorists travelling on state highways are often from outside the region and just passing through. These motorists may not be competent at driving in icy conditions, or, in the case of black ice, they may simply be unaware of ice on the road surface.

In addition, the Clutha District Council has been removing the vegetation overhanging the road to prevent build up of ice on the road surface. If the state-highway network is not similarly protected, ice may build up on the road surface.

3.5.4. *Areas where serious and fatal crashes occur less than minor crashes.*

Compared with minor crashes, serious/fatal crashes in Clutha District are less likely to:

- involve a collision with a road-surface obstruction (e.g. parked vehicle, workman's vehicle, etc.)
- take place in overcast conditions.

Each of the factors listed above have been determined to be statistically significant at the 95% level or higher. (That is, we can be at least 95% confident that the factors listed do represent a systematic difference between serious/fatal crashes and minor crashes in the Clutha District, as opposed to random, chance variation.) The list should be interpreted to indicate that serious/fatal crashes are very rare under the conditions listed above. For example, serious/fatal crashes are very rare under overcast conditions.

3.5.5. Additional insights into the root causes of crashes

Swerving in the Clutha District involves pedestrians, not animals.

Almost all crashes involving swerving in the Clutha District (i.e. where drivers have swerved to avoid a pedestrian, broken-down car, animal, object, etc.) are associated with pedestrians; in particular, children who are playing unsupervised on the road or pedestrians who are behaving dangerously (e.g. stepping out from behind a vehicle, waiting on roadway for moving traffic, jaywalking, etc.).

At first glance, this may not seem surprising; a driver's first instinct upon seeing a child or pedestrian on the roadway in front of them would be to swerve away from them. However, given that the Clutha District is also known to have a high number of animals on the road suggests that most animal-induced crashes do not involve drivers swerving. Perhaps drivers choose to hit animals head-on, or do not see them in time, making swerving impossible.

Failing to give way is associated with night-time in Balclutha.

Crashes on urban roads illuminated by streetlights are strongly associated with failure to give way at a give-way sign. That most urban roads illuminated by streetlights in this district are in Balclutha suggests that most night-time crashes are caused by drivers failing to give way at a give-way sign.

The question is whether drivers failing to give way are simply unaware of the give-way sign (i.e. they do not see it in the darkness), or whether they are deliberately ignoring the sign, thereby causing the crash. If this can be determined, interventions could be shaped around ensuring that drivers give way appropriately at the give-way sign.

Losing control on bends in Clutha District involves excessive speed.

Crashes associated with losing control on bends in the Clutha District are associated with the severity of the bend and the speed of the driver. Excessive speed and more severe curves are likely to lead to driver loss of control. This factor seems to be intuitive, but it indicates that speed is the primary factor in loss-of-control crashes on bends (as opposed to other potential issues, such as ice).

3.5.6. Issues involving high numbers of crashes on both state highways and local roads in the Clutha District

These are:

- the high rate of rural-road crashes
- the high rate of speed-related crashes on corners
- the high rate of bend-related crashes
- the high rate of animal-induced crashes
- the high rate of crashes in light rain
- the high rate of dark-road crashes (on roads without streetlights
- the high rate of moderate-bend crashes
- the high rate of object-related crashes
- the high rate of cornering-related crashes
- the high rate of single-party crashes.

3.6. Dunedin City results

3.6.1. Themes found in the analysis of serious and fatal crashes

Seven themes emerged from analyses of data for Dunedin City:

- Pedestrians crossing the road are disproportionately involved in fatal and serious crashes.
- There is a serious road-safety issue associated with motorcycles.
- There is a serious road-safety issue associated with cyclists.
- There is a serious road-safety issue associated with older drivers.
- Serious and fatal crashes are over represented on roads with high-speed limits (80 km/h or higher).
- Serious and fatal crashes in Dunedin City tend to occur midblock.
- Saturdays are hazardous for road safety.

Other findings:

- Relative to minor crashes, serious and fatal crashes in Dunedin City:
  - are closely associated with motorcycles and cyclists
  - are closely associated with pedestrians, including those crossing the road
  - are closely associated with one or more motorists failing to give way to pedestrians at crossing points (i.e. at zebra crossings or traffic lights)
  - are closely associated with midblock locations
  - are not typically multi-vehicle collisions involving a car in the second road user role or involve rear-end collisions
  - are closely associated with easy and moderate curves and are less likely to take place on straight sections of road
  - are associated with sections of road with '*Unknown*' road markings
  - are less likely to take place on raised-traffic islands or on sections of road with a no-passing line
  - are associated with rural roads (80 km/h speed limit or higher)
  - are closely associated with Saturdays and do not typically take place on Tuesdays
  - are closely associated with weekends
  - are associated with darkness (in the presence of streetlights) and bright sunlight
  - are less likely to take place in overcast conditions
  - are closely associated with drivers with an '*Unknown/Irrelevant*' age in the key-vehicle-driver role (i.e. primarily key-vehicle cyclists)
  - are closely associated with older road users (75+) in the key-vehicle-driver role
  - are closely associated with drivers with an '*Unknown/Irrelevant*' gender in the key-vehicle-driver role (i.e. primarily key-vehicle cyclists)
  - do not typically involve women in the key-vehicle-driver role

  - do not typically involve restricted licence-holders in the key-vehicle-driver role
  - are closely associated with one or more parties recording a blood alcohol level over the legal limit
  - are not usually associated with one or more parties following too closely, merging incorrectly or crowding a cyclist
- Many of Dunedin's intersection crashes involve failing to look and subsequently failing to give way at a give-way sign.
- Pedestrian-vehicle crashes are mainly associated with dangerous pedestrian behaviour.
- Running a red light/stop sign is usually associated with inattention, not deliberate violation.
- Most crashes caused by drivers above the BAC limit in Dunedin occur at night.
- Losing control on bends usually involves excessive speed.
- The high rate of crashes caused by turning vehicles failing to give way to oncoming traffic is mainly associated with the local-road network.
- The high rate of crashes occurring in dark conditions (in the presence of street lights) in is mainly associated with the local-road network.
- The high rate of crashes occurring at intersections in is mainly associated with the local-road network.
- The high rate of crashes occurring on urban roads in is mainly associated with the local-road network.
- Relative to state highways, local roads tend to have a high proportion of crashes occurring on sections of road without any road markings at all.
- The high rate of crashes caused by vehicle crowding is mainly associated with the state-highway network rather than the local-road network.
- The high rate of crashes caused by failure to stop at stop signs and/or traffic light is mainly associated with the state-highway network.
- Relative to local roads, state highways in Dunedin City tend to have a high proportion of crashes occurring on no-passing lines.

Recommendations for Dunedin City Council (DCC) and/or NZTA to consider:

1. Determine where the most dangerous urban-road locations, and target these for interventions, provided that altering the road design or signage do not simply move the black spot to another location.

2. Determine which intersections are most problematic for poor give-way behaviour, and consider whether to install stop signs or traffic lights; analyses reveal that Dunedin City motorists often are poor at giving way (which probably causes a lot of intersection crashes), but tend to obey the road rules with respect to stop signs and traffic lights.

3. Focus police and education resources on improving driver behaviour at give-way signs. Many driver education messages focus on ensuring that drivers stop correctly at stop signs and traffic lights. It seems, however, that most of intersection crashes in Dunedin are actually associated with failing to give way at the relevant time.

4. Investigate whether increase the number of green arrows at traffic lights in the city; allowing motorists to turn right uninterrupted would help to alleviate intersection crashes caused by drivers attempting to turn right in front of oncoming traffic, mistakenly believing they have enough time to reach their target road.

5. Determine which factors are associated with failure-to-stop crashes on Dunedin City's state-highway network. Intervention choice will depend on whether motorists are failing to stop at traffic lights or stop signs. Raising police enforcement of this issue may be worth considering. Many police operations focus around enforcing drivers' stopping at red lights and stop signs, but it seems that few crashes are caused by reckless drivers running a red light (or stop sign). Instead, most crashes associated with this behaviour are caused by drivers simply failing to notice the stop sign.

6. Investigate which state highways are susceptible to crashes associated with vehicle crowding; it may be that a certain type of traveller is causing the high rate of crowding-related crashes on state highways (e.g. motorists visiting Port Chalmers, or travelling south to Balclutha and Invercargill). If so, these travellers can be targeted for educational information and perhaps enforcement, if the Police feel that this is a viable option.

7. Investigate whether, for night-time crashes (in the presence of streetlights) taking place on Dunedin City's local-road network, a focus on visibility upgrades would help, or whether traffic calming measures may be more appropriate if these crashes are taking place due to speed.

8. Investigate which local roads are prone to pedestrian-behaviour injury crashes, and whether the crashes occur at night during the weekend (indicating that alcohol and/or peer pressure may be factors), or during the daytime working week. This will shed light on those pedestrians prone to this sort of behaviour, which can inform targets for intervention.

9. Research why pedestrians are driven to behave dangerously in Dunedin; people do not usually have a death wish when crossing the road. It is more likely that they are frustrated by the way the system is designed to operate efficiently for those in cars rather than those on foot.

10. Consider establishing more mobile-testing stations after dark rather than in the in the twilight hours (e.g. 8-10pm). Alcohol checkpoints will be more successful in apprehending drunk drivers later at night.

11. Tightly enforcing the speed limit may be advisable, in combination with advertising and media initiatives. Identifying the worst-performing bends and curves in terms of road safety, and targeting signage and potentially infrastructural upgrades to those bends may be useful.

3.6.2. Themes found in the analyses of serious and fatal crashes

Theme 1: Pedestrians crossing the road are disproportionately involved in fatal and serious crashes in Dunedin City.

Figure 22 **Fatal and serious crashes in Dunedin City, 2010-2013, by movement type**

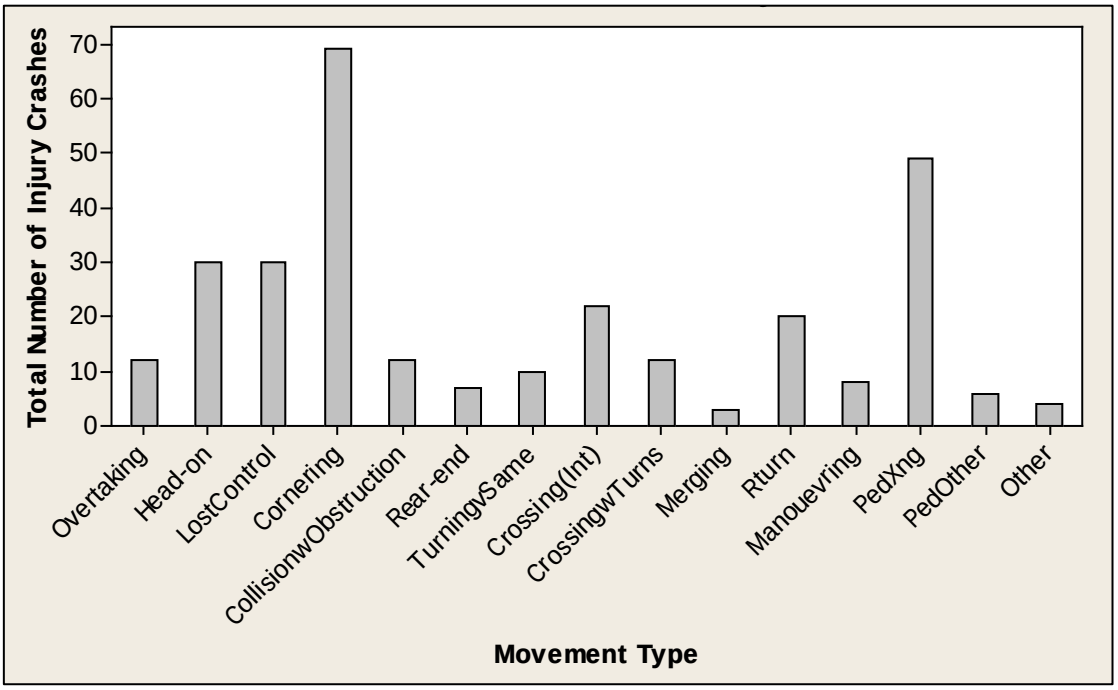
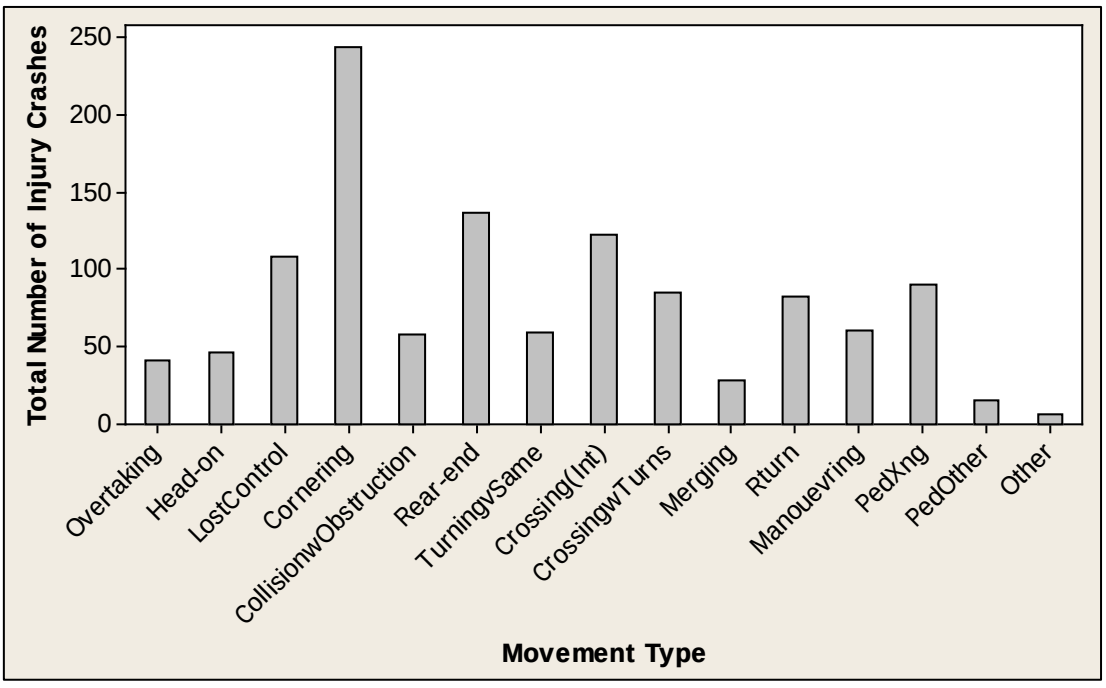


Figure 23 **Minor crashes in Dunedin City, 2010-2013, by movement type**



About a third of all injury crashes involving one or more pedestrians crossing the road in Dunedin City (2010-2013) have resulted in a serious injury to at least one road user (presumably the pedestrian). Some of those injuries have even been fatal. (See '*PedXing'* in figures 22 and 23.) For reference, only 19.9% of all injury crashes in Dunedin City over this period were classed as '*fatal or serious'*. The section on Movement-type below discusses this further.

This previous point is not surprising as pedestrians are a vulnerable road-user group, and the literature shows that they are at risk of suffering serious injury in collisions with vehicles, particularly at higher impact speeds[24]. This concept has led to a 'shared space' approach in many cities, where pedestrians and vehicles are permitted to coexist in the same area at very low speeds (often with a speed limit of 10 km/h or lower).

Notably, however, '*PedOther'* is not over represented in the '*Fatal/Serious'* graph (Figure 22). '*PedOther'* refers to crashes involving pedestrians walking with traffic, walking facing traffic, walking on the footpath, entering or leaving their vehicle, and so on. In other words, pedestrians are not necessarily inherently more at risk in Dunedin; it is the crossing movement that is particularly dangerous.

A matter requiring further investigation if this finding is to be explained is whether pedestrians are behaving in an unsafe manner, crossing the road when it is not appropriate to do so, and/or motorists are behaving in an unsafe manner, and are not allowing pedestrians to cross at appropriate locations (i.e. at designated crossing points, pedestrian crossings or traffic lights). 'Risky-pedestrian-behaviour crashes' are over represented in the '*serious and fatal*' category (see Figure 24), suggesting that some of these crashes can be attributed to pedestrians behaving in an unsafe manner.

Crashes involving motorists' failure to give way to pedestrians at designated-crossing points (e.g. zebra crossings and traffic lights) are also over represented in the serious and fatal category (see Figure 25). This finding indicates that some of these fatal/serious crashes associated with pedestrians crossing the road can be attributed to motorists behaving in an unsafe manner. Thus, evidence exists for inappropriate pedestrian behaviour and inappropriate motorist behaviour as to injuries suffered by pedestrians crossing the road.

For further evidence that pedestrians are particularly at risk for serious and fatal crashes in Dunedin City, compare the pedestrian column in figures 26 and 27.

[24] Davis, G.A. (2001). Relating severity of pedestrian injury to impact speed in vehicle-pedestrian crashes: simple threshold model. *Transportation Research Record: Journal of the Transportation Research Board, 1773,* 108-113. doi: 10.3141/1773-13

Figure 24 **Comparative severity of injury crashes in Dunedin City, 2010-2013, by type of pedestrian-behaviour involved**

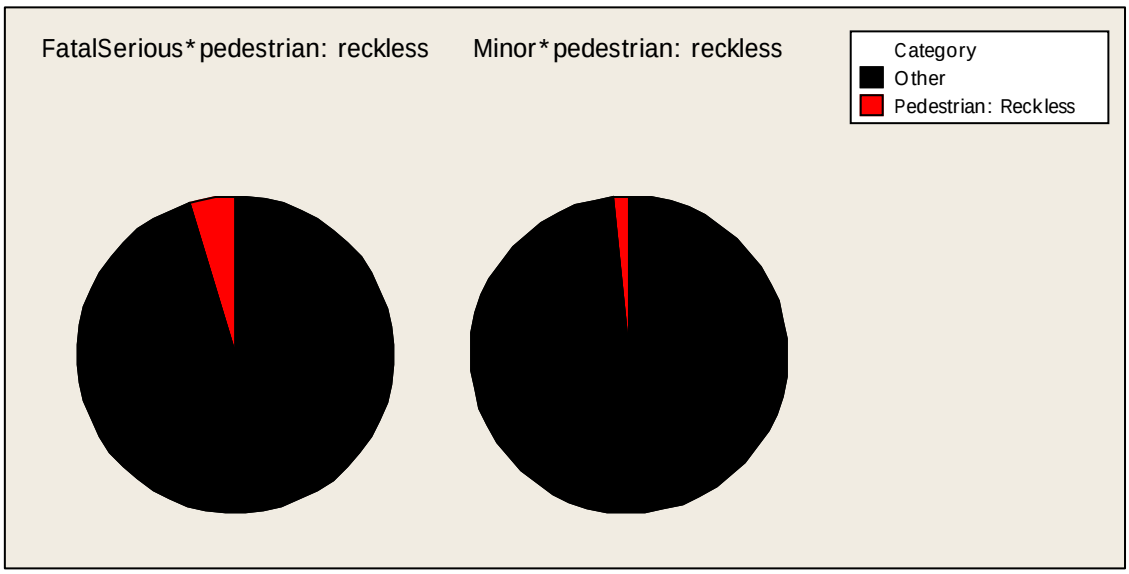


Figure 25 **Comparative severity of injury crashes in Dunedin City where motorist have and have not failed to give way to a pedestrian, 2010-2013**

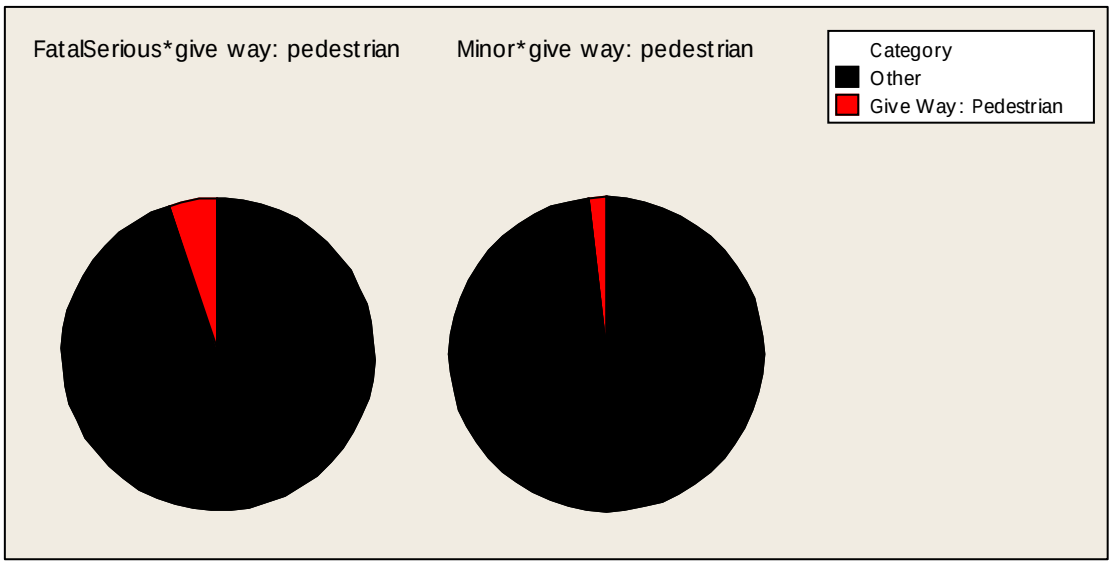


Figure 26 **Fatal and serious crashes in Dunedin City, 2010-2013, by type of second road user involved**

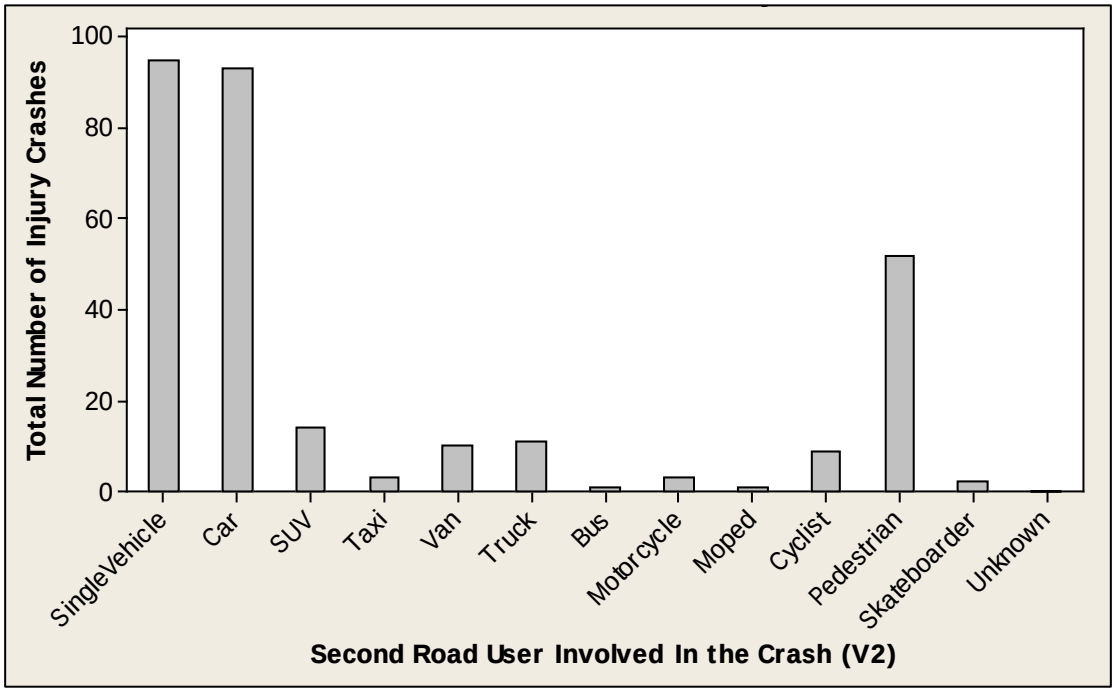
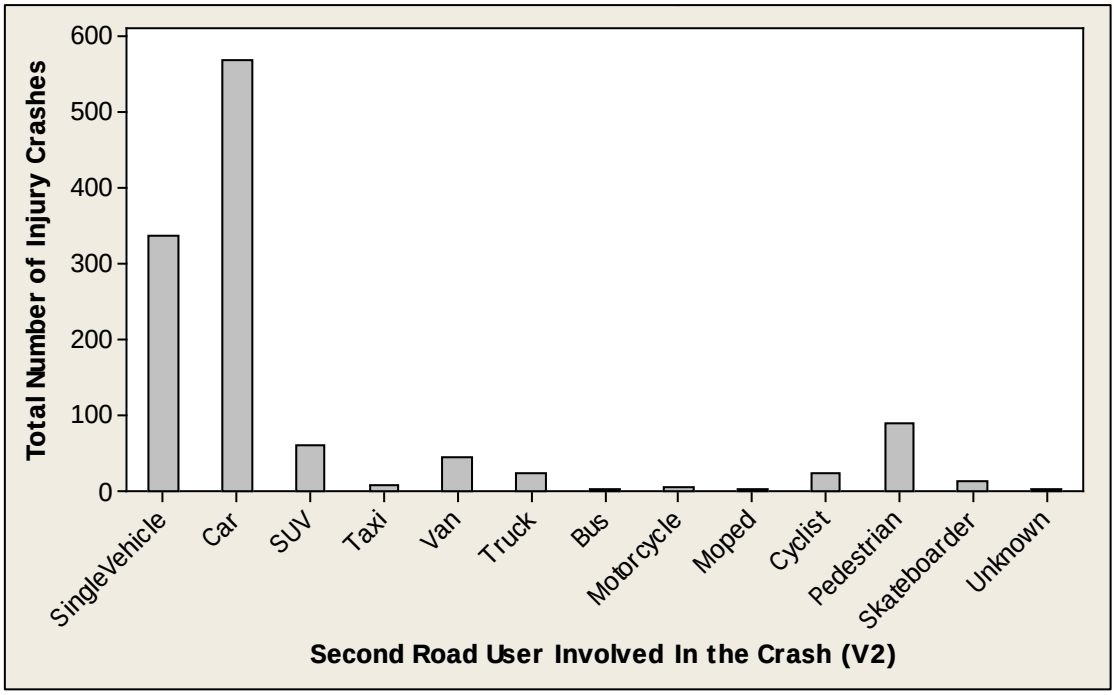


Figure 27 **Minor crashes in Dunedin City, 2010-2013, by type of second road user involved**



Theme 2: There is a serious road-safety issue associated with motorcycles in Dunedin City.

Figure 28 **Fatal and serious crashes in Dunedin City, 2010-2013, by key vehicle**

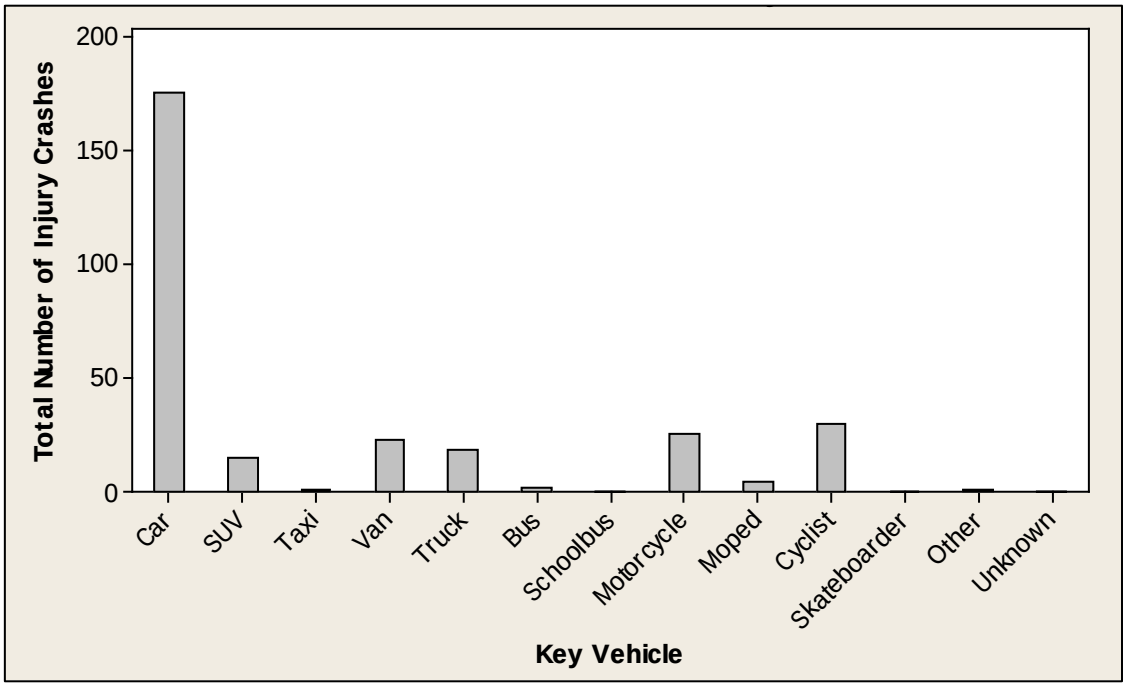
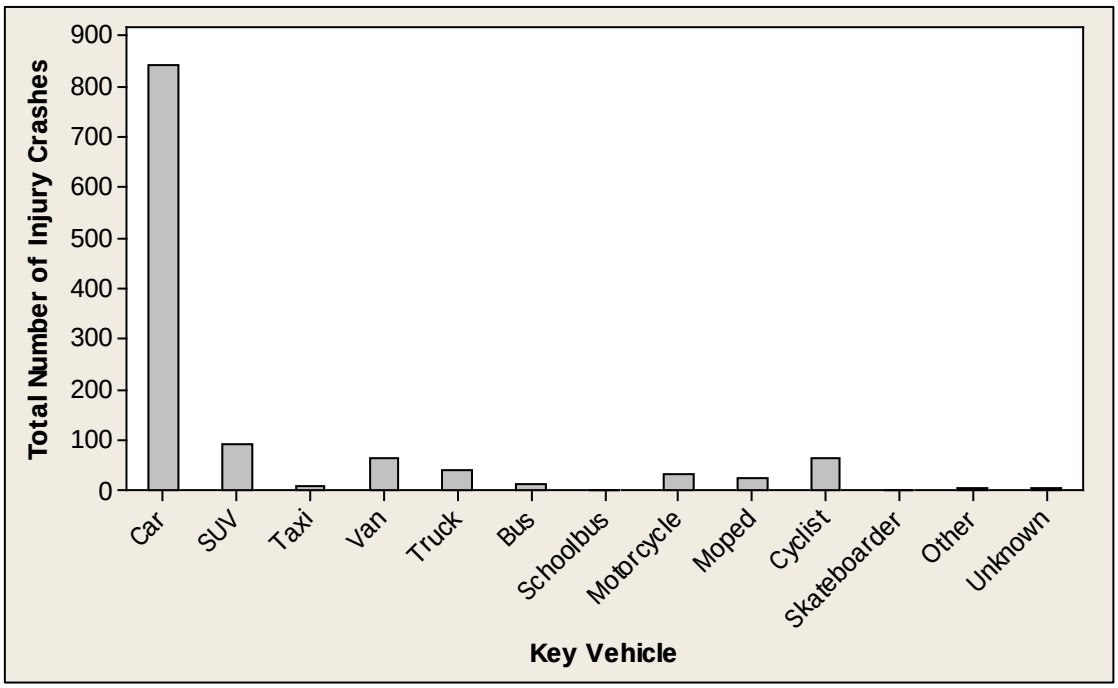


Figure 29 **Minor crashes in Dunedin City, 2010-2013, by key vehicle**



Almost half of all injury crashes involving a motorcycle in the key-vehicle role in Dunedin City (2010-2013) resulted in a serious injury to at least one road user (and some of those injuries proved fatal). By comparison, 19.9% of all injury crashes over this period were classed as '*fatal or serious'*.

As figures 28 and 29 show, motorcycle riders are at a much higher risk of death or serious injury when compared with other road users. (Compare the differences between the two graphs, for each vehicle type.) This finding is not surprising; academic research has long indicated that motorcycles are over represented in traffic accidents, including serious-traffic accidents (i.e. serious- and fatal-injury accidents). This means that not only are motorcyclists more likely to be involved in a crash than other road users, but that the crash is more likely to be serious or fatal. Singaporean data, for example, indicate that motorcycle crashes comprise about 40% of all fatalities, but only comprise 19% of motorised vehicles in Singapore[25]. This raises the question as to whether there is something about Dunedin City that makes it susceptible to serious traffic crashes.

Theme 3: There is a serious road-safety issue associated with cyclists in Dunedin City.

About a third of all injury crashes involving a cyclist in the key-vehicle role in Dunedin City (2010-2013) resulted in a serious injury to at least one road user (and some of those injuries may have proved fatal). In comparison, 19.9% of all injury crashes over this period were classed as '*fatal or serious'*.

Crashes involving cyclists tend to result in serious levels of trauma (as figures 41 and 42 show). It is not surprising that cyclists are vulnerable road users, and their survivable impact speed is much lower than that of two cars colliding. This is mainly because cyclists do not have a protective outer shell around them in the case of a crash, as car occupants do, and they lack all of the safety features inherent in cars (e.g. airbags).

This finding is not surprising as international research shows that cyclists are an at-risk group for serious road trauma. Some literature even suggests that cyclists should be separated completely from motor vehicles, because prevention of serious bicycle injuries resulting from a motor-vehicle-bicycle collision is impossible even with appropriate helmet use[26].

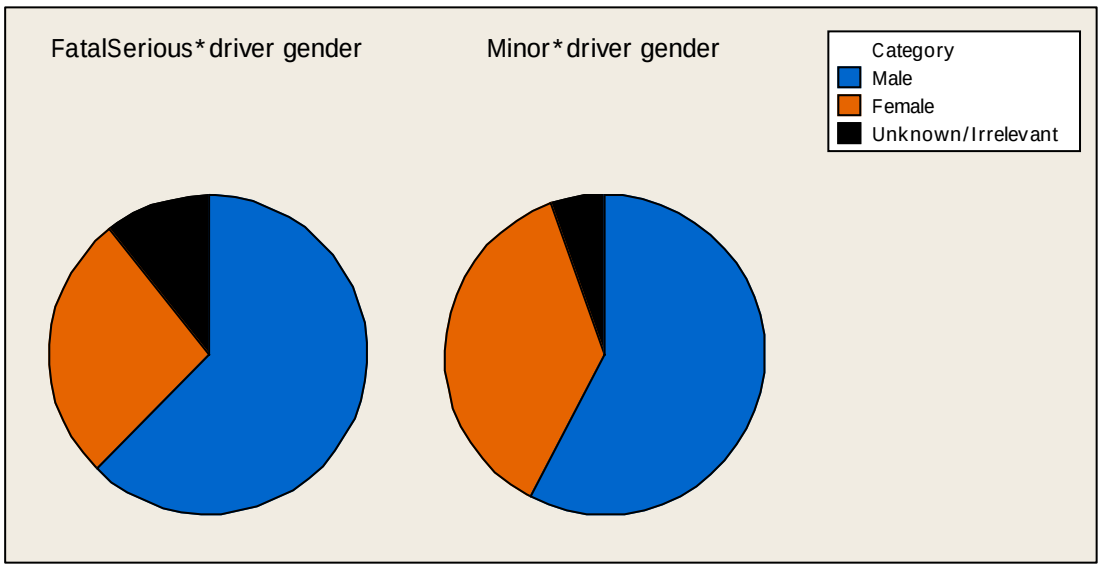
Further research in this field will examine the actual location of these cyclist crashes to determine where they are occurring and what is causing them. This will be actioned in mid-2014 (possibly in June-July).

For more evidence that cyclists represent a serious road-safety issue in Dunedin City, note the differences between the two pie charts in Figure 30. In each pie chart, crashes involving '*Unknown/Irrelevant'* age/gender/licence type in the key-vehicle-driver role—largely cyclists (as discussed earlier)—are over represented in the '*fatal/serious*' category.

[25] Quddus, M.A., Noland, R.B. & Chin, H.C. (2002). An analysis of motorcycle injury and vehicle damage severity using ordered probit models. *Journal of Safety Research, 33,* 445-462. doi: 10.1016/S0022-4375(02)00051-8

[26] Rivara, F., Thompson, D. & Thompson, R. (1997). Epidemiology of bicycle injuries and risk factors for serious injury. *Injury Prevention, 3,* 110-114. doi: 10.1136/ip.3.2.110

Figure 30 **Comparative severity of injury crashes in Dunedin City, 2010-2013, by gender of driver/rider**



Theme 4: There is a serious road-safety issue associated with older drivers in Dunedin City.

29.9% of injury crashes involving an older driver (75+) in the key-vehicle-driver role in Dunedin City (2010-2013) were classed as '*fatal or serious'*. For reference, 19.9% of all injury crashes over this period were classed as '*fatal or serious'*. Figures 31 and 32 compare the number of fatal and serious crashes (Figure 31) and minor crashes (Figure 32) for each age group of driver.

Figures 31 and 32 look very similar, with the exception of *75*+ and '*Unknown/Irrelevant'*. Both of these categories are much more prominent in the '*Fatal/Serious'* graph than in the '*Minor'* graph. This indicates that, when an older road user (75+) is involved in an injury crash, the crash is more likely to result in high levels of road trauma than crashes involving other road-user groups. In other words, older road users are more likely to suffer injury when they are a victim of a traffic crash and that injury is more likely to result in a fatal outcome for an older person than for a younger person with the same injury.

It has long been known that older road users are more susceptible to death and serious injury when involved in a traffic crash; research from 1989 indicates that older road users are not only more likely to sustain more serious injury in any given accident, but they are also significantly more likely to die from a given injury severity[27]. It is not surprising, therefore, that older road users are over represented in the '*Fatal/Serious'* crash category. It is, however, noteworthy that Dunedin City is the only district examined that shows such a pattern. It is possible that the city has the largest population of older drivers in Otago and Southland; this pattern probably exists elsewhere, but due to a smaller sample size, the difference has not been statistically significant.

[27] McCoy, G.F., Johnstone, R.A. & Duthie, R.B. (1989). Injury to the elderly in road traffic accidents. *Journal of Trauma and Acute Care Surgery*, *29*, 494-497.

It seems likely that older road users are simply frailer and thus more susceptible to serious road trauma, as international research indicates. Dunedin's status as the only district to show this pattern is probably a function of its larger sample size; the other districts simply do not have enough crashes involving older drivers to detect a notable pattern.

For further evidence that older drivers are more susceptible to serious road trauma, see Figure 33 below, which demonstrates that crashes associated with '*Illness: Other'* (which includes issues such as physical disability, defective vision and impaired ability due to old age) tend to be more serious than other crashes.

Figure 31 Fatal and serious crashes in Dunedin City, 2010-2013, by driver age

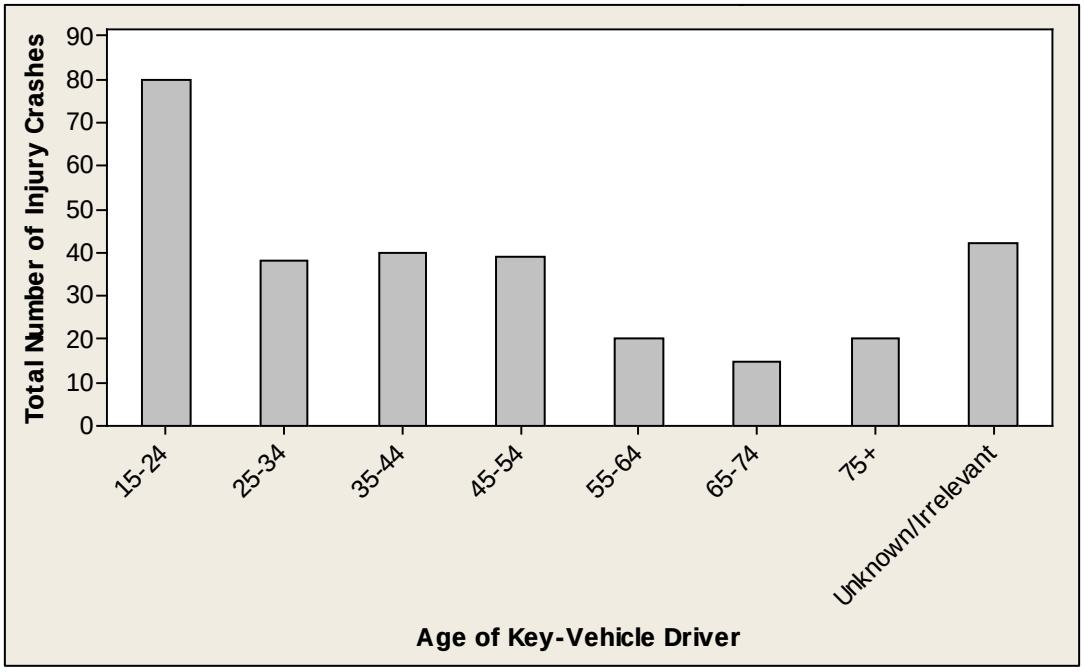


Figure 32 Minor crashes in Dunedin City, 2010-2013, by driver age

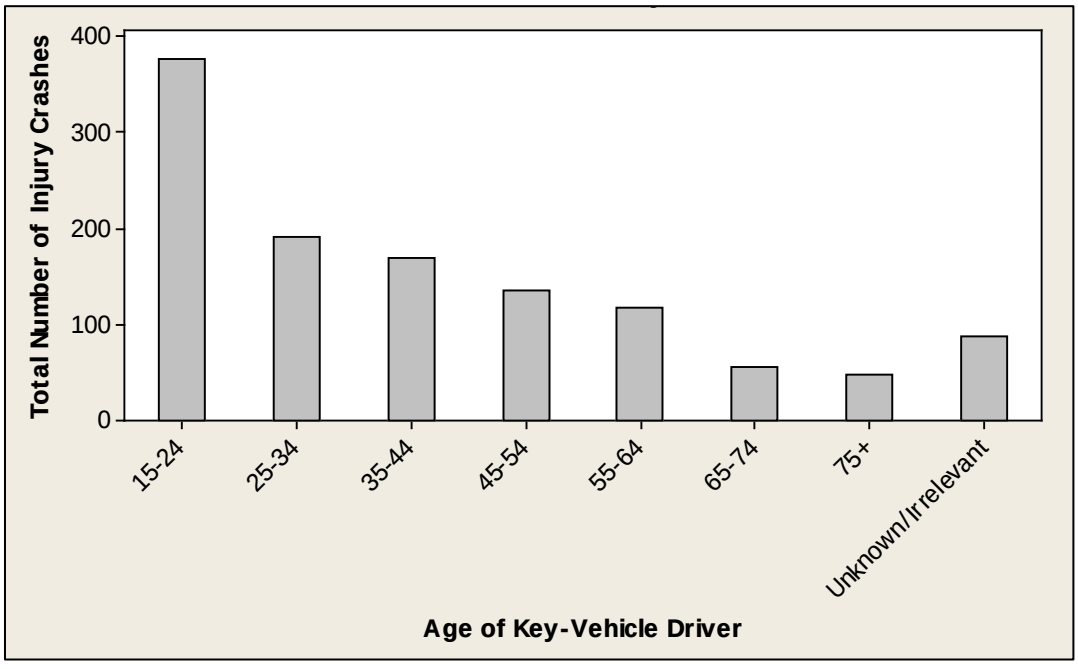
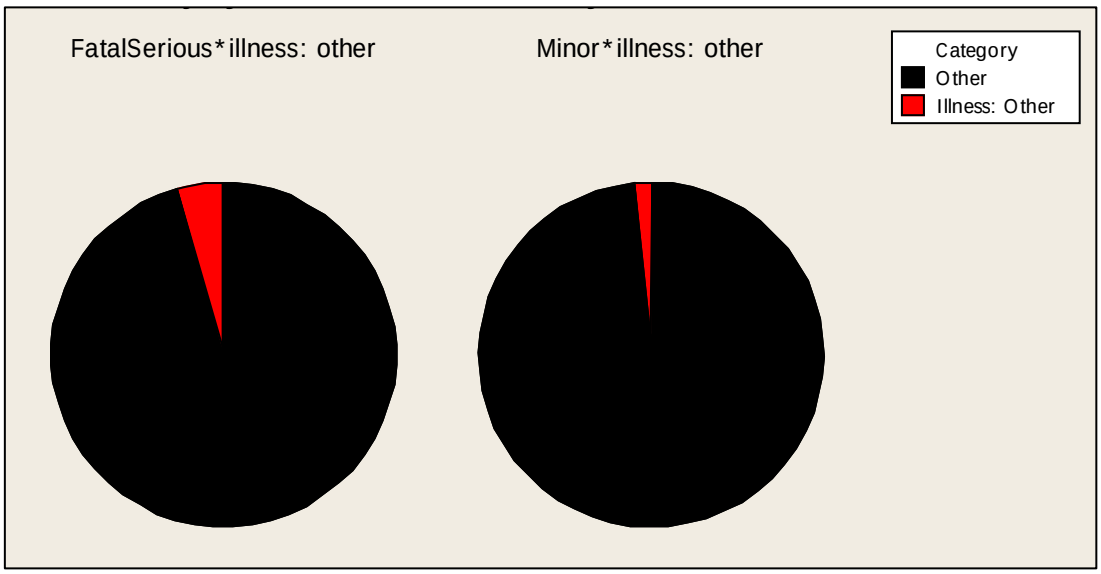


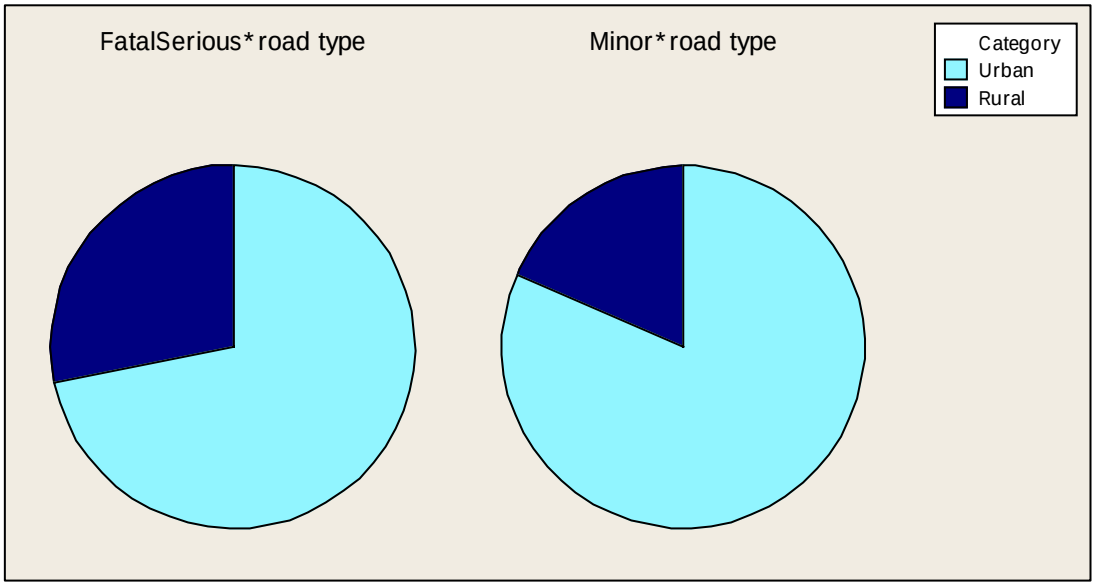
Figure 33 **Comparative severity of injury crashes in Dunedin city associated with illness, 2010-2013**



Theme 5: Serious and fatal crashes are over represented on roads with high-speed limits (80 km/h or higher) in Dunedin City.

Figure 34 indicates that fatal and serious crashes are more closely associated with rural-road crashes (roads with an 80 km/h speed limit or higher), compared with minor crashes.

Figure 34 **Comparative severity of injury crashes on urban and rural roads in Dunedin City, 2010-2013**

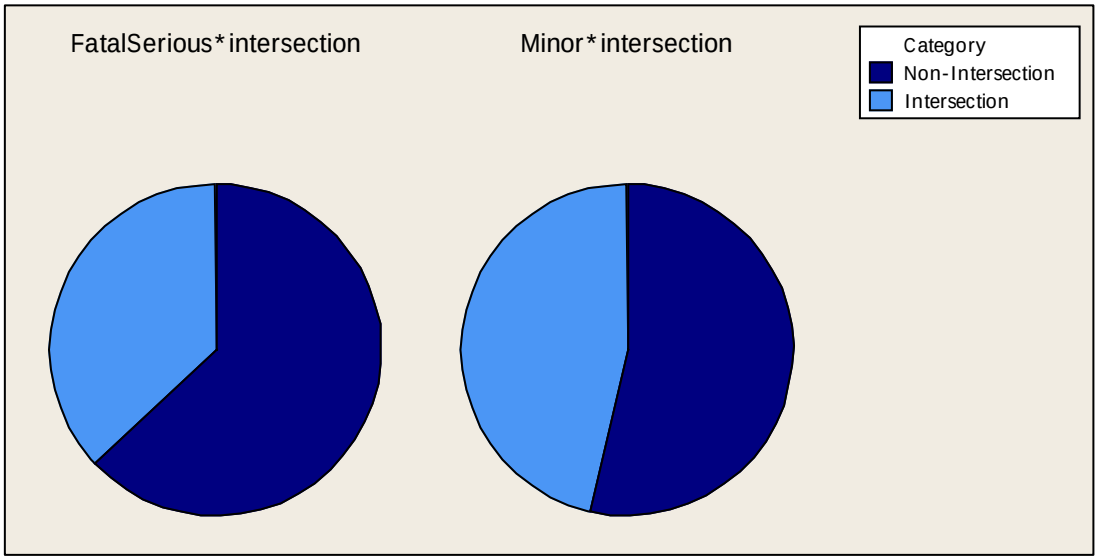


This finding is not surprising as research evidence indicates that higher travel speeds are associated not only with increased likelihood of crashing, but also with increased crash severity. That is, travelling at higher speeds tends to lead to more crashes, and these high-

speed crashes are usually more severe than low-speed crashes[28].The DCC may wish to investigate whether this is a natural consequence of higher-travel speeds, or whether it is associated with some inherent danger on the high-speed roads in this city.

Theme 6: Serious and fatal crashes in Dunedin City tend to occur midblock.

Figure 35 **Comparative severity of injury crashes at intersections and not at intersections (i.e. midblock) in Dunedin City, 2010-2013**



As Figure 35 illustrates, 62.9% of Dunedin City's fatal and serious crashes have taken place midblock. In contrast, 53.6% of Dunedin City's minor crashes have taken place midblock (shown as '*Non-intersection'* in the legend of the figure). This finding indicates that, on average, midblock crashes tend to be more serious than intersection crashes.

There are two possible reasons for this. The first is that many intersection crashes tend to be rear-end crashes, which analyses indicate are often minor. This means that the proportion of serious and fatal crashes at intersections is lower than perhaps one would expect, because of the high number of minor rear-end crashes.

Furthermore, many midblock crashes involve vulnerable-road users (particularly cyclists and pedestrians). For example, research located in Brisbane indicates that fatal and serious cycle-related accidents involving children often occur midblock in urban areas[29].

This is probably a combination of two factors: The prevalence of minor rear-end crashes at intersections, which drives the fatal/serious crash rate down, and the prevalence of serious pedestrian/cyclist crashes midblock, which drives the fatal/serious-crash rate up.

[28] Aarts, L. & van Schagen, I. (2006). Driving speed and the risk of road crashes: A review. *Accident Analysis & Prevention, 38,* 215-224. doi: 10.1016/j.aap.2005.07.004.

[29] Nixon, J., Clacher, R., Pearn, J. & Corcoran, A. (1987). Bicycle accidents in childhood. *British Medical Journal (Clinical Research Ed.)*, *294*, 1267-1269.

Theme 7: Saturdays are hazardous for road safety in Dunedin City.

Figure 36 **Fatal and serious crashes in Dunedin City, 2010-2013, by day of week**

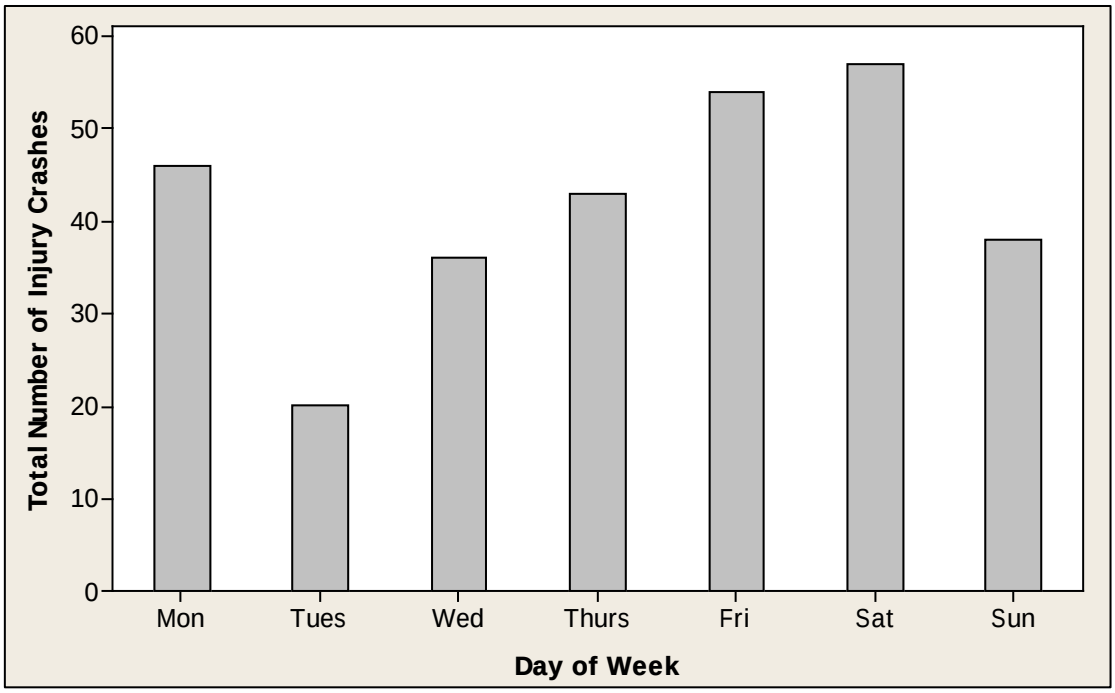
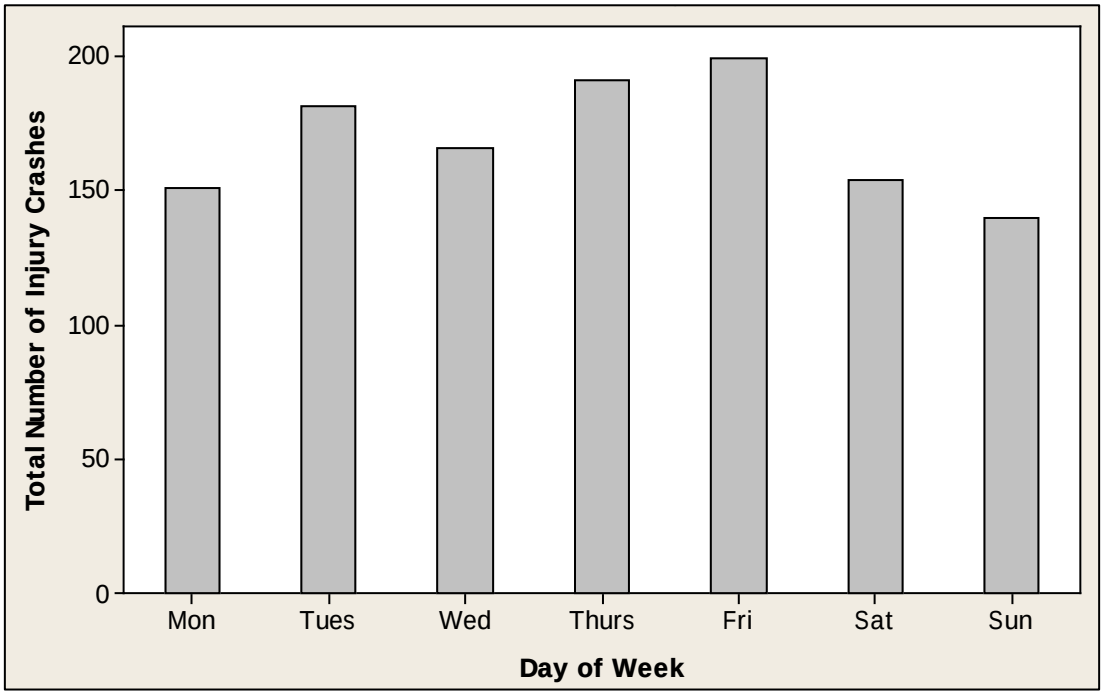


Figure 37 **Minor crashes in Dunedin City, 2010-2013, by day of week**



Figures 36 and 37 show that, when crashes take place on a Saturday, they have a high probability (relative to other days of the week) of being serious or fatal. About a quarter of all injury crashes taking place on a Saturday in Dunedin City (2010-2013) have resulted in a serious injury to at least one road user, and those injuries may have proved fatal. For

reference, 19.9% of all injury crashes in Dunedin City over this period were classed as '*fatal or serious*'.

This finding raises questions about why crashes on the weekend (particularly Saturday) are so serious in Dunedin City. If this finding is to be explained, the subjects that would need to be investigated are:

- whether Saturdays are an inherently risky time to drive in Dunedin City (e.g. perhaps there is less traffic on the roads on Saturdays, increasing the level of risk for road users). (Other analyses in this report indicate that multi-vehicle collisions involving cars often tend to be less severe than other sorts of crashes, so decreased congestion in the city associated with the weekend could be associated with a higher degree of serious road trauma).
- whether other sorts of behaviour, which are linked to serious road trauma, are more common on Saturdays, (e.g. excess intoxication). (Other analyses in this report indicate that drink-driving is associated with higher-crash-severity.)
- whether more people tend to walk and cycle on Saturdays, which increases the serious-crash risk (as crashes involving pedestrians and cyclists tend to be quite serious).

3.6.3. Factors associated with serious and fatal crashes

Crash characteristics and causes

Movement type

Findings:

Relative to minor crashes, serious and fatal crashes in Dunedin City:

- are closely associated with pedestrians crossing the road (as discussed in Theme 1)
- do not typically involve rear-end collisions.

There are 15 crash types identified by the Police: '*Overtaking'* (and lane change), '*Head-on'*, '*Lost control'* (on a straight section), '*Cornering'* (on a bend), '*Collision'* (with obstruction of some kind), '*Rear-end'*, '*Turning versus same direction'* (i.e. crash involved two vehicles on the same side of the road, with one or both attempting to turn, often resulting in a sideswipe crash), '*Crossing' (no turns)* (i.e. side-impact crash), '*Crossing' (vehicle turning)* (i.e. crash involved at least one vehicle turning, usually at an intersection), '*Merging'*, '*Right-turn against'* (i.e. making a right turn against the flow of through traffic), '*Manoeuvring'* (crash during complex manoeuvre (e.g. parking, U-turn), '*Pedestrian crossing road'*, '*Pedestrian other'* (crash involved pedestrian not crossing the road (e.g. on footpath or leaving vehicle)) and '*Miscellaneous'*.

There is strong evidence (99.9%) suggesting that serious and fatal crashes in Dunedin City tend to involve different crash-movement types, when compared with minor crashes in the city. A high proportion of injury crashes involving pedestrians crossing the road in Dunedin City are classed as '*fatal or serious'*. By contrast, a low proportion of rear-end injury crashes are classed as 'fatal or serious'.

Specifically, 35.3% of all injury crashes involving a pedestrian crossing the road in Dunedin City (2010-2013) have been classed as '*fatal or serious'*. By contrast, 4.9% of all rear-end injury crashes have been classed as '*fatal or serious'*. This finding means that about a third of all injury crashes involving one or more pedestrians crossing the road in Dunedin City (2010-2013) have resulted in a serious injury to at least one road user (presumably the pedestrian), and some of those injuries may have proved fatal.

There are two main differences between figures 22 and 23 for *Rear-end* and *PedXng*. *PedXng* is much more prominent in the '*Fatal/Serious'* graph than in the '*Minor'* graph. In contrast, *Rear-end* is a dominant force in the '*Minor'* graph but barely features at all in the '*Fatal/Serious'* graph.

Key vehicle involved in crashes

Finding:

Relative to minor crashes, serious and fatal crashes in Dunedin City are closely associated with motorcycles and cyclists (as discussed in Themes 2 and 3 above).

The Police have classified key vehicles into 13 categories: '*Car'* (or station wagon), '*SUV*' (or 4x4), '*Taxi'*, '*Van'* (or ute), '*Truck'*, '*Bus'*, '*School bus'*, '*Motorcycle'*, '*Moped'*, '*Cyclist'*, '*Skateboarder*, '*Other'* and '*Unknown'*. (See footnote 16 for explanation of the term key vehicle.)

The main differences between figures 28 and 29 are '*Motorcycle'* and 'C*yclist'*. A sizeable minority of fatal and serious crashes in Dunedin City have involved motorcycles and cyclists in the key-vehicle role. by contrast, few minor crashes have involved motorcycles or cyclists. This finding means that when a motorcycle crash or a cyclist crash takes place, they often result in severe road trauma (relative to other types of crashes).

There is strong evidence (99.9%) that serious and fatal crashes in Dunedin City tend to involve motorcycles and cycles, when compared with minor crashes in the city. With respect to crashes involving motorcycles in the key-vehicle role, fatal and serious crashes make up a high proportion of overall injury crashes. Crashes involving cyclists in the key-vehicle role, fatal and serious crashes also make up a high proportion of overall injury crashes.

Specifically, 45.5% of all injury crashes involving a motorcycle in the key-vehicle role in Dunedin City (2010-2013) were classed as *'fatal or serious'*, and 32.3% of all injury crashes involving a cyclist in the key-vehicle role were classed as *'fatal or serious'*. This finding means that almost a half of all injury crashes involving a motorcycle in the key-vehicle role in resulted in a serious injury to at least one road user (and some of those injuries proved fatal).

Furthermore, about a third of all injury crashes involving a cyclist in the key-vehicle role resulted in a serious injury to at least one road user (and some of those injuries may have proved fatal).

Multi-vehicle crashes

Finding:

Relative to minor crashes, serious and fatal crashes in Dunedin City:

- are closely associated with pedestrians
- do not typically involve multi-vehicle collisions involving a car in the second road user role.

There is strong evidence (99.9%) that serious and fatal crashes in Dunedin City tend to involve different combinations of road users, when compared with minor crashes.

For crashes involving pedestrians in the second road user role, fatal and serious crashes make up a high proportion of overall injury crashes. By contrast, for crashes involving cars in the second road user role (this refers to multi-vehicle collisions involving at least one car or station wagon), fatal and serious crashes make up a low proportion of overall injury crashes.

Specifically, 36.9% of injury crashes involving a pedestrian in the second road-user role in Dunedin City (2010-2013) have been classed as *'fatal or serious'*. By contrast, 14.0% of injury crashes involving a car or station wagon in the second road user role have been classed as *'fatal or serious'*.

This finding means that about a third of all injury crashes involving a pedestrian as the second road user in the crash resulted in a serious injury to at least one road user (presumably the pedestrian), and some of those injuries may have proved fatal.

Figures 26 and 27 show this. There are two main differences between these two figures: *Car* and *Pedestrian*. *Car* features prominently in the '*Minor'* graph; a huge number of minor crashes in Dunedin City have been associated with multi-vehicle collisions involving at least one car or station wagon. By contrast, while a sizeable proportion of serious and fatal crashes have also fallen into this category, other categories are much more prominent in the '*Fatal/Serious'* graph. The most noticeable of these is '*Pedestrian',* which features heavily in the '*Fatal/Serious'* graph, with a sizeable minority of fatal and serious crashes involving pedestrians. by contrast, pedestrian crashes hardly feature at all in the '*Minor'* graph. This indicates that when pedestrian crashes occur, they tend to result in severe road trauma.

Above the legal BAC limit

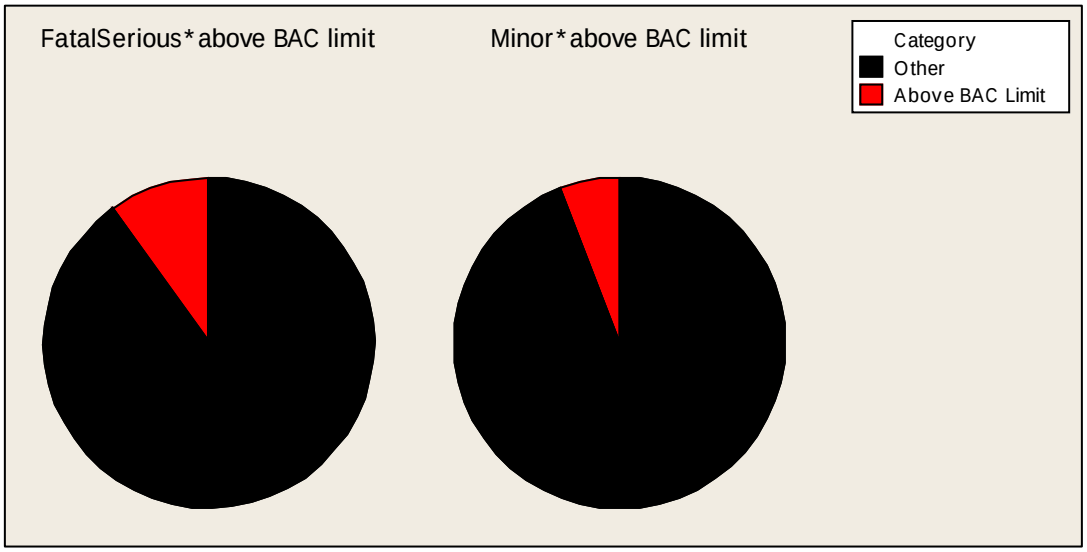
Finding:

Relative to minor crashes, serious and fatal crashes in Dunedin City are closely associated with one or more parties recording a blood alcohol level over the legal limit.

There is significant evidence (97.5%) that fatal and serious crashes in Dunedin City are more likely to involve one or more drivers over the legal blood alcohol limit, compared with minor crashes. A crash was categorised as '*Above BAC limit*' if one or more parties in the crash were noted to be above the legal limit for alcohol and/or refusing to take the test (crash code

103). According to the Police, refusing the test is very rare, and most of the 103-coded crashes involve road users who were above the legal alcohol limit[30].

Figure 38 Comparative severity of injury crashes in Dunedin City where a driver was above the BAC limit, or not, 2010-2013



Overall, as Figure 38 depicts, 9.9% of fatal and serious crashes in Dunedin City involved one or more parties in the crash recording an alcohol level over the legal limit. By contrast, 5.8% of minor crashes involved one or more parties in the crash recording an alcohol level over the legal limit.

Driving space

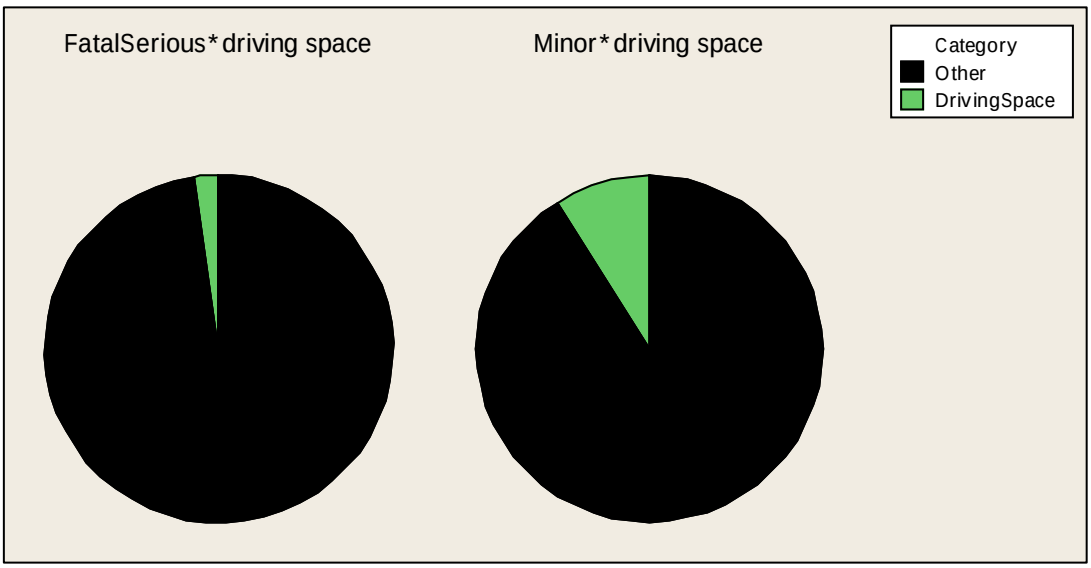
Finding:

Relative to minor crashes, serious and fatal crashes in Dunedin City are not usually associated with one or more parties following too closely, merging incorrectly or crowding a cyclist.

There is strong evidence (99.9%) suggesting that fatal and serious crashes are actually less likely to involve issues with vehicle crowding and/or driving space, compared with minor crashes. A crash was categorised as '*Driving space*' if one or more parties in the crash were following too closely in line of traffic (crash code 181), if a motorist crowded a cyclist (crash code 183), and/or if an incorrect merging/diverging manoeuvre was followed (crash code 184).

[30] *Pers. comm.*, Steve Larking, Acting Road Policing Manager for the Southern District. 13th Nov., 2013.

Figure 39 **Comparative severity of injury crashes in Dunedin City involving driver(s) following another vehicle too closely, 2010-2013**



Overall, as Figure 39 depicts, 2.4% of fatal and serious crashes in Dunedin City involved one or more parties in the crash following too closely, merging incorrectly or crowding a cyclist. by contrast, 9.0% of minor crashes involved one or more parties in the crash following too closely, merging incorrectly or crowding a cyclist.

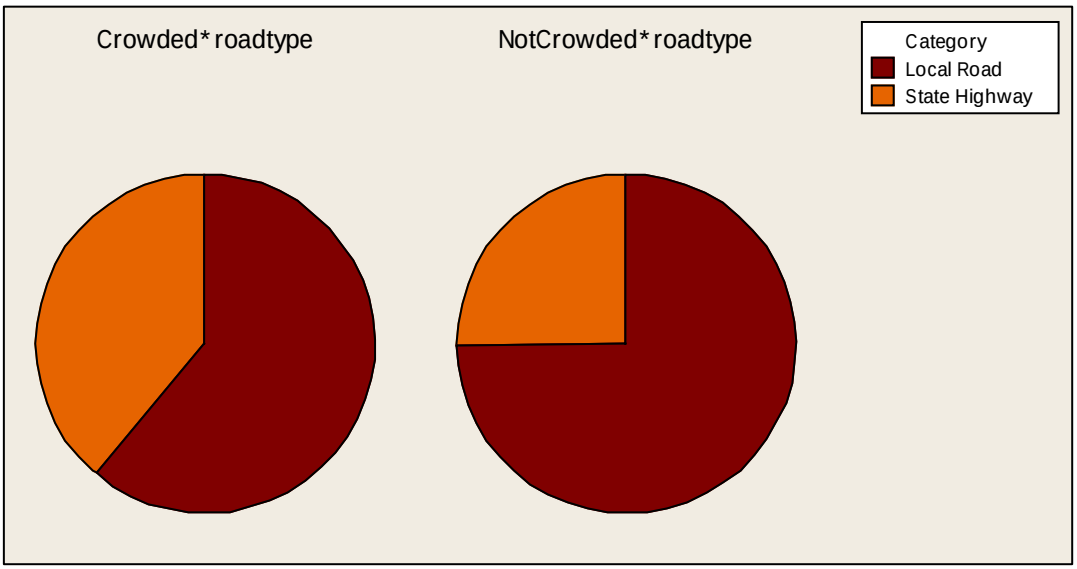
Vehicle crowding

Finding:

The high rate of crashes caused by vehicle crowding in Dunedin City is primarily associated with the state-highway network rather than the local-road network.

There is powerful evidence (99.5%) that the distribution of crowding-related crashes is uneven across the local-road and state-highway networks.

Figure 40 **Comparative incidence on local roads or state highways of injury crashes associated with driver(s) following another vehicle too closely in Dunedin City, 2010-2013**



Crashes in the left pie chart of Figure 40 involved some sort of vehicle-crowding issue (e.g. following too closely, crowding another, merging incorrectly, etc.), while crashes included in the right pie chart did not involve a vehicle-crowding issue. Note that the right figure is roughly representative of overall crash numbers in the region: 74.9% of non-crowding crashes from 2010-2013 occurred on local roads, with 25.1% on state highways. By contrast, 61.1% of crowding-related crashes occurred on local roads, with a full 38.9% on state highways.

This finding is interesting, and is not necessarily intuitive. Common sense would seem to indicate that vehicle crowding would be more of a problem in the close confines of Dunedin's CBD, which mainly consists of local roads. However, the above analysis indicates that state highways are actually over represented in crowding-related crashes (both incorrect merging and following too closely).

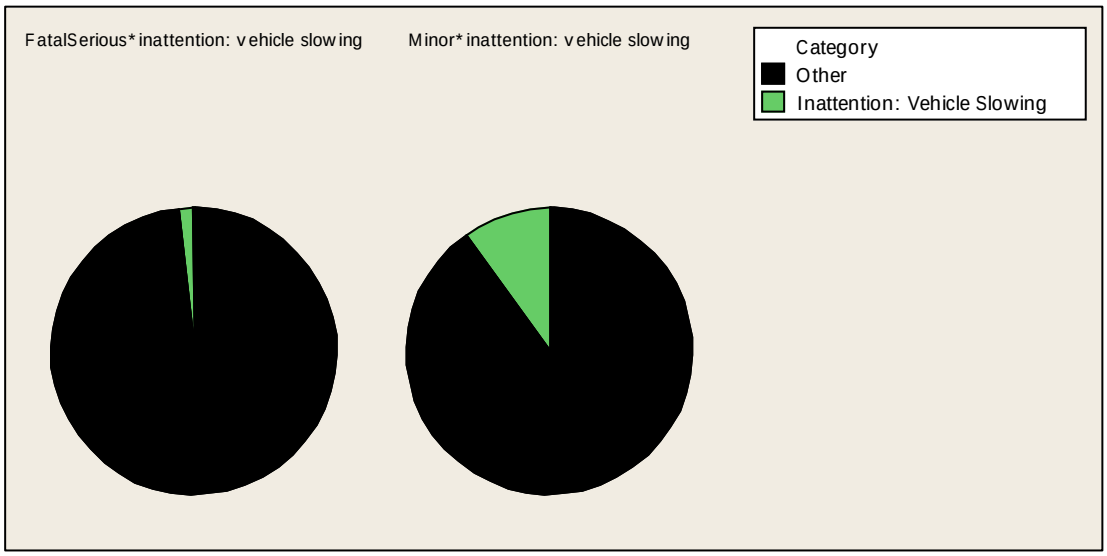
Inattention: Vehicle slowing

Finding:

Relative to minor crashes, fatal and serious crashes in Dunedin City are less likely to be associated with road users' inattention to a vehicle's motions in front.

A crash was classed as *'Inattention: Vehicle slowing'* if a driver was inattentive: failed to notice a vehicle slowing, stopping or stationary in front (crash code 331). There is strong evidence (99.9%) that fatal and serious crashes in Dunedin City are less likely to involve inattention on the part of road users to vehicles in front of them, when compared with minor crashes.

Figure 41 **Comparative severity of injury crashes in Dunedin City associated, or not, with failing to notice that the vehicle in front is slowing, stopping or stationary, 2010-2013**



Overall, as Figure 41 depicts, 1.7% of fatal and serious crashes in Dunedin City involved a driver failing to notice a vehicle slowing, stopping or stationary in front. By contrast, 9.9% of minor crashes involved a driver failing to notice a vehicle slowing, stopping or stationary in front.

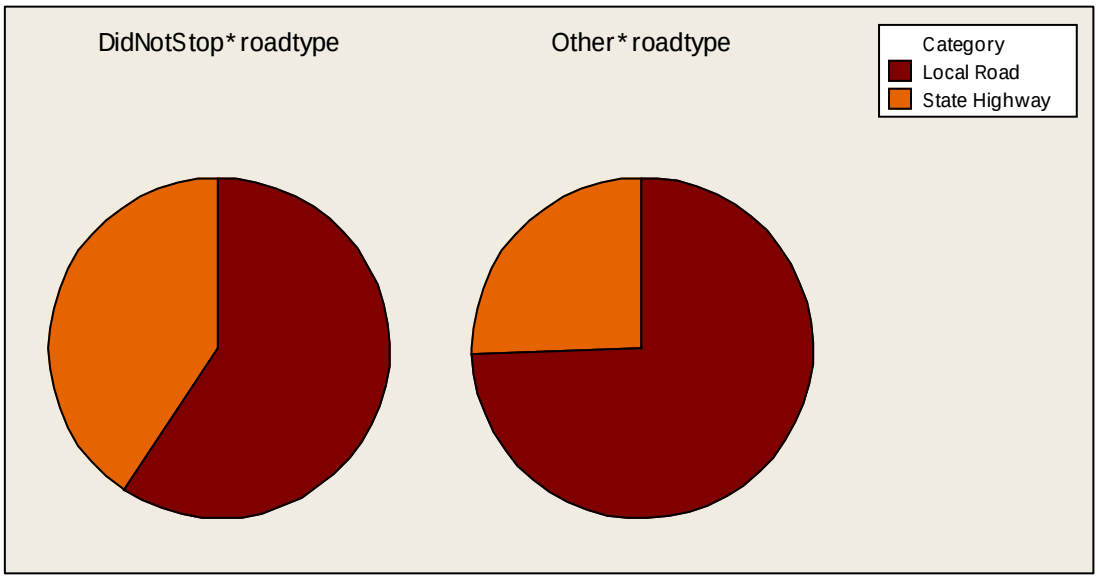
Failing to stop

Finding:

The high rate of crashes caused by failure to stop at stop signs and/or traffic lights in Dunedin City is mainly associated with the state-highway network.

There is strong evidence (99%) that distribution of failing-to-stop crashes is uneven across the local-road and state-highway network.

Figure 42 **Comparative incidence on local roads or state highways of injury crashes occurring when a driver failed to stop at stop sign or traffic lights in Dunedin City, 2010-2013**



Crashes in the left pie chart in Figure 42 involved some sort of failure to stop (at a steady red or orange light, or at a stop sign), while crashes included in the right pie chart did not involve a failure-to-stop issue.

Note that the right pie chart is roughly representative of overall crash numbers in the region: 74.5% of non-stopping-related crashes from 2010-2013 occurred on local roads, with 25.5% occurring on state highways. By contrast, 59.3% of crashes related to failure-to-stop occurred on local roads, with 40.7% occurring on state highways.

As with vehicle crowding, this finding is interesting and not necessarily intuitive. Common sense indicates that failure to stop is likely to be more of a problem in the close confines of Dunedin's CBD, with multiple sets of traffic lights and stop signs. However, the above analysis indicates that state highways are actually over represented in failure-to-stop-related crashes.

Give way: Pedestrian

Finding:

Relative to minor crashes, serious and fatal crashes in Dunedin City are closely associated with one or more motorists failing to give way to pedestrians at crossing points (i.e. at zebra crossings or traffic lights).

A crash was categorised as *'Give Way: Pedestrian*' if a driver failed to give way to a pedestrian on a crossing (crash code 306) or failed to give way when turning at signals to pedestrians (crash code 307). There is powerful evidence (99.5%) that fatal and serious crashes in Dunedin City are more likely to involve a failure to give way on the part of one or more motorists to pedestrians at crossing points, compared with minor crashes.

Overall, as Figure 25 depicts, 5.1% of fatal and serious crashes involved one or more motorists failing to give way to pedestrians at crossing points (i.e. at zebra crossings or traffic lights). by contrast, 1.9% of minor crashes involved one or more motorists failing to give way to pedestrians at crossing points (i.e. at zebra crossings or traffic lights).

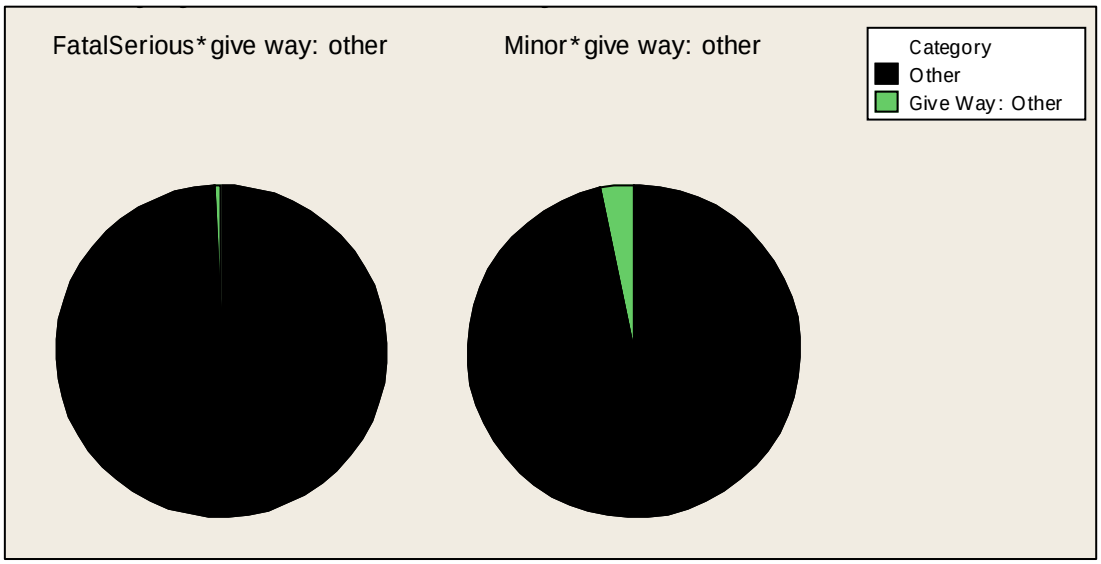
Give way: Other

Finding:

Relative to minor crashes, serious and fatal crashes in Dunedin City are not usually associated with one or more parties failing to give way for a variety of reasons (e.g. failed to give way at one-lane bridge, failed to give way when entering roadway from driveway, failed to give way to an emergency vehicle, etc.).

A crash was categorised as *'Give way: Other'* if a road user failed to give way when entering a roadway from a driveway (crash code 308); failed to give way when entering a roadway not from a driveway or intersection (crash code 312); failed to give way at a one-lane bridge or road (crash code 310); failed to give way to an emergency vehicle (crash code 313); or failed to give way for unspecified reasons (crash code 300). There is significant evidence (97.5%) that fatal and serious crashes in Dunedin City are actually less likely to involve issues with vehicles failing to give way in a variety of situations (specified below), when compared with minor crashes.

Figure 43 **Comparative severity of injury crashes in Dunedin City associated, or not, with driver failing to give way when required by road rules, 2010-2013**



Overall, as Figure 43 depicts, 0.7% of fatal and serious crashes in Dunedin City involved the failure of one or more motorists to give way in a variety of situations (in a manner specified above, or for unspecified reasons). However, 3.3% of minor crashes involved one or more motorists failing to give way in a variety of situations (in a manner specified above, or for unspecified reasons).

Did not look: Give way

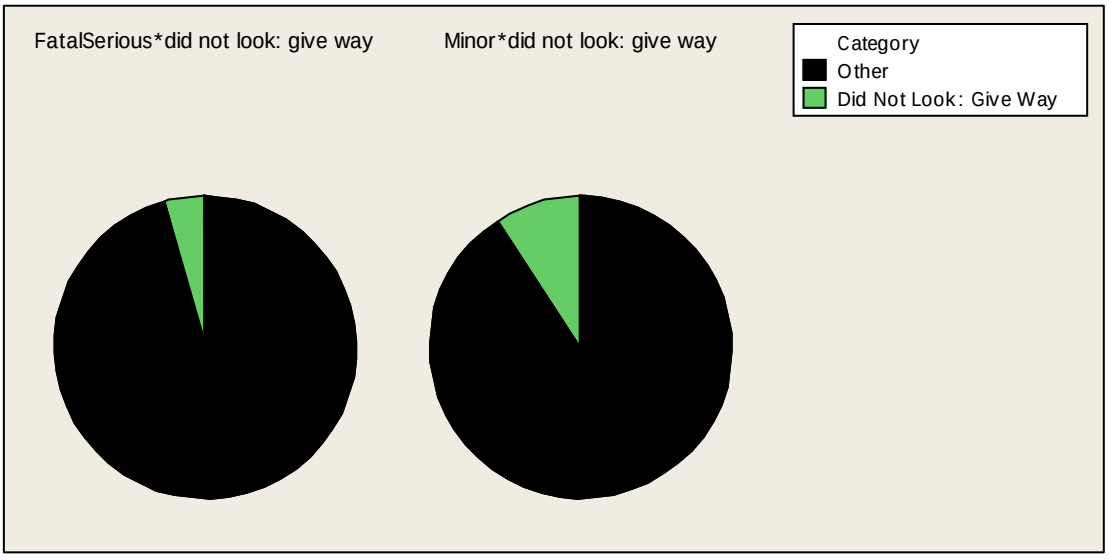
Finding:

Relative to minor crashes, fatal and serious crashes in Dunedin City are less likely to be associated with road users' failing to see or look for another party when required to give way.

A crash was classed as '*Did not look: Give way*' if a driver did not see or look for another party until too late when required to give way to traffic from another direction (crash code 375) and/or if a driver did not see or look for another party until too late when required to give way to pedestrians (crash code 376). There is strong evidence (99.0%) that fatal and serious crashes are less likely to involve one or more road users failing to look for another party when required to give way, compared with minor crashes.

Overall, as Figure 44 depicts, 4.4% of fatal and serious crashes in Dunedin City involved a driver failing to see or look for another party until too late when required to give way. By contrast, 9.2% of minor crashes involved a driver failing to see or look for another party until too late when required to give way.

Figure 44 **Comparative severity of injury crashes in Dunedin City associated, or not, with driver required to give way by the road rules, failing to see or look for another party until too late, 2010-2013**



Give way: Turning and give way, pedestrian

Findings:

- The high rate of crashes caused by turning vehicles failing to give way to oncoming traffic in Dunedin City is mainly associated with the local-road network.

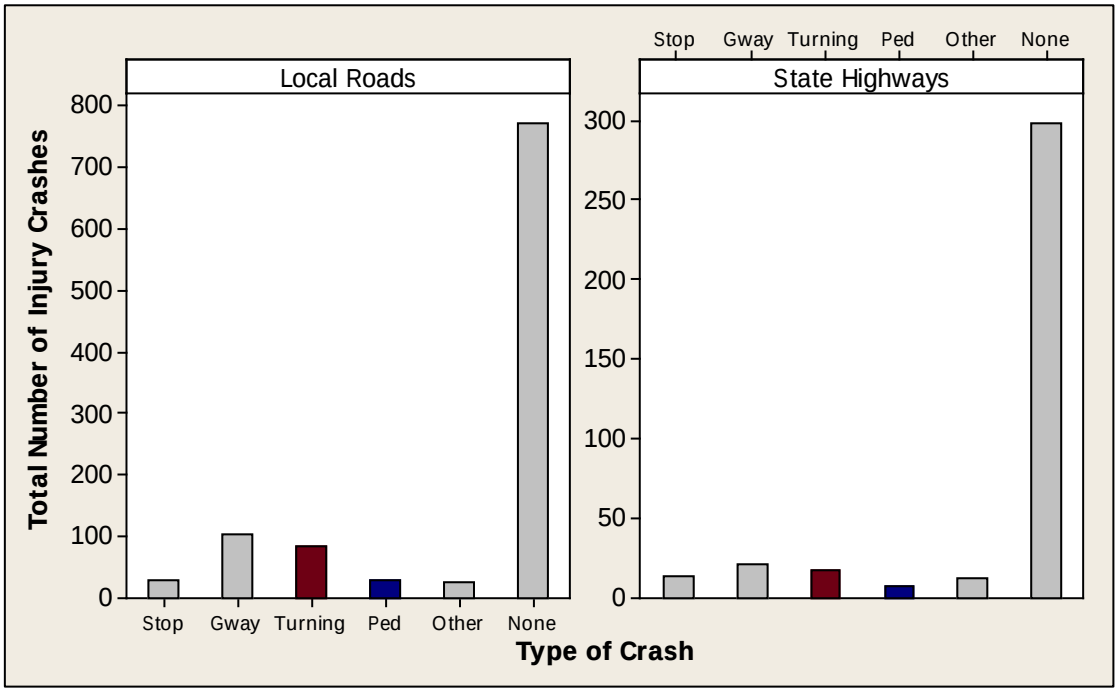
There is significant evidence (97.5%) that the distribution of give-way-related crashes is different between the state-highway and local-road network. Failure to give way to pedestrians was distributed equally across the local-road and state-highway network.

Note that the left and right panel of Figure 45 have different *y*-axes. The left scale (local road) ranges from 0 to 800 injury crashes, while the right scale (state highway) ranges from 0 to 300 injury crashes.

In Figure 45, *'Stop'* indicates a failure to give way at stop signs; '*Gway'* indicates a failure to give way at give-way signs; '*Turning'* indicates a failure to give way when turning (to oncoming through traffic); '*Ped'* indicates a failure to give way to pedestrians at zebra crossings or traffic lights; '*Other'* indicates a failure to give way in 'other' situations (e.g. to an emergency vehicle, on a one-way bridge, etc.); '*None'* indicates that the crash did not involve a failure to give way.

'Turning' has been highlighted in red in both graphs, and '*Ped'* has been highlighted in blue. These are the two categories of most interest, as they are the categories where Dunedin City is over represented relative to the rest of the Otago region.

Figure 45 **Comparative incidence of different types of give-way crashes on local roads or state highways of injury crashes in Dunedin City, 2010-2013**



Note that the distribution of failure-to-give-way-to-pedestrian crashes (*Ped*) is approximately equal across local roads and state highways: 2.9% of all local-road crashes and 1.9% of all state-highway crashes. By contrast, the distribution of failure-to-give-way-when-turning crashes (*Turning*) is distributed unevenly between the two-road networks. This crash type makes up 7.9% of all local-road crashes and 4.6% of all state-highway crashes.

It is unsurprising that this crash type is associated most with local roads. There are many situations in a busy urban environment like Dunedin City where turning traffic must give way to oncoming traffic. The most prominent examples are X-junction crossroads and T-junctions, where drivers turning right onto the stem of the T from the crossbar must wait for oncoming traffic to clear before turning. By contrast, motorists travelling along state highways encounter fewer intersections, and thus turn less often than motorists using the local-road network.

Reckless pedestrian behaviour

Finding:

Relative to minor crashes, serious and fatal crashes in Dunedin City are closely associated with reckless behaviour (e.g. walking heedless of traffic, not keeping to the side of the road, etc.) on the part of one or more pedestrians involved in the crash.

A crash was classed as *'Pedestrian: Reckless behaviour*' if one or more pedestrians in the crash was not keeping to the footpath (crash code 701); was not keeping to the side of the road (crash code 702); was not facing oncoming traffic (crash code 703); and/or was crossing the road while walking heedless of traffic (crash code 711). There is powerful evidence (99.5%) to suggest that fatal and serious crashes in Dunedin City are more likely to involve reckless behaviour on the part of one or more pedestrians involved in the crash, when compared with minor crashes.

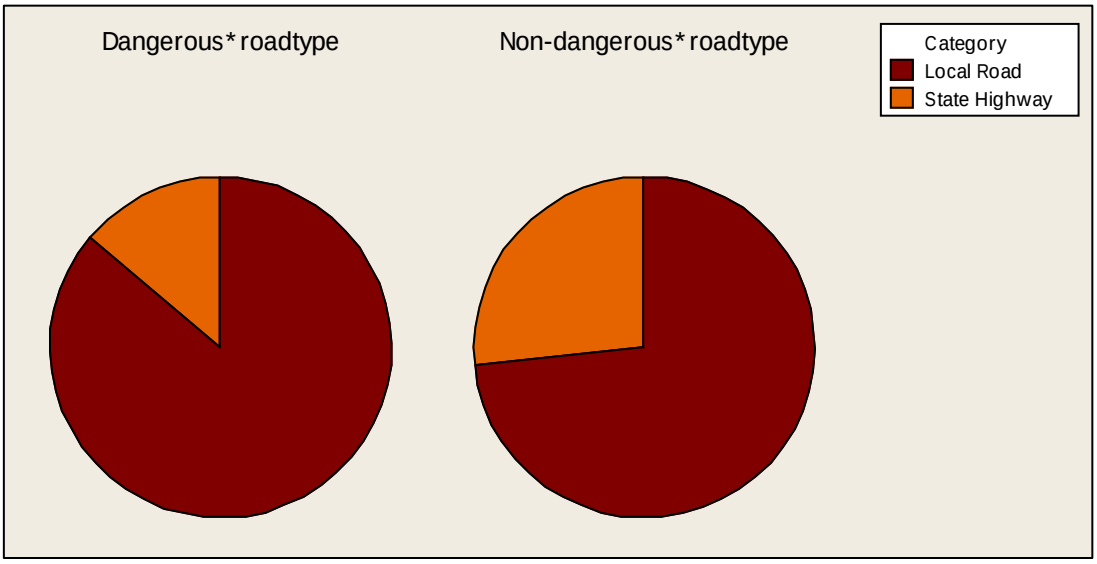
Overall, as Figure 24 shows, 4.8% of fatal and serious crashes have involved reckless behaviour (of the kind described above) on the part of one or more pedestrians in the crash. By contrast, 1.6% of minor crashes have involved the sort of reckless behaviour detailed above on the part of one or more pedestrians involved in the crash.

Dangerous pedestrian behaviour

Finding:

The high rate of crashes caused wholly, or in part, by reckless pedestrian behaviour (e.g. running heedless of traffic, jaywalking, stepping out from behind a parked vehicle, waiting on the roadway for moving traffic, etc.) in Dunedin City is mainly associated with the local-road network.

Figure 46 **Comparative incidence on local roads or state highways of injury crashes occurring in Dunedin City when a pedstrian behaves dangerously, 2010-2013**



There is evidence (95%) that the distribution of dangerous pedestrian behaviour is uneven across the local-road and state-highway network. Figure 46 shows this phenomenon clearly. The left pie chart relates to crashes that could be attributed to 'dangerous' pedestrian ,behaviour (e.g. pedestrian stepped out from behind a vehicle, was running heedless of traffic, did not comply with traffic signals/school patrols, was waiting on roadway for moving traffic, wearing dark clothing, listening to music, etc.). The right pie chart involves all other crashes and is included for comparison.

Note that in the right pie chart in Figure 46, 73.3% of injury crashes took place on local roads, and 26.7% took place on the state-highway network. In the left pie chart, involving dangerous pedestrian behaviour, 86.2% of injury crashes took place on local roads and 13.8% took place on state highways.

This is an interesting finding, which possibly indicates that dangerous pedestrian behaviour in Dunedin City is mostly associated with areas of the CBD and suburban roads. Further investigation should focus on whether the city's student population is mostly to blame for reckless-behaviour/pedestrian crashes, or the older population working in the CBD. Further investigation should also examine whether reckless-behaviour/pedestrian crashes increase during the weekend and over holiday periods. This could shed light on whether alcohol is a factor in these types of crashes.

It is also noteworthy that the state-highway network in Dunedin City is mainly comprised of one-way streets. These one-way streets are much easier for pedestrians to navigate and cross successfully outside designated-crossing areas, given that they only have to watch for oncoming traffic in one direction.

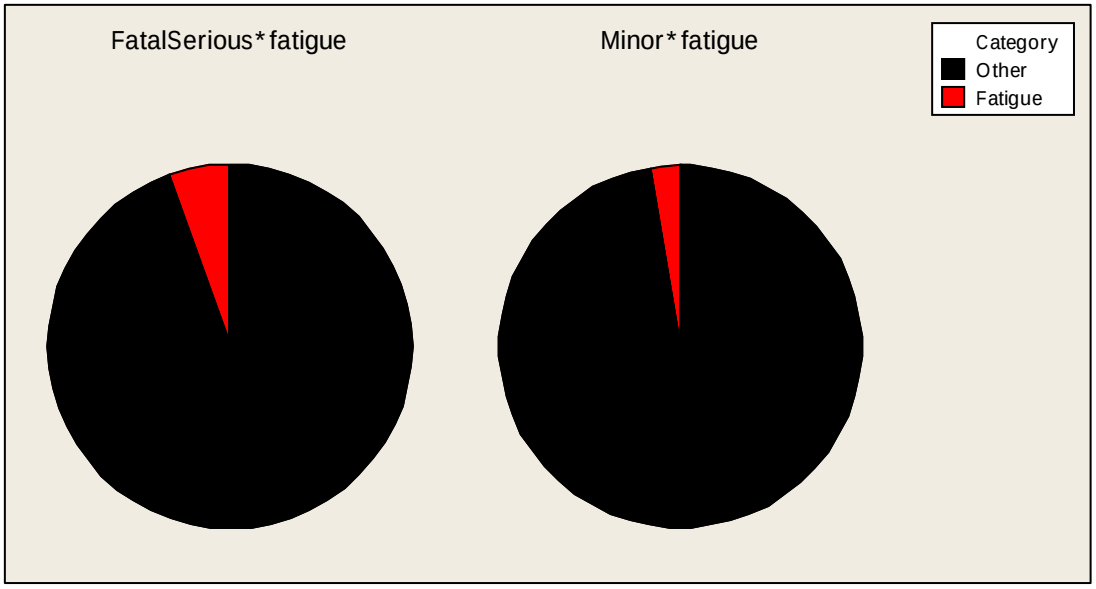
It is possible that dangerous pedestrian behaviour is equally common on the state-highway network as in the local-road network, but the relative safety of the one-way streets means that fewer injury accidents result from such behaviour; thus, local roads are perceived, perhaps erroneously, to have a higher rate of dangerous pedestrian behaviour.

Fatigue

Finding:

Relative to minor crashes, serious and fatal crashes in Dunedin City are closely associated with fatigue.

Figure 47 Comparative severity of injury crashes assciated with fatigue in Dunedin City, 2010-2013



A crash was classed as being caused by '*Fatigue*' if one or more road users were fatigued (drowsy, tired, fell asleep) for unspecified reasons (crash code 410); fatigued due to a long trip (crash code 411); fatigued due to lack of sleep (crash code 412); fatigued due to exhaust fumes (crash code 413); fatigued due to working long hours before driving (crash code 414); and/or fatigued due to exceeding driving hours (crash code 415). There is significant evidence (97.5%) that fatal and serious crashes in Dunedin City are more likely to involve fatigue, compared with minor crashes.

Overall, as Figure 47 depicts, 5.4% of fatal and serious crashes in Dunedin City have involved fatigue. By contrast, 2.6% of minor crashes have involved fatigue.

Illness: Other

Finding:

Relative to minor crashes, serious and fatal crashes in Dunedin City are closely associated with prolonged illness on the part of one or more road users in the crash.

A crash was classed as being caused by *'Illness: Other*' if one or more road users involved in the crash was ill or disabled (crash code 500); was physically disabled (crash code 502); had defective vision (crash code 503); was experiencing a medical illness (not sudden), such as flu or diabetes (crash code 504); was experiencing a mental illness (e.g. depression, psychosis) (crash code 505); was suicidal (but unsuccessful) (crash code 506); and/or suffered impaired ability due to old age (crash code 507). There is powerful evidence (99.5%) that fatal and serious crashes are more likely to involve prolonged illness on the part of one or more road users in the crash, compared with minor crashes.

Overall, as Figure 33 depicts, 4.4% of fatal and serious crashes in Dunedin City have involved prolonged illness on the part of one or more road users in the crash. By contrast, 1.6% of minor crashes have involved prolonged illness on the part of one or more road users in the crash.

Timing

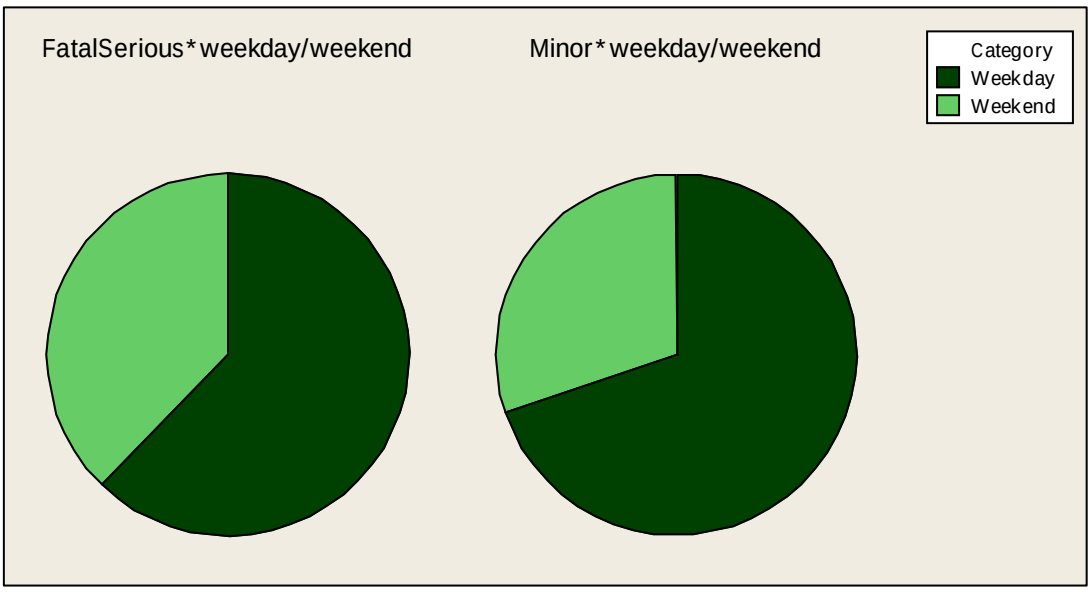
Weekend

Finding:

Relative to minor crashes, serious and fatal crashes in Dunedin City are closely associated with weekends.

Crashes are classed into '*Weekday*' and '*Weekend*', where '*Weekend*' indicates that the crash occurred between 6 pm on Friday and 5:59 am on Monday on ordinary weekends, or between 4 pm on the first day and 5:59 am on the final day for holiday weekends. All other crashes are classed as '*Weekday*'. There is significant evidence (97.5%) that serious and fatal crashes are more likely to take place during the weekend, when compared with minor crashes.

Figure 48 **Comparative severity of injury crashes on weekdays and weekends in Dunedin City, 2010-2013**



The two pie charts in Figure 48 show a different pattern. A minority of fatal and serious crashes in Dunedin City during 2010-2013 have occurred during the weekend. By comparison, a much smaller proportion of minor crashes have taken place during the weekend.

Overall, 37.8% of serious and fatal injury crashes in Dunedin City (2010-2013) have taken place over the weekend. By contrast, 30.1% of minor crashes took place over the weekend.

Days of week

Finding:

Relative to minor crashes, serious and fatal crashes in Dunedin City are closely associated with Saturdays (as discussed in Theme 7 above) and do not typically take place on Tuesdays.

There is powerful evidence (99.5%) to suggest that serious and fatal crashes tend to occur on different days of the week, compared with minor crashes. That is, with respect to injury crashes taking place on a Saturday, a large proportion is classed as *'fatal or serious'*. By contrast, with respect to injury crashes taking place on a Tuesday in Dunedin City, a low percentage is classed as *'fatal or serious'*.

Specifically, 10.0% of injury crashes occurring on a Tuesday in Dunedin City (2010-2013) have been classed as *'fatal or serious'*. By contrast, 27.0% of injury crashes occurring on a Saturday were classed as *'fatal or serious'*. This means that about a quarter of all injury crashes taking place on a Saturday have resulted in a serious injury to at least one road-user, and those injuries may have proved fatal.

Figures 36 and 37 show a different pattern. The *'Minor*' graph appears almost evenly distributed across the week, with an approximately equal number of minor crashes on each day of the week. By contrast, the *'Fatal/Serious*' graph shows a distinct pattern across the

week, with a noticeable peak on the weekend (particularly Saturday) and a trough on Tuesday.

Infrastructure characteristics

Road type

Finding:

Relative to minor crashes, serious and fatal crashes in Dunedin City are associated with rural roads (80 km/h speed limit or higher), as discussed in Theme 7.

Roads are divided into *'Urban;* (70 km/h speed limit or lower) and *'Rural*' (80 km/h speed limit or higher). There is strong evidence (99.9%) that serious and fatal crashes in Dunedin City tend to take place on roads with higher speed limits, on average, when compared with minor crashes.

The two pie charts in Figure 34 show a different pattern; a much higher proportion of fatal and serious crashes take place on high-speed roads (80 km/h speed limit or higher), while few minor crashes take place on these high-speed roads (80 km/h speed limit or higher). Specifically, 28.2% of serious and fatal crashes in Dunedin City over the 2010-2013 period have taken place on rural roads (defined as roads with a speed limit of 80 km/h or lower); by contrast, 18.5% of minor crashes took place on rural roads.

Thus, when an injury crash takes place on a high-speed road (80 km/h speed limit or higher) in Dunedin City, it is more likely to be serious or fatal than a crash taking place on a lower-speed road (70 km/h speed limit or lower).

Urban roads

Finding:

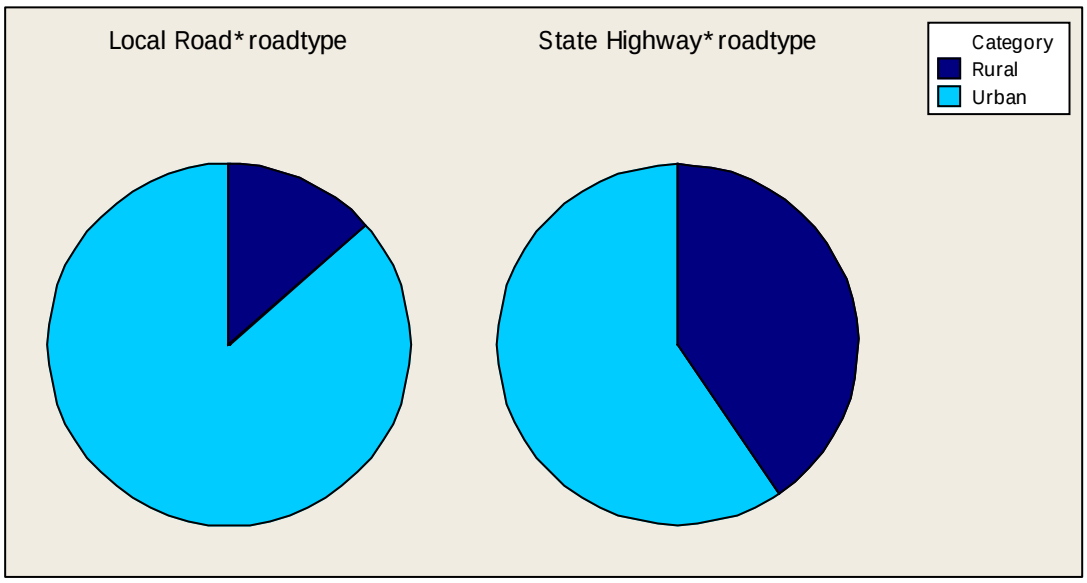
The high rate of crashes occurring on urban roads in Dunedin City is mainly associated with the local-road network.

There is strong evidence (99.9%) that the distribution of urban-road crashes is uneven across the local-road and state-highway networks.

Overall:

- the state-highway network has a high proportion of rural-road crashes, relative to the local-road network
- the local-road network has a high proportion of urban-road crashes, relative to the state-highway network.

Figure 49 **Comparative incidence of injury crashes on local roads and state highways in Dunedin City, distinguished by urban- and rural-road type, 2010-2013**



In Figure 49, rural-road crashes are shown in dark blue, with urban-road crashes being shown in the lighter blue. The figure shows that the local-road network has a higher proportion of urban-road crashes. Specifically, 86.5% of local-road crashes took place on urban roads in Dunedin City. However, 59.5% of state-highway crashes took place on urban roads. This is predictable, given the fact that Dunedin City is a major-urban centre and the local-road network in the area has a much lower speed limit, on average, than the state-highway network. Dunedin's centre and suburbs are mainly made up of local roads with a 50 km/h speed limit; most local-road crashes are likely to occur in this area and so are categorised as urban-road crashes.

Location of crashes, midblock or intersection

Findings:

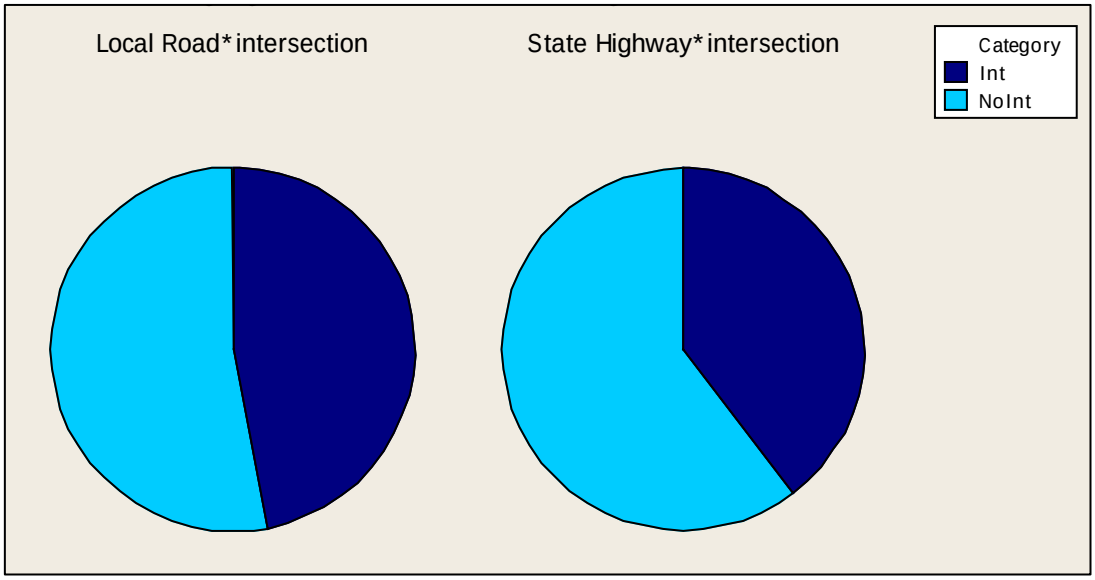
- Relative to minor crashes, serious and fatal crashes are closely associated with midblock locations, as discussed in Theme 6 above.
- The high rate of crashes occurring at intersections is mainly associated with the local-road network.

There is powerful evidence (99.5%) that serious and fatal crashes in Dunedin City tend to take place midblock, compared to minor crashes. Figure 35 clearly shows that fatal and serious crashes are more closely tied to non-intersection (midblock) locations, compared with minor crashes. Specifically, 62.9% of the city's fatal and serious crashes have taken place midblock. By contrast, 53.6% of minor crashes have taken place midblock. This indicates that, on average, midblock crashes tend to be more serious than intersection crashes.

There is significant evidence (97.5%) that the distribution of intersection crashes between the local-road and state-highway network is uneven. In Figure 50, intersection crashes are shown in dark blue, with non-intersection crashes being shown in lighter blue. The figure shows that the local-road network has a higher proportion of intersection crashes.

Specifically, 47.0% of local-road crashes took place at intersections in Dunedin City; however, 39.7% of state-highway crashes took place at intersections.

Figure 50 **Comparative incidence of injury crashes occuring either at intersections or other parts of the roading network, on local roads and state highways in in Dunedin City, 2010-2013**



This is predictable, given that Dunedin City is a major-urban centre, and its local-road network has many more intersections than the state-highway network. Dunedin's CBD is mainly made up of local roads, for example, and it is likely that the bulk of intersection crashes occur in this area.

Road curvature

Findings:

Relative to minor crashes, serious and fatal crashes in Dunedin City:

- are closely associated with easy and moderate curves
- are less likely to take place on straight sections of road.

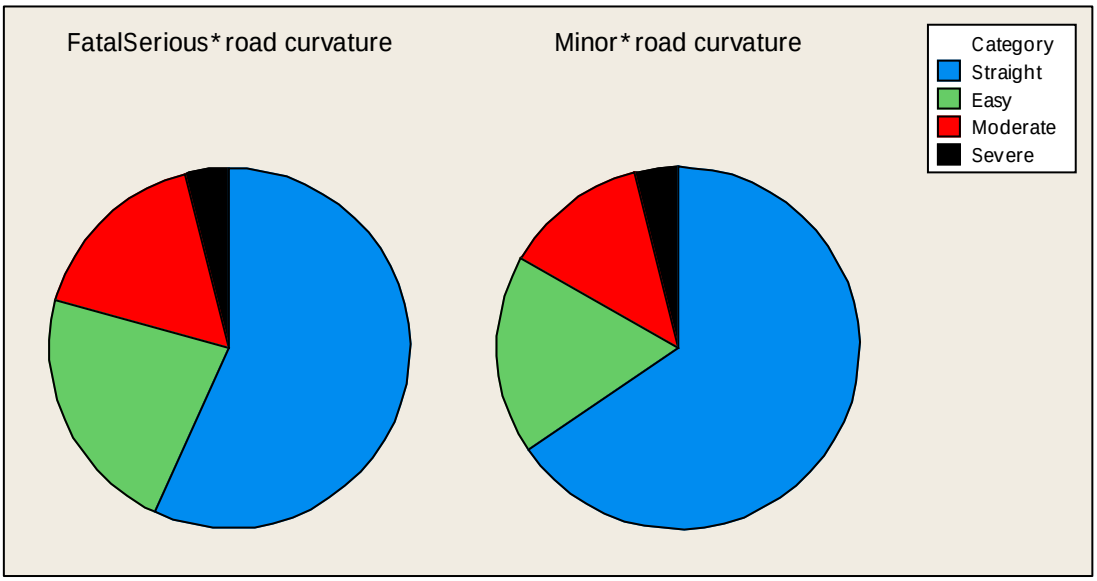
Crash sites are classed as *'Straight', 'Easy curve', 'Moderate curve' and 'Severe curve'*. The judgement of curve severity at the crash site is made by Police officers attending the crash scene. There is some evidence (95.0%) that serious and fatal crashes in Dunedin City are more likely to take place on curves, particularly easy and moderate curves, compared to minor crashes.

Fatal and serious crashes taking place on easy and moderate curves make up a relatively high proportion of overall injury crashes. By contrast, fatal and serious crashes taking place on straight sections of road make up a low percentage of overall injury crashes.

Specifically, 24.0% of injury crashes taking place on an easy curve in Dunedin City (2010-2013) have been classed as '*fatal or serious'*. 24.5% of injury crashes taking place on a moderate curve have also been classed as '*fatal or serious'*. By contrast, 17.7% of injury crashes taking place on a straight section of road have been classed as '*fatal or serious'*.

To clarify, this means that almost a quarter of all injury crashes taking place on easy or moderate curves in Dunedin City (2010-2013) have resulted in a serious injury to at least one road user, and some of those injuries may have proved fatal.

Figure 51 **Comparative severity of injury crashes in Dunedin City, 2010-2013, by degree of road curvature**



The pie charts in Figure 51 follow a noticeably different pattern. The slices corresponding to '*Easy'* and '*Moderate'* curves are much larger on the '*Fatal/Serious'* graph; by contrast, the '*Minor'* graph is dominated by '*Straight'*.

Road markings

Findings:

Relative to minor crashes, serious and fatal crashes in Dunedin City:

- are associated with sections of road with 'Unknown' road markings
- are less likely to take place on raised-traffic islands or on sections of road with a no-passing line.

There is significant evidence (97.5%) that serious and fatal crashes tend to take place on roads with different markings, when compared with minor crashes.

A description of how each crash scene was coded is present in NZTA's Coded Crash Report Guide[31], and the relevant section is reproduced here:

'The following codes are used to indicate what road markings were present at the crash location, if recorded by the attending officer. Only one marking is recorded. The list below is ordered in significance ranking, i.e. a pedestrian crossing is considered to be more important than a centre line, although both may be present at the crash location'.

[31] See NZTA's *Guide for the interpretation of coded crash reports from the Crash Analysis System (CAS)*, version 5.1, March 2012.

The list is given here:

- pedestrian crossing
- raised island
- painted island
- no-passing line
- centre line
- no markings.

Therefore, if the crash occurred at a scene with a pedestrian crossing (and a raised island and centre line), it will be coded as a pedestrian crossing; if the crash occurred at a scene with a no-passing line and a centre line, it will be coded as a no-passing line; if the crash occurred at a scene with a painted island and a centre line, it will be coded as a painted island, and so forth.

There are three main findings from this analysis:

- Fatal and serious crashes in Dunedin City are associated with sections of road that have not had their road-marking type recorded by the Police at the crash scene (or the recorded-marking type has not been transferred into NZTA's CAS database. (That is, fatal and serious crashes are associated with sections of road with unknown road markings, relative to minor crashes.)
- Fatal and serious crashes are less likely to take place on raised islands, relative to minor crashes.
- Fatal and serious crashes are less likely to take place on sections of road with no-passing lines, relative to minor crashes.

Fatal and serious crashes taking place on sections of road with unknown-road markings make up a large proportion of overall injury crashes. By contrast, fatal and serious crashes taking place on raised islands or on sections of road with no-passing lines make up a low proportion of overall injury crashes.

Specifically, 100.0% of the two crashes that have taken place on sections of road with unknown road markings in Dunedin City (2010-2013) were classed as '*serious or fatal'*. In contrast, 14.1% of injury crashes that have taken place on a raised-traffic island were classed as '*serious or fatal'*. Similarly, 9.7% of injury crashes that have taken place on sections of road with a no-passing line were classed as '*serious or fatal'*.

Thus, although only two injury crashes took place on sections of road with unknown road markings, both resulted in a serious injury to at least one road user, and some of those injuries may have proved fatal.

The three categories that show a noticeable difference between figures 52 and 53 are '*Raised island'*, '*No passing'* and '*Unknown'*. '*Unknown'* is more prominent in the '*Fatal/Serious*' graph than in the '*Minor'* graph. By contrast, '*Raised island'* and '*No passing'* feature more strongly in the '*Minor'* graph than in the '*Fatal/Serious'* graph.

Figure 52 **Fatal- and serious-injury crashes in Dunedin City, 2010-2013, by type of road marking at the crash site**

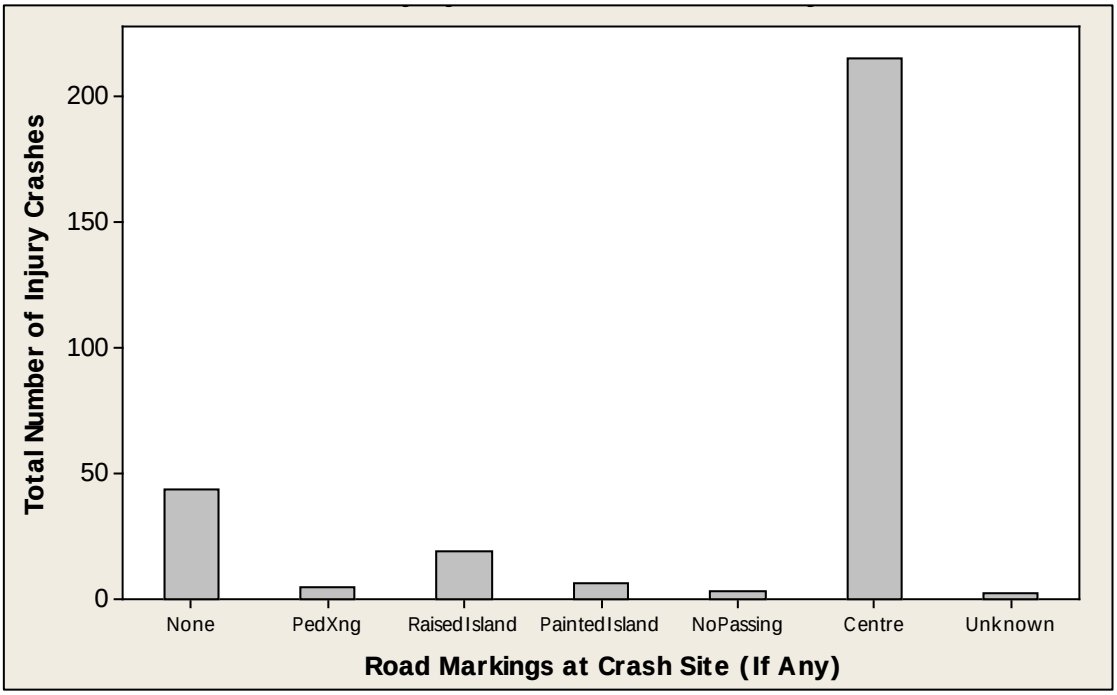
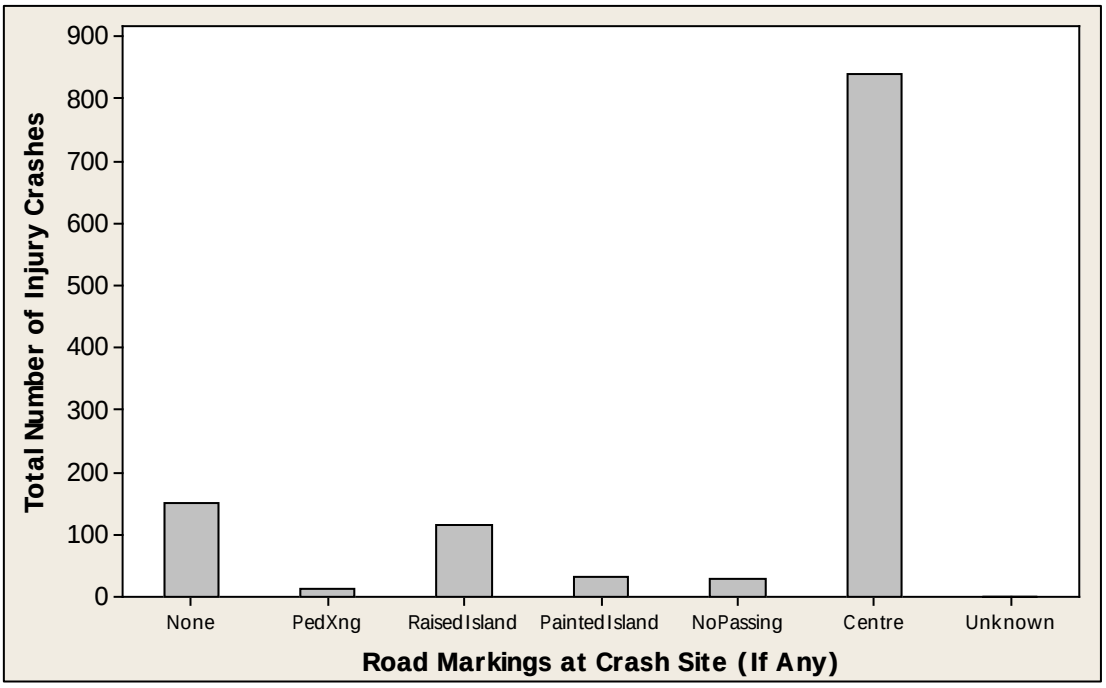


Figure 53 **Minor-injury crashes in Dunedin City, 2010-2013, by type of road marking at the crash site**



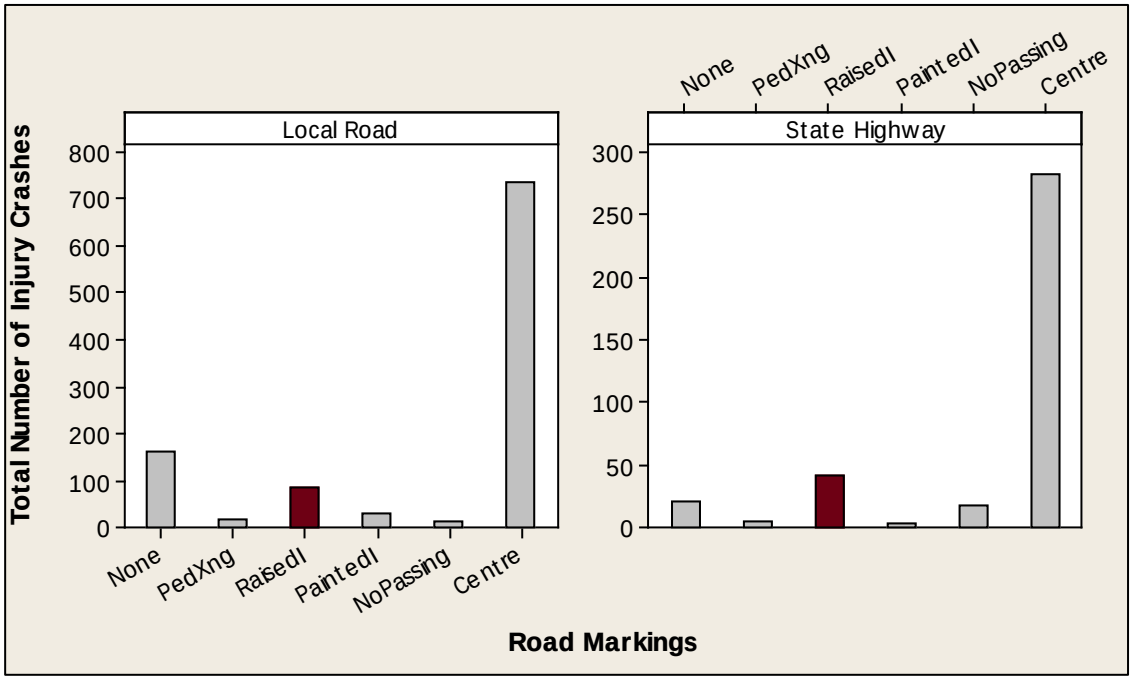
Road markings

Findings:

- Relative to state highways, local roads tend to have a high proportion of crashes occurring on sections of road without any road markings at all.
- Relative to local roads, state highways tend to have a high proportion of crashes occurring on no-passing lines.

There is strong evidence (99.9%) to suggest that the distribution of crashes throughout the local-road and state-highway networks is uneven with respect to crashes on various road markings. The distribution of raised-island crashes is even across the state-highway and local-road network, however; any apparent disparity in proportions is not systematic, and can be attributed to random chance.

Figure 54 **Comparative incidence of injury crashes on local roads or state highways in Dunedin City, 2010-2013, by type of road marking**



Note that the left and right graphs in Figure 54 have different *y*-axes. The left scale (local road) ranges from 0 to 800 injury crashes, while the right scale (state highway) ranges from 0 to 300 injury crashes.

Crashes occurring on a raised island have been highlighted in red, for purposes of comparison. This is the most important feature of the graph, given that Dunedin City is known to have a high-crash rate on raised islands relative to other areas of Otago.

The statistical analysis indicates that there is no significant difference between the distribution of raised-island crashes on the local-road and state-highway networks. This is confirmed by the graph, which shows approximately the same proportion of raised-island crashes on state highways and local roads.

These findings are not surprising. The relatively high rate of local-road crashes without any road markings at all is typical of comparisons between local roads and state highways. Local roads without road markings are navigated relatively easily by local drivers, while state highways are often traversed by drivers from outside the region who expect a centre line to be present most of the time. The higher average speed on state highways also requires that a centre line be present to prevent drivers from straying over into the wrong half of the road.

Moreover, there are very few no-passing line areas on local-road networks; most of these are found on state highways. It is not surprising, then, that most of no-passing line crashes occur on state highways.

Environmental factors

Lighting conditions

Findings:

Relative to minor crashes, serious and fatal crashes in Dunedin City:

- are associated with darkness (in the presence of streetlights) and bright sunlight
- are less likely to take place in overcast conditions.

There is some evidence (95.0%) that fatal and serious crashes in Dunedin City tend to take place in different lighting conditions, when compared with minor crashes.

Crashes are classified into '*BrightSunllight'* (crash occurred in bright sunlight), '*Overcast'* (crash occurred in overcast conditions), '*Twilight'* (crash occurred in twilight conditions), '*Darkw/lights'* (crash occurred in darkness, but streetlights were present and turned on at the time of the crash), and '*DarkW/oLights'* (crash occurred in darkness, but streetlights were absent, not working or off at the time of the crash).

There are three main findings from this analysis:

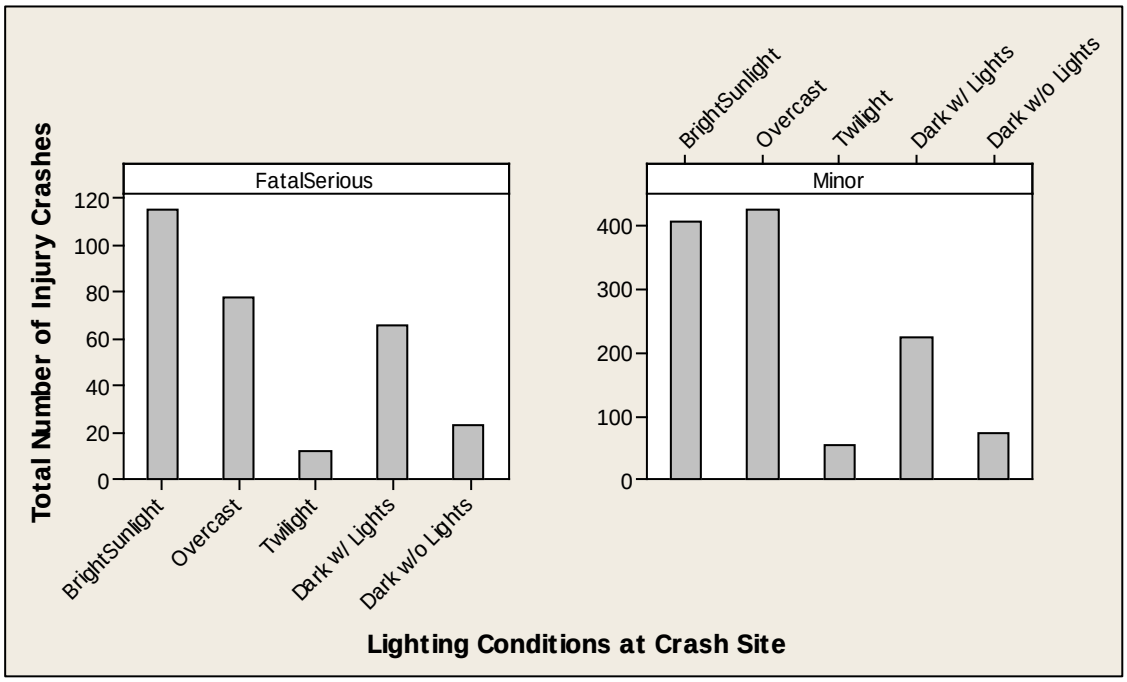
- Fatal and serious crashes are actually less likely to take place in overcast conditions, relative to minor crashes.
- Fatal and serious crashes frequently take place in darkness (in the presence of streetlights), relative to minor crashes.
- Fatal and serious crashes frequently take place in bright sunlight, relative to minor crashes.

As for crashes taking place in darkness (in the presence of streetlights) and in bright sunlight, fatal and serious crashes make up a high proportion of overall injury crashes. By contrast, with respect to crashes taking place in overcast conditions, fatal and serious crashes make up a low proportion of overall injury crashes.

Specifically, 15.5% of injury crashes taking place in overcast conditions in Dunedin City (2010-2013) were classed as '*serious or fatal'*. By contrast, 22.8% of injury crashes taking place in dark conditions (in the presence of streetlights) were classed as '*serious or fatal'*. Similarly, 22.1% of injury crashes taking place in bright sunlight were classed as '*serious or fatal'*.

This means that almost a quarter of all injury crashes taking place in dark conditions (in the presence of streetlights) or in bright sunlight resulted in a serious injury to at least one road user, and some of those injuries may have proved fatal.

Figure 55 **Comparative severity of injury crashes in Dunedin City, 2010-2013, by type/degree of lighting at crash site**



These two graphs in Figure 55 show a very different pattern. The '*Fatal/Serious'* graph is dominated by '*Bright Sunlight*', with a significant minority of crashes taking place in '*DarkW/Lights')*. '*Overcast'* plays a small role in the '*Minor'* graph.

Dark crashes (with street lighting)

Finding:

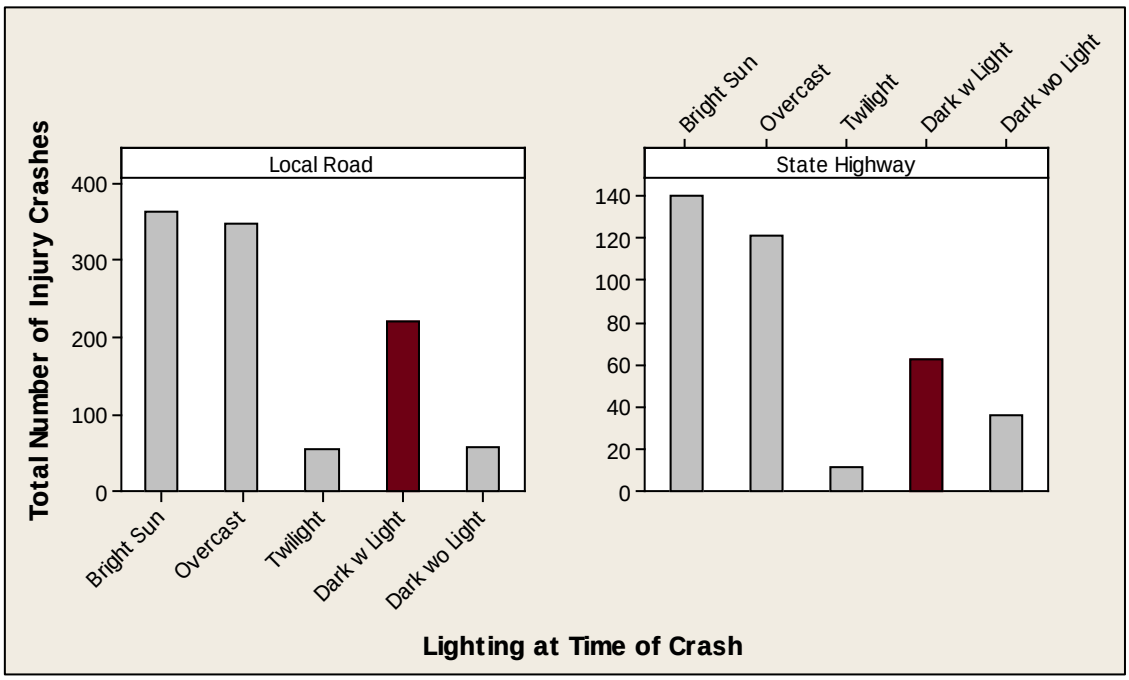
The high rate of crashes occurring in dark conditions (in the presence of street lights) in Dunedin City is mainly associated with the local-road network.

There is strong evidence (99%) to suggest that the distribution of crashes in varying lighting conditions is uneven between the state-highway and local-road networks. There are three main findings from this analysis:

- The state-highway network has a high proportion of crashes in dark conditions (without streetlights), compared with the local-road network.
- The local-road network has a high proportion of crashes in twilight conditions, compared with the state-highway network.
- The local-road network has a high proportion of crashes in dark conditions (in the presence of streetlights), compared with the state-highway network.

As a result, we can indicate that Dunedin City's high rate of night-time crashes (in the presence of streetlights), relative to other Otago districts, is associated with the local-road network.

Figure 56 **Comparative incidence of injury crashes on local roads or state highways in Dunedin City, 2010-2013, by type/degree of lighting at crash site**



Note that the *y*-axes are different in the two graphs in Figure 56: the local-road scale ranges from 0 to 400 injury crashes over the 4-year period (2010-2013), while the state-highway scale ranges from 0 to 140.

Crashes occurring in dark conditions, in the presence of streetlights, have been coloured in red for ease of recognition. Given that Dunedin City has a high number of crashes of this type relative to the other four districts (after adjusting for population size), the distribution of this crash category between the local-road and state-highway networks is likely to be the most important bar in the above graph. Specifically, 83.3% of twilight crashes from 2010-2013 took place on the local-road network, with 16.7% on the state-highway network. 61.7% of night-time crashes (in the absence of streetlights) from 2010-2013 took place on the local-road network, with 38.3% taking place on the state-highway network. Finally, 78.1% of night-time crashes (in the presence of streetlights) took place on the local-road network, with only 21.9% taking place on the state-highway network.

It is not surprising that the state-highway network hosts a higher proportion of crashes in the dark (without streetlights); much of the state-highway network is unlit, particularly towards the outskirts of Dunedin City. It is equally unsurprising that most of the twilight crashes occur on the city's local-road network. Much of the travel in Dunedin on the local-road network involves students and workers travelling to and from University and other businesses; travelling home often takes place in twilight, particularly in the autumn and winter months when the days are shorter.

The fact that Dunedin City's local-road network is mainly responsible for the high rate of crashes in the dark (in the presence of streetlights) is also not surprising. Travel after dark is common in Dunedin, both because of the high-student population (who tend to prefer travelling at night) and the long-winter months, where darkness can descend as early as 5:00 pm.

Demographic factors

Driver gender

Findings:

Relative to minor crashes, serious and fatal crashes in Dunedin City:

- are closely associated with drivers with an 'Unknown/Irrelevant' gender in the key-vehicle-driver role (i.e. mainly key-vehicle cyclists, as discussed earlier)
- do not typically involve women in the key-vehicle-driver role (see Figure 30).

There is strong evidence (99.9%) that fatal and serious crashes in Dunedin City tend to involve a different distribution of men, women and '*Unknown/Irrelevant'* drivers in the key-vehicle role, when compared with minor crashes.

With respect to crashes with an '*Unknown/Irrelevant'*-gender driver in the key-vehicle-driver role, fatal and serious crashes make up a high proportion of overall injury crashes; by contrast, with respect to crashes with a woman in the key-vehicle-driver role, fatal and serious crashes make up a low proportion of overall injury crashes.

As already discussed in this document (*Key Vehicle*), cyclists do show an elevated serious/fatal crash rate in Dunedin City: 32.3% of all injury crashes involving a cyclist in the key-vehicle role were classed as '*serious or fatal'*. For comparison, 19.9% of all injury crashes were classed as '*serious or fatal'*.

32.6% of injury crashes involving a driver with an '*Unknown/Irrelevant'* gender in the key-vehicle-driver role in Dunedin City (2010-2013) were classed as '*serious or fatal'*. By contrast, just 15.5% of injury crashes involving a woman in the key-vehicle-driver role were classed as '*serious or fatal'*.

The two pie charts in Figure 30 show a different pattern. '*Unknown/Irrelevant'* features strongly in the '*Fatal/Serious'* graph; by contrast, it barely features at all in the '*Minor'* graph: Women make up a much larger proportion of the '*Minor'* graph but feature less strongly in the '*Fatal/Serious'* graph.

Driver age

Findings:

Relative to minor crashes, serious and fatal crashes in Dunedin City:

- are closely associated with drivers with an '*Unknown/Irrelevant'* age in the key-vehicle-driver role (i.e. mainly key-vehicle cyclists).
- are closely associated with older road users (75+) in the key-vehicle-driver role , as discussed in Theme 4 above.

There is powerful evidence (99.5%) that fatal and serious crashes in Dunedin City tend to involve a different distribution of younger, older and '*Unknown/Irrelevant'* drivers in the key-vehicle role, when compared with minor crashes. With respect to crashes with an '*Unknown/Irrelevant'*-aged driver in the key-vehicle-driver role, fatal and serious crashes

make up a high proportion of overall injury crashes; similarly, with respect to crashes with an older road user (75+) in the key-vehicle-driver role, fatal and serious crashes also make up a high proportion of overall injury crashes.

As already discussed above (under the 'Key Vehicle findings'), cyclists have an elevated serious/fatal crash rate in Dunedin City: 32.3% of all injury crashes involving a cyclist in the key-vehicle role in Dunedin City (2010-2013) were classed as '*serious or fatal'*. By comparison, 19.9% of all injury crashes were classed as '*serious or fatal'*.

32.3% of injury crashes involving a driver with an '*Unknown/Irrelevant'* age in the key-vehicle-driver role in Dunedin City (2010-2013) were classed as '*serious or fatal'*. Similarly, 29.9% of injury crashes involving an older road user (75+) in the key-vehicle-driver role were classed as '*serious or fatal'*.

Driver licence

Finding:

Relative to minor crashes, serious and fatal crashes in Dunedin City:

- are closely associated with drivers with an '*Unknown/Irrelevant'* licence type in the key-vehicle-driver role (i.e. mainly key-vehicle cyclists).
- do not typically involve restricted licence-holders in the key-vehicle-driver role.

The category, *'Unknown/Irrelevant',* is used by Police when the key vehicle is a cyclist (in which case, the cyclist's licence is determined '*Irrelevant*') or where the licence type of the driver of the key vehicle is unknown ('*Unknown'*). There is strong evidence (99.9%) to suggest that fatal and serious crashes in Dunedin City tend to involve a different distribution of licence-holders in the key-vehicle role, when compared with minor crashes.

With respect to crashes with a driver holding an '*Unknown/Irrelevant'* licence in the key-vehicle-driver role, fatal and serious crashes make up a high proportion of overall injury crashes; by contrast, as to crashes with a restricted licence-holder in the key-vehicle-driver role, fatal and serious crashes make up a low proportion of overall injury crashes.

As already discussed (under the '*Key Vehicle'* findings), cyclists show an elevated serious/fatal crash rate in Dunedin City: 32.3% of all injury crashes involving a cyclist in the key-vehicle role were classed as '*serious or fatal'*. In comparison, 19.9% of all injury crashes were classed as '*serious or fatal'*.

Specifically, 9.1% of injury crashes involving a restricted licence-holder in the key-vehicle-driver role in Dunedin City (2010-2013) have been classed as '*serious or fatal'*. By contrast, 30.1% of injury crashes involving a driver with an '*Unknown/Irrelevant'* licence in the key-vehicle-driver role were classed as '*serious or fatal'*.

There are two main points of difference between figures 57 and 58: '*Restricted'* and '*Unknown/Irrelevant*'. '*Restricted'* features noticeably in the '*Minor'* graph, but is not prominent in the '*Serious or Fatal'* graph. By contrast, '*Unknown/Irrelevant'* holds a sizeable minority in the '*Fatal/Serious'* graph, but does not feature strongly in the '*Minor'* graph.

Figure 57 **Fatal and serious crashes in Dunedin City, 2010-2013, by type of licence holder**

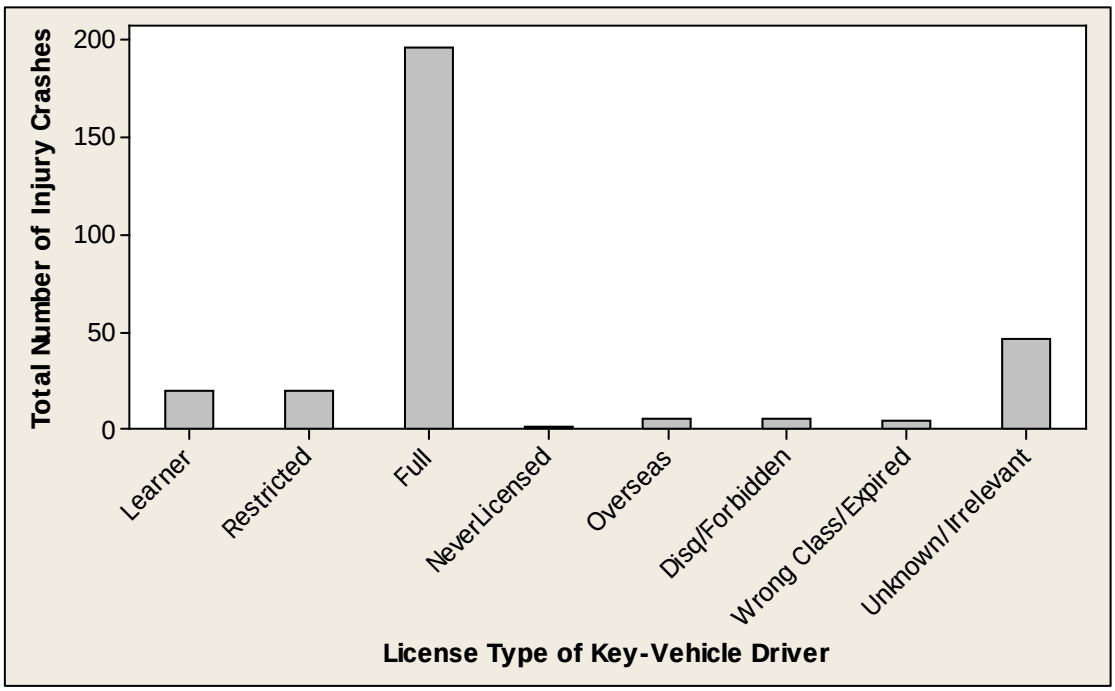
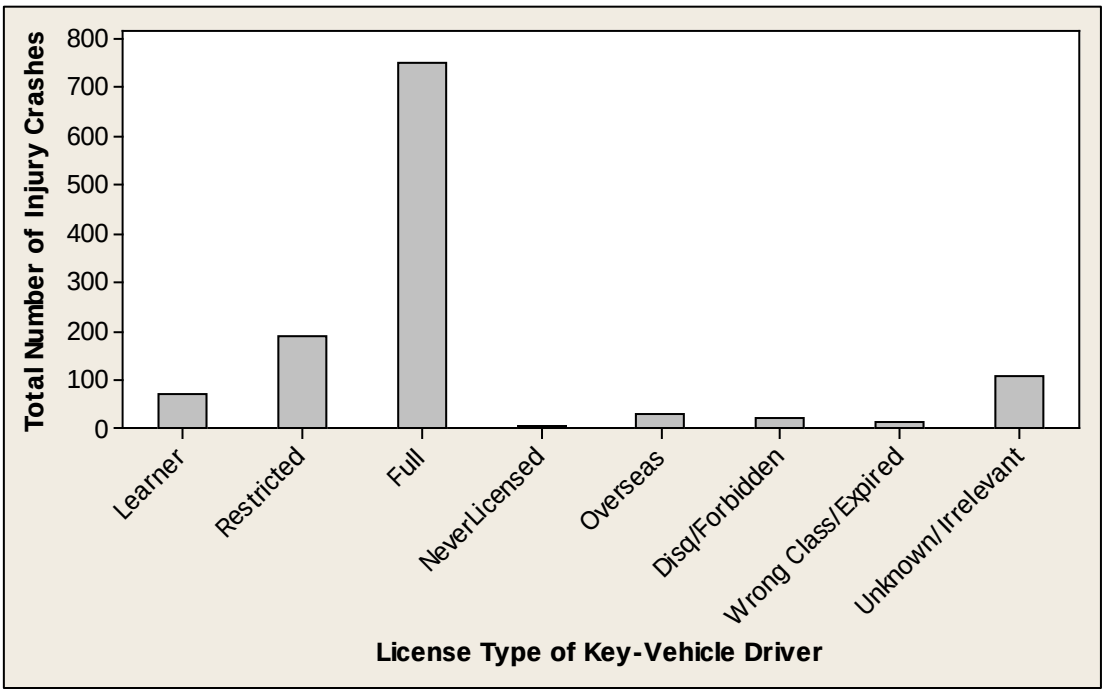


Figure 58 **Minor crashes in Dunedin City, 2010-2013, by type of licence holder**



3.6.4. *Areas where serious and fatal crashes perform better than minor crashes*

Listed below are areas where serious and fatal crashes perform better than minor crashes in Dunedin City (i.e. serious and fatal crashes are less likely to occur than minor crashes under the conditions outlined below).

Compared with minor crashes, serious/fatal crashes in Dunedin City are less likely to:

- occur on a Tuesday
- be associated with rear-end collisions
- have a car/station wagon in the second vehicle role (i.e. this essentially means that fatal and serious crashes rarely involve a multi-vehicle collision with at least one car/station wagon)
- occur on straight sections of road
- take place on raised-traffic islands
- take place on sections of road with a no-passing line
- occur in overcast conditions
- involve a woman in the key-vehicle-driver role
- involve a restricted licence-holder in the key-vehicle-driver role
- involve one or more parties following too closely, merging incorrectly or crowding a cyclist
- involve one or more parties failing to give way for a variety of reasons (e.g. failed to give way at one-lane bridge, failed to give way when entering roadway from driveway, etc.)
- involve inattention to a vehicle's movements in front
- involve failing to see or look for another party when required to give way.

Each of the factors listed are statistically significant at the 95% level or higher (i.e. we can be at least 95% confident that the factors listed do represent a systematic difference between serious/fatal crashes and minor crashes in Dunedin City, as opposed to random, chance variation). The list should be interpreted to indicate that serious/fatal crashes are very rare in Dunedin City under the conditions outlined below. For example, serious/fatal crashes are very rare on Tuesdays.

3.6.5. Additional insights into the root causes of crashes in Dunedin City

A large proportion of intersection crashes in Dunedin involve a failure to give way.

A large proportion of Dunedin's intersection crashes are not associated with failing to stop at traffic lights; rather, many of the intersection crashes involve failing to look and subsequently failing to give way at a give-way sign. This is perhaps counter-intuitive, given that intersection crashes are often thought to involve stop signs or traffic lights. However, many of Dunedin's intersection crashes actually involve driver error at give-way signs, not stop signs or traffic lights. This is informative for law enforcement officials.

Pedestrian-vehicle crashes are mainly associated with dangerous pedestrian behaviour.

This factor provides information associated with pedestrian-vehicle crashes, an area of high concern in Dunedin under the city's Road Safety Action Plan[32]. Pedestrian-vehicle crashes are strongly associated with dangerous behaviour on the part of pedestrians, specifically jaywalking, running heedless of traffic, stepping out from behind a parked vehicle, waiting on the roadway for moving traffic, wearing dark clothing and/or listening to music, and so on.

There is also a smaller relationship between pedestrian-vehicle crashes and drivers failing to give way to pedestrians at zebra crossings and at traffic lights (i.e. driver-at-fault crashes); however, the majority of pedestrian-vehicle crashes are associated with dangerous behaviour on the part of pedestrians.

Specifically, drivers were (partially) at fault, through failing to give way, in 32 pedestrian-vehicle crashes in Dunedin City over the 2010-2013 period. Pedestrians were (partially) at fault in 77 pedestrian-vehicle crashes over the same period. Note that some crashes involved attribution of blame to both pedestrian and driver; these have been placed in both categories. Skateboarders have been excluded from the above numbers.

In the case of skateboarders, only one skateboarder-vehicle crash involved the driver (partially) at fault; seven crashes were attributed partly to dangerous behaviour on the part of the skateboarder.

Running a red light/stop sign is associated with inattention, not deliberate violation.

Running a red light or a stop sign in Dunedin is not associated with deliberate violation (as in the case of failing to give way at a give-way sign), but is related to not noticing the traffic light or stop sign. Crashes involving one driver failing to stop at the relevant traffic signal or stop sign are more likely to be due to simple inattention than a deliberate and dangerous manoeuvre (as in the case of failing to give way).

Crashes caused by drivers above the BAC limit in Dunedin occur at night

Many compulsory stops in the region take place during the morning and day-time; however, a large proportion of drivers over the BAC limit drive mostly or exclusively at night. This is mainly associated with social norms such as drinking in pubs or bars after dark. This factor analysis indicates that the darker it is outside, and the later in the day, the more drink-drivers will be on the road. In general, police alcohol checkpoints should be scheduled as late as possible to apprehend the highest proportions of drunk drivers.

Losing control on bends in Dunedin City involves excessive speed

Crashes associated with losing control on bends in Dunedin City are associated both with the severity of the bend and the speed of the driver. Excessive speed and more severe curves

[32] See Dunedin City Council's website: http://www.dunedin.govt.nz/whats-on/transport-strategy-2013/areas-of-focus/9-1-focus-on-safety .

are likely to lead to driver loss of control. These factors seem intuitive; it indicates that speed is the major factor in loss-of-control Dunedin City crashes on bends (as opposed to other potential issues, such as ice).

3.6.6. Issues involving high numbers of crashes on both state highways and local roads in Dunedin City

These are:

- the high rate of inattention-related crashes
- the high rate of crashes associated with failing to look at give-way signs and failing to look in 'other' situations (e.g. when pulling out from a parked position)
- the high rate of crashes caused by vehicles failing to give way to pedestrians
- the high rate of crashes occurring at raised islands
- the high rate of traffic light-related crashes
- the high rate of crashes occurring at crossroads
- the high rate of multi-vehicle crashes
- the high rate of heavy rain-related crashes.

3.7. Gore and Southland Districts combined results

3.7.1. Findings and recommendations, summarised

Three themes emerged from the analysis of data for Gore and Southland districts.

5. There is a serious road-safety issue associated with motorcycles.

6. There is an extensive-testing regime for intoxication among road users involved in serious and fatal crashes, but alcohol does not play a huge role in fatal/serious crashes in these districts (which raises the question as to whether this is due in part or whole to the high-visibility approach being taken by the Police to BAC testing in these districts).

7. Distraction, when implicated in a crash in these districts, leads to fatal or serious injuries (rather than to minor injury).

Relative to minor crashes in Gore and Southland districts, fatal and serious crashes in these two districts:

- frequently involve motorcycles as the key vehicle
- are associated with key vehicles classified as '*Other'* by the Police
- are closely associated with rural roads (roads with an 80 km/h speed limit or higher)
- are less likely to take place in wet conditions, and in fact, frequently take place in dry conditions
- are more likely to involve one or more road users testing below the legal blood alcohol limit (due to a more extensive-testing regime)
- are less likely to be associated with a slippery-road surface (than a non-slippery one).

Compared to state-highway crashes in Gore and Southland, local-road crashes in these districts are more likely to:

- involve motorcycles and SUVs/4x4s in the key-vehicle role
- take place on unsealed sections of road
- involve key-vehicle drivers who were disqualified and/or forbidden from driving at the time of their crash
- involve one or more parties in the crash being suspected of being under the influence of alcohol and/or drugs (based on Police opinion)
- involve one or more parties in the crash recording an alcohol level over the legal limit (based on police opinion, but noting that alcohol does not play a huge role in fatal and serious crashes here)
- be caused, wholly or partly, by deep, loose metal (gravel) on the road surface (based on police opinion)
- involve obstruction and/or visibility issues at the crash site(based on police opinion).

Compared to local-road crashes in Gore and Southland, state-highway crashes in these two districts are more likely to:

- involve sideswipe and overtaking movements before the crash

- involve cars/station wagons in the key-vehicle role (as opposed to motorcycles, trucks, vans, etc.)
- involve an older driver (75+) in the key-vehicle-driver role
- involve one or more parties in the crash attempting to overtake without due care, or in an inappropriate location (based on police opinion)
- involve one or more parties in the crash following too closely (based on police opinion)
- involve one or more parties in the crash failing to pay adequate attention to movements or indication of the vehicle in front (based on police opinion)
- be caused, wholly or partly according to police opinion, by fatigue associated with lack of sleep..

Recommendations for Gore and Southland district councils and/or NZTA to consider:

1. Investigate whether the extensive-testing regime for intoxication among road users involved in serious and fatal crashes in these districts - the high-visibility approach being taken by the Police to BAC testing – has been a causal factor in why alcohol has not played a huge role in fatal/serious crashes in 2010-13

2. Investigate whether the fact that fatal and serious crashes in these two districts frequently take place in dry conditions is related to recreational motorcyclists choosing not to ride in inclement weather conditions

3. Investigate the factors underlying why crashes involving drivers who were disqualified and/or forbidden from driving at the time of their crash are much more likely on local roads than state highways in these districts.

3.7.2. Themes found in the analysis of serious and fatal crashes

Theme 1: there is a serious road-safety issue associated with motorcycles in Gore and Southland districts.

Figure 59 **Fatal and serious crashes in Gore and Southland districts, 2010-2013, by vehicle type**

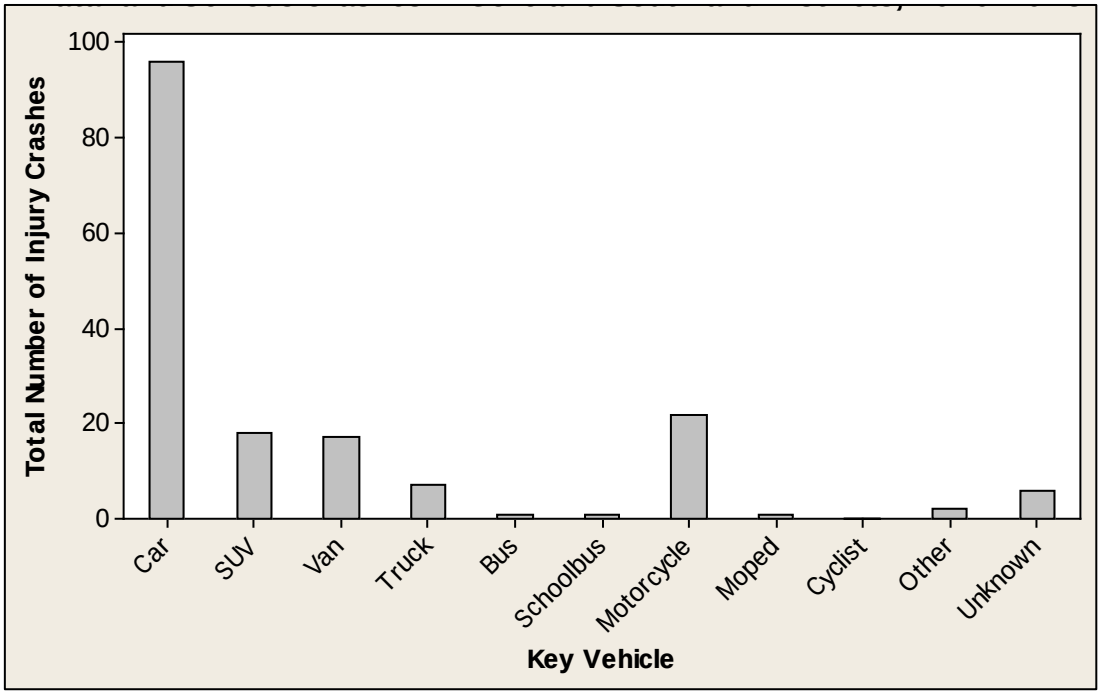
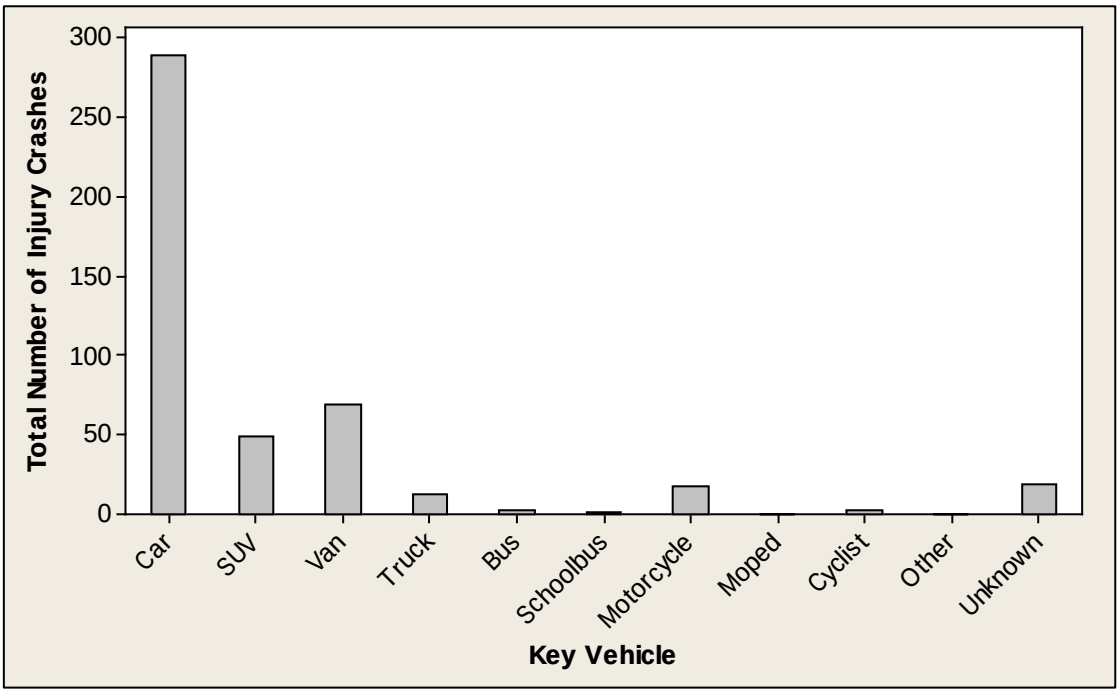


Figure 60 **Minor crashes in Gore and Southland districts, 2010-2013, by vehicle type**



Over half of all injury crashes involving a motorcycle in the key-vehicle role were classed as '*serious or fatal'*. By comparison, 27.0% of all injury crashes in the districts were classed as '*serious or fatal'*.

The biggest difference between figures 59 and 60 is clearly the '*Motorcycle*' category, which features above SUVs and vans in the ''*fatal or serious'* category. By contrast, it barely features in the '*minor*' category (Figure 60). Clearly, most crashes involving a motorcycle in the key-vehicle role do have serious outcomes for at least one road user in the crash (probably the motorcyclist). By contrast, a sizeable minority of minor crashes occur in wet conditions.

These figures show that motorcycle riders are at a much higher risk of death or serious injury when compared with other road users in Gore and Southland districts. This is not surprising; academic research has long indicated that motorcycles are over represented in traffic accidents, including serious-traffic accidents (i.e. serious- and fatal-injury accidents). This means that not only are motorcyclists more likely to be involved in a crash than other road users, but that crash is more likely to be serious or fatal. Singaporean data, for example, indicate that motorcycle crashes comprise about 40% of all fatalities, but only comprise 19% of motorised vehicles in Singapore[33].

Although motorcyclists are known to be vulnerable users, is there something about Gore and Southland districts that make them particularly susceptible to serious traffic crashes (given that Queenstown Lakes District Council , for example, does not show this pattern)?

Theme 2: There is an extensive-testing regime for intoxication among road users involved in serious and fatal crashes, but alcohol does not play a huge role in fatal/serious crashes in these districts.

There is powerful evidence (99.5%) that fatal and serious crashes in Gore and Southland districts are more likely to involve one or more road users testing below the legal blood alcohol limit, compared with minor crashes. A crash was categorised as *'Below BAC limit'* if at least one driver tested below the legal blood alcohol limit (crash code 102).

Overall, 5.3% of fatal and serious crashes in Gore and Southland districts involved one or more drivers testing below the legal blood alcohol limit; by contrast, 1.3% of minor crashes involved one or more drivers testing below the legal blood alcohol limit.

At first glance, this finding seems counterintuitive: fatal and serious crashes in Gore and Southland have a higher proportion of '*Below BAC imit'* crashes. Does this mean that fatal and serious crashes are *less* likely to involve alcohol?

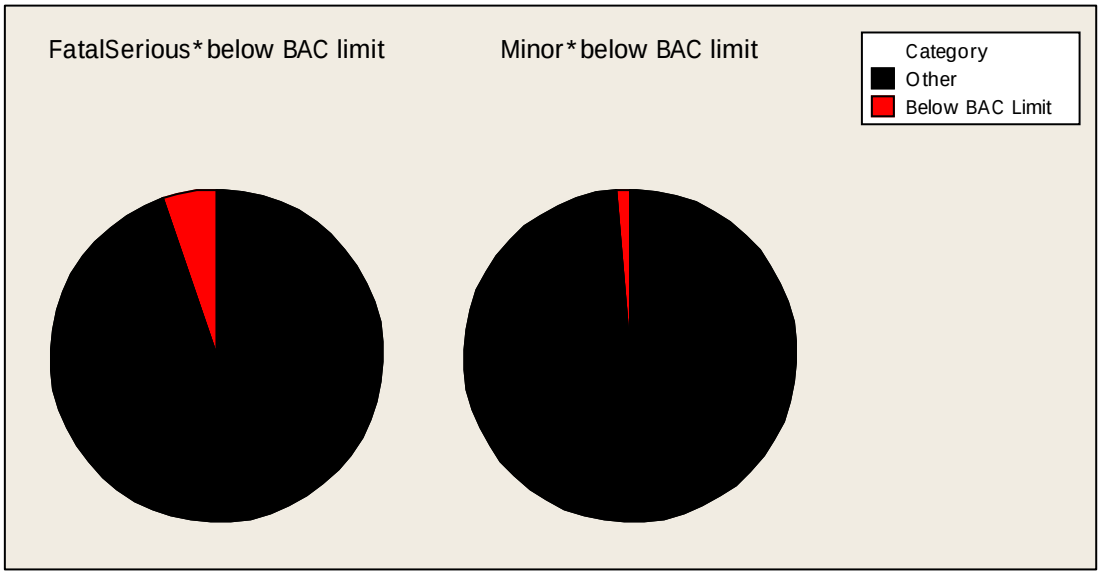
The important thing to remember when analysing this finding is that road users involved in fatal and serious crashes are much more likely to be tested for alcohol intoxication than road users involved in minor crashes. The reasons for this are discussed below, but this explains why a higher proportion of road users will score '*Below BAC limit*' in fatal and serious

[33] Quddus, M.A., Noland, R.B., & Chin, H.C. (2002). An analysis of motorcycle injury and vehicle damage severity using ordered probit models. *Journal of Safety Research, 33,* 445-462. doi: 10.1016/S0022-4375(02)00051-8

crashes when compared to minor crashes; very few road users are *tested* in minor crashes, meaning that most are placed in the category '*Other'* shown in Figure 61. By contrast, many road users are tested in fatal and serious crashes. This means that even if a high proportion are over the BAC limit, many will also be under, thus giving the incorrect perception above that fatal and serious crashes are *less* likely to involve alcohol.

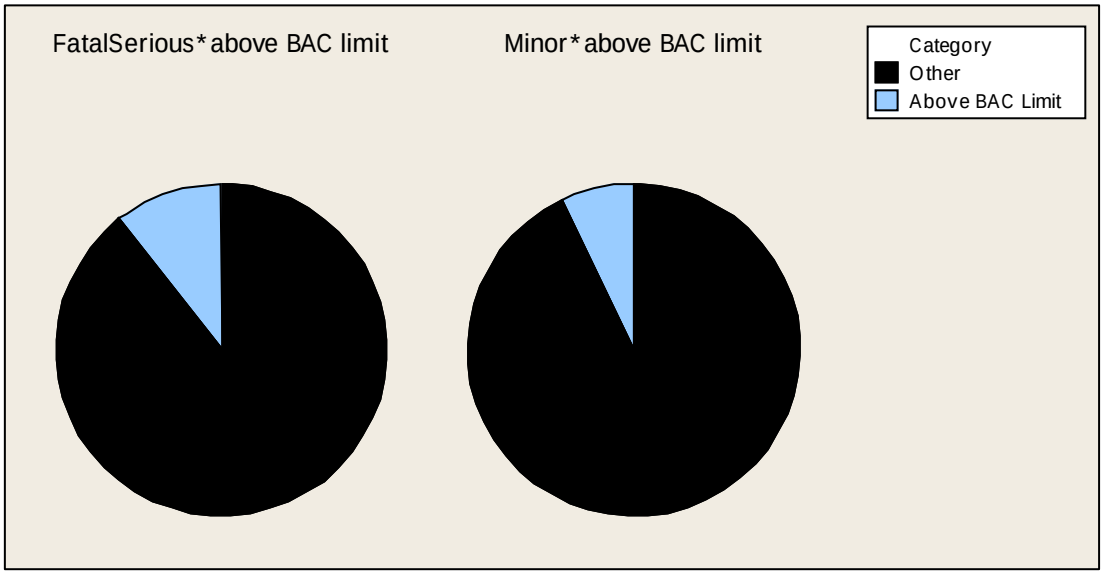
To summarise, road users involved in a minor crash are less likely to be tested, for temporal reasons. (Minor crashes are often not reported until long after the actual-crash event, meaning that testing road users for blood-alcohol level is pointless). They are also less likely to be tested for practical reasons. (There are many minor crashes on New Zealand roads, and the Police do not have the logistical capacity to breath- or blood-test all road users involved in minor crashes.) By contrast, as for fatal and serious crashes, alcohol is often suspected as a factor and the level of alcohol in the road users' blood must be determined (often for insurance reasons or to aid in judicial proceedings). The result is a high rate of '*Below BAC limit*' findings for fatal and serious crashes relative to minor crashes, which simply indicates that a more intensive alcohol-testing regime for fatal and serious crashes is required.

Figure 61 **Comparative severity of injury crashes in Gore and Southland districts where the driver was above the BAC limit, 2010-2013**



However, it is still worth noting that alcohol does not play a major role in fatal and serious crashes in these districts (see figure 62). Examining the proportion of crashes involving at least one road user over the BAC limit revealed no statistically significant difference between fatal/serious and minor crashes. This contrasts to Queenstown Lakes District, where excess alcohol consumption was clearly linked to serious road trauma.

Figure 62 **Comparative severity of injury crashes in Gore and Southland districts where the driver was above the BAC limit, 2010-2013**

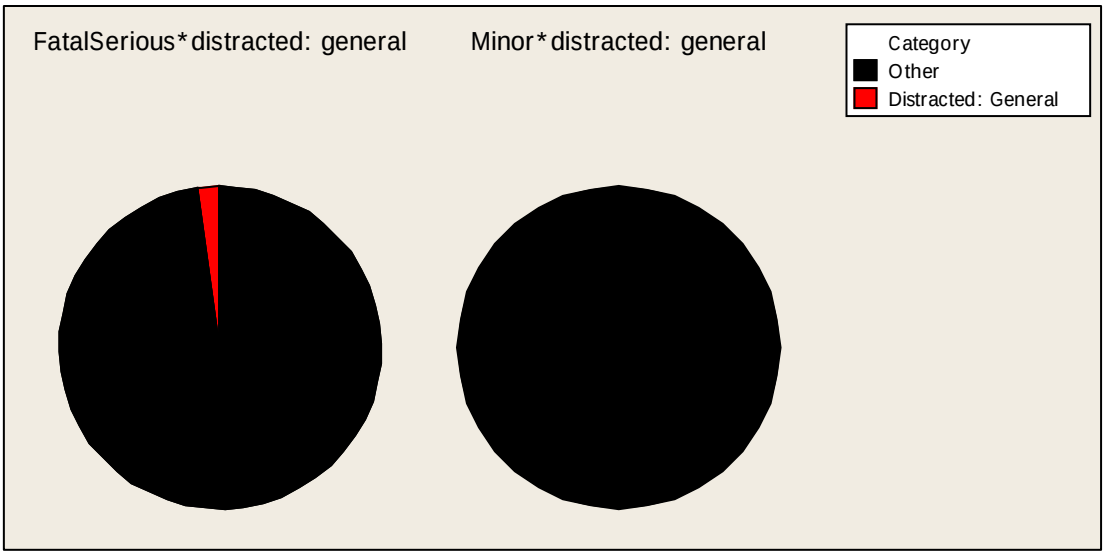


There is no statistical evidence ($\chi^2 = 1.929$, $p > 0.1$) that crashes involving at least one road user over the blood alcohol limit tend to result in more severe road trauma than other sorts of crashes in Gore and Southland districts. Any apparent differences between the left and right panel in figure 62 can be attributed to chance.

It is interesting that alcohol plays such a small role in fatal/serious crashes in Gore and Southland districts, compared to other districts where it is a major risk factor for serious road trauma.

Theme 3: Serious and fatal crashes in Gore and Southland districts are associated with distraction just prior to the crash.

Figure 63 **Comparative severity of injury crashes in Gore and Southland districts where the driver was distracted just prior to the crash, 2010-2013**



Overall, as Figure 63 shows, 2.3% of fatal and serious crashes in Gore and Southland districts involved the attention of one or more road users being diverted for unspecified reasons; by contrast, no minor crashes in these districts involved the attention of one or more road users being distracted for unspecified reasons. This means that every single injury crash associated with distraction (for unspecified reasons) that occurred in Gore/Southland districts (2010-2013) resulted in a fatal or serious injury to at least one road user.

A crash was categorised as '*Distracted: General*' if at least one driver's attention was diverted for unspecified reasons (crash code 350). There is strong evidence (99.9%) that fatal and serious crashes in Gore and Southland districts are more likely to involve one or more road users in the crash being distracted just before the crash.

Research indicates that distraction is closely associated with incidence of crashes[34]. However, it is difficult to find evidence that distraction is associated with severity of crashes (i.e. that distracted drivers are not only more likely to have crashes, but are more likely to have severe or fatal crashes). It is possible that this is relatively unique to Gore and Southland districts. It raises the question as to whether there is something about the landscape, topography or road environment in these districts that causes distraction to be particularly dangerous.

3.7.3. Factors associated with serious and fatal crashes

Crash characteristics

Key vehicle

Findings:

- Fatal and serious crashes in Gore and Southland districts frequently involve motorcycles as the key vehicle, relative to minor crashes, as discussed in Theme 1.
- Fatal and serious crashes in Gore and Southland districts are associated with key vehicles classified as 'Other' by Police, relative to minor crashes.

There is strong evidence (99.9%) that fatal and serious crashes in Gore and Southland districts tend to involve different key vehicles, when compared to minor crashes.

There are 11 categories in CAS that key vehicles: '*Car'* (or station wagon), '*SUV'* (or 4x4), '*Van'* (or ute), '*Truck'*, *'Bus'*, '*School bus'*, '*Motorcycle'*, '*Moped'*, '*Cyclist'*, '*Other'* and '*Unknown'*. (See footnote 16 for explanation of the term key vehicle.)

As for crashes involving motorcycles in the key-vehicle role, fatal and serious crashes make up a high proportion of overall injury crashes; similarly, with respect to crashes involving '*Other'* vehicles in the key-vehicle role, fatal and serious crashes also make up a high proportion of overall injury crashes. 56.4% of all injury crashes involving a motorcycle in the key-vehicle role in Gore and Southland districts (2010-2013) were classed as '*serious or fatal'*.

[34] Horberry, T., Anderson, J., Regan, M.A., Triggs, T.J. & Brown, J. (2006). Driver distraction: The effects of concurrent in-vehicle tasks, road environment complexity and age on driving performance. *Accident Analysis & Prevention, 38,* 185-191.

Similarly, 100% of all injury crashes involving an '*Other*' vehicle in the key-vehicle role in Gore and Southland districts (2010-2013) were classed as '*serious or fatal*'. (Note, however, that only two injury crashes involved '*Other*' vehicles in the key-vehicle role during this period; both were classed as '*serious or fatal*'.)

The '*Other*' category is also clearly different between figures 59 and 60, but given that only two fatal/serious crashes in Gore and Southland districts involved a vehicle classed as '*Other*', the practical importance of this category is low.

Crash characteristics and causes

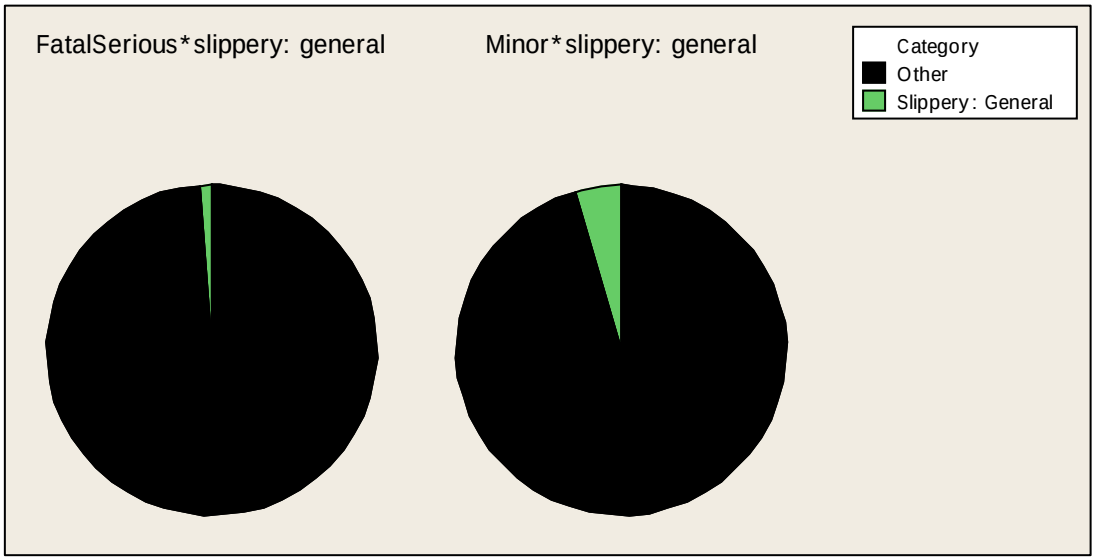
Slippery: General

Finding:

Relative to minor crashes, fatal and serious crashes in Gore and Southland districts are less likely to be associated with a slippery-road surface (than a non-slippery one).

A crash was categorised as 'Slippery: General' if the road surface at the crash site was slippery for unspecified reasons (crash code 800), due to loose material on seal (crash code 804), due to mud (crash code 805), and/or due to oil/diesel/fuel on the road surface (crash code 806). There is evidence (95.0%) that fatal and serious crashes in Gore and Southland districts are less likely to involve a slippery-road surface at the crash site.

Figure 64 **Comparative severity of injury crashes in Gore and Southland districts occurring on surfaces judged either sippery or non-slippery, 2010-2013**



Overall, as Figure 64 shows, 1.2% of fatal and serious crashes in Gore and Southland districts took place on a road surface that was slippery (for the above reasons). By contrast, 4.5% of minor crashes took place on a road surface that was slippery (for the above reasons).

Infrastructure characteristics

Road type

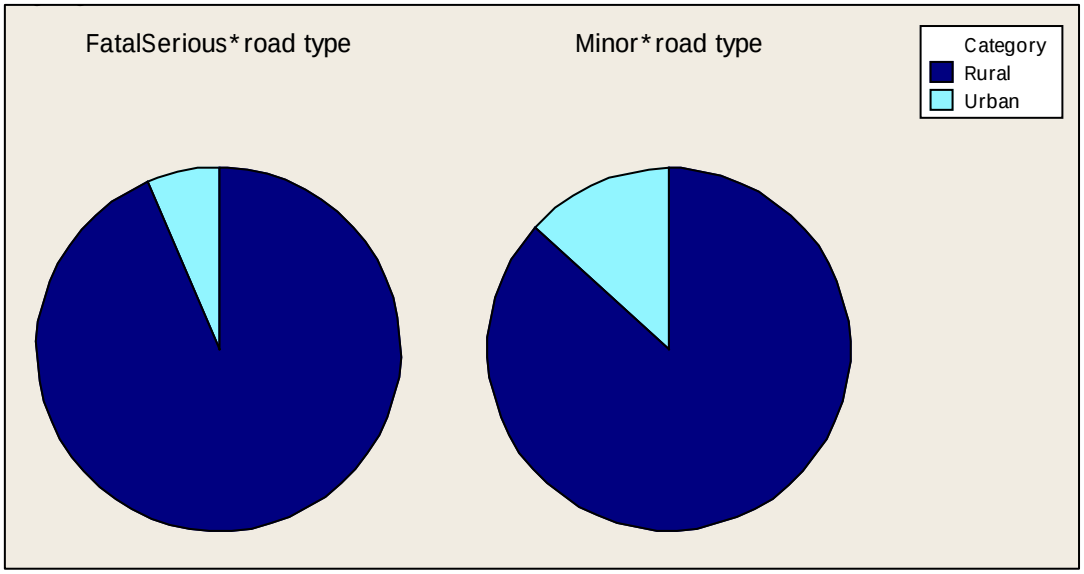
Finding:

Relative to minor crashes, serious and fatal crashes in Gore and Southland districts are closely associated with rural roads (roads with an 80 km/h speed limit or higher).

Roads have been categorised into '*Urban'* (70 km/h speed limit or lower) and '*Rural'* (80 km/h speed limit or higher). There is significant evidence (97.5%) that fatal and serious crashes in Gore and Southland districts tend to occur on roads with higher speed limits, when compared with minor crashes.

Overall, as Figure 65 shows, 93.6% of fatal and serious crashes in Gore and Southland districts have occurred on rural roads (speed limit of 80 km/h or higher); by contrast, 86.8% of minor crashes in Gore and Southland districts have occurred on rural roads (speed limit of 80 km/h or higher).

Figure 65 Comparative severity of injury crashes on urban and rural roads in Gore and Southland districts, 2010-2013



Environmental Factors

Road moisture

Finding:

Relative to minor crashes in Gore and Southland districts, fatal and serious crashes are less likely to take place in wet conditions and frequently take place in dry conditions.

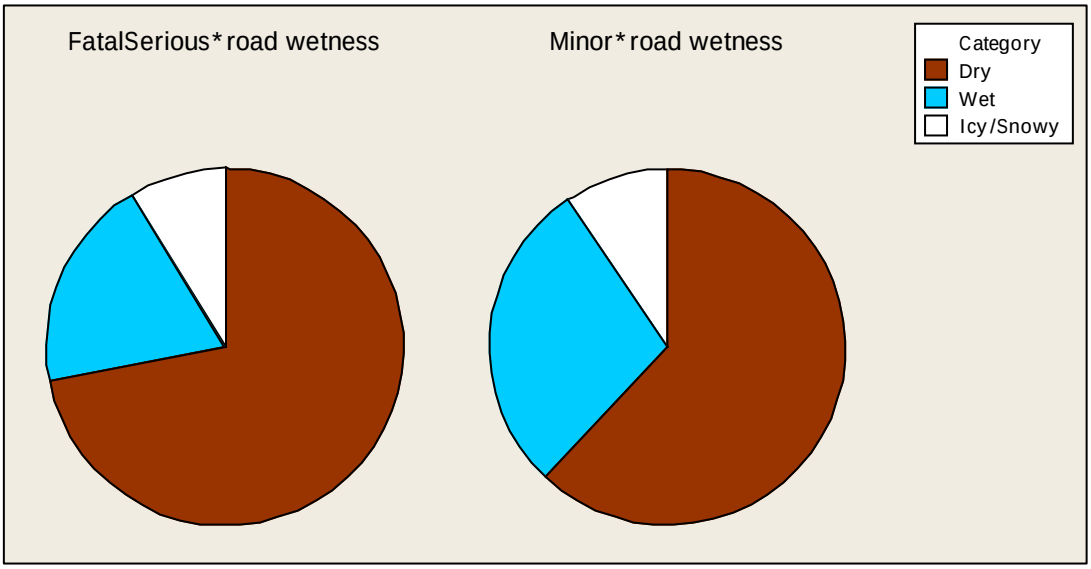
Crashes are categorised into '*Dry'*, '*Wet'* and '*Icy/Snowy'* categories. There is evidence (95.0%) that fatal and serious crashes are associated with drier-road conditions, compared

with minor crashes. Figure 66 shows that most fatal and serious crashes take place during dry conditions.

As for crashes taking place in dry-road conditions, fatal and serious crashes make up a high proportion of overall injury crashes. However, as to crashes taking place in wet conditions, fatal and serious crashes make up a small proportion of overall injury crashes.

20.0% of injury crashes taking place in wet conditions in Gore and Southland districts (2010-2013) were classed as '*serious or fatal*'. By contrast, 30.1% of injury crashes taking place in dry conditions were classed as '*serious or fatal*'. This means that almost a third of all injury crashes in dry conditions over the 2010-2013 period resulted in a serious injury to at least one road user in the crash (and some of those injuries may have proved fatal).

Figure 66 **Comparative severity of injury crashes on wet, dry and icy/snowy roads in Gore and Southland districts, 2010-2013**



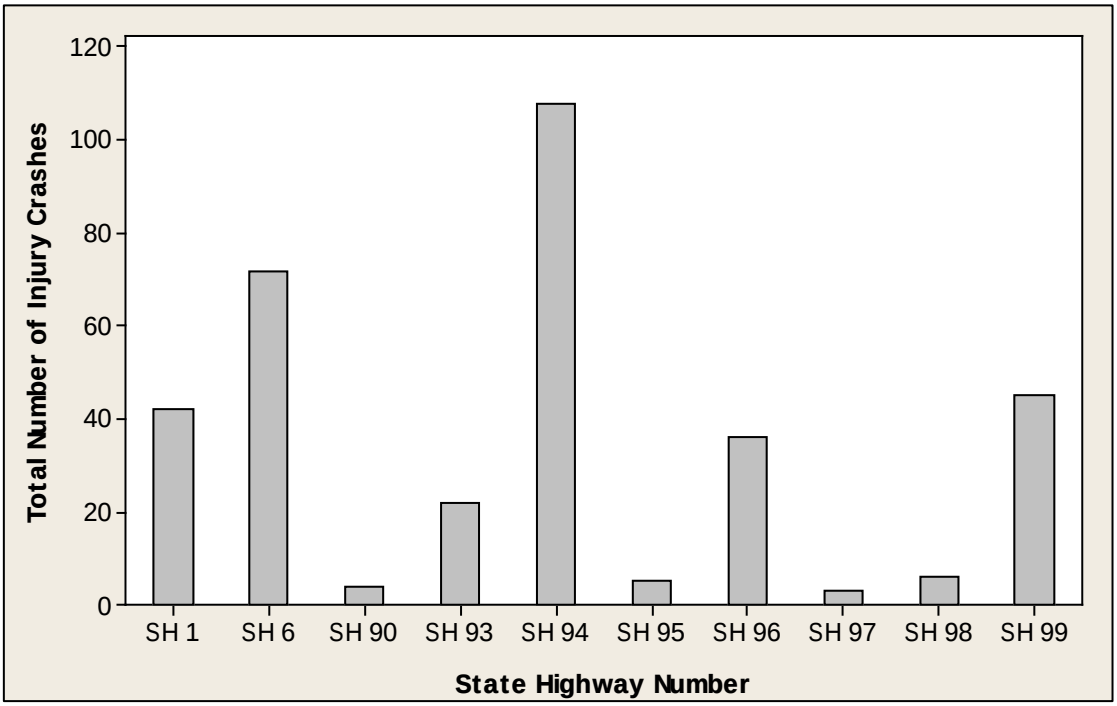
3.7.4. Location: State highway or local road

Overall, state-highway crashes in Gore and Southland during the 2010-2013 period have been distributed across the state-highway network in the manner shown in Figure 67.

A high proportion of state-highway crashes in Gore and Southland take place on State Highway (SH) 94, with a sizeable minority occurring on SH 6. SHs 1, 93, 96 and 99 make up significant proportions of the remaining state-highway crashes in Gore and Southland (see Figure 96).

Note that the number of 2013 crashes in the dataset used to produce this report is artificially low, given that it was obtained in mid-January while unfiled police reports from November and December were still being processed. This is not anticipated to affect the results of the statistical analysis, as data from November and December are available for 2010, 2011 and 2012 (and only very few crashes, relative to the size of the total dataset, were excluded in late-2013).

Figure 67 Number of injury crashes on each state highway in Gore and Southland districts, 2010-2013



Movement type

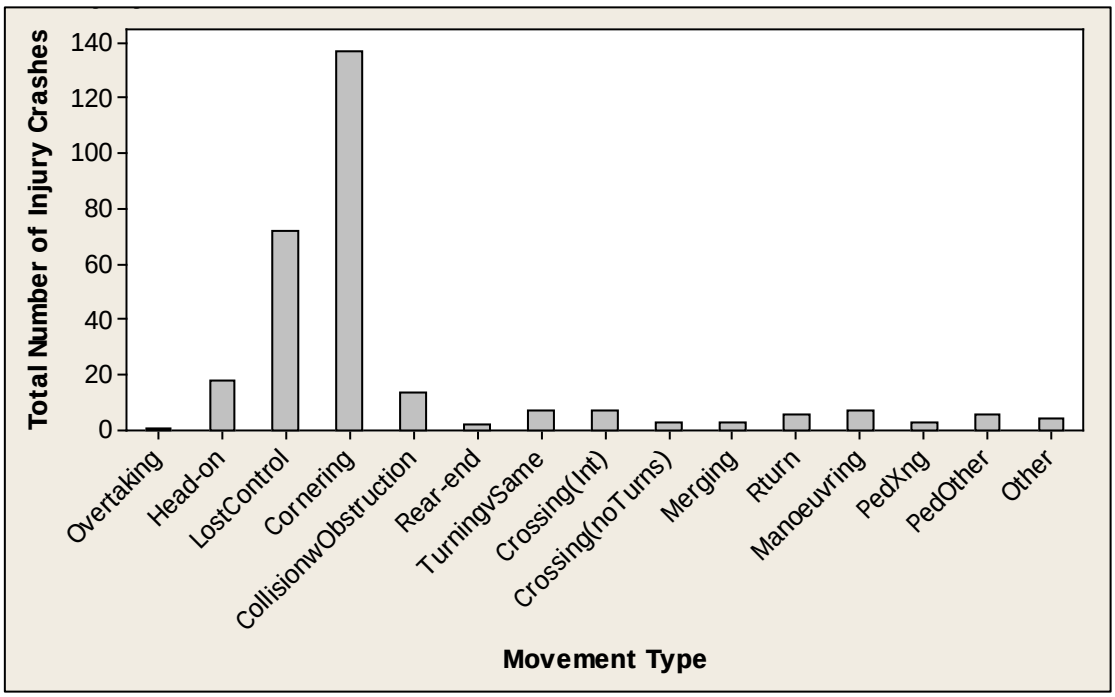
Finding:

Relative to local-road crashes, state-highway crashes in Gore and Southland are closely associated with sideswipe and overtaking crashes.

There are 15 movement types identified by the Police: '*Overtaking'* (and lane change), '*Head-on'*, '*Lost control'* (on a straight section), '*Cornering'* (on a bend), '*Collision'* (with obstruction of some kind), '*Rear-end'*, '*Turning versus same direction'* (i.e. crash involved two vehicles on the same side of the road, with one or both attempting to turn, often resulting in a sideswipe crash), '*Crossing' (no turns)* (i.e. side-impact crash), '*Crossing' (vehicle turning)* (i.e. crash involved at least one vehicle turning, usually at an intersection), '*Merging'*, '*Right-turn against'*(i.e. making a right turn against the flow of through traffic), '*Manoeuvring'* (crash during complex manoeuvre (e.g. parking, U-turn)), '*Pedestrian crossing road'*, '*Pedestrian other'* (crash involved pedestrian **not** crossing the road (e.g. on footpath or leaving vehicle) and '*Miscellaneous'*.

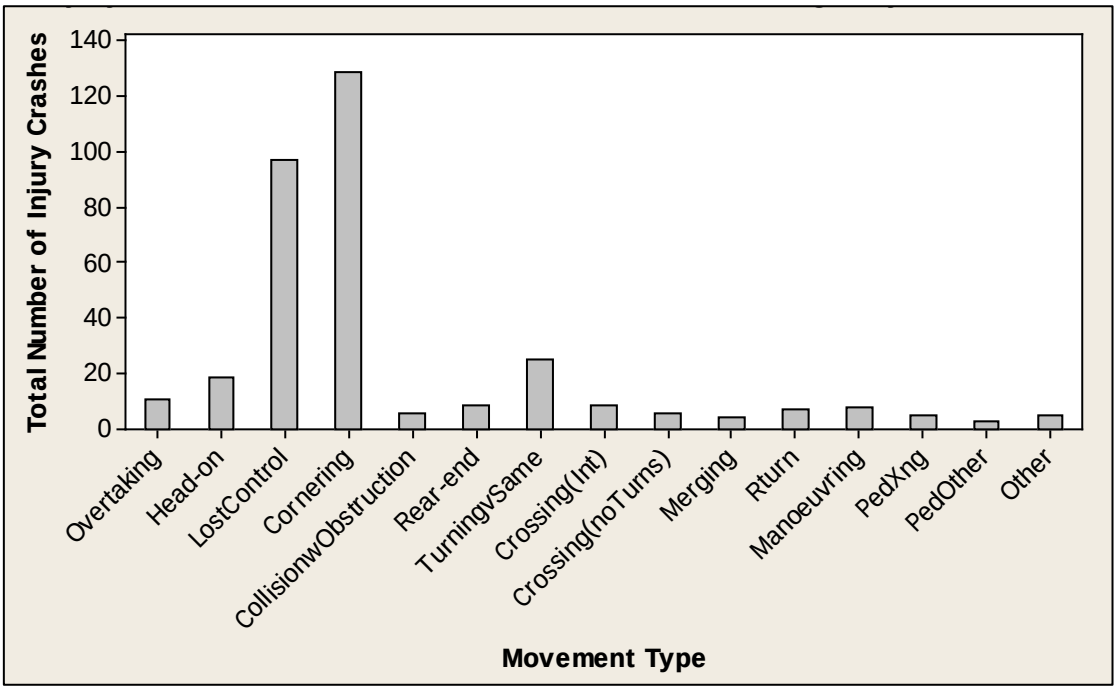
There is significant evidence (97.5%) that crashes taking place on local roads tend to involve different movement types, compared with crashes that take place on state highways (compare figures 97 and 98). This indicates that most crash-movement types are evenly distributed across the local-road and state-highway networks, with two exceptions: State highways are prone to sideswipe, and overtaking crashes, relative to local roads.

Figure 68 **Injury crashes on Gore and Southland local roads, 2010-2013, by movement type**



Most injury crashes on local roads in Gore and Southland involve losing control, either on a straight section ('*LostControl*') or on a bend of some kind ('*Cornering*'): See Figure 68.

Figure 69 **Injury crashes on Gore and Southland state highways, 2010-2013, by movement type**



While state highways show a similar overall pattern to local roads with respect to '*LostControl'* and '*Cornering'*, the '*Overtaking'* and '*TurningvSame'* bars in Figure 69 are much higher than in Figure 68 for local roads.

The main difference between figures 68 and 69 is in the categories '*Overtaking'* and '*TurningvSame'* (mainly representing sideswipe crashes). This indicates that crashes involving overtaking and sideswipe movements are much more frequent on the state-highway than the local-road network.

Key vehicle

Finding:

- Local-road crashes in Gore and Southland, relative to state-highway crashes, tend to involve motorcycles and SUVs/4x4s in the key-vehicle role.
- State-highway crashes in Gore and Southland, relative to local-road crashes, tend to involve cars/station wagons in the key-vehicle role.

There is significant evidence (97.5%) that crashes on the local-road network in Gore and Southland tend to involve different key vehicles, compared with crashes on the state-highway network. (See footnote 16 for explanation of the term key vehicle.) There are 11 vehicle types identified here: '*Car'* or station wagon, '*SUV'* (or 4x4), '*Van'*, '*Truck'*, '*Bus'*, '*School bus'*, '*Motorcycle'*, '*Moped'*, '*Cyclist'*, '*Other'* and '*Unknown'*.

Figures 59 and 60 indicate that while most vehicles are evenly distributed across the local-road and state-highway networks, there are a few exceptions. The local-road network is prone to crashes involving motorcycles and SUVs/4x4s as the key vehicle. On the other hand, the state-highway network is prone to crashes involving passenger vehicles/station wagons as the key vehicle.

While most injury crashes on local roads involve '*Cars'* (and station wagons) as the key vehicle in the crash, a sizeable minority involve '*Vans'*, '*SUVs/4x4s'* and '*Motorcycles'* in that role. '*Vans'* also show up at a high frequency on the state-highway network, suggesting that the main points of difference between the local-road and state-highway network is the much higher proportion of '*SUVs/4x4'* and '*Motorcycle'* key-vehicle crashes on the local-road network.

Note that crashes occurring on the state-highway network tend to overwhelmingly involve cars (and station wagons) as the key vehicle: See Figure 100. Compared with the local-road network, very few state-highway crashes involve '*SUVs/4x4s'* or '*Motorcycles'* in the key-vehicle role (compare figures 59 and 60).

Road markings

Finding:

Local-road crashes in Gore and Southland, relative to state-highway crashes, are associated with sections of road with no markings at all.

There is strong evidence (99.9%) to suggest that crashes taking place on the local-road network in Gore and Southland tend to occur on different sections of road compared to crashes taking place on the state-highway network in that area.

A description of how each crash scene was coded is present in NZTA's Coded Crash Report Guide[35], and the relevant section is reproduced here:

'*The following codes are used to indicate what road markings were present at the crash location, if recorded by the attending officer. Only one marking is recorded. The list below is ordered in significance ranking, i.e. a pedestrian crossing is considered to be more important than a centre line, although both may be present at the crash location'.*

The list is reproduced below:

1. Pedestrian crossing
2. Raised island
3. Painted island
4. No-passing line
5. Centre line
6. No markings.

Therefore, if the crash occurred at a scene with a pedestrian crossing (and a raised island and centre line), it will be coded as a pedestrian crossing; if the crash occurred at a scene with a no-passing line and a centre line, it will be coded as a no-passing line; if the crash occurred at a scene with a painted island and a centre line, it will be coded as a painted island, and so forth.

While most of injury crashes on Gore and Southland districts' local roads tend to occur on sections of road with a centre line, a sizeable minority take place on sections of road with no markings at all, as Figure 70 shows. Most injury crashes on Gore and Southland districts' state highways tend to occur on sections of road with a centre line. A negligible number have taken place on sections of road with no markings at all, as Figure 71 shows.

Clearly, the main difference between figures 70 and 71 is in the '*None*' category. A sizeable proportion of local-road crashes in Gore and Southland take place on sections of road with no road markings at all. However, almost all state-highway crashes in Gore and Southland took place on sections of road with appropriate markings (usually at least a centre line).

[35] See NZTA's *Guide for the interpretation of coded crash reports from the Crash Analysis System (CAS)*, version 5.1, March 2012.

Figure 70 **Injury crashes on Gore and Southland local roads, 2010-2013, by type of road marking at crash site**

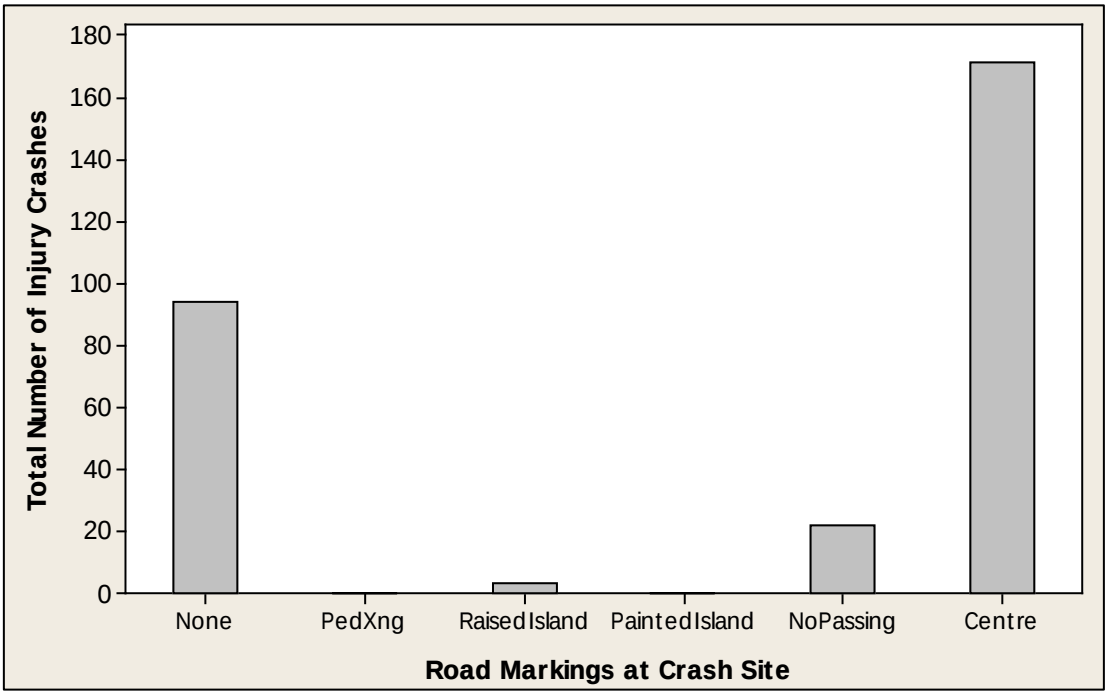
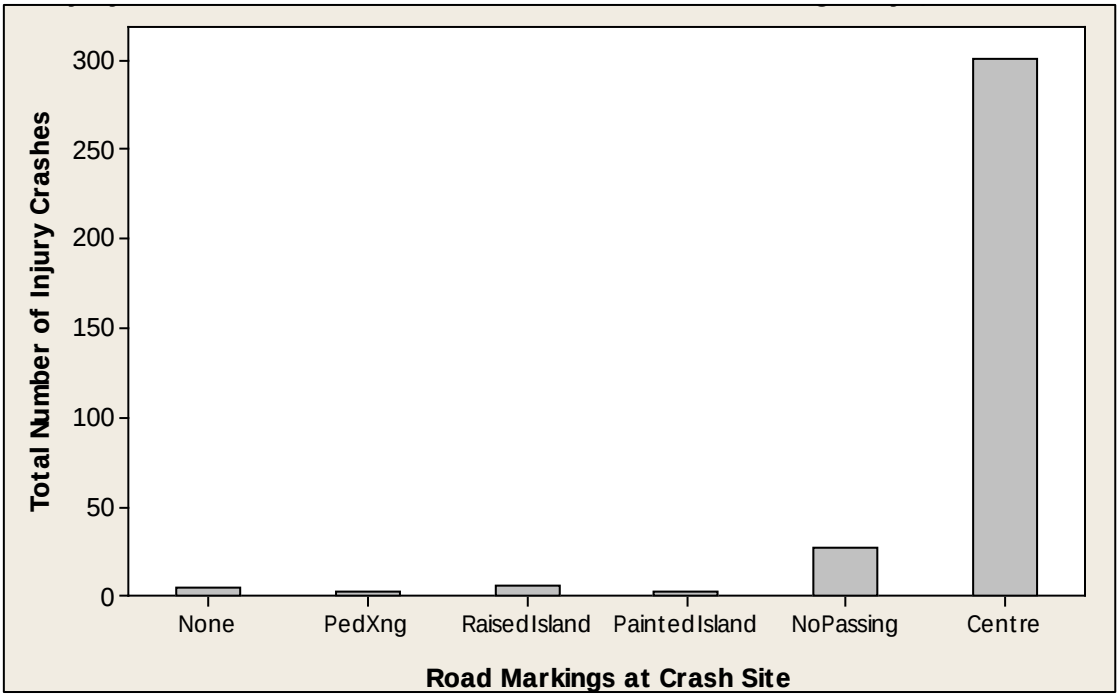


Figure 71 **Injury crashes on Gore and Southland state highways, 2010-2013, by type of road marking at crash site**



Driver age

Finding:

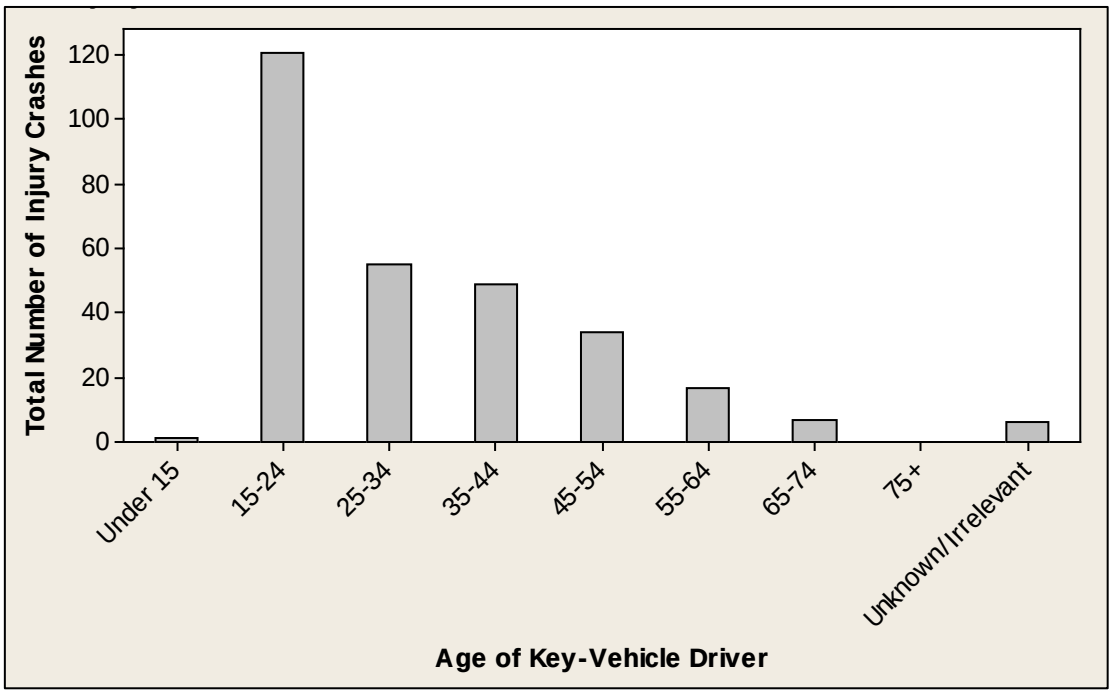
Crashes taking place on the state-highway network are closely associated with older drivers (75+) at the helm of the key vehicle, compared to crashes on the local-road network.

There is significant evidence (97.5%) that crashes taking place on the local-road network in Gore and Southland districts tend to involve a different age distribution of drivers at the helm of the key vehicle, compared to on the state-highway network, as comparison of figures 72 and 73 illustrates.

For this analysis, only the driver of the key vehicle (vehicle with role 1, as assigned by the Police) in each crash will be analysed to avoid the tendency to afford greater weight to multi-vehicle crashes. If all drivers involved in injury crashes were analysed, crashes involving multiple vehicles would effectively be counted at least two or three times over, depending on the number of vehicles involved. Note, the '*Unknown/Irrelevant'* classification is given by the Police when the key vehicle is a cyclist (in which case, the road user is a rider, not a driver: their age is thus determined '*Irrelevant*') or where the age of the driver of the key vehicle is unknown ('*Unknown'*).

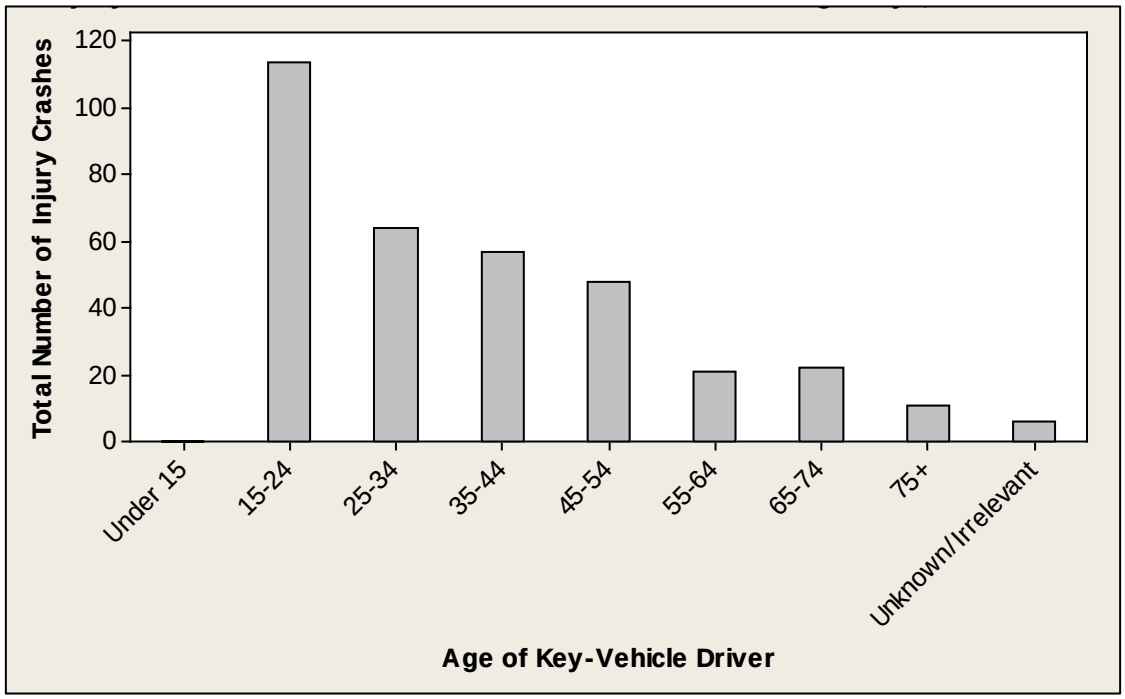
In fact, not a single key-vehicle older driver (75+) was involved in a crash on the Gore/Southland local-road network. However, 11 key-vehicle older drivers (75+) were involved in a crash on the Gore/Southland state-highway network. This is a much higher figure than expected.

Figure 72 **Injury crashes on Gore and Southland districts' local roads, 2010-2013, by driver age**



A high proportion of key-vehicle young drivers (15-24) are involved in local-road crashes in Gore and Southland; notably, however, very few key-vehicle older drivers are involved in local-road crashes.

Figure 73 **Injury crashes on Gore and Southland districts' state highways, 2010-2013, by driver age**



The peak associated with young drivers at the helm of the key vehicle (15-24) is still present on the state-highway network in Gore and Southland; the biggest difference between the two graphs is clearly towards the older end of the age range, where the state-highway network hosts a sizeable minority of older key-vehicle drivers.

This difference is particularly noticeable in the highest-age category, those classed as '*Older drivers*' (aged 75 and over). Older key-vehicle drivers make up a sizeable proportion of state-highway crashes, but do not feature at all in local-road crashes.

Driver-licence type

Finding:

Crashes taking place on the local-road network are closely associated with drivers who have been disqualified and/or forbidden from driving at the helm of the key vehicle, relative to crashes on the state-highway network.

There is powerful evidence (99.5%) that local-road crashes in Gore and Southland tend to involve a different licence distribution of drivers at the helm of the key vehicle, compared to state-highway crashes.

For this analysis, only the driver of the key vehicle (vehicle with role 1, as assigned by the Police) in each crash will be analysed to avoid the tendency to afford greater weight to multi-vehicle crashes. If all drivers involved in injury crashes were analysed, crashes involving

multiple vehicles would effectively be counted at least two or three times, depending on the number of vehicles involved. Note, the Police provide the '*Unknown/Irrelevant'* classification when the key vehicle is a cyclist, in which case, the road user is a rider, not a driver. Their licence is thus determined '*Irrelevant'*) or where the age of the driver of the key vehicle is unknown ('*Unknown'*).

To emphasise this finding, not a single disqualified/forbidden key-vehicle driver was involved in a crash on the Gore/Southland state-highway network. However, ten key-vehicle disqualified/forbidden drivers were involved in a crash local-road network. This is a much higher figure than expected.

Figure 74 **Injury crashes on Gore and Southland districts' local roads, by licence type for the driver of the key vehicle, 2010-2013**

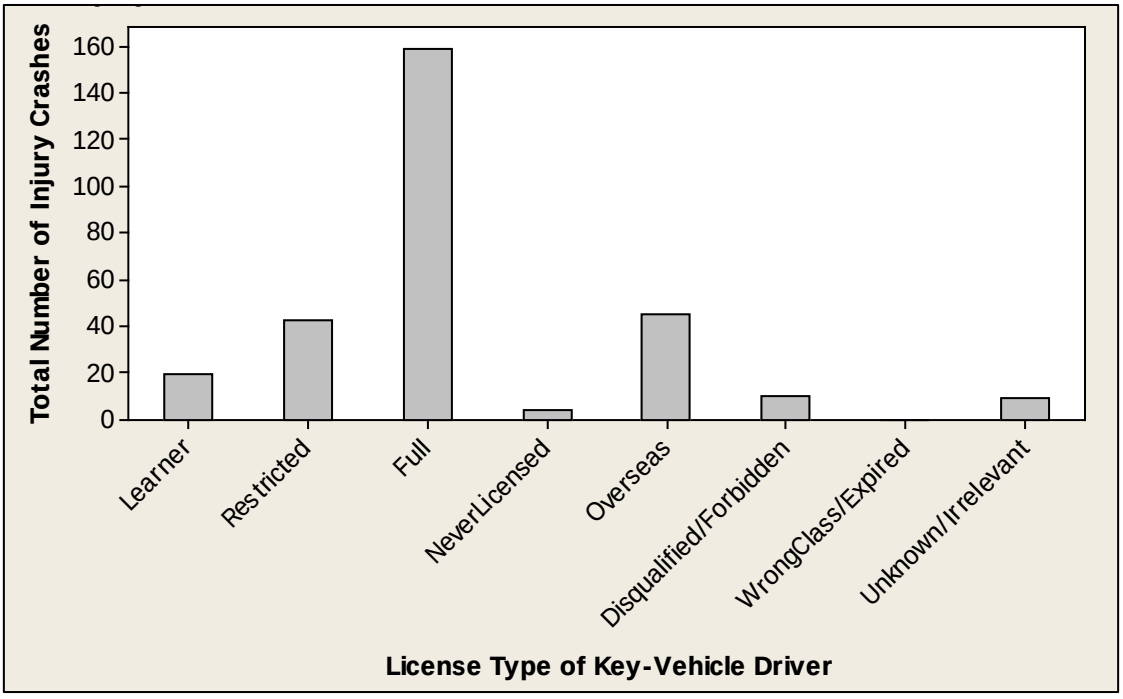
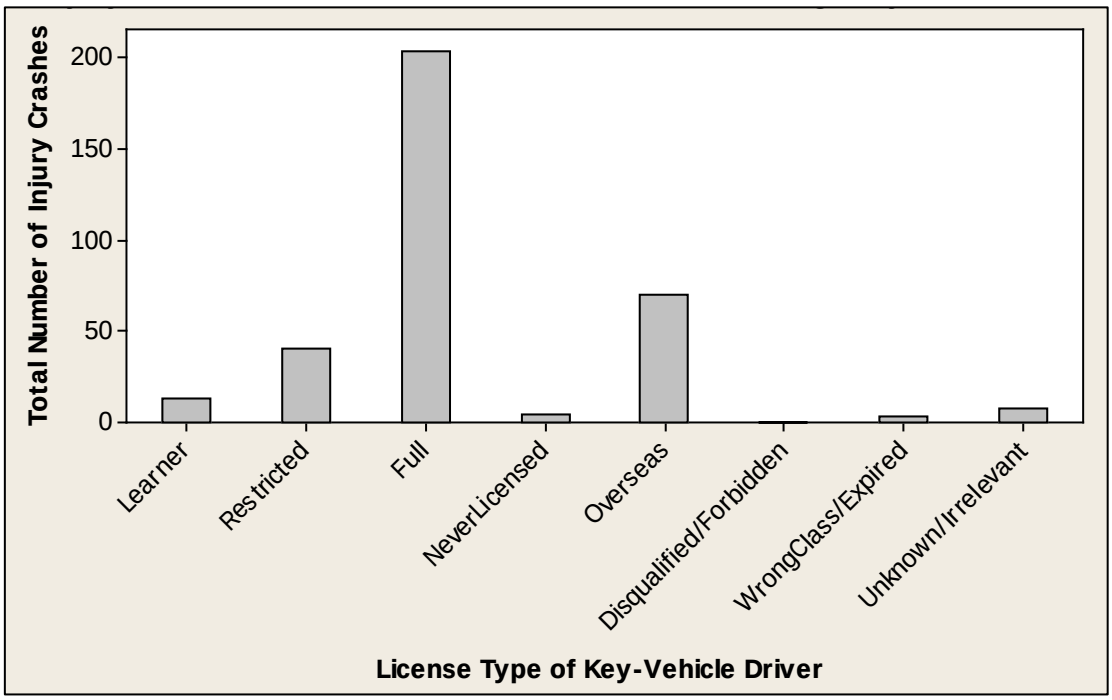


Figure 75 **Injury crashes on Gore and Southland districts' state highways, by licence type for the driver of the key vehicle, 2010-2013**



Most injury crashes on local roads and state highways in the Gore and Southland districts involve key-vehicle drivers with their full New Zealand licence. Note the sizeable minority of key-vehicle drivers on local roads who were disqualified and/or forbidden from driving at the time of their crash. Figures 74 and 75 look nearly identical, with the exception of the '*Disqualified/Forbidden'* category. Clearly, the local-road network hosts a much higher number of crashes involving key-vehicle drivers who were disqualified and/or forbidden from driving at the time of their crash.

Suspected under the influence

Finding:

In local-road crashes in Gore and Southland, relative to state-highway crashes, one or more parties in the crash are believed by the Police to be under the influence of alcohol and/or drugs.

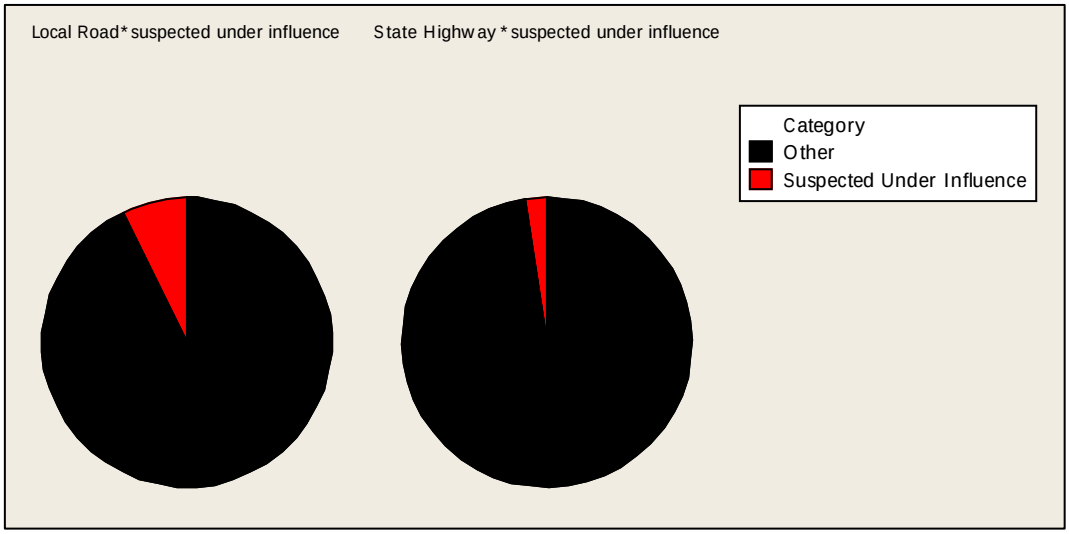
A crash was categorised as '*Suspected under influence'* if one or more parties in the crash were noted to have some involvement with alcohol or drugs (crash code 100); and/or if the Police suspected alcohol (crash code 101); and/or if Police suspected drugs (crash code 108).

There is powerful evidence (99.5%) that local-road crashes in Gore and Southland are more likely to be categorised as '*Suspected under influence'* than state-highway crashes.

Overall, as Figure 76 shows, 7.2% of injury crashes on Gore and Southland districts' local roads from 2010-2013 have been categorised as *'Suspected under influence'*; by comparison, 2.3% of injury crashes on state highways have been categorised as '*Suspected*

under influence'. A crash categorised as '*Other'* indicates that it was not categorised as *'Suspected under influence'*.

Figure 76 **Comparative incidence of injury crashes on local roads and state highways in Gore and Southland districts, in which the driver is suspected of being under the influence, or not, 2010-2013**



Above BAC limit

Finding:

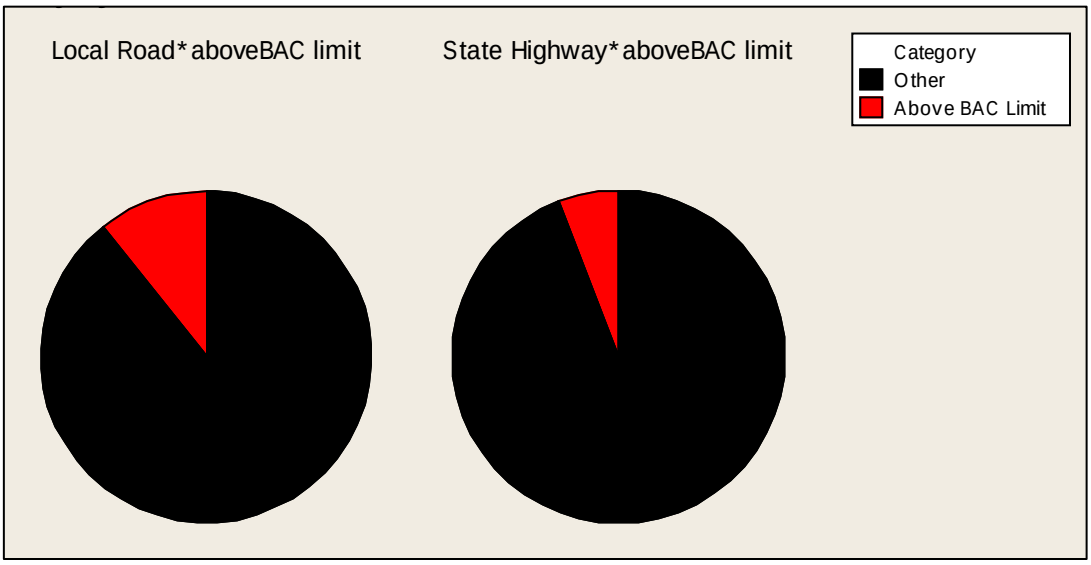
Local-road crashes in Gore and Southland, relative to state-highway crashes, are associated with one or more parties in the crash recording an alcohol level over the legal limit.

A crash was categorised as '*Above BAC limit'* if one or more parties in the crash were noted to be above the legal limit for alcohol and/or refusing to take the test (crash code 103). According to the Police, refusing the test is very rare; therefore, the majority of 103-coded crashes involve road users who would have been above the legal alcohol limit[36].

There is evidence (95.0%) that local-road crashes in Gore and Southland are more likely to be categorised as '*Above BAC Limit'* than state-highway crashes in Gore and Southland.

[36] *Pers. comm.*, Steve Larking, Acting Road Policing Manager for the Southern District. 13th Nov., 2013.

Figure 77 **Comparative incidence of injury crashes on state highways and local roads where drivers have been '*Above BAC Limit*' in Gore and Southland districts, 2010-2013**



A crash categorised as '*Other*' indicates that it was not categorised as '*Above BAC Limit*'.

Overall, as Figure 77 shows, 10.7% of injury crashes on Gore and Southland districts' local roads from 2010-2013 have been categorised as being caused by the driver being '*Above BAC Limit*'; whereas 5.8% of injury crashes have been categorised as '*Above BAC Limit*'.

Overtaking

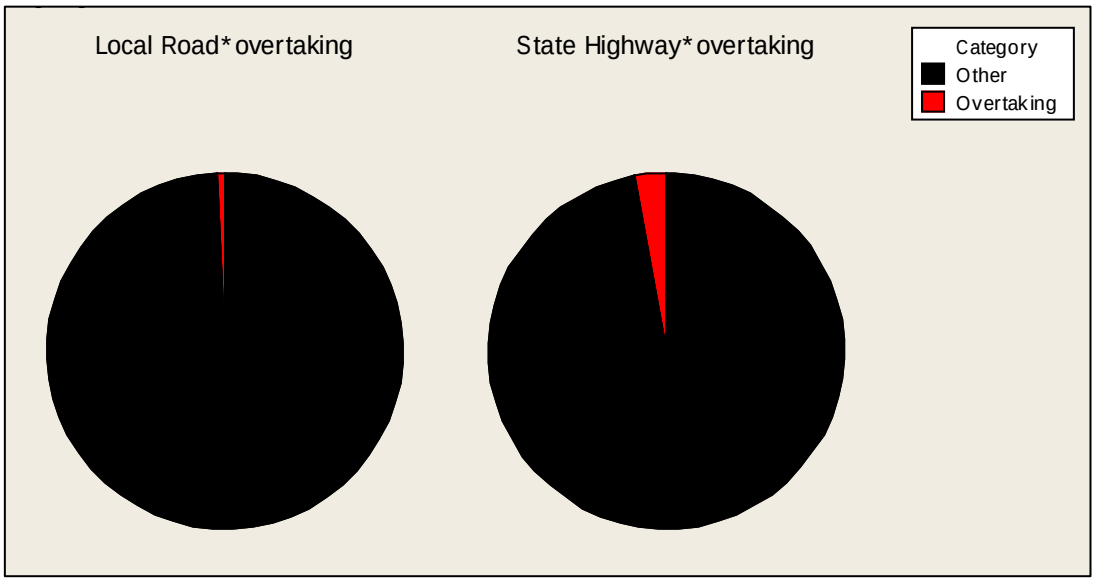
Finding:

State-highway crashes in Gore and Southland, relative to local-road crashes, are associated with one or more parties in the crash attempting to overtake without due care, or in an inappropriate location.

A crash was categorised as *'Overtaking'* if one or more parties in the crash was noted to be overtaking a line of traffic or queue (crash code 151), was overtaking and failed to notice oncoming traffic (crash code 153), was overtaking at a no-passing line (crash code 155), was overtaking at an intersection without due care (crash code 157), was overtaking on the left without due care (crash code 158), and/or was overtaking a vehicle signalling a right turn (crash code 160).

There is evidence (95.0%) that state-highway crashes in Gore and Southland are more likely to be categorised as '*Overtaking'* than local-road crashes, as illustrated in Figure 78.

Figure 78 **Comparative incidence of injury crashes on state highways and local roads in Gore and Southland districts involving drivers overtaking, or not, 2010-2013**



A crash categorised as '*Other'* indicates that it was not categorised as '*Overtaking'*. Overall, 0.7% of injury crashes on Gore and Southland districts' local roads from 2010-2013 have been categorised as '*Overtaking'*. However, 2.9% of injury crashes on state highways have been categorised as '*Overtaking'*.

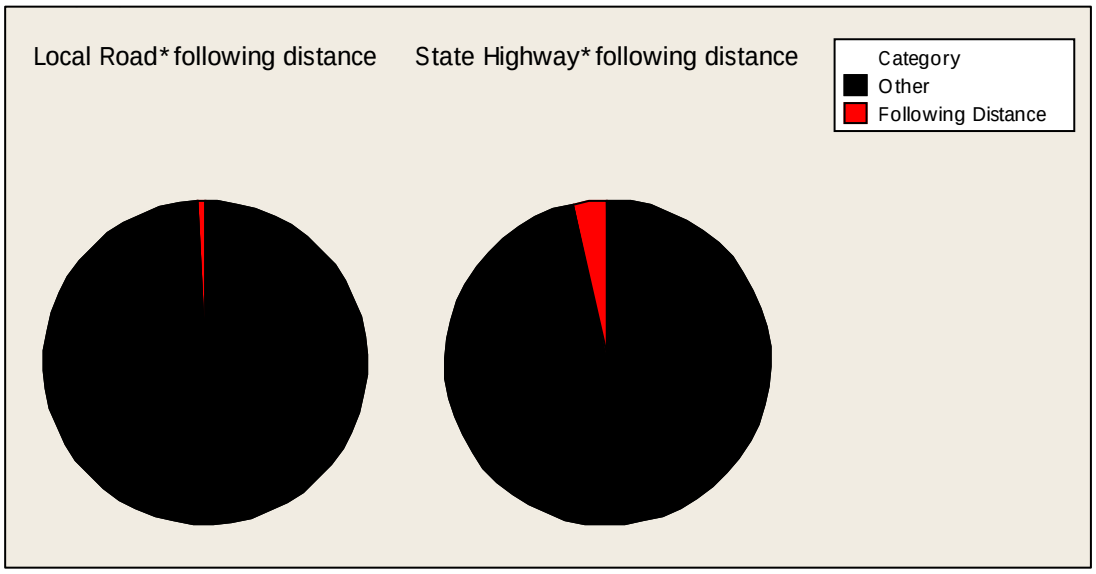
Following distance

Finding:

State-highway crashes in Gore and Southland, relative to local-road crashes, are associated with one or more parties in the crash following too closely.

A crash was categorised as '*Following distance'* if one or more parties in the crash was noted to be following too closely in a line of traffic (crash code 181). There is significant evidence (97.5%) that state-highway crashes in Gore and Southland are more likely to be categorised as '*Following distance'* than local-road crashes, as Figure 79 illustrates.

Figure 79 **Comparative incidence of injury crashes on state highways and local roads in Gore and Southland districts associated with a driver following too closely, or not, 2010-2013**



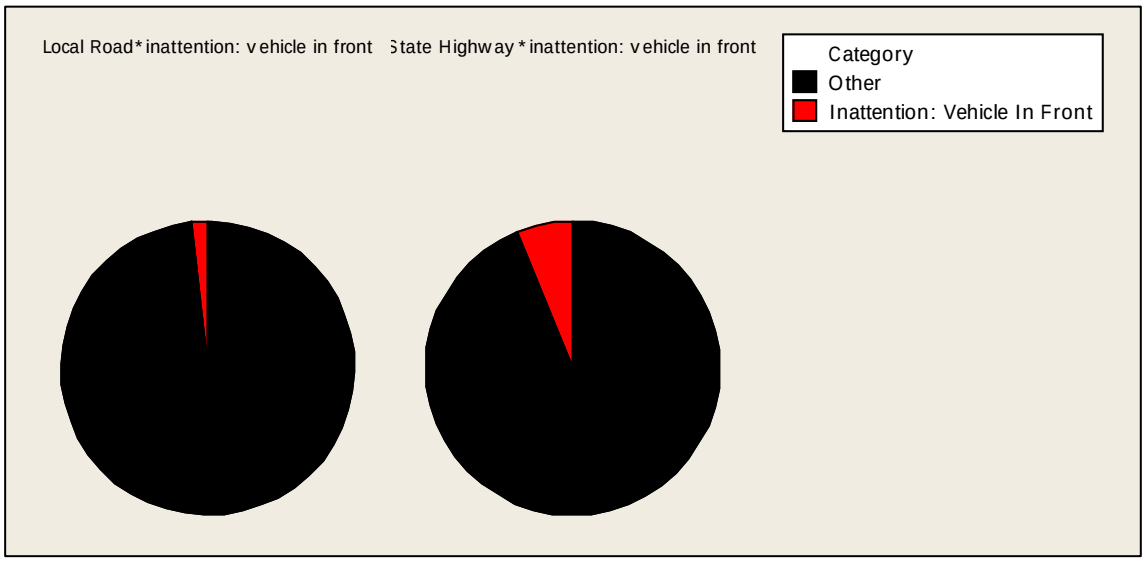
A crash categorised as *'Other'* indicates that it was not categorised as '*Following distance'*. Overall, 0.7% of injury crashes on Gore and Southland districts' local roads from 2010-2013 have been categorised as '*Following distance'*. However, 3.5% of injury crashes on state highways have been categorised as '*Following distance'*.

Inattention: Vehicle in front

Finding:

State-highway crashes in Gore and Southland, relative to local-road crashes, are associated with one or more parties in the crash failing to pay adequate attention to movements or indication of the vehicle in front.

Figure 80 **Comparative incidence of injury crashes on state highways and local roads in Gore and Southland districts associated with a failing to pay adequate attention to another vehicle, or not, 2010-2013**



There is strong evidence (99.0%) that state-highway crashes in Gore and Southland are more likely to be categorised as '*Inattention: Vehicle in front'* than local -crashes. A crash was categorised as '*Inattention: Vehicle in front'* if one or more parties in the crash was noted to be inattentive through failing to notice a vehicle slowing, stopping or stationary in front (crash code 331) and/or inattentive through failing to notice the indication of a *'Vehicle in front*' (crash code 333).

A crash categorised as '*Other'* indicates that it was not categorised as '*Inattention: Vehicle In front'*.

Overall, as Figure 80 shows, 1.7% of injury crashes on Gore and Southland districts' local roads from 2010-2013 have been categorised as '*Inattention: Vehicle in front'*. However, 6.1% of injury crashes on state highways have been categorised as '*Inattention: Vehicle in front*'.

Fatigue: Lack of sleep

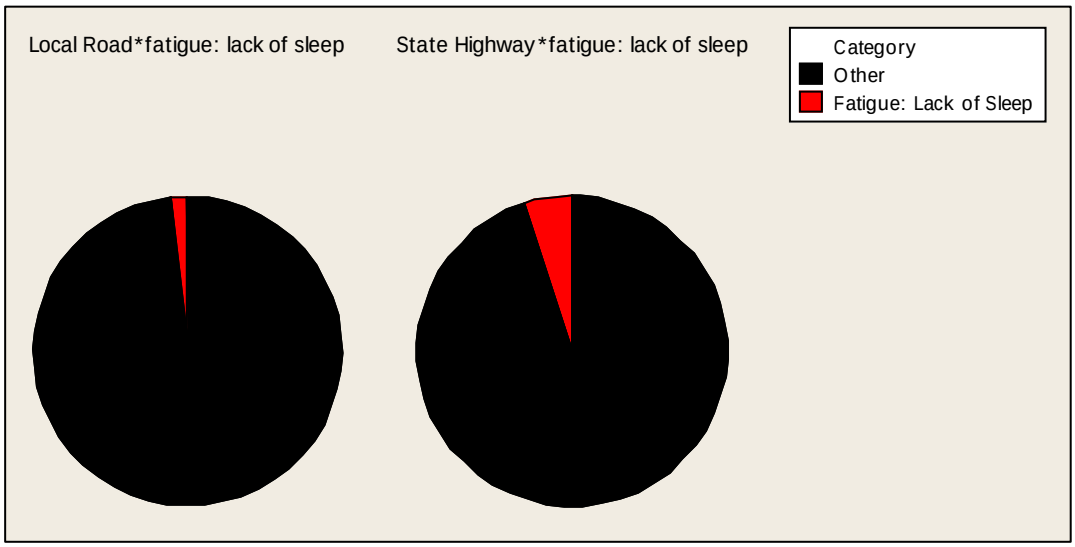
Finding:

State-highway crashes in Gore and Southland, relative to local-road crashes, are associated with fatigue due to lack of sleep on the part of one or more parties in the crash (see Figure 81).

A crash was categorised as *'Fatigue: Lack of sleep*' if one or more parties in the crash was noted to be fatigued (drowsy, tired, and/or fell asleep) through lack of sleep (crash code 412). A crash categorised as *'Other'* indicates that it was not categorised as '*Fatigue: Lack of sleep*'.

There is evidence (95.0%) that state-highway crashes in Gore and Southland are more likely to be categorised as *'Fatigue: Lack of sleep'* than local-road crashes.

Figure 81 **Comparative incidence of injury crashes on state highways and local roads in Gore and Southland districts where the driver lacked sleep, or not, 2010-2013**



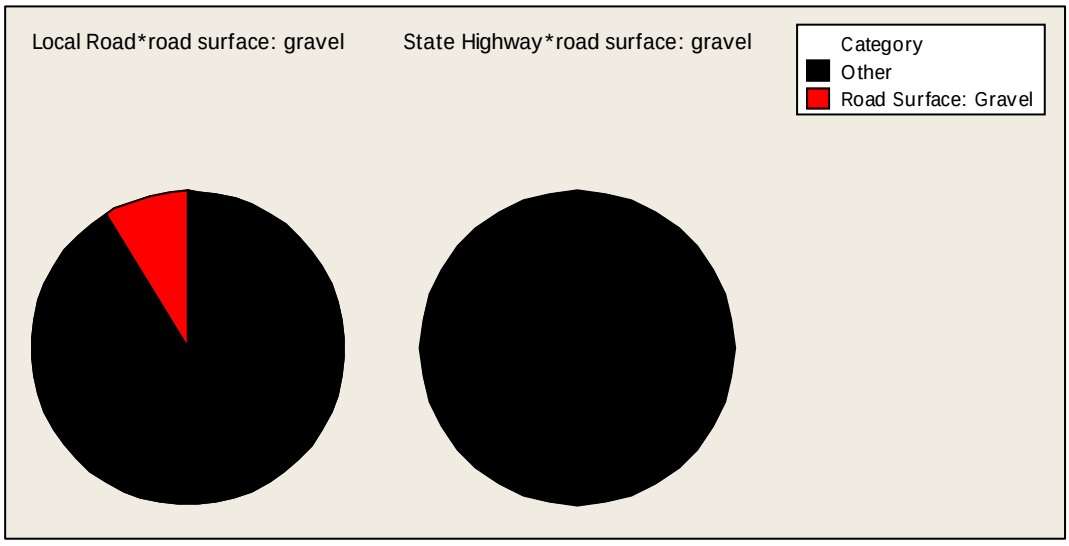
Overall, 1.7% of injury crashes on Gore and Southland districts' local roads from 2010-2013 have been categorised as *'Fatigue: Lack of sleep'*. However, 5.0% of injury crashes on state-highways have been categorised as *'Fatigue: Lack of sleep'*.

Road surface: Gravel

Finding:

Local-road crashes in Gore and Southland, relative to state-highway crashes, tend to be associated with deep loose metal [gravel] on the road surface.

Figure 82 **Comparative incidence of injury crashes on state highways and local roads in Gore and Southland districts associated with deep, loose gravel, or not, 2010-2013**



A crash was categorised as *'Road surface: Gravel'* if a contributing factor to the crash was deep, loose metal on the road surface (crash code 813). A crash categorised as *'Other'* indicates that it was not categorised as *'Road Surface: Gravel'*.

There is strong evidence (99.9%) that local-road crashes in Gore and Southland are more likely to be categorised as *Road surface: Gravel'* than state-highway crashes.

Overall, as shown in Figure 82, 8.6% of injury crashes on Gore and Southland districts' local roads from 2010-2013 have been categorised as '*Road surface: Gravel*'. However, 0% of injury crashes have been categorised as '*Road surface: Gravel*'.

Obstruction and visibility issues

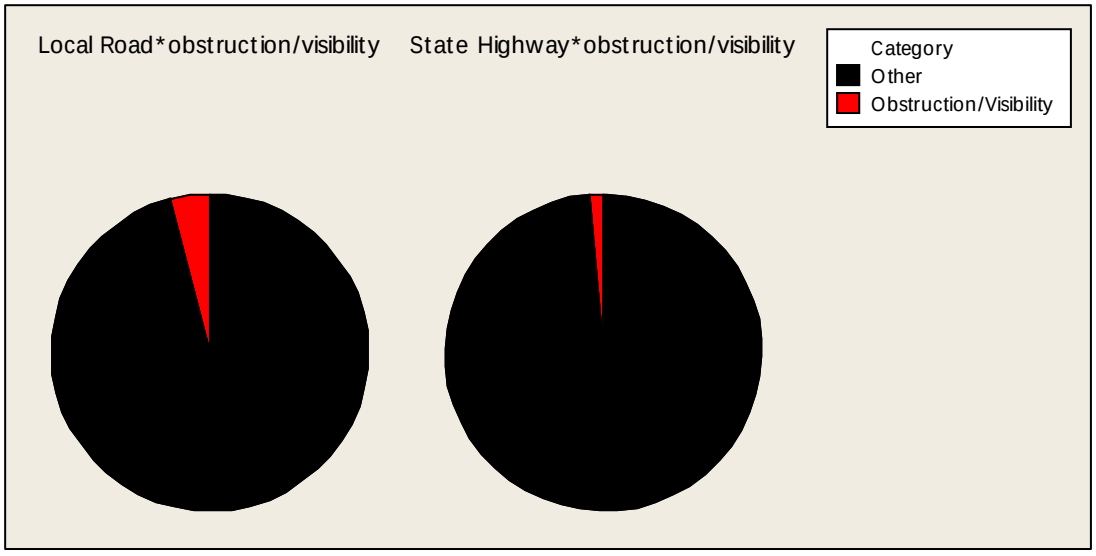
Finding:

Local-road crashes in Gore and Southland, relative to state-highway crashes, tend to be associated with obstruction and/or visibility issues at the crash site (see Figure 83).

A crash was categorised as *'Obstruction/Visibility'* issues if one or more parties in the crash was obstructed for unspecified reasons (crash code 820); was obstructed due to flood waters, large puddles and/or a ford (crash code 823); if visibility was limited for unspecified reasons (crash code 830); if visibility was limited due to a curve (crash code 831); if visibility was limited due to a crest (crash code 832); if visibility was limited due to trees (crash code 834); if visibility was limited due to a hedge or fence (crash code 835); if visibility was limited due to a temporary obstruction, dust or smoke (crash code 838); and/or if visibility was limited due to the presence of a parked vehicle (crash code 839).

There is evidence (95.0%) that local-road crashes in Gore and Southland are more likely to be categorised as '*Obstruction/Visibility'* issues than state-highway crashes.

Figure 83 **Comparative incidence of injury crashes on state highways and local roads in Gore and Southland districts associated with an obstruction or visibility issue, or not, 2010-2013**



A crash categorised as '*Other*' indicates that it was not categorised as '*Obstruction/Visibility*'. Overall, 4.1% of injury crashes on Gore and Southland districts' local roads from 2010-2013 have been categorised as '*Obstruction/Visibility*'; however, 1.5% of injury crashes on state highways have been categorised as '*Obstruction/Visibility*".

3.7.5. *Areas where serious and fatal crashes perform better than minor crashes*

Compared with minor crashes in Gore and Southland districts, serious/fatal crashes in these two districts are rarely likely to:

- take place in wet conditions
- be caused by a slippery-road surface.

3.8. Invercargill City results

3.8.1. Findings and recommendations, summarised

Three themes emerge from the analysis of data for Invercargill City:

- There is a serious road-safety issue associated with pedestrians.
- Serious and fatal crashes are over represented on roads with high-speed limits (80 km/h or higher).
- When an obstruction or lack of visibility is implicated as a factor in a crash, that crash is highly likely to have resulted in a fatal or serious injury to at least one road user (rather than in a minor injury).

Findings:

Relative to minor crashes, serious and fatal crashes in Invercargill City:

- are closely associated with evening (4 pm-9:59 pm) and night-time (10 pm-3:59 am)
- do not typically take place during the morning (4 am-9:59 am) or daytime (10 am-3:59 pm)
- are closely associated with pedestrians
- are not typically multi-vehicle crashes involving cars
- are closely associated with rural roads (roads with an 80 km/h speed limit or higher)
- relative to minor crashes, fatal and serious crashes are less likely to be associated with road users' inattention to a vehicle's motions or indications in front.

Compared to state-highway crashes in Invercargill, local-road crashes are more likely to:

- occur at certain types of intersection:
  - take place on crossroads (X-junctions) and driveways
  - occur at give-way signs
  - involve one or more parties failing to give way at a give-way sign (based on police opinion).
- involve side-impact collisions
- involve one or more parties failing to see or look for another party until too late (based on police opinion)

- involve one or more parties visiting a private house/farm, or other non-commercial premises (based on police opinion)
- involve a cyclist, as indicated by the Police recording the gender of the person at the helm of the key vehicle as irrelevant or unknown
- involve a woman as the driver of the key vehicle.

Compared to local-road crashes in Invercargill, state-highway crashes are more likely to:

- involve rear-ends
- take place on easy curves
- occur at T-junctions
- take place at traffic lights
- occur on, or near, raised-traffic islands
- take place on 'rural' roads (roads with an 80 km/h speed limit or higher)
- involve a man as the driver of the key vehicle
- involve a 35-44 year-old as the driver of the key vehicle
- involve fatigue on the part of one or more of those involved (according to police opinion).

Recommendations for Invercargill City Council and/or NZTA to consider:

- *to be added*

3.8.2. Themes found in the analysis of serious and fatal crashes

Theme 1: There is a serious road-safety issue associated with pedestrians in Invercargill City.

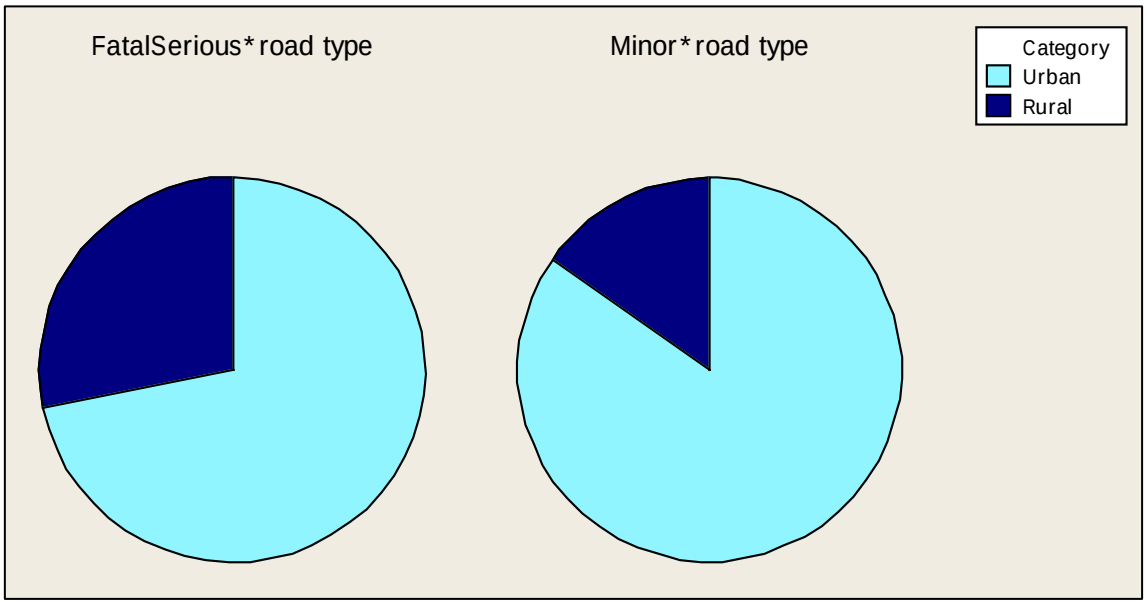
About a third of pedestrian-injury crashes in Invercargill City have resulted in serious injury or death for at least one road user (probably the pedestrian). By way of comparison, 18.1% of all injury crashes were classed as '*serious or fatal'*.

As Figures 86 and 87 illustrate, pedestrians are at a much higher risk of death or serious injury when compared with other road users in Invercargill City. This is not surprising; pedestrians are a vulnerable road-user group, and the research literature clearly indicates that they are at risk of suffering serious injury in collisions with vehicles, particularly at higher impact speeds[37]. This is a major driving force behind the 'shared space' concept in many cities, where pedestrians and vehicles are permitted to coexist in the same area at low speeds (often with a speed limit of 10 km/h or lower).

This is likely to be an issue shared by all major-urban areas in New Zealand (and indeed internationally); pedestrians are extremely vulnerable to serious road trauma. Investigating the location of serious and fatal pedestrian crashes in Invercargill City may be the most useful next move to determine where these crashes tend to occur.

Theme 2: Serious and fatal crashes are over-represented on roads with high-speed limits (80 km/h or higher) in Invercargill City.

Figure 84 **Comparative severity of injury crashes on urban and rural roads in Invercargill City, 2010-2013**



[37] Davis, G.A. (2001). Relating severity of pedestrian injury to impact speed in vehicle-pedestrian crashes: simple threshold model. *Transportation Research Record: Journal of the Transportation Research Board, 1773,* 108-113. doi: 10.3141/1773-13

Roads have been categorised into *'Urban'* (70 km/h speed limit or lower) and *'Rural'* (80 km/h speed limit or higher). There is powerful evidence (99.5%) that fatal and serious crashes in Invercargill City tend to occur on roads with higher-speed limits, when compared with minor crashes.

Figure 84 indicates that fatal and serious crashes are more closely associated with rural-road crashes (roads with an 80 km/h speed limit or higher) in Invercargill City, compared with minor crashes. 28.2% of fatal and serious crashes have occurred on rural roads (speed limits of 80 km/h or higher); by contrast, 15.3% of minor crashes have occurred on rural roads (speed limits of 80 km/h or higher).

This is not surprising. Research evidence indicates that higher travel speeds are associated not only with increased likelihood of crashing, but also with increased crash severity. That is, travelling at higher speeds tends to lead to more crashes, and these high-speed crashes are usually more severe than low-speed crashes[38].

It is also possible that roads with a high-speed limit in Invercargill City (80 km/h or higher) tend to be more dangerous than roads with a lower-speed limit, with respect to roadside environment and infrastructure. This would also help to explain the high rate of fatal and serious crashes on high-speed roads.

Invercargill City Council may wish to consider whether this is a natural consequence of higher-travel speeds, or whether it is associated with some inherent danger on the high-speed roads in the city.

Theme 3: Serious and fatal crashes are closely associated with 'Obstruction/Visibility' issues in Invercargill City.

There is strong evidence (99.9%) that fatal and serious crashes in Invercargill City tend to be associated with locations featuring an obstruction or lack of visibility, when compared with minor crashes in the city. Overall, 5.9% of fatal and serious crashes were caused, or partially caused, by obstruction and/or visibility issues at the crash site; by contrast, 0.3% of minor crashes were caused, or partially caused, by '*Obstruction/Visibility'* issues at the crash site.

[38] Aarts, L., & van Schagen, I. (2006). Driving speed and the risk of road crashes: A review. *Accident Analysis & Prevention, 38,* 215-224. doi: 10.1016/j.aap.2005.07.004.

Figure 85 **Comparative severity of injury crashes in Invercargill City asscoiated with obstrsution or visibility issues, or not 2010-2013**

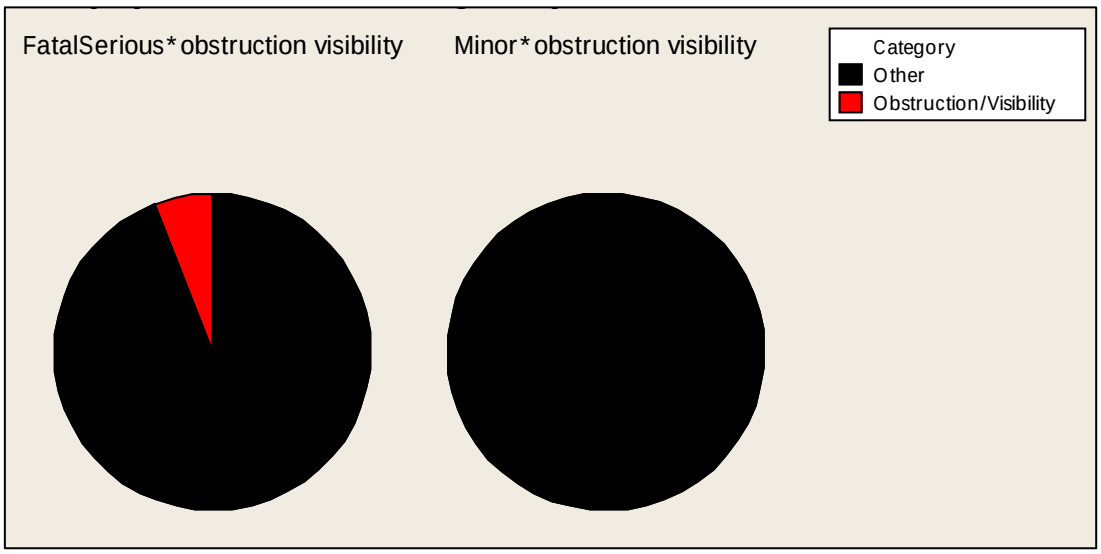


Figure 85 indicates that fatal and serious crashes in Invercargill City are closely associated with obstruction and/or visibility issues at the crash site, relative to minor crashes. 83% of injury crashes associated with obstruction and/or visibility issues at the crash site have resulted in serious or fatal injury to at least one road user. Although there appears to be a solid black circle on the right panel (indicating no minor crashes associated with '*Obstruction/Visibility'* issues), there was in fact one minor crash over this period (2010-2013) that was caused, or partially caused, by '*Obstruction/Visibility'* issues. It cannot be detected in the above graph because it represents such a small proportion of all minor crashes.

A crash was classed as '*Obstruction: Visibility'* when one or more road users were obstructed for unspecified reasons (crash code 820); obstructed due to flood waters, large puddles, or a ford (crash code 823); and/or when the visibility of one or more road users was limited for unspecified reasons (crash code 830); visibility was limited due to a curve (crash code 831); to a crest (crash code 832); to trees (crash code 834); to a hedge or fence (crash code 835); to a temporary obstruction, dust or smoke (crash code 838); and/or to a parked vehicle (crash code 839).

Although research on this issue is sparse, there is some literature available that indicates that crashes caused by visibility issues (due, in this study, to fog or smoke in the US state of Florida) tend to be more severe than crashes under clear-visibility conditions[39]. It is also possible, however, that visibility issues in Invercargill City are particularly dangerous for other reasons. Invercargill City Council may wish to consider whether this is a global issue that is related to the sorts of crashes associated with visibility problems (for example, excess speed for the conditions), or whether this issue is unique to Invercargill's roading network.

[39] Abdel-Aty, M., Ekram, A.-A., Huang, H. & Choi, K. (2011). A study on crashes related to visibility obstruction due to fog and smoke. *Accident Analysis & Prevention, 43,* 1730-1737. doi: 10.1016/j.aap.2011.04.003

3.8.3. Factors associated with serious and fatal crashes

Crash characteristics and causes

Multi-vehicle crashes

Findings:

Relative to minor crashes, serious and fatal crashes in Invercargill City:

- are closely associated with pedestrians
- are not typically multi-vehicle crashes involving cars.

Here, the second vehicle in the crash is being analysed. There are 12 categories: '*Single/vehicle'* (the crash involved just one vehicle), '*Car'* (or station wagon), '*SUV'* (or 4x4), '*Taxi'*, '*Van'* (or ute), '*Truck'*, '*Motorcycle'*, '*Moped'*, '*Cyclist'*, '*Pedestrian'*, '*Skateboarder'* and '*Unknown'*. There is powerful evidence (99.5%) that serious and fatal crashes in Invercargill City tend to involve different sorts of road users, compared with minor crashes.

As for crashes involving pedestrians, a high proportion is classed as '*serious or fatal'*; by contrast, with respect to multi-vehicle car crashes, fatal and serious crashes make up just a small proportion of overall injury crashes.

35.3% of injury crashes involving a pedestrian as the second road user in a crash in Invercargill City (2010-2013) have been classed as '*serious or fatal'*. By contrast, 10.5% of injury crashes involving multiple vehicles, with a car (or station wagon) as the second road user have been classed as '*serious or fatal'*. Thus, about a third of pedestrian-injury crashes have resulted in serious injury or death for at least one-road-user (possibly the pedestrian).

Figure 86 **Fatal and serious crashes in Invercargill City, 2010-2013, by type of second road user involved**

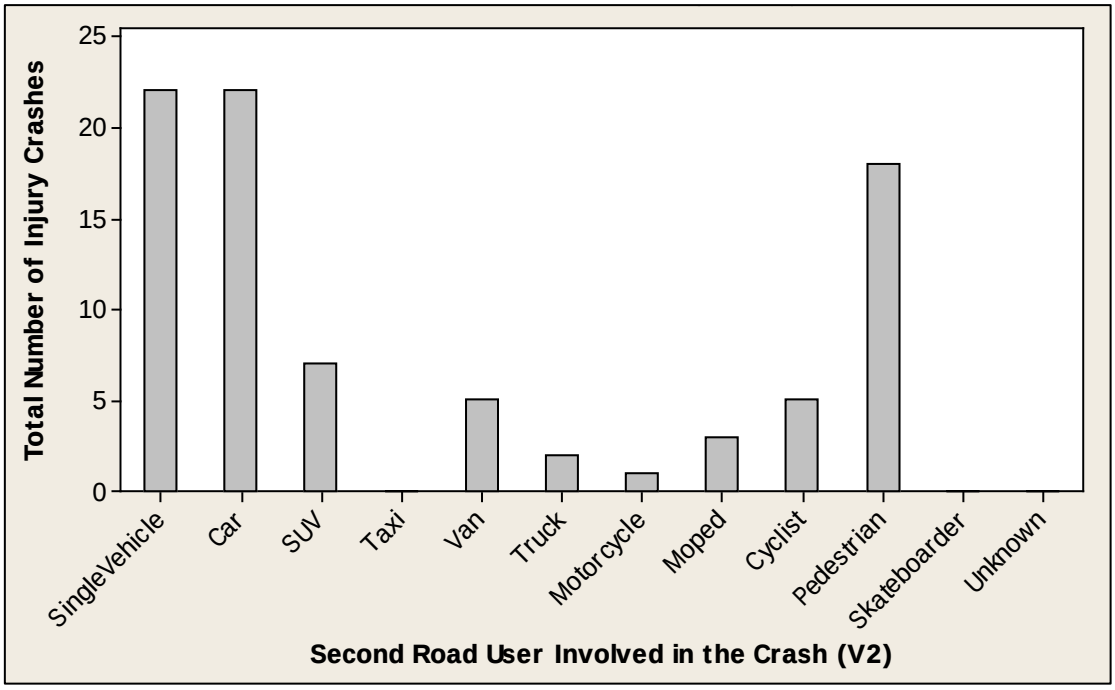
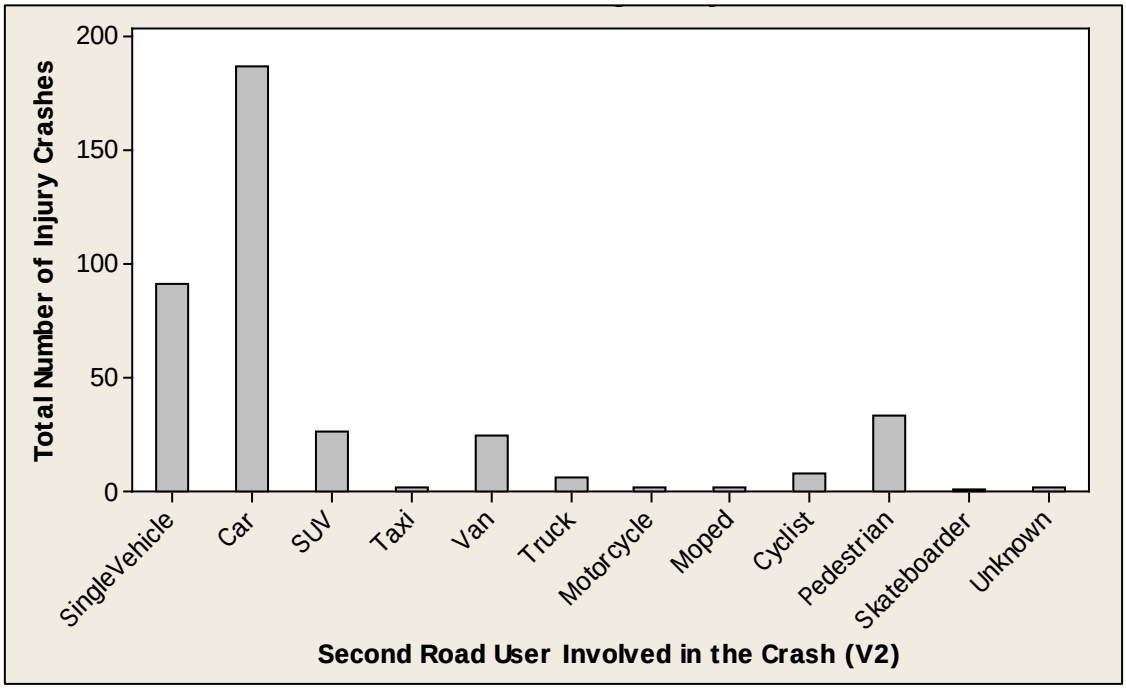


Figure 87 **Minor crashes in Invercargill City, 2010-2013, by type of second road user involved**



Figures 86 and 87should be interpreted as follows: '*SingleVehicle'* = the crash was a single-vehicle crash; '*Car'* = the crash was a multi-road user crash, with at least one car (or station wagon); '*SUV'* = the crash was a multi-road user crash, with at least one SUV (or 4x4); '*Pedestrian'* = the crash was a multi-road user crash, involving at least one pedestrian. Note that these categories are not mutually exclusive, such that a crash involving a car and an SUV could be categorised under this system as either '*Car'* or '*SUV'*. The choice of classification depends on which vehicle is the key vehicle (as determined by the Police).

Because this analysis involves examining the second road user involved in the crash, the crash example just described would be classified as '*SUV'* if the car was the key vehicle, or *Car*, if the SUV was the key vehicle. The '*key vehicle'* is defined by the Police as the vehicle exhibiting the bolded movement on the police-movement coding sheet[40]. It does not necessarily indicate fault.

Figures 86 and 87 show a completely different pattern: a large minority of fatal and serious crashes involve at least one pedestrian. By contrast, a high proportion of minor crashes is either caused by a single-vehicle or involve multiple vehicles with at least one car or station wagon, shown as the category, *Car*, in the graph. This can be interpreted to indicate that crashes involving pedestrians in Invercargill City often result in serious physical trauma; however, multi-vehicle crashes involving cars tend to be quite minor.

Inattention: Vehicle in front

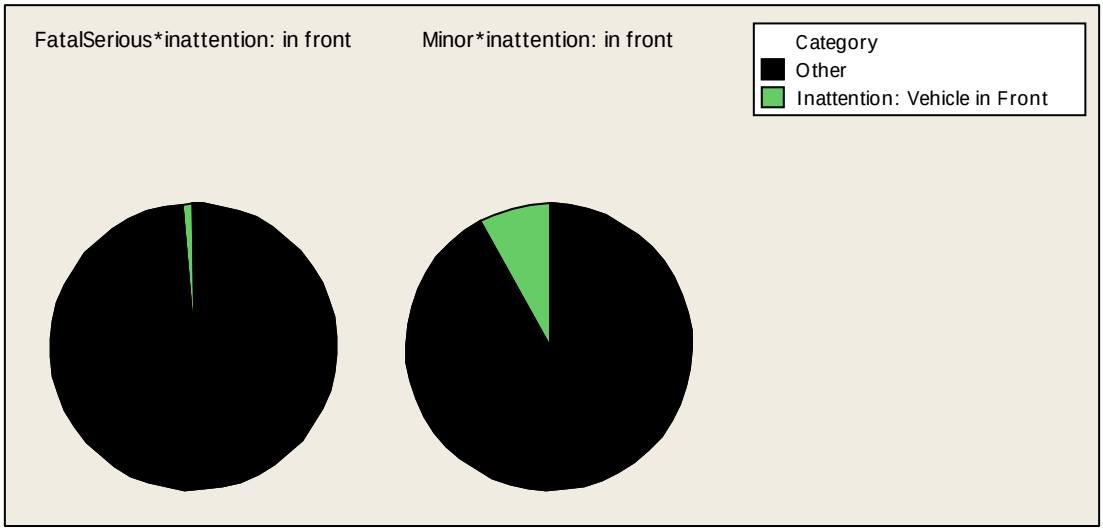
Finding:

[40] See NZTA's *Guide for the Interpretation of Coded Crash Reports from the Crash Analysis System (CAS),* January 2014, http://www.nzta.govt.nz/resources/guide-to-coded-crash-reports/index.html .

Relative to minor crashes, fatal and serious crashes in Invercargill City are less likely to be associated with road users' inattention to a vehicle's motions or indications in front.

A crash is classed as *'Inattention: Vehicle in front'* if one or more road users was inattentive through failing to notice a vehicle slowing, stopping or stationary in front (crash code 331) and/or failed to notice indication of vehicle in front (crash code 333). There is significant evidence (97.5%) to suggest that fatal and serious crashes in Invercargill City tend not to involve inattention on the part of road users to vehicles in front of them, when compared with minor crashes.

Figure 88 Comparative severity of injury crashes in Invercargill City asscoiated with inattention to another vehicle, or not, 2010-2013



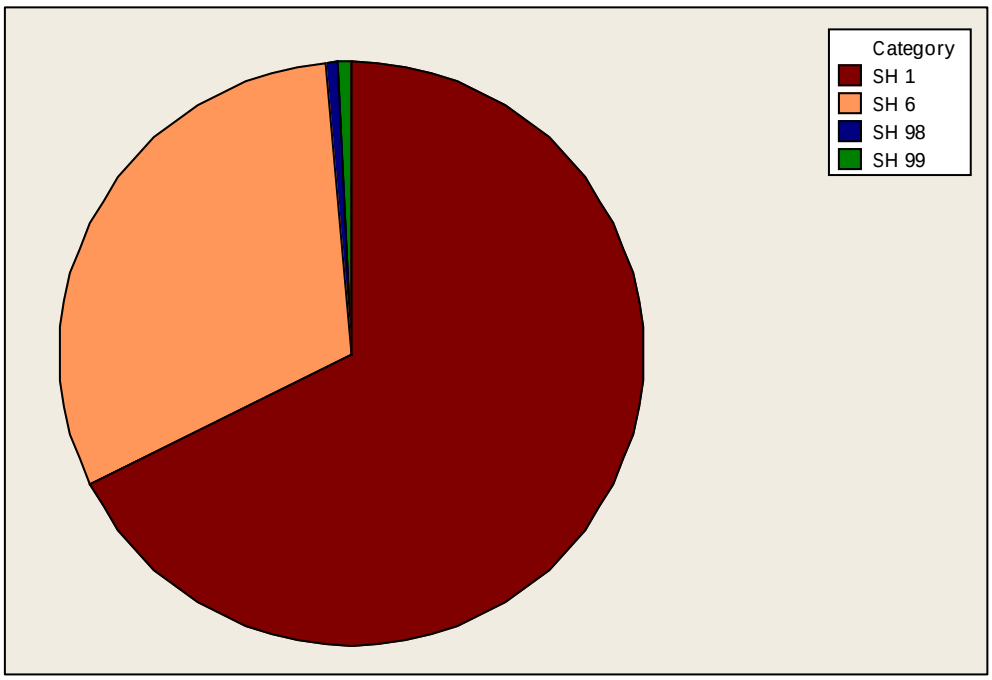
Overall, as Figure 88 depicts, 1.2% of fatal and serious crashes in Invercargill City involved a road user's inattention to a vehicle's motions or indications in front; however, 8.1% of minor crashes involved a road user's inattention to a vehicle's motions or indications in front.

Infrastructure characteristics

Location: State highway or local road

Overall, state-highway crashes in Invercargill City over the 2010-2013 period have been distributed across the state-highway network, as shown in figure 89.

Figure 89 **Injury crashes taking place on each state highway in Invercargill City, 2010-2013**



The majority of state-highway crashes in Invercargill City from 2010-2013 have taken place on SH 1, with a sizeable minority occurring on SH 6. Very few have occurred on SHs 98 and 99.

Time of day

Findings: relative to minor crashes, serious and fatal crashes in Invercargill City:

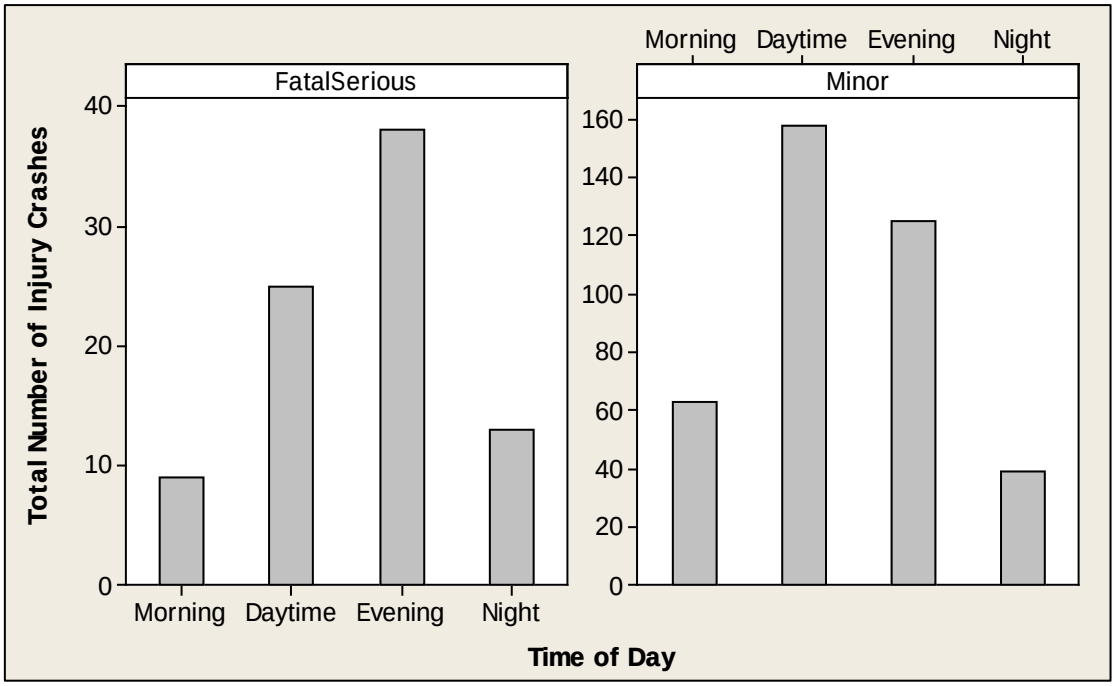
- are closely associated with evening (4 pm-9:59 pm) and night-time (10 pm-3:59 am)
- tend not to take place during the morning (4 am-9:59 am) or daytime (10 am-3:59 pm).

There are four categories that crashes have been categorised into: '*Morning'* (4 am- 9:59 am), '*Daytime'* (10 am-3:59 pm), '*Evening'* (4 pm-9:59 pm) and '*Night'* (10 pm-3:59 am). There is evidence (95.0%) that serious and fatal crashes in Invercargill City tend to happen towards the end of the day (4 pm onwards), while minor crashes are more strongly associated with the daytime hours.

As for crashes taking place towards the end of the day (4 pm onwards), a high proportion are serious or fatal; by contrast, as for crashes taking place at the beginning of the day and during daytime hours (4 am-4 pm), fatal and serious crashes make up just a small proportion of overall injury crashes, as Figure 90 illustrates.

23.3% of injury crashes taking place during the evening (4 pm-9:59 pm) in Invercargill City (2010-2013) have been classed as '*serious or fatal'*. Similarly, 25.0% of injury crashes taking place at night (10 pm-3:59 am) have been classed as '*serious or fatal'*. By contrast, 12.5% of injury crashes taking place during the morning (4 am-9:59 am) have been classed as '*serious or fatal'*.

Figure 90 Injury crashes in Invercargill City, 2010-2013, by time of day



Similarly, 13.7% of injury crashes taking place during the daytime (10 am-3:59 pm) in Invercargill City (2010-2013) have been classed as '*serious or fatal'*. This means that almost a quarter of all injury crashes taking place between 4 pm and 4 am have resulted in a serious or fatal injury to at least one road user.

Crashes involving serious road trauma follow a different pattern to minor crashes: the numbers of serious and fatal crashes tend to peak in the evening (4 pm-9:59 pm), with fewer serious and fatal crashes in the daytime (10 am-3:59 pm). By contrast, minor crashes peak during the day, with fewer crashes in the evening and at night.

3.8.4. Location: State highway or local road

Movement type

Finding:

Local-road crashes in Invercargill City, relative to state-highway crashes, are closely associated with side-impact collisions and rear ends.

There is strong evidence (99.9%) to suggest that crashes taking place on local roads tend to involve different movement types, compared with crashes that take place on state highways.

There are 15 movement types identified by Police: *Overtaking* (and lane change), *Head-on*, *Lost control* (on a straight section), *Cornering* (on a bend), *Collision* (with obstruction of some kind), *Rear-end*, *Turning versus same direction* (i.e. crash involved two vehicles on the same side of the road, with one or both attempting to turn, often resulting in a sideswipe crash), *Crossing (no turns)* (i.e. side-impact crash), *Crossing (vehicle turning)* (i.e. crash involved at least one vehicle turning, usually at an intersection), *Merging*, *Right-turn against* (i.e. making a right turn against the flow of through traffic), *Manoeuvring* (crash during complex

manoeuvre e.g. parking, U-turn), *Pedestrian-crossing (road)*, *Pedestrian (Other)* (crash involved pedestrian not crossing the road (e.g. on footpath or leaving vehicle)) and *Miscellaneous*.

A comparison of figures 91 and 92 indicates that most crash-movement types are distributed evenly across the local-road and state-highway network, except for two: Local roads are prone to side-impact crashes in Invercargill, and state highways are prone to rear-end crashes.

Few state-highway crashes involve side-impacts; instead, they tend to be much more diverse (see Figure 92). In particular, the proportion of rear-end crashes is much higher on state highways, compared with local roads.

A high proportion of local-road crashes involve side-impact collisions (see Figure 91).

Figure 91 **Injury crashes taking place on local roads in Invercargill City, 2010-2013, by movement type**

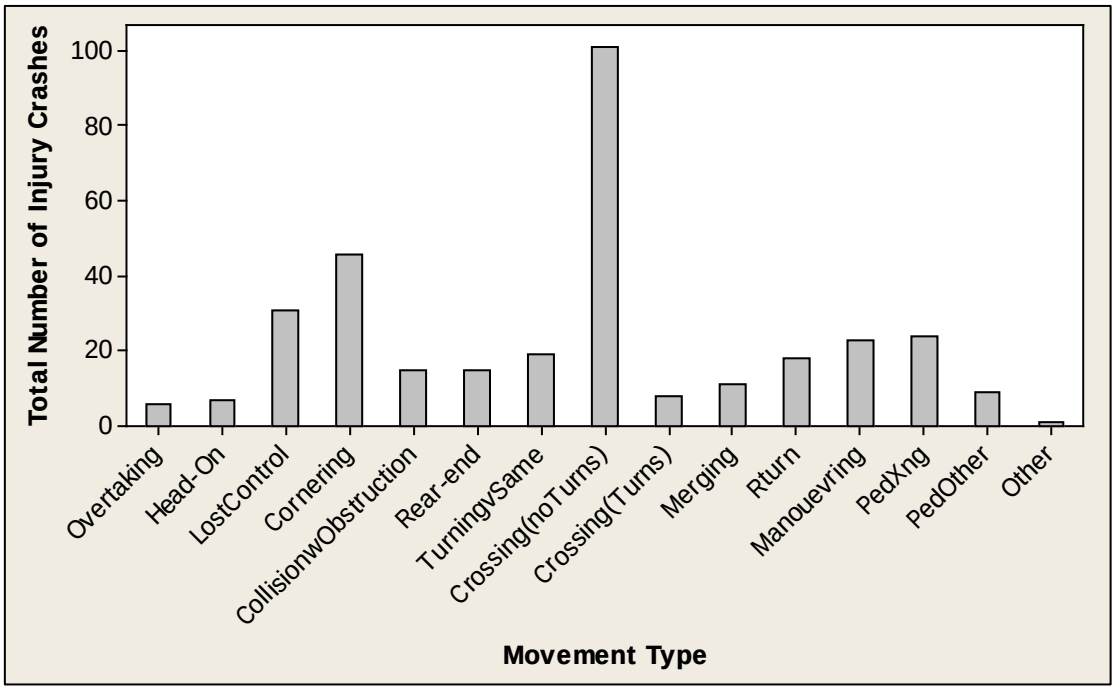
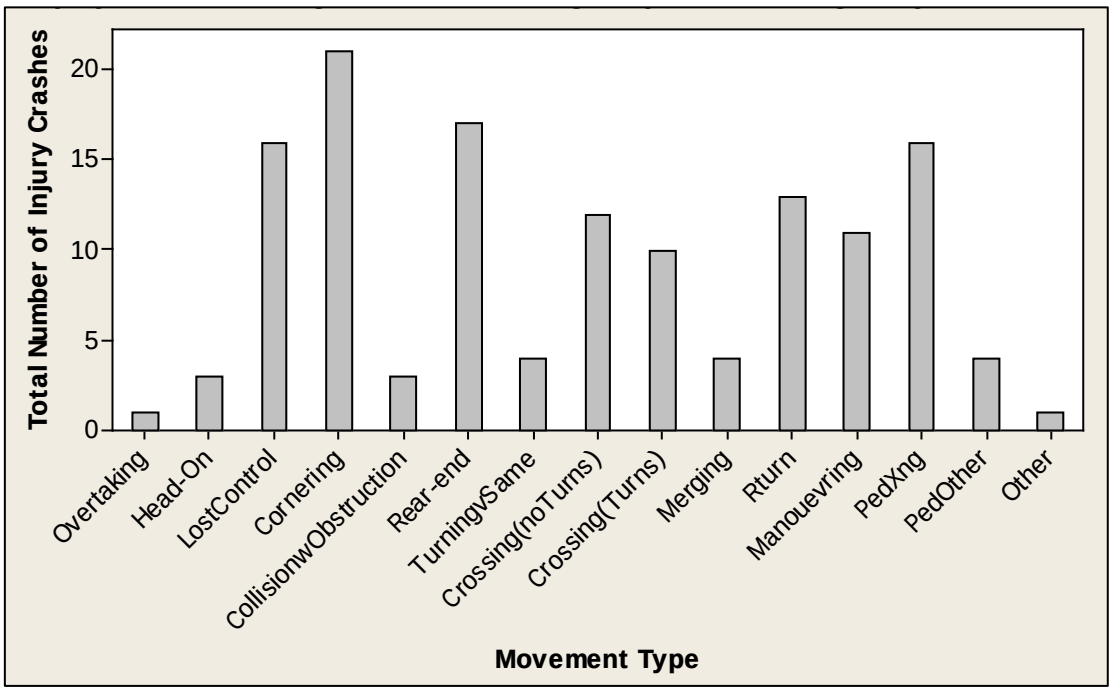


Figure 92 **Injury crashes taking place on state highways in Invercargill City, 2010-2013, by movement type**



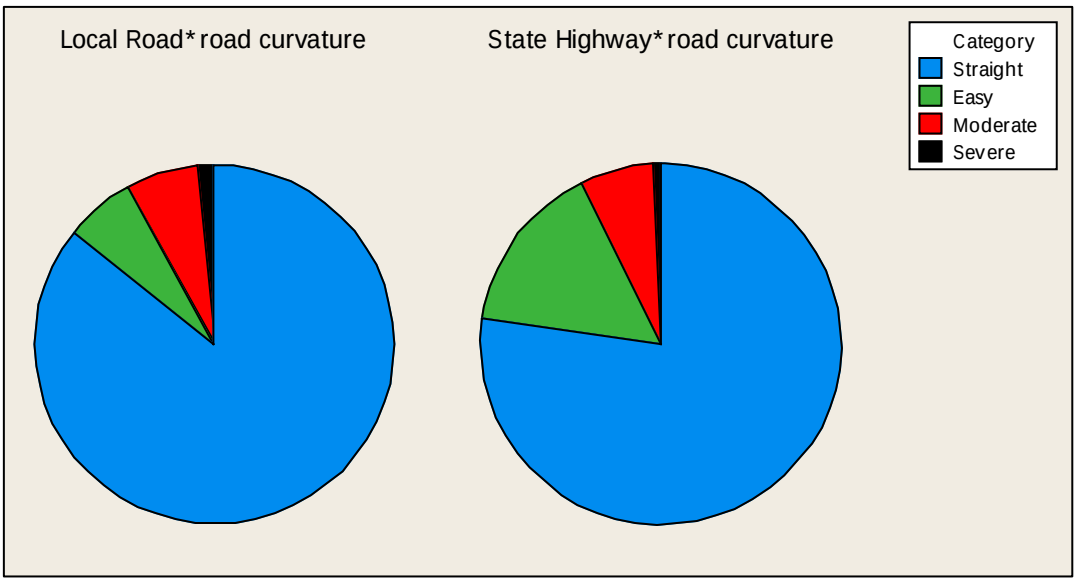
Road curvature

Finding:

State-highway crashes in Invercargill City, relative to local-road crashes, are closely associated with easy curves, and are very common.

There is significant evidence (97.5%) that crashes on local roads tend to occur on curves, with a different frequency to crashes on the state-highway network, as Figure 93 shows.

Figure 93 **Comparative incidence of injury crashes on state highways and local roads in Invercargill City, 2010-2013, by degree of road curvature**



The severity of the road's curvature is determined by the Police at the crash scene. The Police categorise the section of road where the crash occurred as either '*Straight'*, '*Easy curve'*, '*Moderate curve'* or '*Severe curve'*.

The proportion of crashes on straight sections of road, as well as moderate and severe curves, is similar across the local-road and state highway-networks; however, the state-highway network has a higher proportion of injury crashes on easy curves compared with the local-road network.

Junction type

Findings:

- Local-road crashes, relative to state-highway crashes, are closely associated with crossroads (X-junctions) and driveways.
- State-highway crashes, relative to local road crashes, are closely associated with T-junctions.

There is evidence (95.0%) that crashes on the local-road network tend to occur at different junction types, compared with crashes on the state-highway network.

Crashes are divided into six categories: '*Not at Junction'* (crash occurred at least 10 m from a junction of any kind), '*Driveway'*, '*Roundabout'*, '*Crossroads'* (X-junction), *'T-Junction'* and '*Multileg'*, which is defined as 'any junction with more than four legs entering or leaving the intersection'.

The findings indicate that crashes at many junction types are distributed evenly across the local-road and state-highway network, except for a few points of difference. Specifically, state highways are prone to crashes at T-junctions, and local roads are prone to crashes at crossroads (X-junctions) and driveways.

Most crashes on Invercargill City's local roads take place at some kind of junction, particularly at crossroads (X-junctions) (see Figure 94). Compared to state-highway crashes, the proportion of driveway crashes is also high on local roads.

As with the local-road network, most crashes on state-highways also take place at a junction of some description (see Figure 95). Compared with the local-road network, the proportion of crashes occurring at T-junctions is very high.

Figure 94 **Injury crashes on Invercargill City local roads, 2010-2013, by junction type**

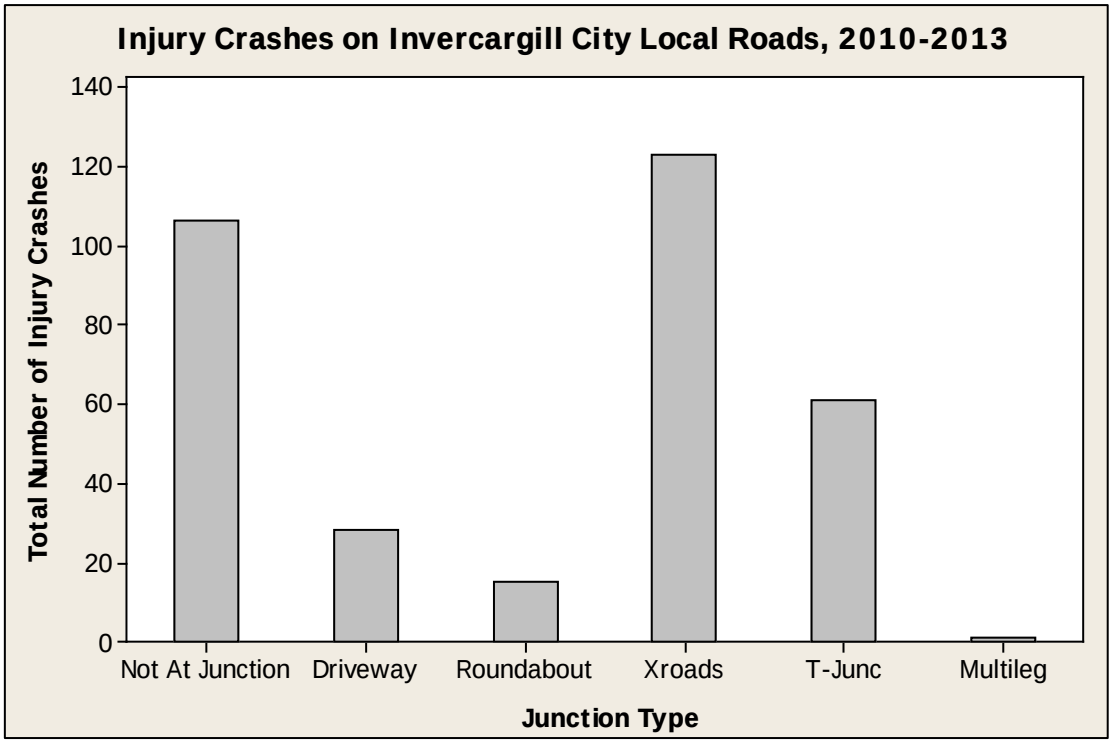
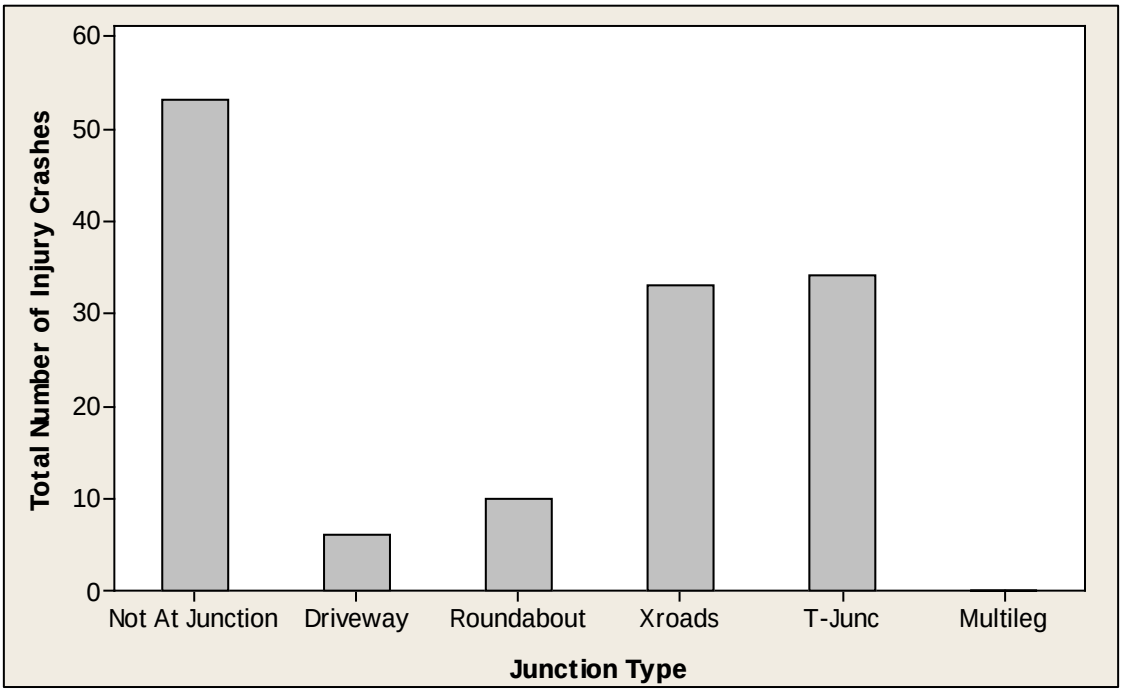


Figure 95 **Injury crashes on Invercargill City state highways, 2010-2013, by junction type**



Traffic control

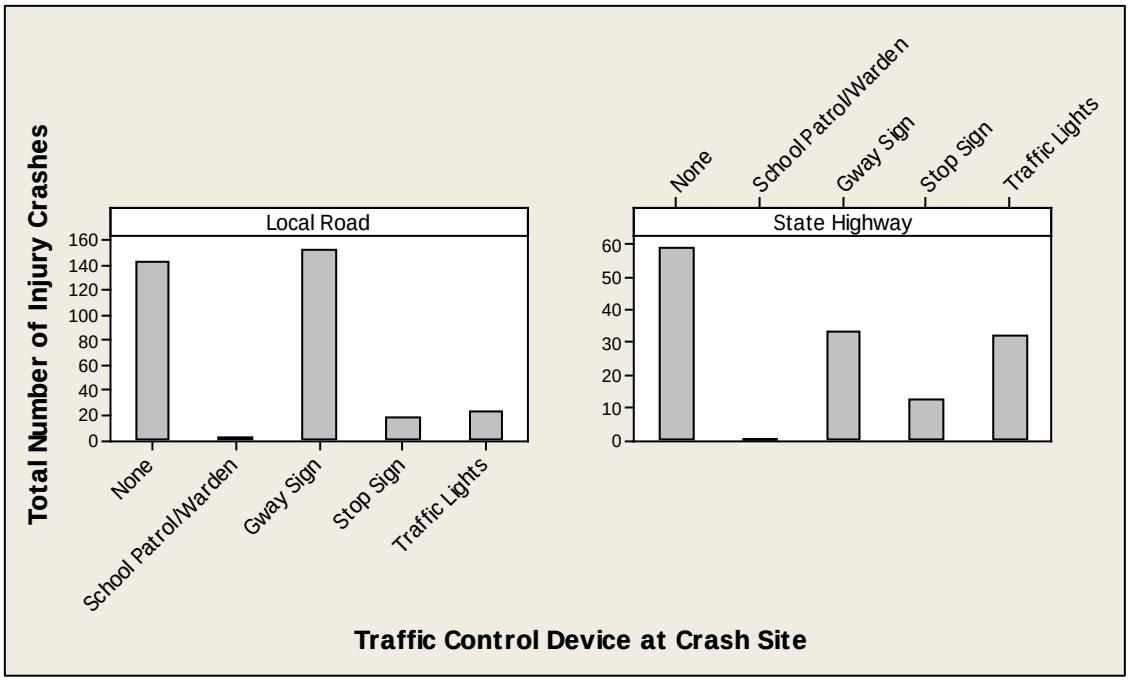
Findings:

- Local-road crashes, relative to state-highway crashes, are closely associated with crashes at give-way signs.
- State-highway crashes, relative to local-road crashes, are closely associated with traffic lights.

Crashes are divided into five categories: '*None'* (crash did not take place at a traffic control device), '*School patrol'* (or school warden), '*Give-way sign'*, '*Stop sign'* and '*Traffic lights'*. There is strong evidence (99.9%) that crashes taking place on the local-road network in Invercargill tend to occur at different sorts of traffic-control devices, compared with crashes on the state-highway network.

These findings indicate that crashes at many traffic-control devices are distributed evenly across the local-road and state-highway network, except for a few points of difference. Specifically, state highways are prone to crashes at traffic lights, and local roads are prone to crashes at give-way signs.

Figure 96 **Comparative incidence of injury crashes onstate highways and local roads in Invercargill City, 2010-2013, by traffic-control device**



Few injury crashes in Invercargill City have taken place at school patrol/warden locations or at stop signs.

The main difference between the two graphs in Figure 96 is associated with '*Give-way'* and '*Traffic Lights'*. The left panel, corresponding to local-road crashes, hosts a high number of *Give-way-sign* crashes relative to the right panel (state-highway crashes); on the other hand, the right panel (state-highway crashes) hosts a high number of crashes at traffic lights, relative to the left panel (local-road crashes). There are actually more crashes at traffic lights

on the state-highway network, despite the state-highway network only hosting a small percentage of Invercargill's crashes.

Road markings

Findings:

- Local-road crashes in Invercargill City, relative to state-highway crashes, are closely associated with crashes on sections of road with no markings at all.
- State-highway crashes in Invercargill City, relative to local-road crashes, are closely associated with crashes taking place on raised-traffic islands.

There is strong evidence (99.9%) that crashes taking place on the local-road network in Invercargill tend to occur on different sections of road, compared to crashes taking place on the state-highway network.

A description of how each crash scene was coded is present in NZTA's Coded Crash Report Guide[41], and the relevant section is reproduced here:

'The following codes are used to indicate what road markings were present at the crash location, if recorded by the attending officer. Only one marking is recorded. The list below is ordered in significance ranking, i.e. a pedestrian crossing is considered to be more important than a centre line, although both may be present at the crash location'.

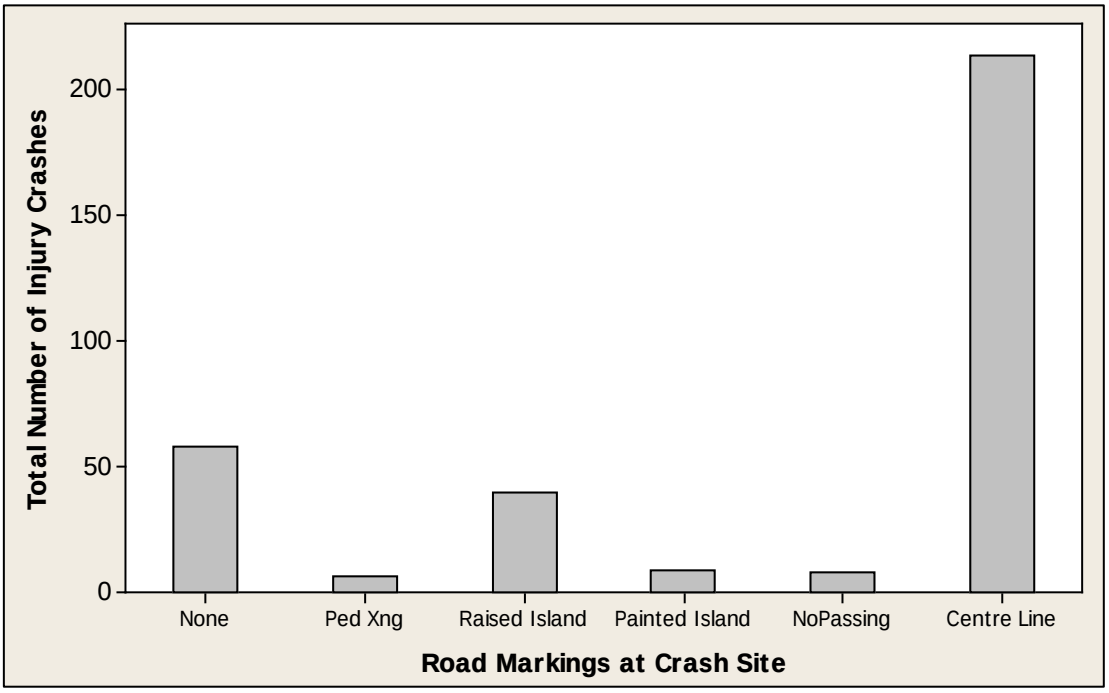
The list is given here:

1. Pedestrian crossing
2. Raised island
3. Painted island
4. No-passing line
5. Centre line
6. No markings.

Therefore, if the crash occurred at a scene with a pedestrian crossing (and a raised island and centre line), it will be coded as a '*Pedestrian crossing'*; if the crash occurred at a scene with a '*No-passing line'* and a '*Centre line'*, it will be coded as a '*No-passing line'*; if the crash occurred at a scene with a '*Painted island'* and a '*Centre line'*, it will be coded as a '*Painted island*', and so forth.

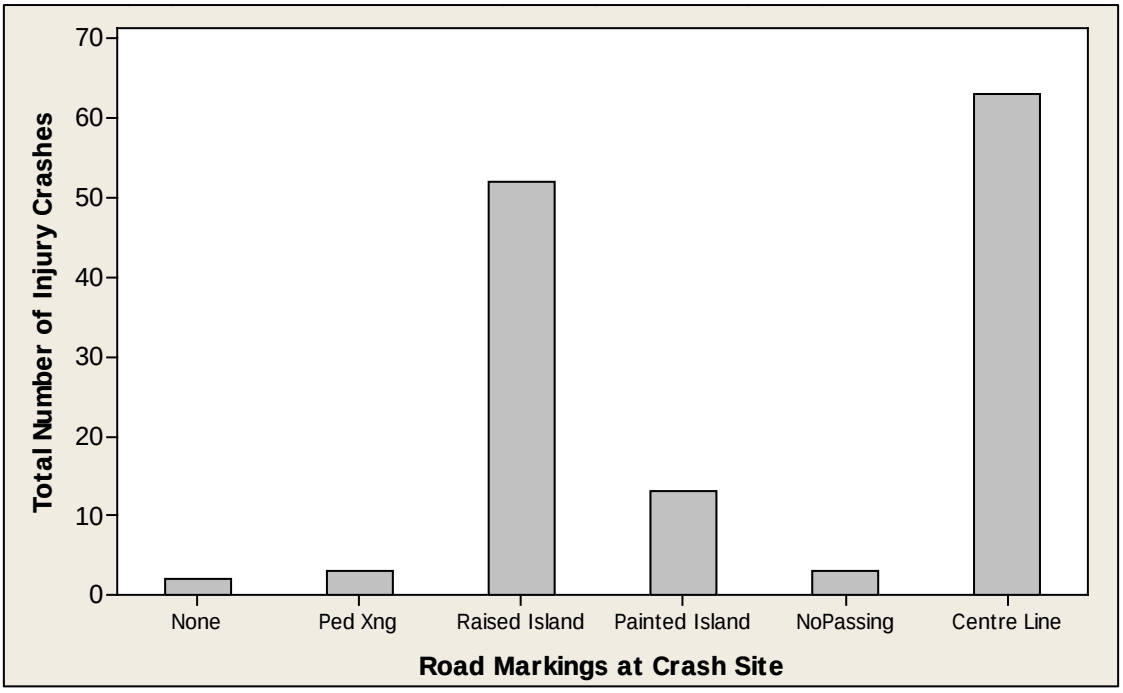
[41] See NZTA's *Guide for the interpretation of coded crash reports from the Crash Analysis System (CAS)*, version 5.1, March 2012.

Figure 97 **Injury crashes on local roads in Invercargill City, 2010-2013, by type of road marking at crash site**



While most injury crashes on Invercargill City's local roads take place on sections of road with a centre line (but no other markings), a sizeable minority take place on sections of road with no markings at all ('*None*') (see Figure 97).

Figure 98 **Injury crashes on state highways in Invercargill City, 2010-2013, by type of road marking at crash site**



While a high number of injury crashes on Invercargill City's state highways also take place on sections of road with a centre line (but no other markings), very few take place on sections of road with no markings at all (see Figure 98).

The biggest difference between the two graphs comes in the form of '*Raised Island*': Crashes taking place on a '*Raised Island'* make up a sizeable proportion of state-highway injury crashes in Invercargill, but barely feature on the local roads.

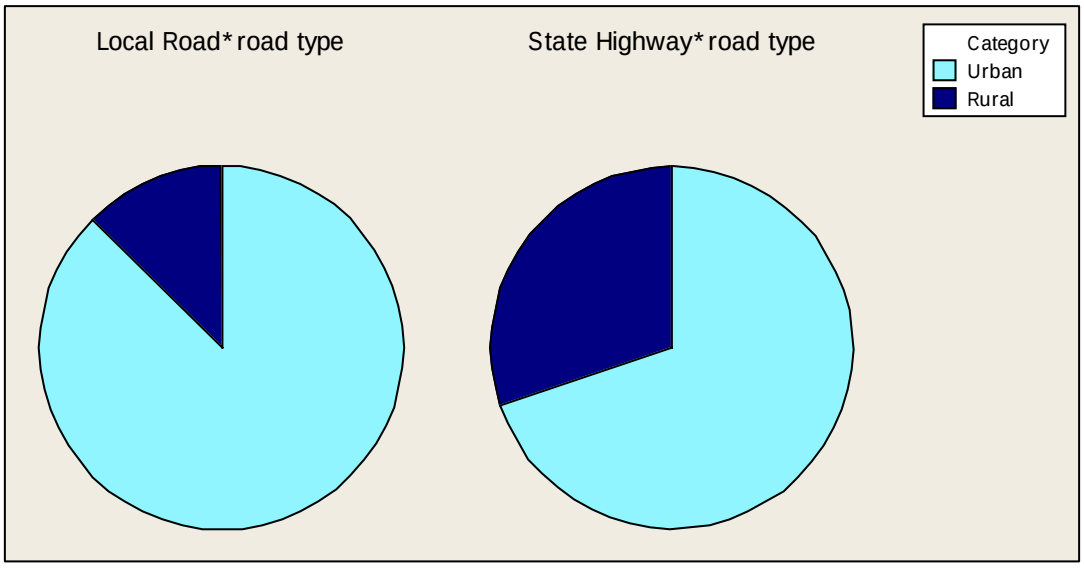
Road type

Finding:

State-highway crashes in Invercargill City, relative to local-road crashes, are closely associated with crashes taking place on rural roads (roads with an 80 km/h speed limit or higher).

There is strong evidence (99.9%) that crashes on the state-highway network in Invercargill tend to occur on roads with higher speed limits ('rural' roads), compared to crashes on the local-road network.

Figure 99 **Comparative incidence of injury crashes on urban and rural state highways and local roads in Invercargill City, 2010-2013**



The left pie chart of Figure 99 shows injury crashes taking place on the local-road network in Invercargill City, and the right pie chart shows injury crashes taking place on the state-highway network. Specifically, 12.6% of injury crashes on the local-road network from 2010-2013 took place on '*Rural*' roads (roads with an 80 km/h speed limit or higher). By contrast, 30.1% of injury crashes on the state-highway network took place on '*Rural'* roads (roads with an 80 km/h speed limit or higher). Clearly, rural-road crashes are over-represented on the state-highway network.

Driver gender

Findings:

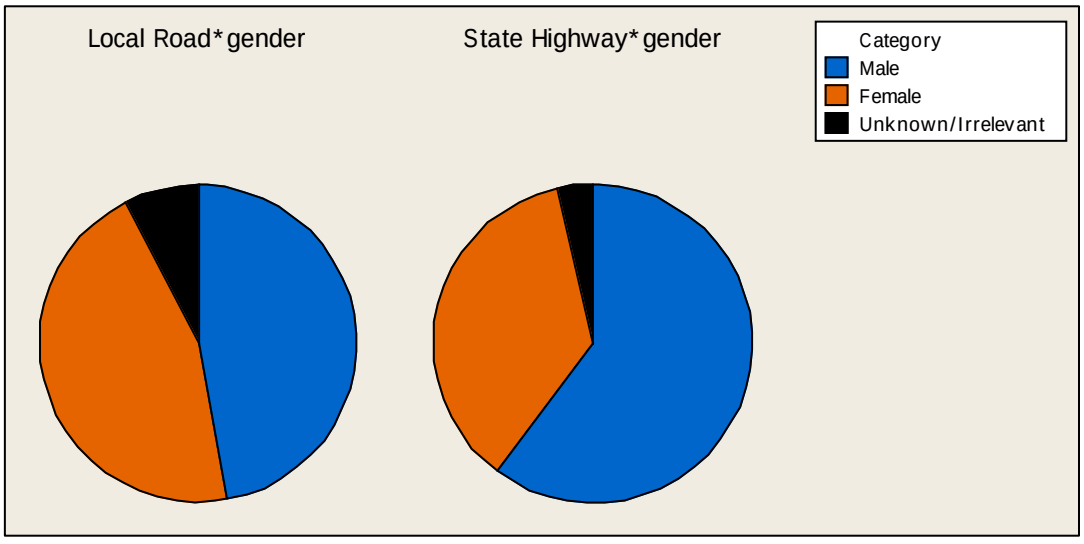
- Local-road crashes in Invercargill City, relative to state-highway crashes, are closely associated with crashes involving women as the key-vehicle driver, and crashes involving drivers with an '*Unknown/Irrelevant'* gender (i.e. key-vehicle cyclists).
- State-highway crashes in Invercargill City, relative to local road crashes, are closely associated with crashes involving men as the key-vehicle driver.

There is significant evidence (97.5%) that crashes taking place on the local-road network in Invercargill City tend to involve different proportions of male, female and '*Unknown/Irrelevant*' gender drivers at the helm of the key vehicle, compared to crashes on the state-highway network.

Only the driver of the key vehicle (vehicle with role 1, as assigned by the Police) in each crash was analysed to avoid the tendency to afford greater weight to multi-vehicle crashes; if all drivers involved in injury crashes had been analysed, crashes involving multiple vehicles would effectively be counted at least two or three times, depending on the number of vehicles involved.

Crashes involving men, women and those categorised as '*Unknown/Irrelevant'*-gender key-vehicle drivers—the latter are usually cyclists, as discussed earlier— are not equally distributed across the local-road and state-highway networks. Crashes involving men as the key-vehicle driver tend to associated with the state-highway network, while crashes involving women as the key-vehicle driver tend to be associated with the local-road network.

Figure 100 Comparative incidence of injury crashes in Invercargill City, 2010-2013, by gender of driver



The left pie chart in Figure 100 shows injury crashes taking place on the local-road network in Invercargill City; the right pie chart shows injury crashes taking place on the state-highway network. Figure 100 indicates that most injury crashes on the state-highway network involve men as the driver of the key vehicle, with smaller numbers of women and key-vehicle cyclists ('*Unknown/Irrelevant*') involved in state-highway crashes. By contrast, on local roads, men

and women are almost evenly split as key-vehicle drivers; a sizeable number of key-vehicle cyclists are also involved in local-road crashes.

Driver age

Finding:

Crashes involving 35-44 year-olds as the driver of the key vehicle are very common on the state-highway network, relative to the local-road network.

There is significant evidence (97.5%) to suggest that crashes taking place on the local-road network in Invercargill tend to involve a different-age distribution of drivers at the helm of the key vehicle, compared to the state-highway network (compare figures 101 and 102).

For this analysis, only the driver of the key vehicle (vehicle with role 1, as assigned by the Police) in each crash will be analysed to avoid the tendency to afford greater weight to multi-vehicle crashes; if all drivers involved in injury crashes were analysed, crashes involving multiple vehicles would effectively be counted at least two or three times, depending on the number of vehicles involved. The category, '*Unknown/Irrelevant'*, is supplied by the Police when the key vehicle is a cyclist (in which case, the road user is a rider, not a driver: their age is thus determined '*Irrelevant*') or where the age of the driver of the key vehicle is unknown ('*Unknown'*).

This finding indicates that the various age groups are evenly distributed across the local-road and state-highway networks, with the exception of the 35-44 year-old age group. This age group is associated with the state-highway network (relative to the local-road network).

Figure 101 Injury crashes on Invercargill City local roads, 2010-2013, by driver age

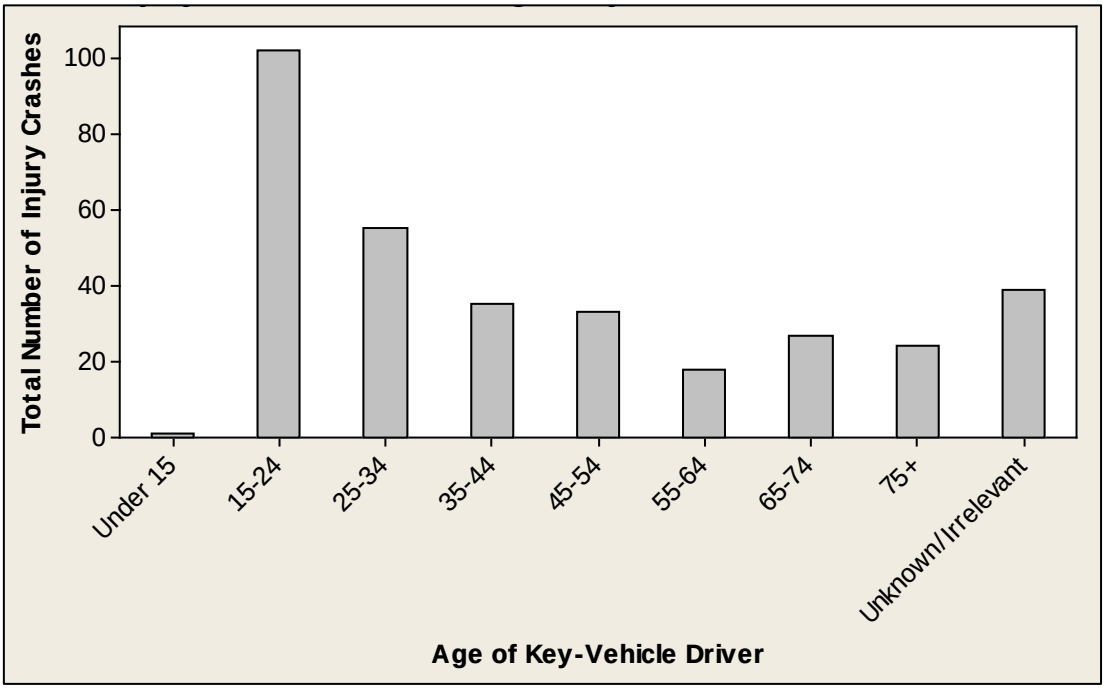
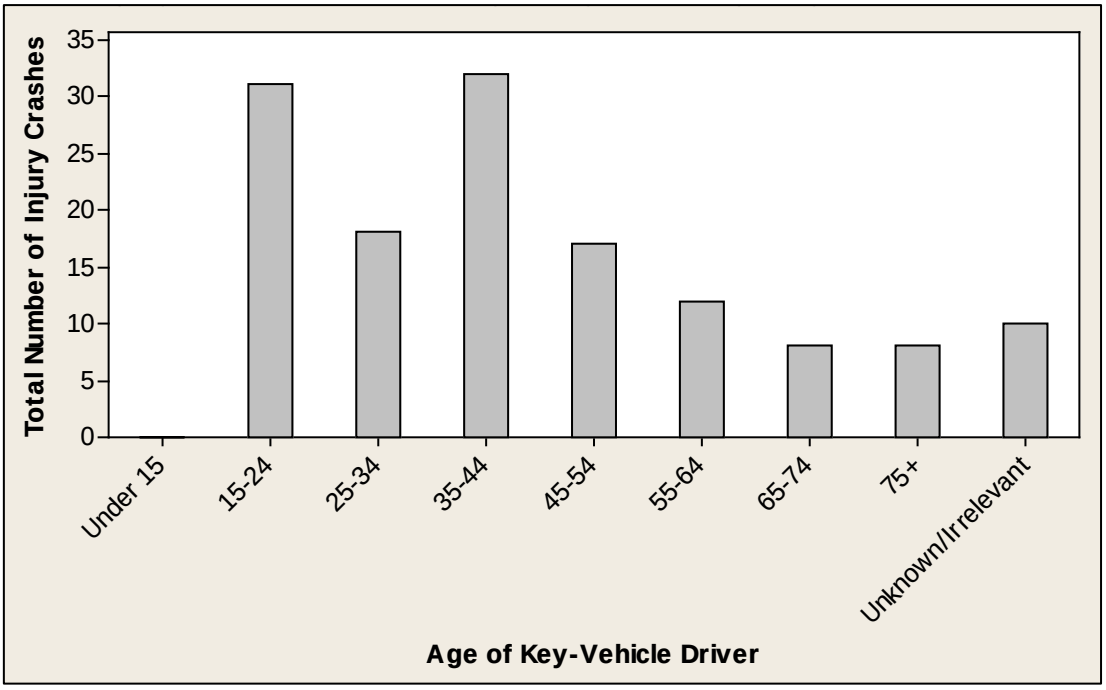


Figure 102 Injury crashes on Invercargill City state highways, 2010-2013, by driver age



As with most crash analyses, younger drivers make up a large proportion of key-vehicle drivers in local-road crashes (drivers aged 24 and under). The crash numbers decrease steadily until the onset of older age (65+), where the number of crashes starts to increase again.

The age distribution on Invercargill's state highways is almost identical to that for the local-road graph, with the notable exception of the 35-44 year-old age range (see Figure 102). This group is heavily over represented among state-highway injury crashes.

Giving way at a give-way sign

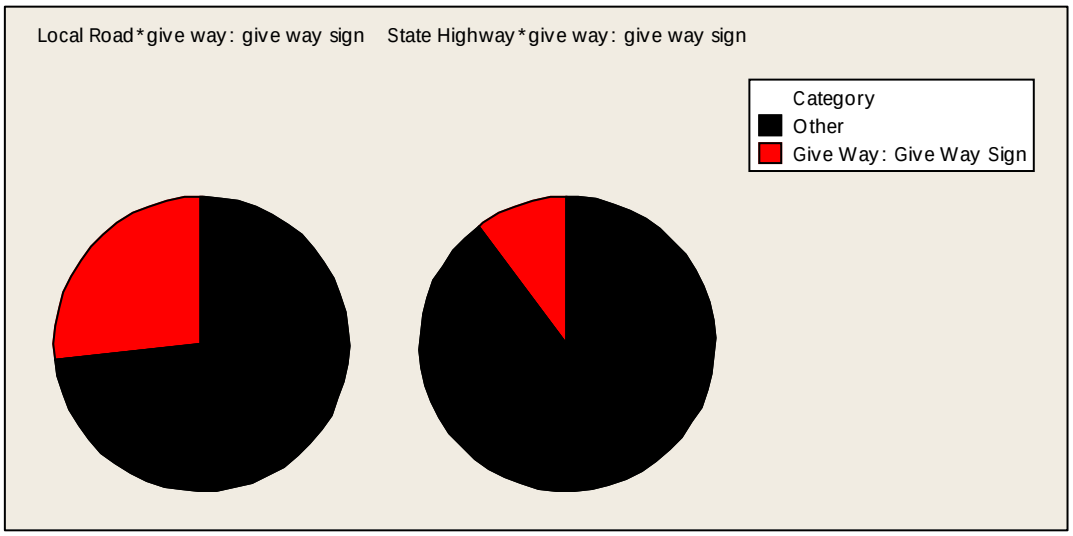
Finding:

Local-road crashes in Invercargill City, relative to state-highway crashes, are closely associated with crashes involving one or more parties failing to give way at a give-way sign.

A crash was categorised as *'Give way: Give-way sign*' if one or more parties in the crash was noted to have failed to give way at a give-way sign (crash code 302).

There is strong evidence (99.9%) to suggest that local-road crashes in Invercargill are more likely to be categorised as *'Give way: Give-way sign*' than state-highway crashes.

Figure 103 **Comparative incidence of injury crashes involving one or more parties failing to give way at a give-way sign, or not, on a state highway or local road in Invercargill City, 2010-2013**



Overall, as Figure 103 shows, *'Give way: Give-way sign*' crashes comprised 26.6% of all local-road injury crashes in Invercargill City from 2010-2013; *'Give way: Give-way sign*' crashes comprised just 10.3% of all state-highway injury crashes from 2010-2013.

A crash categorised as '*Other*' in Figure 103 indicates that it was not categorised as '*Give way: Give-way sign'*.

Failed to look: General

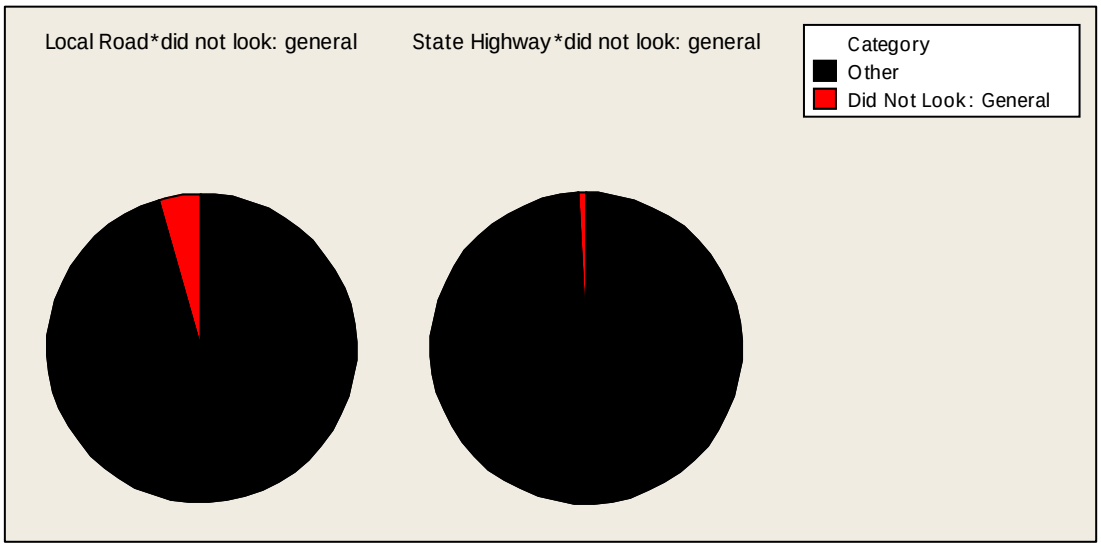
Fining:

Local-road crashes in Invercargill City, relative to state-highway crashes, are closely associated with crashes involving one or more parties failing to see or look for another party until too late.

A crash was categorised as *'Failed to look: General'* if one or more parties in the crash was noted to have failed to see or look for another party until too late (crash code 370); failed to see or look for another party until too late when required to give way to pedestrians (crash code 376); failed to see or look for another party until too late when visibility was obstructed by other vehicles (crash code 377); and/or failed to see or look for another party until too late when visibility was limited by roadside features (crash code 378).

There is evidence (95.0%) that local-road crashes in Invercargill are more likely to be categorised as *Failed to look: General'* than state-highway crashes.

Figure 104 **Comparative incidence of injury crashes involving one or more parties failing to look for another party until too late, or not, on a state highway or local road in Invercargill City, 2010-2013**



Overall, as Figure 104 depicts, '*Did not look: General*' crashes comprised 4.5% of all local-road injury crashes in Invercargill City from 2010-2013; '*Did not look: General*' crashes comprised 0.7% of all state-highway injury crashes. A crash categorised as '*Other*' in Figure 104 indicates that it was not categorised as '*Did not look: General*'.

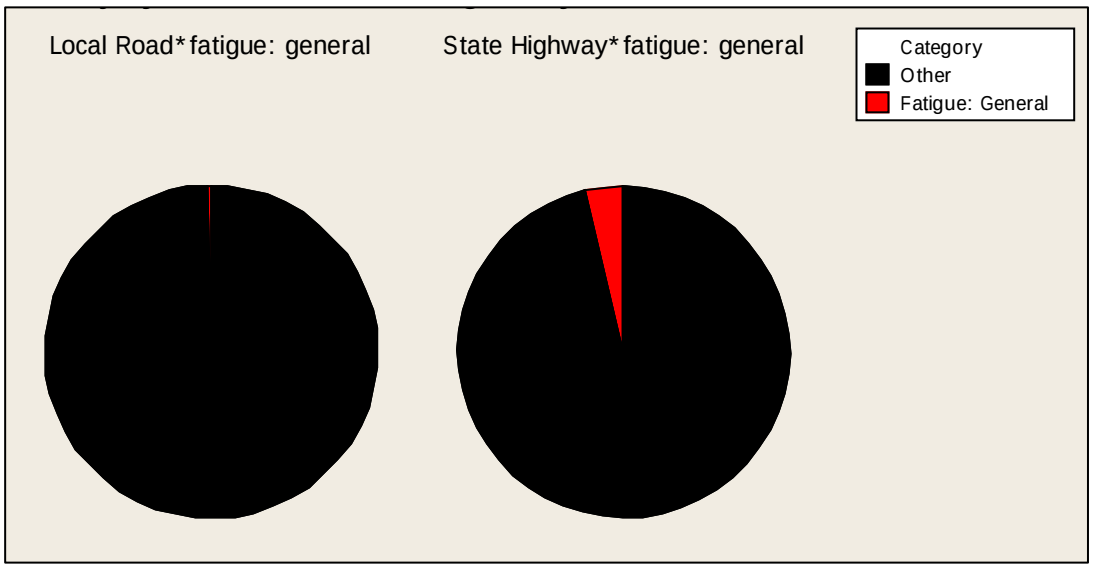
Fatigue: general

Finding:

State-highway crashes in Invercargill City, relative to local-road crashes, are closely associated with crashes involving fatigue.

A crash was categorised as '*Fatigue: General*' if one or more parties in the crash was noted to be fatigued (drowsy, tired, fell asleep) (crash code 410) and/or fatigued (drowsy, tired, fell asleep) due to working long hours before driving (crash code 414). The evidence is powerful (99.5%) that state-highway crashes in Invercargill are more likely to be categorised as '*Fatigue: General*' than local-road crashes.

Figure 105 Comparative incidence of injury crashes on a state highway or local road in Invercargill City, associated with fatigue, or not, 2010-2013



Specifically, 0.3% of local-road crashes have involved one or more drivers being fatigued (as described above (i.e. excluding lack of sleep as a specified cause); however, 3.7% of state-highway crashes have involved one or more drivers being fatigued (as described above).

A crash categorised as '*Other*' in Figure 105 indicates that it was not categorised as '*Fatigue: General*'.

3.8.5. Areas where serious and fatal crashes perform better than minor crashes

Compared with minor crashes in Invercargill City, serious/fatal crashes in this city are rarely likely to**:**

- take place during the morning (4 am-9:59 am)
- take place during the daytime (10 am-3:59 pm)
- be associated with multiple-vehicle crashes involving cars (or station wagons)
- be caused, or partially caused, by road users' inattention to a vehicle's motions or indications in front.

3.9. Queenstown Lakes District results

3.9.1. Findings and recommendations, summarised

Three themes emerged from analysis of data for Queenstown Lakes District:

- Serious and fatal crashes happen when the road is dry.
- Serious and fatal crashes disproportionately involve cyclists.
- Serious and fatal crashes disproportionately involve blood alcohol in excess of the legal limit.

Other findings:

- Relative to minor crashes, serious and fatal crashes in Queenstown Lakes District:
  - are closely associated with dry-road conditions at the crash location
  - do not typically take place in wet and icy/snowy conditions
  - do not typically involve a slippery-road surface (caused by unspecified conditions, as well as rain, mud, diesel/fuel, painted road markings, etc.)
  - do not typically involve a slippery-road surface caused by ice/frost.
- Fatal and serious crashes in Queenstown Lakes District:
  - are less likely to involve women in the key-vehicle-driver role, relative to minor crashes
  - frequently involve men in the key-vehicle-driver role, relative to minor crashes.
- Fatal and serious crashes are less likely to involve restricted-licence-holders in the key-vehicle-driver role than are minor crashes in the district.
- Fatal and serious crashes frequently involve road users with an *'Unknown'* or '*Irrelevant'* licence in the key-vehicle-driver role, relative to minor crashes.
- There is strong evidence that fatal and serious crashes are more likely to involve one or more drivers over the legal blood alcohol limit, compared with minor crashes.
- Crashes caused by drivers above the BAC limit occur at night.
- Most intersection crashes involve a failure to give way.
- Tourists tend to cut corners or swing wide (deliberately failing to keep left).
- Pedestrian-vehicle crashes are mainly associated with dangerous pedestrian behavior.
- Losing control on bends involves excessive speed.

Recommendations for Queenstown Lakes District Council and/or NZTA to consider:

1. Focus police and education resources on improving driver behaviour at give-way signs. Many driver education messages focus on ensuring that drivers stop correctly at stop signs and traffic lights; however, most intersection crashes in Queenstown Lakes District are associated with failing to give way at the relevant time.

2. Consider establishing more mobile-testing stations in Dunedin City after dark rather than in the in the twilight hours (e.g. 8-10pm). Alcohol checkpoints will be more successful in apprehending drunk drivers later at night.

3. Given that local drivers do not generally seem to have a problem with cutting corners or swinging wide (aside from those who should not be driving due to disqualification, being forbidden or an expired licence), it is cost-effective to focus education efforts for this matter on tourists.

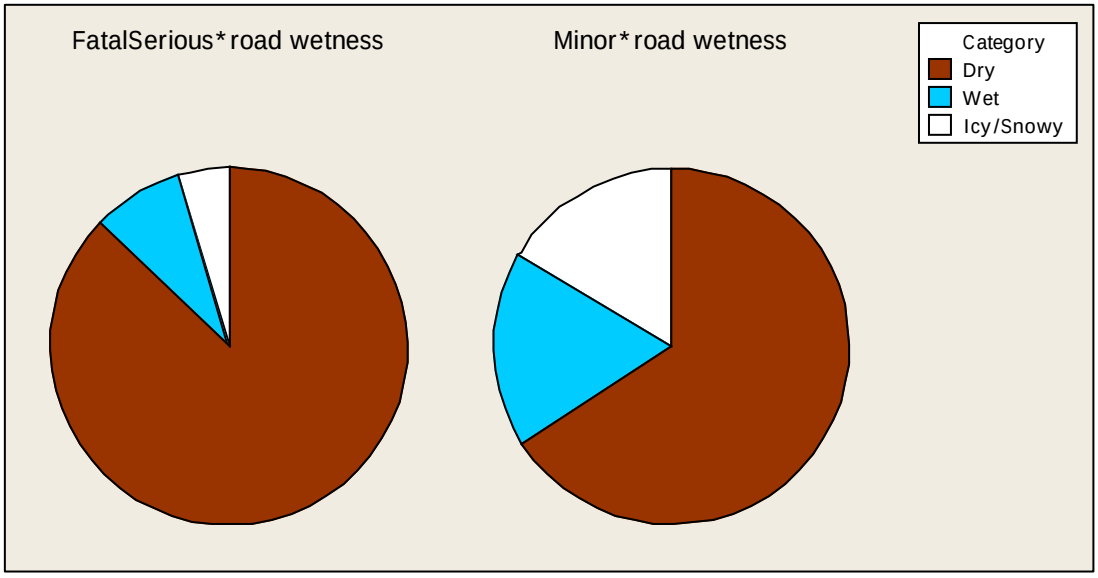
4. Consider increasing pedestrian education surrounding the danger of crossing roads outside the pedestrian crossing in the district; identify the worst-performing stretches of road for pedestrian safety and target these for interventions, provided that altering road design or signage will be effective and not simply move the back spot to another location.

5. Tightly enforcing the speed limit may be advisable, in combination with advertising and media initiatives. Identifying the worst-performing bends and curves in terms of road safety, and targeting signage and potentially infrastructural upgrades to those bends may be useful.

3.9.2. Themes found in the analysis of serious and fatal crashes

Theme 1: Serious and fatal crashes in Queenstown Lakes District happen when the road is dry.

Figure 106 **Comparative severity of injury crashes on dry, wet and icy/snowy roads in Queenstown Lakes District, 2010-2013**



The majority (87%) of serious and fatal crashes in Queenstown Lakes District (2010-2013) have taken place in dry road conditions. By contrast, 66% of minor crashes have taken place in dry-road conditions (see Figure 106).

Moreover, relative to minor crashes, serious and fatal crashes do not typically take place in wet and icy/snowy conditions. The evidence is strong (99.9%) that fatal and serious crashes are associated with drier-road conditions, compared with minor crashes.

Specifically, 14.3% of injury crashes taking place in wet conditions were classed as '*serious or fatal*'. Similarly, 9.3% of injury crashes taking place in snowy/icy conditions were classed

as '*serious or fatal*'. By contrast, 32.5% of injury crashes taking place in dry conditions were classed as '*serious or fatal*'.

These findings indicate that, to reduce serious road trauma, road-safety authorities in Queenstown Lakes District may wish to focus on reducing the factors associated with dry-road crashes. A great deal of road-safety initiatives have been focused on reducing the incidence and severity of wet-road and icy-road crashes in alpine Queenstown Lakes; it seems that these techniques have been largely successful, as few wet-road and icy-road crashes result in severe road trauma.

The fact that serious and fatal crashes happen almost exclusively in dry-road conditions raises the questions of whether this pattern is associated with additional risk-taking in dry-road conditions, and if so, what kind of risk-taking (e.g. drinking behaviours, or excessive speed)?

Factors requiring investigation if these findings are to be explained are:

- the consumption of alcohol: Many fatal and serious crashes are associated with high blood alcohol levels, and perhaps motorists are less likely to drive drunk when it is raining or snowing outside, either because social drinking is less common in winter, or because party attendees leave gatherings early due to weather issues
- the perception of risk, given that excessive risk-taking often leads to serious crashes).

Further evidence for this pattern can be found by comparing figures 107 and 108, which show that serious and fatal crashes very rarely involve a slippery=road surface.

Figure 107 Comparative severity of injury crashes on roads judged slippery, or not, in Queenstown Lakes District, 2010-2013

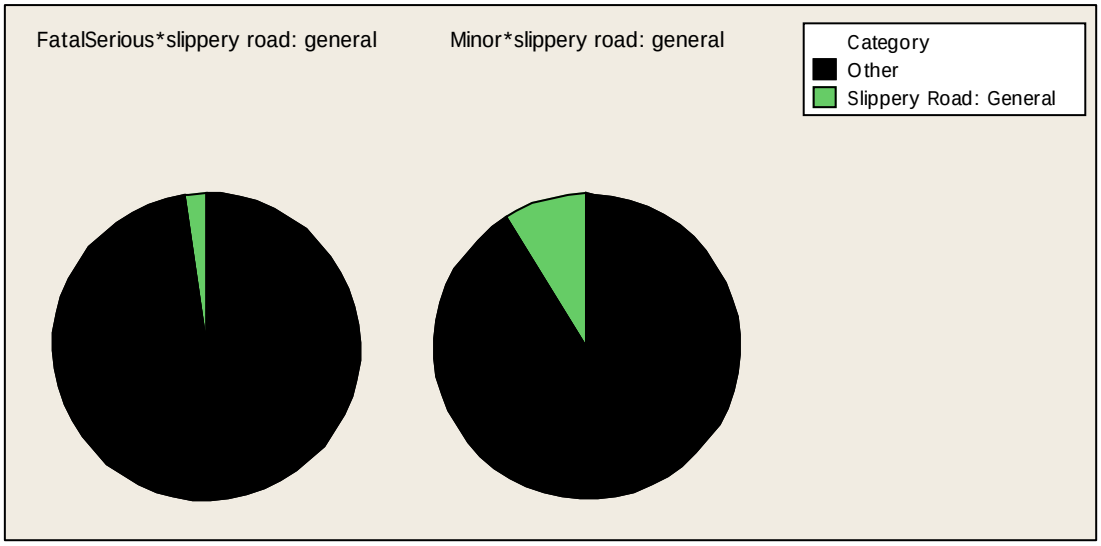
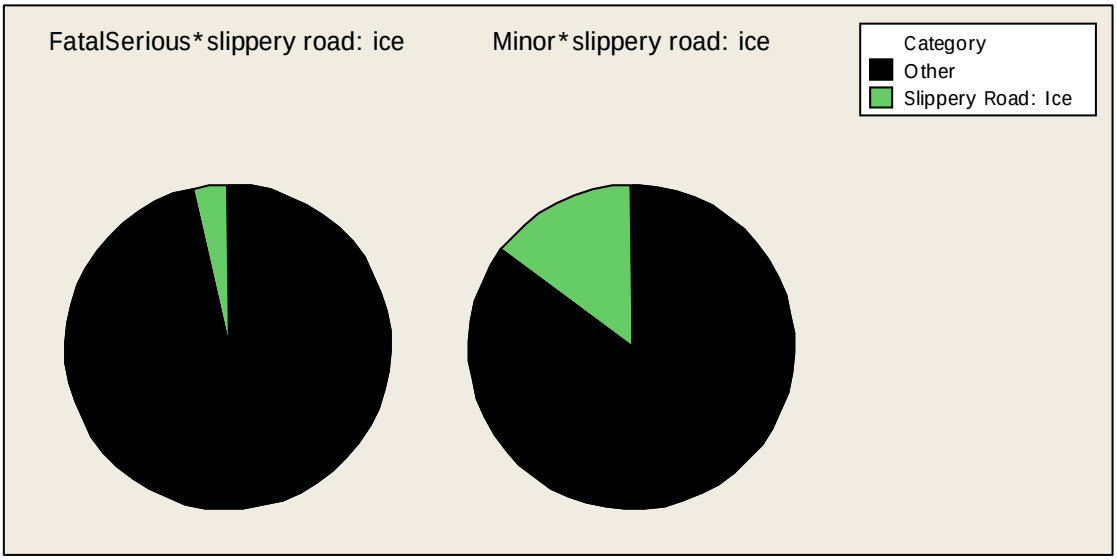


Figure 108 **Comparative severity of injury crashes on roads judged slippery due to ice, or not, in Queenstown Lakes District, 2010-2013**



Theme 2: Serious and fatal crashes in Queenstown Lakes District disproportionately involve cyclists.

Figure 109 **Fatal and serious injury crashes in Queenstown Lakes District, 2010-2013, by licence type**

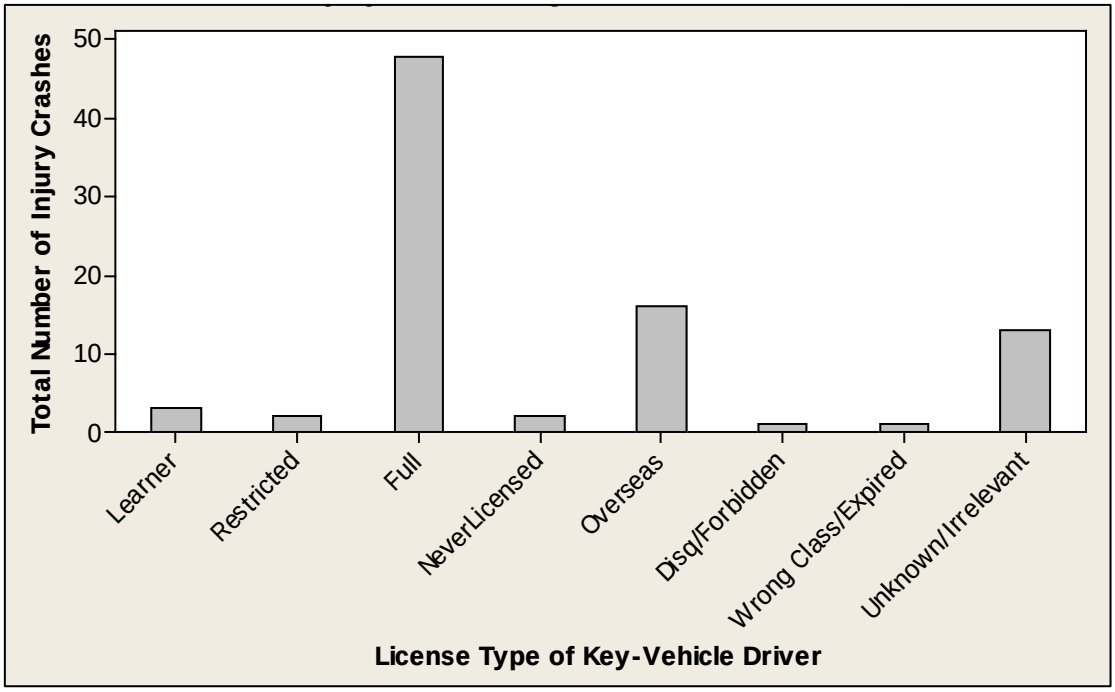
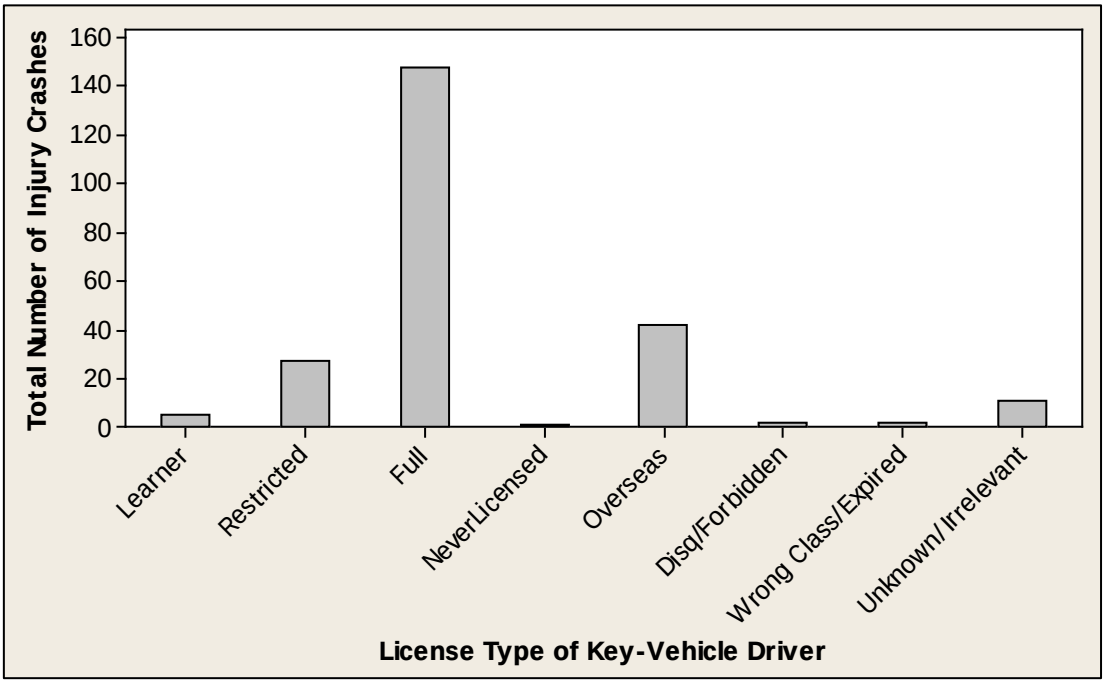


Figure 110 **Minor injury crashes in Queenstown Lakes District, 2010-2013, by licence type**



In Figures 109 and 110, '*Unknown/Irrelevant'* mainly refers to situations where the key vehicle was a cyclist (and thus the key-vehicle rider's licence type is '*Irrelevant'*).

It is not surprising that crashes involving cyclists tend to result in serious levels of trauma. Cyclists are vulnerable road users, and their survivable impact speed is much lower than that of two cars colliding. This is mainly because cyclists do not have a protective outer shell around them in the case of a crash, as car occupants do, and they also lack the safety features in cars (e.g. airbags).

This is not a surprising finding; international research overwhelmingly shows that cyclists are an at-risk group for serious road trauma. Some research literature even suggests that cyclists should be separated completely from motor vehicles, as prevention of serious-bicycle injuries resulting from a motor-vehicle-bicycle collision is impossible even with appropriate helmet use[42].

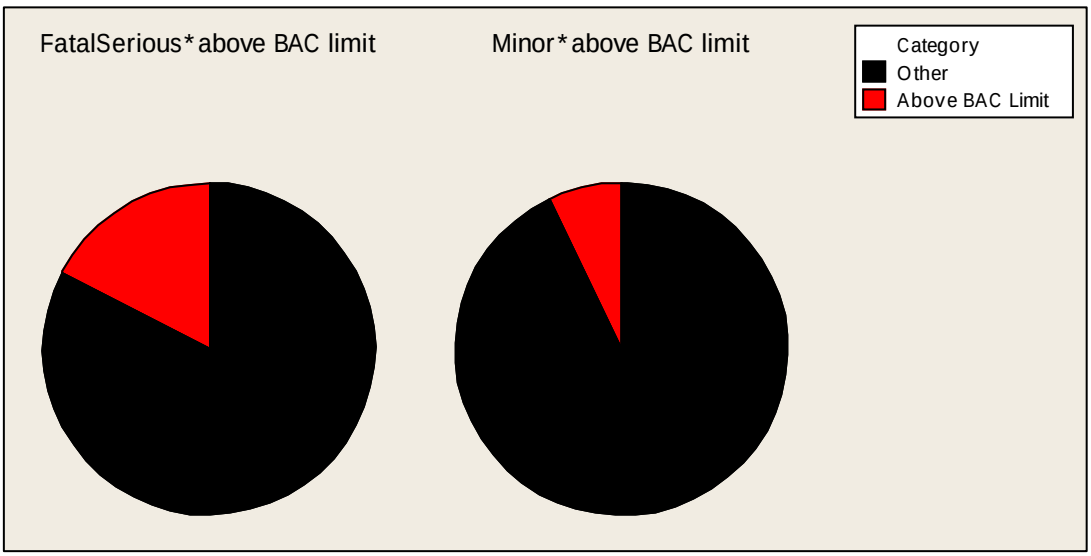
Further research should examine the actual location of these cyclist crashes in the Queenstown Lakes District to determine exactly where they are occurring and potentially what they are caused by.

Theme 3: Serious and fatal crashes in Queenstown Lakes District disproportionately involve blood alcohol in excess of the legal limit.

A crash was categorised as '*Above BAC Limit*' if one or more parties in the crash were noted to be above the legal limit for alcohol and/or refusing to take the test (crash code 103).

[42] Rivara, F., Thompson, D. & Thompson, R. (1997). Epidemiology of bicycle injuries and risk factors for serious injury. *Injury Prevention, 3,* 110-114. doi: 10.1136/ip.3.2.110

Figure 111 **Comparative severity of injury crashes in Queenstown Lakes District where driver was over BAC limit, or not, 2010-2013**



The pie charts in Figure 111 show that excess blood alcohol is a factor in a sizeable proportion of fatal and serious crashes, but is a much smaller factor in minor crashes. Specifically, 17.4% of fatal and serious crashes in Queenstown Lakes District involved one or more parties in the crash recording an alcohol level over the legal limit; by contrast, 7.2% of minor crashes involved one or more parties in the crash recording an alcohol level over the legal limit.

This is also not a surprising finding; excess blood alcohol has long been linked to negative outcomes in road safety, including both an increased incidence (drivers are more likely to crash when under the influence of excess blood alcohol) and crash severity (crashes involving intoxicated drivers tend to be serious or fatal, rather than minor incidents)[43].

Finding:

There is strong evidence (99.0%) that fatal and serious crashes in Queenstown Lakes are more likely to involve one or more drivers over the legal blood alcohol limit, compared with minor crashes.

3.9.3. Factors associated with serious and fatal crashes

Crash characteristics and causes

Slippery road: All causes

Finding:

Relative to minor crashes, serious and fatal crashes in Queenstown Lakes District do not typically involve a slippery-road surface (caused by unspecified conditions, as well as rain, mud, diesel/fuel, painted road markings, etc.).

[43] Kim, K., Nitz, L., Richardson, J. & Li, L. (1995). Personal and behavioral predictors of automobile crash and injury severity. *Accident Analysis & Prevention, 27,* 469-481.doi: 10.1016/0001-4575(95)00001-G

A crash was categorised as *'Slippery road: General*' if a slippery road was a factor in the crash for unspecified reasons (crash code 800), due to rain (crash code 801), snow or hail (crash code 803), mud (crash code 805), oil/diesel/fuel (crash code 806), painted markings on the road (crash code 807) and/or situations where large puddles, floodwaters or a ford was obstructing the roadway (crash code 823). There is evidence (95.0%) suggesting that fatal and serious crashes in Queenstown Lakes are very unlikely to occur on slippery roads, compared with minor crashes.

Overall, as Figure 107 depicts, 2.3% of fatal and serious crashes in Queenstown Lakes District were caused, wholly or partially, by a slippery-road surface; by contrast, 8.9% of minor crashes were caused, wholly or partially, by a slippery-road surface.

Slippery road: Ice

Finding:

Relative to minor crashes, serious and fatal crashes in Queenstown Lakes District do not typically involve a slippery-road surface caused by ice/frost.

A crash was categorised as *'Slippery road: Ice'* if a slippery road, caused by ice and/or frost (crash code 802), was a factor in the crash. There is strong evidence (99.0%) to suggest that fatal and serious crashes in Queenstown Lakes are very unlikely to occur on slippery roads caused by ice, compared with minor crashes.

Overall, as Figure 108 depicts, 3.5% of fatal and serious crashes in Queenstown Lakes District were caused, wholly or partially, by a slippery-road surface caused by ice/frost; by contrast, 14.8% of minor crashes were caused, wholly or partially, by a slippery-road surface caused by ice/frost.

Demographic factors

Driver gender

Findings:

Fatal and serious crashes in Queenstown Lakes District:

- are less likely to involve women in the key-vehicle-driver role, relative to minor crashes
- frequently involve men in the key-vehicle-driver role, relative to minor crashes.

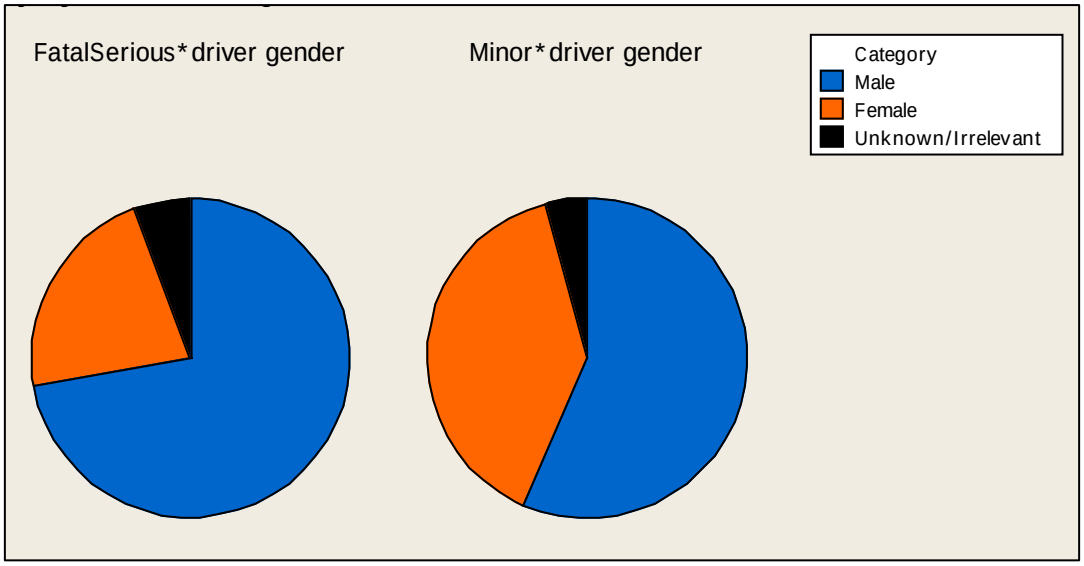
There is significant evidence (97.5%) that fatal and serious crashes are associated with men in the key-vehicle-driver role, compared with minor crashes.

As for crashes involving men in the key-vehicle-driver role, fatal and serious crashes make up a high proportion of overall injury crashes; however, with respect to crashes involving women in the key-vehicle-driver role, fatal and serious crashes make up just a small proportion of overall injury crashes.

17.0% of injury crashes involving a woman in the key-vehicle-driver role in Queenstown Lakes District (2010-2013) were classed as '*serious or fatal'*. By contrast, 31.6% of injury crashes involving a man in the key-vehicle-driver role were classed as '*serious or fatal'*.

This means that almost a third of all injury crashes involving a man in the key-vehicle-driver role over the 2010-2013 period resulted in a serious injury to at least one road user in the crash (and some of those injuries may have proved fatal). This may be associated with exposure (for example, men may tend to drive in more dangerous conditions, such as during dry weather). Further research in this area is needed.

Figure 112 Comparative incidence of injury crashes in Queenstown Lakes District, 2010-2013, by gender of driver



Clearly, these two pie charts in Figure 112 have a completely different pattern. The graph on the left (fatal and serious crashes) indicates that a majority of serious and fatal crashes have been associated with men in the key-vehicle-driver role. By contrast, with respect to minor crashes, the gender split is much more even, with approximately equal numbers of men and women in the key-vehicle-driver role.

Driver licence

Findings:

- There is strong evidence (99.0%) that fatal and serious crashes are associated with different licence categories in the key-vehicle-driver role, compared with minor crashes.
- Fatal and serious crashes in Queenstown Lakes District are less likely to involve restricted licence holders in the key-vehicle-driver role, relative to minor crashes.
- Fatal and serious crashes in Queenstown Lakes District frequently involve road users with an '*Unknown'* or '*Irrelevant*' licence in the key-vehicle-driver role, relative to minor crashes.

The category, '*Unknown/Irrelevant'*, is provided by the Police when the key vehicle is a cyclist (in which case, as the road user is a rider, not a driver, their licence type is thus determined '*Irrelevant*') or where the licence type of the driver of the key vehicle is '*Unknown'*.

As for crashes with an '*Unknown/Irrelevant'* licence-holder in the key-vehicle-driver role, fatal and serious crashes make up a high proportion of overall injury crashes; by contrast, with

respect to crashes with a restricted licence-holder in the key-vehicle-driver role, fatal and serious crashes make up a low proportion of overall injury crashes.

It is notable that cyclists show an elevated rate of fatal or serious injuries (35.7% of key-vehicle-cyclist crashes are fatal or serious, relative to 26.6% of all crashes in Queenstown); however, this difference did not quite reach statistical significance, and so has not been reported in an individual section here.

Despite this lack of formal significance, the combination of a slightly higher fatal/serious crash rate among key-vehicle-cyclists and the above finding of a high fatal/serious crash rate for '*Unknown'* or '*Irrelevant'* key-vehicle licence-holders suggests that cyclists are slightly more likely to be involved in fatal or serious crashes in Queenstown Lakes. This pattern must be interpreted with caution, however, given that examining cyclist crashes through an analysis of key vehicles involved in fatal and serious crashes did not yield a statistically significant result.

54.2% of injury crashes involving an '*Unknown*' or '*Irrelevant'* licence-holder in the key-vehicle-driver role in Queenstown Lakes District (2010-2013) were classed as '*serious or fatal'*. By contrast, 6.9% of injury crashes involving a restricted licence-holder in the key-vehicle-driver role were classed as '*serious or fatal'*.

Figure 113 Fatal and serious injury crashes in Queenstown Lakes District, 2010-2013, by type of licence

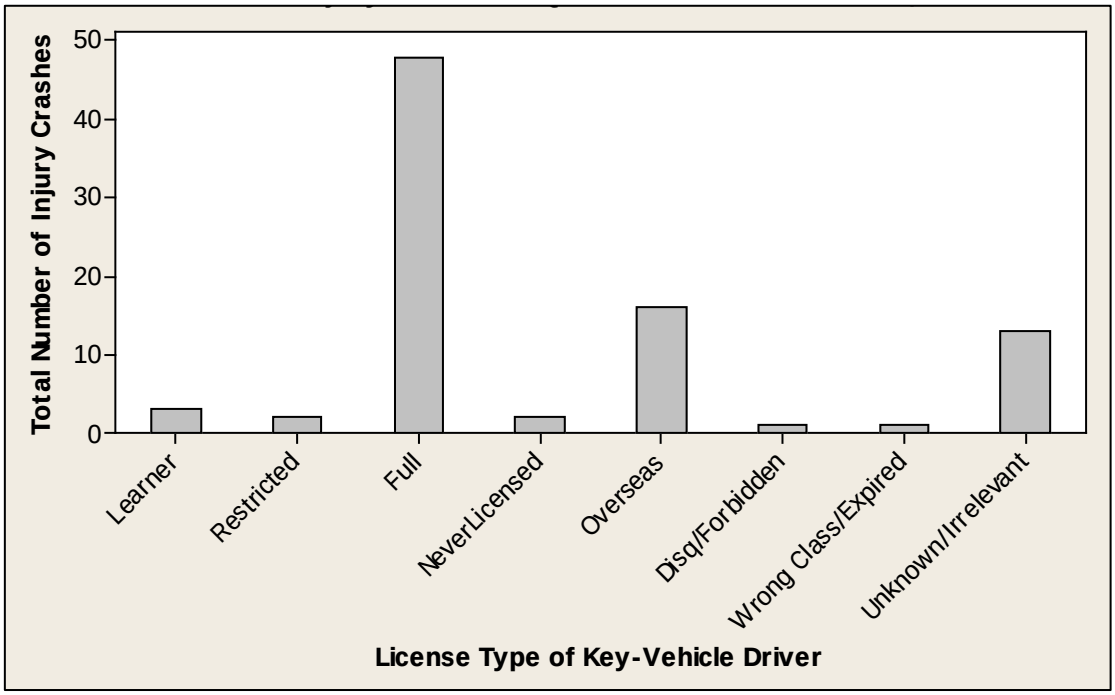
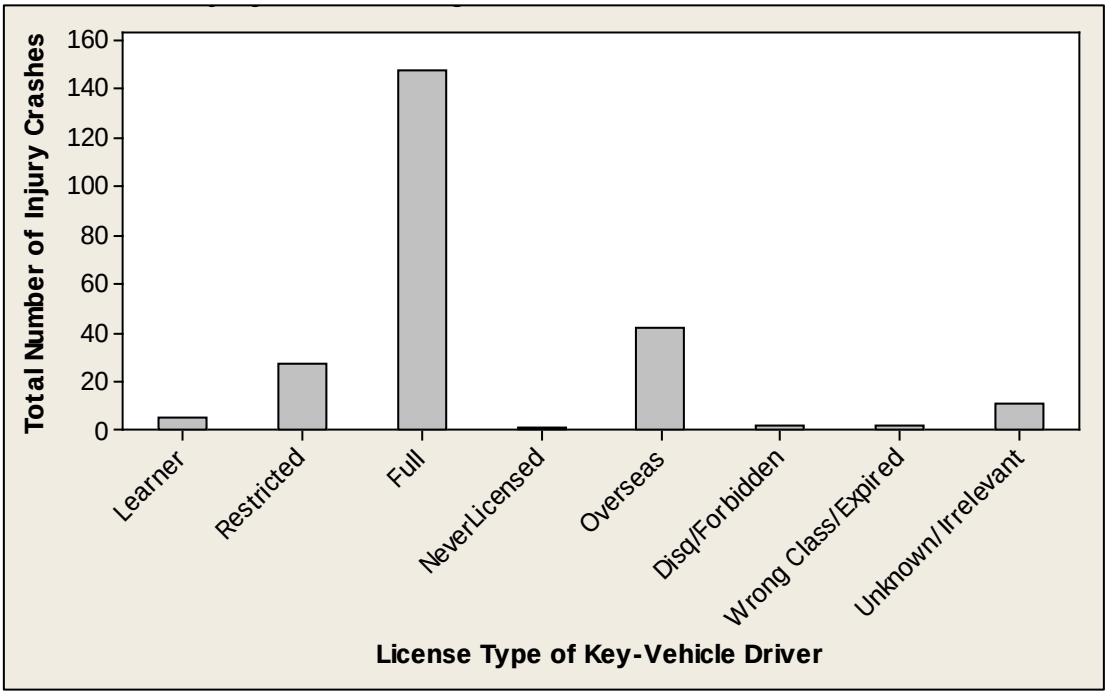


Figure 114 **Minor injury crashes in Queenstown Lakes District, 2010-2013, by type of licence**



In figures 113 and 114, *'Learner'* = 'Key-vehicle-driver held a learner licence'; '*Restricted'* = 'Key-vehicle-driver held a restricted licence'; '*Full'* = 'Key-vehicle-driver held a full licence'; '*NeverLicenced'* = 'Key-vehicle-driver had never been officially licenced by the relevant authority'; '*Overseas'* = 'Key-vehicle-driver held an overseas licence'; '*Disq/Forbidden'* = 'Key-vehicle-driver was disqualified or forbidden from driving at the time of the crash'; '*Wrong Class/Expired'* = 'Key-vehicle-driver held a licence for the wrong class of vehicle, and/or held an expired licence'; '*Unknown/Irrelevant'* = 'Key vehicle was a bicycle, in which case the licence type of the rider is irrelevant'. This category also includes a small number of situations where the key-vehicle-driver's licence was unrecorded or '*Unknown'* on the traffic-crash report form.

The main differences between the figures 113 and 114 are in the '*Restricted'* and '*Unknown/Irrelevant'* categories. With respect to '*Unknown/Irrelevant'*, most of these crashes are classed into the fatal/serious grouping; this possibly reflects the vulnerability of cyclists, who are a major component of this category. As to '*Restricted'*, most of these are classed into the minor grouping, indicating that restricted licence-holders are rarely involved in fatal and serious crashes in the district.

There is no significant difference in fatal/serious crash rate for other key-vehicle licence-holders, including overseas licence-holders. That is, key-vehicle-overseas-licence-holders show the same fatal and serious crash rate as other licence types. Specifically, 27.6% of key-vehicle-overseas-licence-holder crashes are classed as '*serious or fatal'*, which is not significantly different to the average of 26.6% of all-licence crashes classed as '*serious or fatal'*.

3.9.4. Areas where serious and fatal crashes perform better than minor crashes

Compared with minor crashes in Queenstown Lakes District, serious/fatal crashes in the district are much less likely to:

- occur in wet road conditions
- occur in icy/snowy road conditions
- involve a woman in the key-vehicle-driver role
- involve a restricted licence-holder in the key-vehicle-driver role
- be caused, wholly or partially, by a slippery-road surface (caused by unspecified conditions, as well as rain, mud, diesel/fuel, painted road markings, etc.)
- be caused, wholly or partially, by a slippery-road surface caused by ice.

We can be at least 95% confident that the factors listed do represent a systematic difference between serious/fatal crashes and minor crashes in Queenstown Lakes District, as opposed to random, chance variation). The list should be interpreted to indicate that serious/fatal crashes are rare under the conditions listed above. For example, serious/fatal crashes are very rare in wet and icy/snowy conditions.

3.9.5. Additional insights into the root causes of crashes in Queenstown Lakes District

Crashes caused by drivers above the BAC limit in Queenstown Lakes occur at night.

This relationship between night-time and drinking is even stronger in Queenstown Lakes District than in Dunedin, where a small number of alcohol-related crashes have occurred during daylight. In Queenstown, it seems almost all alcohol-related crashes caused by drivers above the BAC limit have occurred at night.

This factor analysis indicates that the darker it is outside, and the later in the day, the more drink-drivers will be on the road. In general, police-alcohol checkpoints should be scheduled as late as possible to apprehend the highest proportions of drunk drivers.

Most intersection crashes in Queenstown Lakes District involve a failure to give way.

As with Dunedin City, most of intersection crashes in Queenstown Lakes District do not involve failure to stop at stop signs or traffic lights, but instead involve failure to give way at a give-way sign. Furthermore, this factor informs the analyst that most of Queenstown-Lakes' intersection crashes are associated with urban environments, as opposed to rural environments. '*Urban'* and '*Rural'* have been designated according to NZTA's speed-limit guidelines (urban roads have a speed limit of 70 km/h or lower; rural roads have a speed limit of 80 km/h or higher).

Tourists in Queenstown Lakes District tend to cut corners or swing wide (deliberately failing to keep left).

This factor indicates that crashes caused by 'overseas inexperience' (as determined by the Police) are frequently associated with motorists cutting corners or swinging wide on bends. This is notable not only because it provides insight into how to improve tourist safety, but also because it indicates what tourists do *not* have trouble with. Driving on the wrong side of the road is not significantly associated with tourist drivers, and nor is excessive speed on corners.

This is perhaps not what one would expect based on popular perception of tourists; however, it indicates that tourists are unfamiliar with how to drive on New Zealand roads, and that cutting corners can be a significant safety hazard if oncoming traffic is not visible. New Zealand roads are quite bendy and winding by OECD standards, and the largely alpine environment of Queenstown Lakes District accentuates this. It is not a safe area to cut corners or swing wide on.

Furthermore, there is a significant correlation between driving while disqualified, forbidden or on an expired licence, and cutting corners (or swinging wide); it seems that failing to hold a valid or current licence is an excellent predictor for this sort of 'lazy' driving. Pedestrian-vehicle crashes are primarily associated with dangerous-pedestrian behaviour.

As with Dunedin City, this factor indicates that most of Queenstown Lakes District's pedestrian-vehicle crashes are associated with dangerous-pedestrian behaviour (as opposed to poor-driver behaviour). Specifically, nine pedestrian-motorist crashes in Queenstown Lakes over the 2010-2013 period were deemed to be caused, wholly or in part, by inappropriate and/or dangerous pedestrian behaviour. No pedestrian-motorist crashes were caused by drivers' failure to give way to pedestrians at appropriate locations (zebra crossings or traffic lights).

Losing control on bends in Queenstown Lakes District involves excessive speed.

Crashes associated with losing control on bends in Queenstown Lakes are associated with the severity of the bend and the speed of the driver. Excessive speed and severe curves are both likely to lead to driver loss of control. This factor seems intuitive, but it indicates that speed is the major factor in loss-of-control Queenstown Lakes crashes on bends (as opposed to other potential issues, such as ice).

3.9.6. Issues involving high numbers of crashes on both state highways and local roads in Queenstown Lakes District

These are:

- the high rate of cornering-related crashes
- the high rate of crashes involving motorists travelling too fast for conditions around corners
- the high rate of crashes involving tourists or 'tourist inexperience'

- the high rate of crashes during snowfall
- the high rate of crashes over the Christmas/New Year holiday period
- the high rate of icy/snowy road crashes
- the high rate of crashes involving the 25-34 year-old age group
- the high rate of crashes involving motorists losing control.

As to the latter, it is interesting to note that '*Other*' inexperience and new driver-related inexperience are unevenly distributed across the local-road and state-highway networks. Motorists driving a new vehicle, such as a campervan or rental car, are more likely to suffer a crash on the state-highway network, due to the higher speeds on this network. Driving a new car at low speeds is relatively safe, but at higher speeds, unfamiliarity can be costly if the car does not react as the driver expects. This is compounded in adverse weather conditions, which are common in Queenstown Lakes.

On the other hand, local roads often demand more of a driver in terms of technical-turning ability and skill in handling poorly-delineated corners. In addition, local roads are more likely to be gravel and less likely to be gritted in the event of snow or ice. This can make traversing local roads much more difficult for new drivers, who may not have the necessary skills to handle these difficult conditions. This may explain why the new-driver crash rate is higher on Queenstown Lakes' local roads.

3.10. Waitaki District results

3.10.1. Findings and recommendations, summarised

Four themes emerged from analysis of data for Waitaki District:

- Fatal and serious crashes tend to happen on high-speed roads.
- Crashes occurring in misty/foggy conditions tend to result in serious road trauma.
- Serious and fatal crashes disproportionately involve blood alcohol in excess of the legal limit.
- Serious and fatal crashes disproportionately involve vehicle-related issues (e.g. inadequate headlights, worn tyres, etc.).

Other findings:

- Waitaki District has a very high number of fatalities for its population size, compared to other regions in Otago.
- Relative to minor crashes, serious and fatal crashes in Waitaki District:
  - are closely associated with night and do not typically take place during the daytime
  - are closely associated with rural roads (roads with an 80 km/h speed limit or higher)
  - are closely associated with darkness (in the absence of streetlights) at the crash site
  - are closely associated with mist/fog at the crash site
  - are closely associated with one or more parties recording a blood alcohol level over the legal limit
  - are not usually associated with one or more parties following too closely, merging incorrectly or crowding a cyclist.
- Fatigue crashes mostly involve experienced drivers and occur on state highways mainly.
- Running a red light/stop sign is associated with inattention, not deliberate violation.
- Pedestrian crashes often involve unsupervised young children.
- Losing control on bends involves excessive speed.

Recommendations for Waitaki District Council and/or NZTA to consider:

1. Investigate to what extent (if at all) the finding that serious and fatal crashes disproportionately involve vehicle-related issues is due to the Police being more likely to report these matters in the district than in others.

2. Investigate which types of vehicles were involved in fatigue-related crashes; the high number of full licence-holders indicates that some of the crashes may have involved commercial drivers. Investigate potential interventions such as more roadside rest stops, or directing media attention to the issue of fatigue, particularly the fact that it can and does affect ordinary drivers with plenty of experience.

3. Many police operations focus around enforcing drivers to stop at red lights and stop signs, but it seems that very few crashes are caused by reckless drivers running a red light (or stop sign). Instead, most crashes associated with this behaviour are caused by drivers simply failing to notice the stop sign. Upgrading stop signs to be more obvious and visible may be advisable, particularly if one or two stop signs are causing many of the failure-to-stop crashes.

4. Identify stretches of road that are susceptible to pedestrian crashes involving children, and consider whether increasing barriers or signage in this area would be useful in protecting children from the high-traffic volumes of SH 1. Increasing parental education regarding the supervision of their children close to major highways may also be useful.

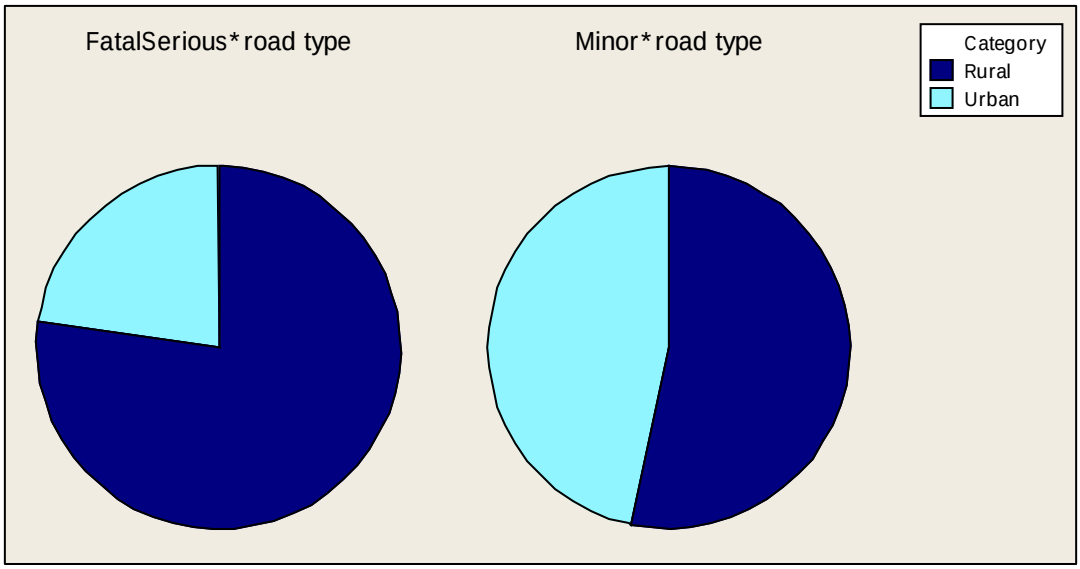
5. Tightly enforcing the speed limit may be advisable, in combination with advertising and media initiatives. Identifying the worst-performing bends and curves in terms of road safety, and targeting signage and potentially infrastructural upgrades to those bends may be useful.

3.10.2. Themes found in the analysis of serious and fatal crashes

Theme 1: Fatal and serious crashes in Waitaki District tend to happen on high-speed roads.

Relative to minor crashes, serious and fatal crashes in Waitaki District are closely associated with rural roads (roads with an 80 km/h speed limit or higher), as Figure 115 shows.

Figure 115 Comparative severity of injury crashes on urband and rural roads in Waitaki District, 2010-2013



Roads have been categorised into '*Urban'* (70 km/h speed limit or lower) and *'Rural'* (80 km/h speed limit or higher). There is strong evidence (99.9%) that fatal and serious crashes in Waitaki District tend to take place on roads with higher-speed limits, compared with minor crashes. In Figure 115, there is a clear difference between the two pie charts. Overall, as Figure 115 shows, 77.3% of fatal and serious crashes have occurred on rural roads (speed

limit of 80 km/h or higher); by contrast, 53.4% of minor crashes have occurred on rural roads (speed limit of 80 km/h or higher).

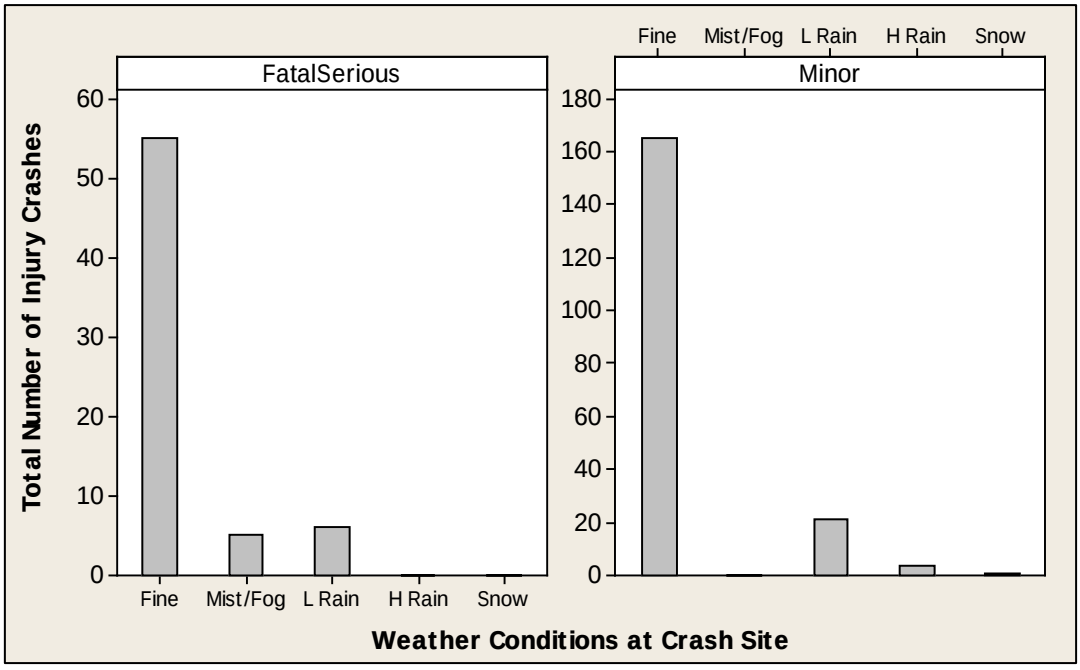
On average, it is likely that motorists travel faster on high-speed roads than on lower-speed roads (i.e. motorists tend to travel faster on 80 or 100 km/h roads, compared with 50 km/h or 70 km/h roads). There is a huge volume of research evidence indicating that a higher impact speed during a crash typically results in more severe injuries to crash victims[44] [45]. Other possible causal or exacerbating factors worth investigating are:

- whether the fact that vast majority of fatal and serious crashes in Waitaki District are occurring on high-speed roads (80 km/h speed limit or higher) is related to the higher-impact speeds on these roads (on average) or to particular infrastructure features of high-speed roads
- whether high-risk road users tend to use high-speed roads, thus giving them a higher-severity profile, including whether travel on high-speed roads is associated with other high-risk behaviours, such as excessive alcohol consumption.

The latter point could also explain the high-severe and fatal-crash rate on these high-speed roads. For example, if heavily intoxicated drivers choose to travel on high-speed roads (and then subsequently crash due to their intoxication), then high-speed roads will have a more severe-crash rate, which is reflective of the road users who choose to use that road.

Theme 2: Crashes occurring in misty/foggy conditions in Waitaki District tend to result in serious road trauma.

Figure 116 **Comparative severity of injury crashes in different weather conditions Waitaki District, 2010-2013**



[44] For one example, see Aarts, L. & van Schagen, I. (2006). Driving speed and the risk of road crashes: a review. *Accident Analysis & Prevention, 38,* 215-224. doi: 10.1016/j.aap.2005.07.004.

[45] More information can be found in Elvik, R., Høye, A., Vaa, T. & Sørensen, M. (2009). *The Handbook of Road Safety Measures* (2nd ed.). Emerald Group Publishing Limited: Bingley, UK.

The only difference between the factors in the two graphs in Figure 116 is '*Mist/Fog'*. Specifically, 100.0% of the five injury crashes that took place in '*Mist/Fog'* in Waitaki District (2010-2013) were classed as '*serious or fatal'*. However, every single one has resulted in a serious injury to at least one road user (and some of those injuries proved fatal).

There is little empirical research on the impact of fog on road-safety outcomes. As for the UK, evidence indicates that there is geographical variation with respect to fog's impact on motor-vehicle injury severity (i.e. depending on the location, fog-related crashes can either be more or less severe than fine-weather crashes)[46]. This is consistent with the findings of this Otago Regional Council statistical analysis, which indicates that fog does not usually result in more severe crashes or injuries, except in Waitaki District, where fog seems to be closely associated with severe road trauma.

It seems likely that accidents in fog are mainly associated with a lack of visibility. If this is the case, why do fog-related accidents tend to be more severe in Waitaki District, but show no greater severity in the other Otago and Southland districts examined?

The main hypothesis for this relates to Waitaki District's roading system. Relative to the other districts in Otago and Southland, Waitaki District tends to have straight roads with few bends and curves. Perhaps motorists in Waitaki District do not take the threat of fog and mist seriously, as the roads are relatively straight and thus easy to navigate. As a result, when they are caught off-guard by the occasional slight bend or curve, they are travelling too fast for the conditions. Consequently, crashes in these conditions tend to be quite serious.

By contrast, other districts in Otago and Southland tend to have roads with a lot of bends and curves. On these roads, motorists must slow down to navigate the bends safely. For this reason, motorists may tend to travel slowly in fog, thus ensuring that crashes in fog and mist are not particularly serious.

More evidence is needed to determine whether this hypothesis is a reasonable explanation for the high-severe-crash rate in fog/mist. Other districts in Otago/Southland also have a high proportion of straight roads (e.g. Central Otago), but do not show this pattern, perhaps because they experience less mist/fog (and so the difference in severity rate between mist-related crashes and fine-weather crashes is not strong enough to be statistically significant).

Presumably, crashes in misty and foggy conditions result from a lack of visibility. This raises the question as to whether the roads in Waitaki District are deceptively easy to navigate in fog, thus lulling motorists into a false sense of security. If so, motorists may well travel too fast for the conditions, resulting in more serious injuries when they crash under these conditions. Additional evidence is needed to support this hypothesis, given that some other districts in Otago and Southland (e.g. Central Otago) also have many straight roads, but do not show the same pattern.

[46] Edwards, J.B. (1998). The relationship between road accident severity and recorded weather. *Journal of Safety Research, 29,* 249-262.

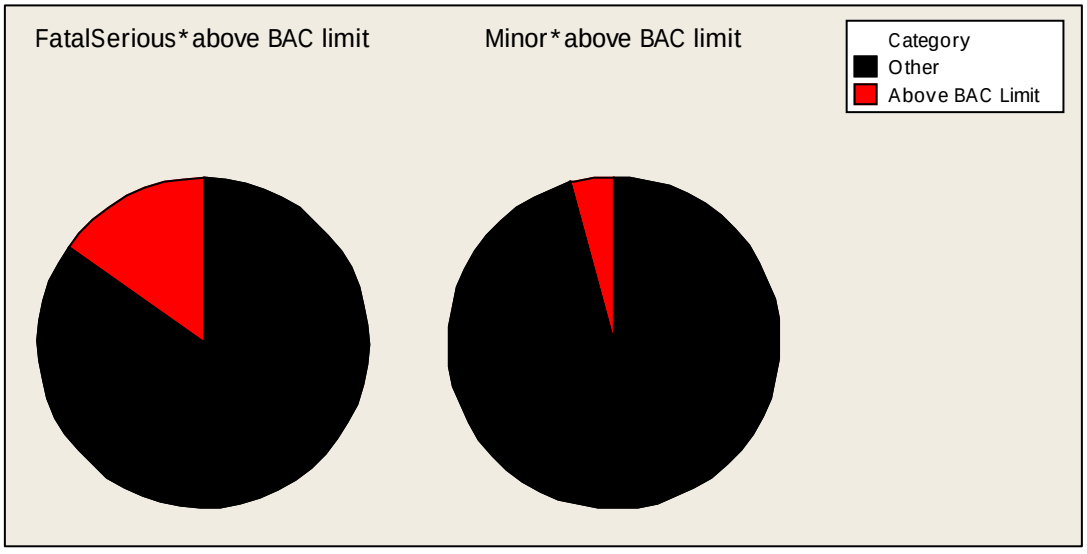
Theme 3: Serious and fatal crashes in Waitaki District disproportionately involve blood alcohol in excess of the legal limit.

Relative to minor crashes, serious and fatal crashes in Waitaki District are closely associated with one or more parties recording a blood alcohol level over the legal limit, as Figure 117 shows. The evidence for this is powerful (99.5%). Specifically 15.2% of fatal and serious crashes in Waitaki District involved one or more parties in the crash recording an alcohol level over the legal limit; by contrast, 4.2% of minor crashes involved one or more parties in the crash recording an alcohol level over the legal limit.

A crash was categorised as '*Above BAC Limit*' if one or more parties in the crash was noted to be above the legal limit for alcohol and/or refusing to take the test (crash code 103). According to the Police, refusing the test is very rare; the strong majority of 103-coded crashes involve road users who were above the legal alcohol limit[47].

The pie charts in Figure 117 show that excess blood alcohol is a factor in a sizeable proportion of fatal and serious crashes, but is a much smaller factor in minor crashes. This is not surprising; excess blood alcohol has long been linked to negative outcomes in road safety, including both an increased incidence (drivers are more likely to crash when under the influence of excess blood alcohol) and crash severity (crashes involving intoxicated drivers tend to be serious or fatal, rather than minor incidents)[48].

Figure 117 **Comparative severity of injury crashes in Waitaki District where the driver has been above the BAC limit, or not, 2010-2013**



[47] *Pers. comm.*, Steve Larking, Acting Road Policing Manager for the Southern District. 13th Nov., 2013.

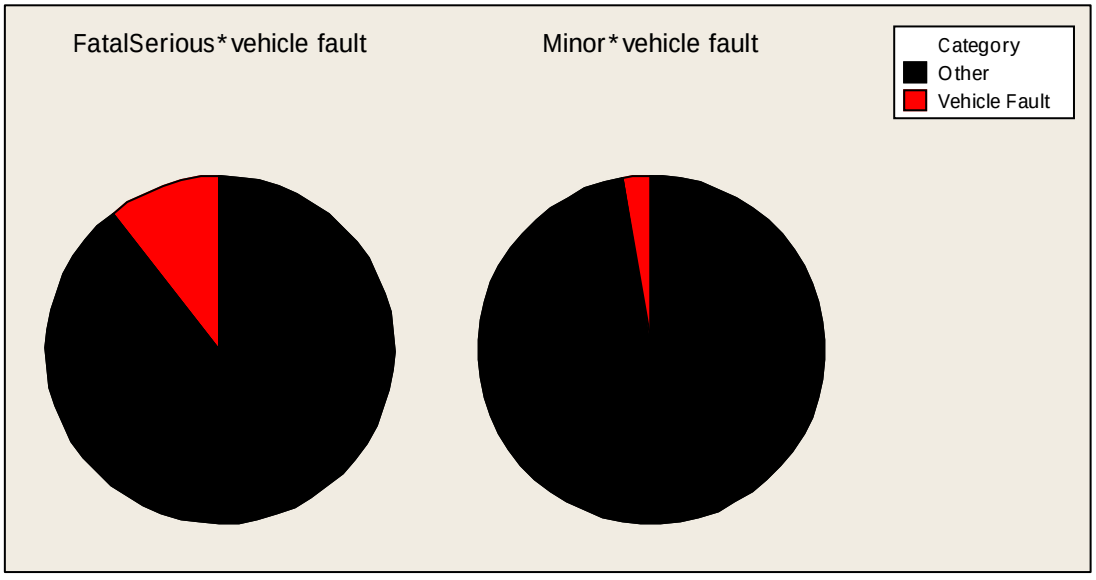
[48] Kim, K., Nitz, L., Richardson, J. & Li, L. (1995). Personal and behavioral predictors of automobile crash and injury severity. *Accident Analysis & Prevention, 27,* 469-481.doi: 10.1016/0001-4575(95)00001-G

Theme 4: Serious and fatal crashes in Waitaki District disproportionately involve vehicle-related issues (e.g. inadequate headlights, worn tyres, etc.).

Relative to minor crashes, serious and fatal crashes in Waitaki District are closely associated with one or more vehicles suffering from a vehicle fault that possibly contributed to the crash. Overall, 10.6% of fatal and serious crashes involved one or more vehicles in the crash suffering from a vehicle fault that possibly contributed to the crash; by contrast, 2.6% of minor crashes involved one or more vehicles in the crash suffering from a vehicle fault that possibly contributed to the crash.

A crash was classed as '*Vehicle fault'* if one or more of the vehicles in the crash experienced a fault that possibly contributed to the crash. These vehicle issues are coded from 600-696 in traffic-crash reports. Some of the most common vehicle faults that are noted in traffic-crash reports include inadequate headlights, worn tyres, shattered windscreens and inappropriate blind-spot coverage. There is strong evidence (99.0%) that fatal and serious crashes in Waitaki District are more likely to involve one or more vehicles suffering a fault or maintenance issue, compared with minor crashes.

Figure 118 Comparative severity o injury crashes in Waitaki District where at least one vehicle in the crash did, or did not, have a fault recorded, 2010-2013



The pie charts in Figure 118 show that vehicle-related issues are a factor in a sizeable proportion of fatal and serious crashes, but are a much smaller factor in minor crashes. While it seems obvious that vehicle faults tend to lead to an increased number of crashes (e.g. inadequate blind-spot coverage would presumably lead to a higher number of merging/reversing crashes). It is unclear why these sorts of vehicle fault-related crashes tend to be more severe, or why this pattern is only visible in Waitaki District.

Matters for further investigation are:

- to what extent (if at all) the finding that serious and fatal crashes in Waitaki District disproportionately involve vehicle-related issues is due to the Police being more likely to report these matters in the district than in others

- whether high-risk drivers (e.g. highly intoxicated drivers) tend to use poor-quality vehicles, and also tend to have severe crashes
- whether the roading system in Waitaki is particularly unforgivable to vehicles that are not of adequate quality.

3.10.3. Factors associated with serious and fatal crashes

This section reports the factors found to be associated with fatal and serious crashes in Waitaki District.

Crash characteristics and causes

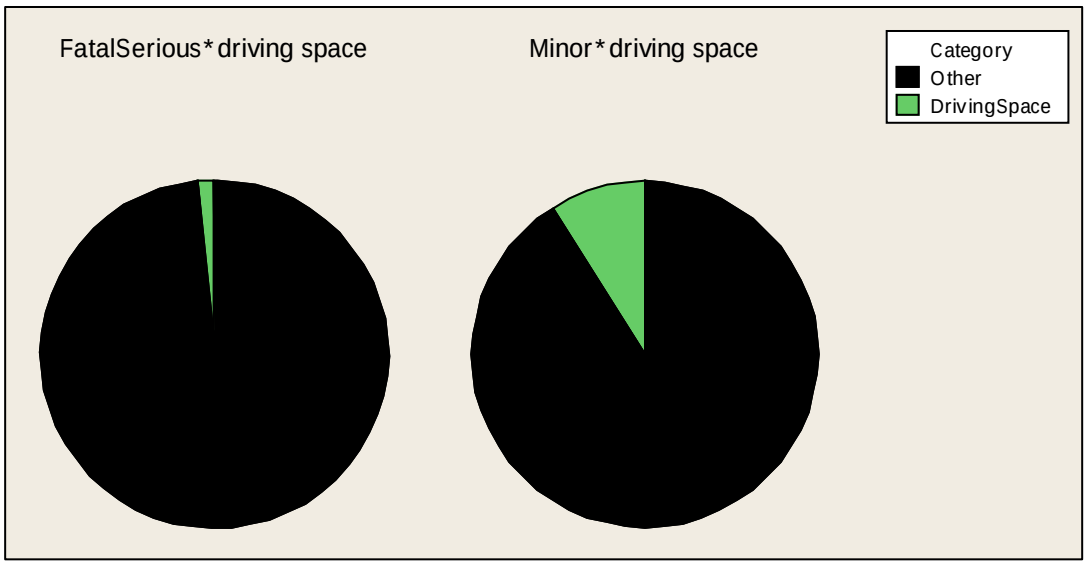
Driving space

Finding:

Relative to minor crashes, serious and fatal crashes in Waitaki District are not usually associated with one or more parties following too closely, merging incorrectly or crowding a cyclist.

A crash was categorised as *'Driving space'* if one or more parties in the crash was following too closely in line of traffic (crash code 181), if a motorist crowded a cyclist (crash code 183), and/or if an incorrect merging/diverging manoeuvre was followed (crash code 184). There is some evidence (95.0%) that fatal and serious crashes in Waitaki are less likely to involve issues with vehicle crowding and/or driving space, compared with minor crashes.

Figure 119 **Comparative severity of injury crashes in Waitaki District where at least one party was, or was not, following too closely, merging incorrectly or crowding a cyclist, 2010-2013**



Overall, as Figure 119 shows, 1.5% of fatal and serious crashes in Waitaki District involved one or more parties in the crash following too closely, merging incorrectly or crowding a cyclist; by contrast, 8.9% of minor crashes involved one or more parties in the crash following too closely, merging incorrectly or crowding a cyclist.

Timing

Time of day

Finding:

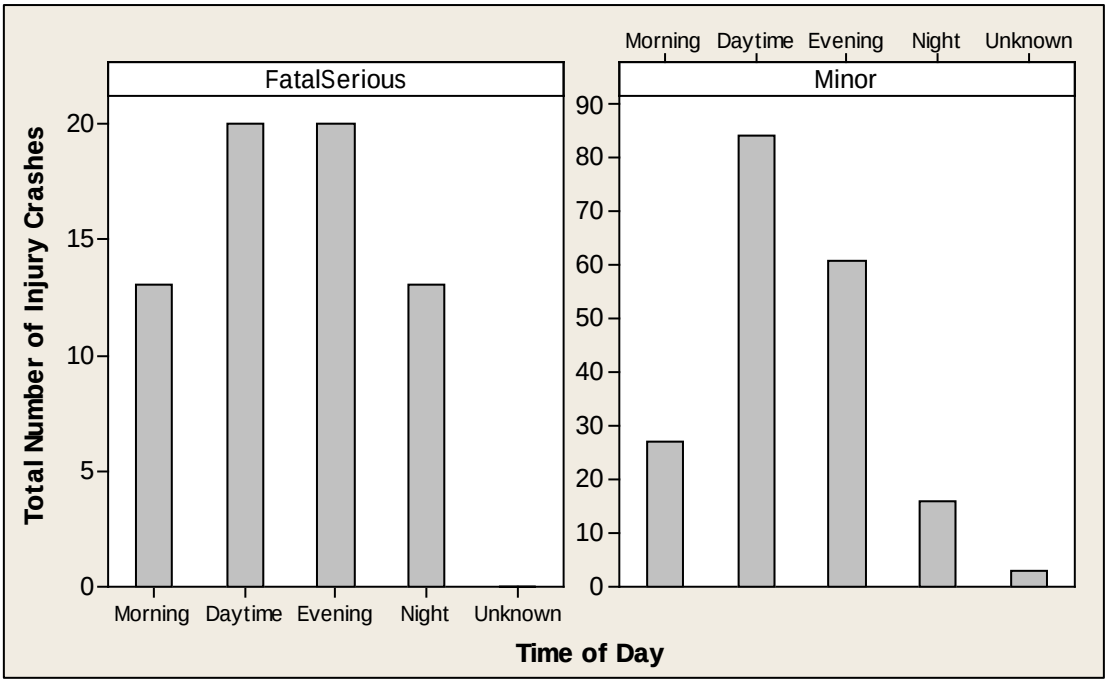
Relative to minor crashes, serious and fatal crashes in Waitaki District are closely associated with night and do not typically take place during the daytime.

Crashes are divided into '*Morning'* (4 am-9:59 am); '*Daytime'* (10 am-3:59 pm); '*Evening'* (4 pm-9:59 pm); '*Night'* (10 pm-3:59 am); and '*Unknown'* (no time was provided in CAS, either because the Police traffic-crash report did not display a time, or because the coders did not transfer the time provided on the report into the CAS database).

There is some evidence (95.0%) that serious and fatal crashes in Waitaki District tend to occur at different times of the day, when compared with minor crashes in the district. A high proportion of injury crashes taking place at night (10 pm-3:59 am) are classed as '*serious or fatal'*; by contrast, with respect to injury crashes taking place during the day, a low proportion are classed as '*serious or fatal'*.

Specifically, 44.8% of injury crashes occurring during the night (10 pm-3:59 am) in Waitaki District (2010-2013) have been classed as '*serious or fatal'*. By contrast, 19.2% of injury crashes occurring during the daytime (10 am-3:59 pm) have been classed as '*serious or fatal'*. This means that almost half of all injury crashes taking place during the night (10 pm-3:59 am) have resulted in a serious injury to at least one road user, and those injuries may have proved fatal.

Figure 120 **Comparative severity of injury crashes in Waitaki District, 2010-2013, by time of day**



The two graphs in Figure 120 show a noticeably different pattern. The left panel (fatal and serious crashes) shows a slight peak across the daytime and evening (10 am-9:59 pm), with a significant minority of crashes taking place during the morning (4 am-9:59 am) and night (10 pm-3:59 am).

By contrast, the '*Minor'* graph shows a clear peak during the daytime (10 am-3:59 pm), with a large proportion of its crashes occurring during these hours. It shows very few crashes occurring at night (10 pm-3:59 am).

Environmental conditions

Lighting conditions

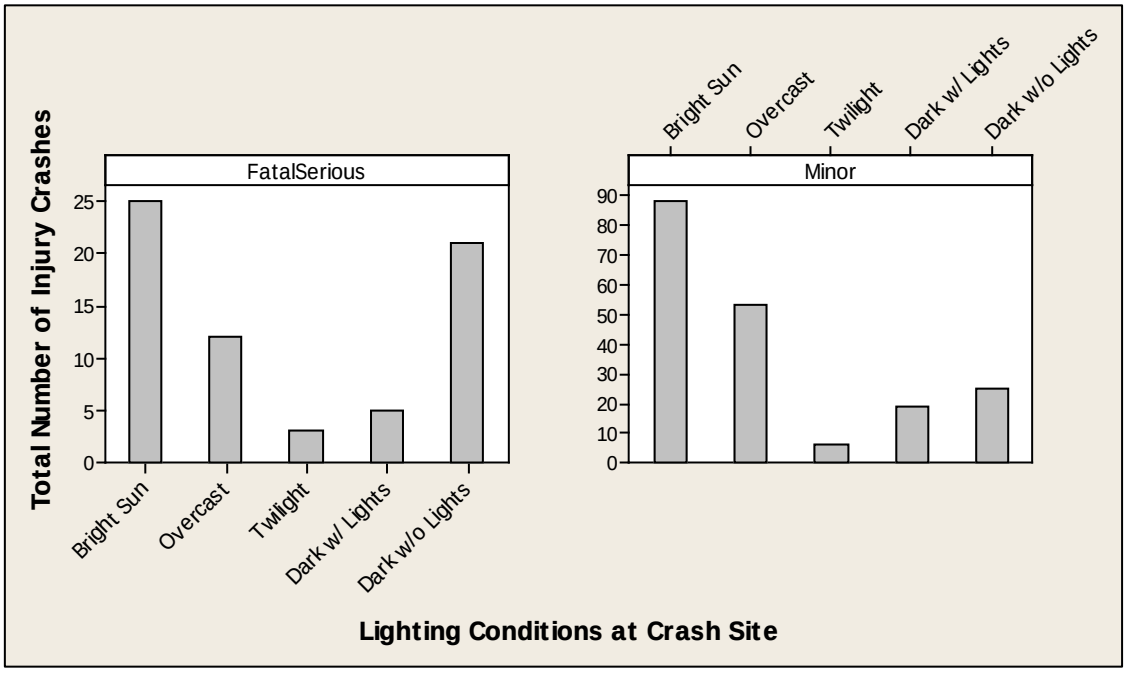
Finding:

Relative to minor crashes, serious and fatal crashes in Waitaki District are closely associated with darkness (in the absence of streetlights) at the crash site.

Crashes have been divided into five categories: '*BrightSunlight'*, '*Overcast'*, '*Twilight'*, '*Darkw/Lights'* (dark conditions, but with working streetlights present at the crash scene) and '*Dark w/oLights'* (dark conditions, and with no streetlights in the vicinity of the crash). There is significant evidence (97.5%) that fatal and serious crashes tend to take place in different lighting conditions, compared to minor crashes in the district. A high proportion of crashes occurring in darkness (in the absence of streetlights) tend to be classed as '*serious or fatal'*.

Specifically, 45.7% of injury crashes occurring in darkness (in the absence of streetlights) were classed as '*serious or fatal'*. This means that almost half of all injury crashes occurring in darkness (in the absence of streetlights) resulted in a serious injury to at least one road user (and some of those injuries may have proved fatal).

Figure 121 Comparative severity of injury crashes in Waitaki District in different lighting conditions, 2010-2013



The two graphs in Figure 121 show a similar pattern for *Bright Sun*, *Overcast*, *Twilight* and *Dark w/ Lights*; the only major point of difference is *Dark w/o Lights* (i.e. those crashes that occurred in dark conditions, in the absence of street lighting). A sizeable minority of fatal and serious crashes have occurred in dark conditions (in the absence of streetlights); by contrast, only a very small minority of minor crashes have occurred in these conditions.

Weather conditions

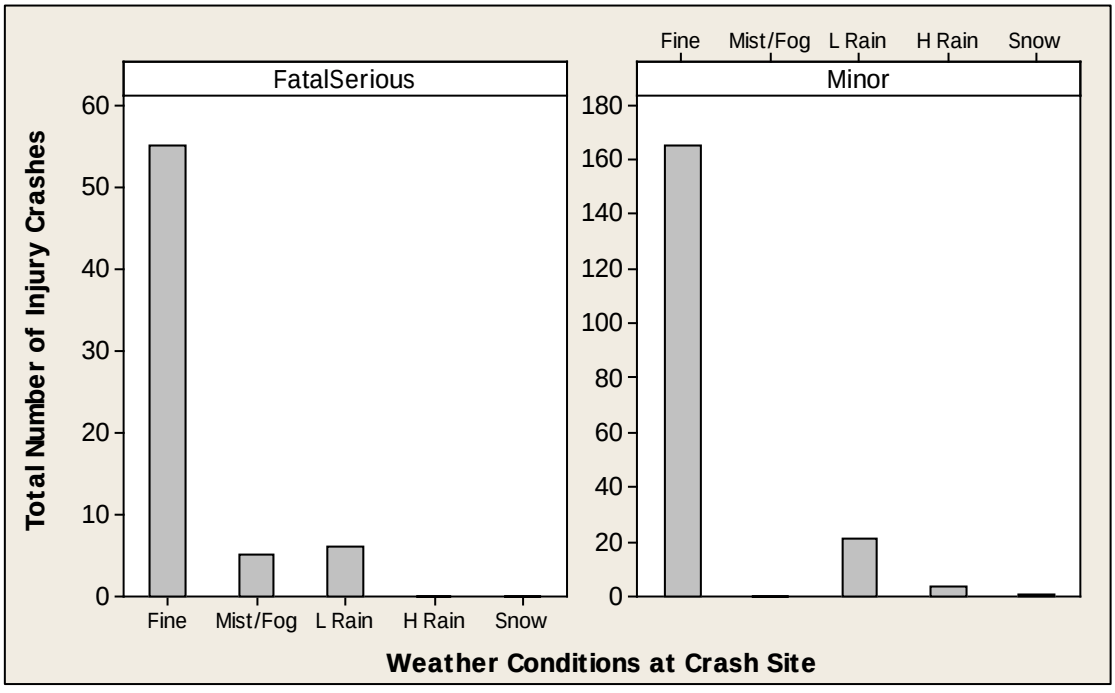
Finding:

Relative to minor crashes, serious and fatal crashes in Waitaki District are closely associated with mist/fog at the crash site.

Crashes are classified into *Fine*, *Mist/Fog*, *Light rain*, *Heavy rain* and *Snow*. There is powerful evidence (99.5%) that fatal and serious crashes in Waitaki District tend to occur in different weather conditions, compared with minor crashes.

A high proportion of crashes occurring in mist and/or fog tend to be classed as '*serious or fatal'*. Specifically, 100.0% of the five injury crashes that took place in mist/fog were classed as '*serious or fatal'*. Thus, although only five injury crashes have taken place in mist/fog in Waitaki over the past few years (2010-2013), every single one has resulted in a serious injury to at least one road user (and some of those injuries may have proved fatal).

Figure 122 Comparative severity of injury crashes in Waitaki District in different weather conditions, 2010-2013



The two graphs in Figure 122 show a very similar pattern, with the exception of *Mist/Fog*. *Mist/Fog* makes up a notable minority of fatal and serious crashes in Waitaki District; by contrast, it does not appear at all in the graph of minor crashes, shown in the right panel.

3.10.4. Areas where serious and fatal crashes perform better than minor crashes

Compared with minor crashes, serious/fatal crashes are less likely to:

- take place during the daytime
- involve one or more road users following too closely, merging incorrectly or crowding a cyclist.

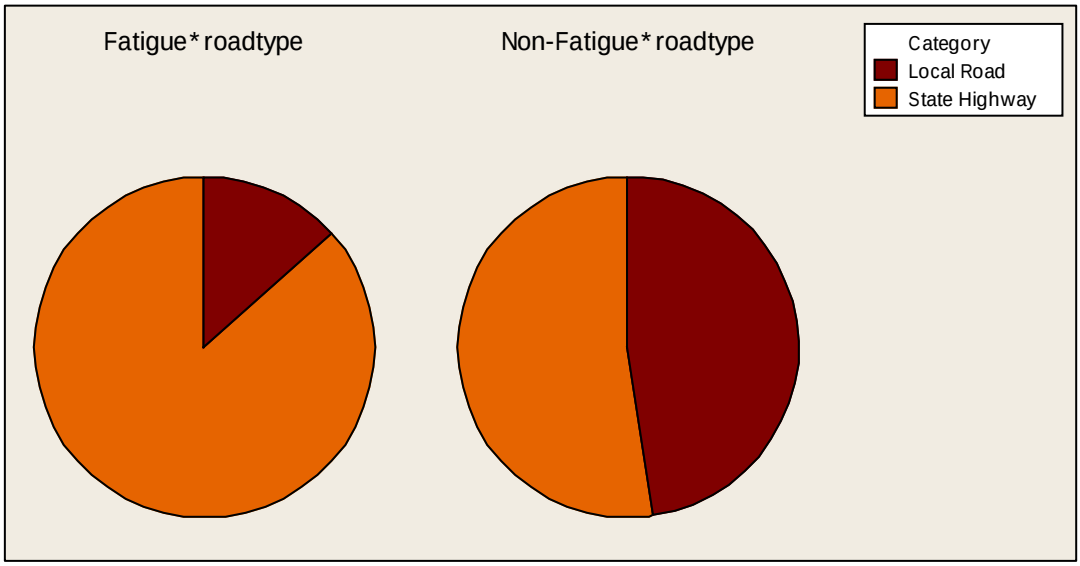
We can be at least 95% confident that the factors listed really do represent a systematic difference between serious/fatal crashes and minor crashes in Waitaki District, as opposed to random, chance variation. The list should be interpreted to indicate that serious/fatal crashes are very rare in Waitaki District under the conditions listed below. For example, serious/fatal crashes are rare during the day.

3.10.5. Additional insights into the root causes of crashes in Waitaki District

Fatigue crashes in Waitaki District mostly occur on state highways and involve experienced drivers.

There is strong evidence (99%) that fatigue-related crashes are unevenly distributed across the local-road and state-highway network. Fatigue-related crashes are much more frequent on the state-highway network than the local-road network.

Figure 123 **Comparative incidence of injury crashes on state highways and local roads in Waitaki District, 2010-2013**



The left pie chart in Figure 123 shows all fatigue-related crashes in Waitaki District over the 2010-2013 period, while the right panel shows all non-fatigue-related crashes (i.e. all other crashes). Specifically, 47.6% of non-fatigue-related crashes took place on local roads, while 52.4% took place on state highways. By contrast, 13.3% of fatigue-related crashes took place on local roads, with 86.7% of fatigue-related crashes occurring on state highways.

This crash distribution supports the hypothesis that fatigue-related crashes in Waitaki District are mainly associated with its status as a thoroughfare district between the two major South

Island cities of Dunedin and Christchurch. Motorists use the state-highway network to travel between Dunedin and Christchurch, indicating that it is probably these motorists who are affected by fatigue (as opposed to Oamaru and/or Waitaki locals). Oamaru is situated about 1.5 hours from Dunedin and 3 hours from Christchurch, suggesting that fatigue may be starting to affect drivers from these locations if drivers have not rested, or have only rested sporadically, since the beginning of their journey.

The majority of crashes involving fatigue are associated with experienced drivers, as opposed to drivers who have just received their licence. Specifically, 80% of the 15 fatigue-related crashes occurring in Waitaki District over the 2010-2013 period involved drivers possessing a full and current New Zealand licence. However, 13% involved drivers carrying a restricted licence, and only one driver with an overseas licence (6.7%) crashed due to fatigue.

This reinforces the idea that fatigue can strike any driver; it is not restricted to those who are not used to driving (i.e. learner and restricted drivers). In fact, full licence-holders seem particularly susceptible to fatigue, perhaps because they underestimate how tired they are after driving long distances.

Running a red light/stop sign is associated with inattention, not deliberate violation.

Running a red light or a stop sign in Waitaki District is not associated with deliberate violation (as in the case of failing to give way at a give-way sign), but is related to not noticing the traffic light or stop sign. Crashes involving one driver failing to stop at a traffic signal or stop sign are more likely to be due to simple inattention than a deliberate and dangerous manoeuvre (as in the case of failing to give way).

Pedestrian crashes in Waitaki District often involve unsupervised young children.

Crashes involving pedestrians in Waitaki District appear to disproportionately involve unsafe behaviour on the part of children on the roadside. Typically, pedestrian crashes involving children are relatively rare. In Waitaki District, one-third of the six pedestrian crashes in the area from 2010-2013 have involved unsupervised children under the age of seven. One of those children was even running heedless of traffic at the intersection of SH 1 and Dee Street.

This result of statistical factor analysis is informative in that children are one of the most vulnerable road-user groups. Not only do they face the same problems as pedestrians regarding lack of protection in a crash, but they are often unsure of how to play safely around motor vehicles, and they tend to behave unpredictably, unaware of the dangers.

Losing control on bends in Waitaki District involves excessive speed.

The fourth factor of interest is identical to factors found in Dunedin, Clutha and Queenstown Lakes District. It suggests that crashes associated with losing control on bends in Waitaki District are associated with the severity of the bend and the speed of the driver. Excessive

speed and more severe curves are likely to lead to driver loss of control. This factor seems intuitive, but it indicates that speed is the major factor in loss-of-control crashes on bends (as opposed to other potential issues, such as ice).

3.10.6. Issue involving high numbers of crashes on both state highways and local roads in Waitaki District

- The high rate of fatalities is associated with state-highway and local-road networks in Waitaki District.

4. Conclusion

4.1. Summarising the priorities for action

The number of serious and fatal crashes in southern New Zealand has not increased over the past few years. It is staying stable, with the exception of Gore and Southland districts, where it is decreasing. This means that we — the organisations involved with road safety in Otago and Southland — must reduce the level of fatal and serious injuries substantially. Then we need to look afresh at how we approach road trauma. In particular, we need to review our priorities to determine the matters on which we should be focusing most of our efforts.

The summary report, *Road safety in Otago and Southland regions: The top priorities for action,* with which this report is paired, identified the matters on which road-safety efforts need to focus in Otago and Southland, setting these out as three levels of priority. These priorities are:

1. The Top 5 issues:

- vulnerable road users:
  - motorcylists — area of high concern in the national strategy
  - pedestrians — area of medium concern in the national strategy
  - cyclists — area of medium concern in the national strategy
- crashes in high-speed areas — area of high concern in the national strategy
- driving under the influence of alcohol — area of high concern in the national strategy.

2. The types of driver behaviour that stand out as being priorities for intervention in Otago and Southland (some of which overlap with the Top 5 issues) are:

- driving a vehicle while impaired:
  - driving while over the BAC limit (particularly in Otago) — area of high concern in the national strategy
  - driving while fatigued — area of medium concern in the national strategy
- non-compliance with road rules
  - failing to give way to a pedestrian (severe only in Otago) — part of an area of medium concern in the national strategy
- unpredictable behaviour:
  - travelling too fast for the conditions — area of high concern in the national strategy
  - making a dangerous manoeuvre.

3. There are some single district issues with lower numbers of crashes but with a likelihood of severe trauma.

The analyses reported in this second report identify the main issues associated with – causing or exacerbating or contributing to – serious road trauma in each district. The themes that stood out for each district are summarised below. The Top 5 priorities are prominent

amongst these themes, but the lists also contain some issues found in only one, or in a small number, of districts. (Note that any reference a single district or city refers to all that district or city's local roads and state highways not just to the roads managed by a district or city council.)

Central Otago District

- Local roads tend to host a high proportion of fatal and serious crashes (which may be associated with under reporting of minor crashes on local roads (yet to be determined).
- The district has a very high number of serious injuries for its population size.
- There is a serious road-safety issue associated with motorcycles.
- Many of the serious and fatal crashes happen on the weekend, particularly on a Saturday.
- Serious and fatal crashes disproportionately involve blood alcohol in excess of the legal limit.

Clutha District

- There is a serious road-safety issue associated with motorcycles.
- Head on collisions tend to involve particularly serious road trauma.
- The district has a serious road-safety problem, with two demographics in particular: young drivers (aged 10-19) and men.

Dunedin City

- Pedestrians crossing the road are disproportionately involved in fatal and serious crashes.
- There is a serious road-safety issue associated with motorcycles.
- There is a serious road-safety issue associated with cyclists.
- There is a serious road-safety issue associated with older drivers.
- Serious and fatal crashes are over-represented on roads with high-speed limits (80 km/h or higher).
- Serious and fatal crashes tend to occur midblock.
- Saturdays are hazardous for road safety.

Gore and Southland districts

- There is a serious road-safety issue associated with motorcycles.
- There is an extensive-testing regime for intoxication among road users involved in serious and fatal crashes, but alcohol does not play a huge role in fatal/serious crashes in these districts.
- Distraction, when implicated in a crash in these districts, leads to fatal or serious injuries (rather than to minor injury).

Invercargill City

- There is a serious road-safety issue associated with pedestrians.
- Serious and fatal crashes are over represented on roads with high-speed limits (80 km/h or higher).

- When an obstruction or lack of visibility is implicated as a factor in a crash, that crash is highly likely to have resulted in fatal or serious injury to at least one road user (rather than in minor injury).

Queenstown Lakes District

- Serious and fatal crashes happen when the road is dry.
- Serious and fatal crashes disproportionately involve cyclists.
- Serious and fatal crashes disproportionately involve blood alcohol in excess of the legal limit (when injuries are minor, these crashes are more likely to involve one or more parties in the crash recording a blood alcohol level over the legal limit).

Waitaki District

- Fatal and serious crashes tend to happen on high-speed roads.
- Crashes occurring in misty/foggy conditions tend to result in serious road trauma.
- Serious and fatal crashes disproportionately involve blood alcohol in excess of the legal limit.
- Serious and fatal crashes disproportionately involve vehicle-related issues (e.g. inadequate headlights, worn tyres, etc.).
- The district has a very high number of fatalities for its population size, compared to other regions in Otago

Although, amongst districts, the degree to which the main issues identified through these statistical analyses varies, one common theme stands out: Vulnerable users (motorcyclists, pedestrians and cyclists) are at particular risk of serious road trauma in southern New Zealand and should be a prime focus – even though they are not equally at risk in all districts. This issue requires tailored intervention programmes to be developed in those districts where the risk is highest.

The priority that this analysis gives to road safety for some vulnerable road users in Otago Southland diverges a little from the national priorities in *Safer Journeys*. Safe walking and cycling are areas of medium priority in *Safer Journeys* (relative to other potential issues), but are of high priority in Otago and Southland regions (specifically, pedestrians in Dunedin and Invercargill cities, and cyclists in Dunedin City and Queenstown Lakes District). In other respects, the other matters that scientific analysis suggests are priorities for reducing serious road trauma in Otago Southland priorities accord well with the national priorities in *Safer Journeys*.

In *Safer Journeys*. increasing the safety of young drivers is an area of great concern and the safety of older drivers is an area that continues to be of emerging focus. Our statistical analyses examined whether younger or older drivers were associated with serious road trauma in any of the districts in Otago-Southland. These demographic groups stand out as being at particular risk of serious road trauma in two districts only:

- older drivers (75 years plus) in Dunedin City
- young drivers (19 years or younger), particularly men, in Clutha District

The fact that the age of youthful drivers did not appear to be a significant-risk factor for serious road trauma in any other district may indicate the success of recent campaigns

targeting younger drivers. We analysed young drivers against crash severity for all districts and found it was associated with severe trauma in the Clutha district only.

It is also worth noting the reason why alcohol-related crashes do not rank particularly highly in Dunedin City and thus do not appear in the list of key findings above. Although alcohol-related crashes happen more frequently in Dunedin (due to population size), they are nowhere near as serious, on average, as alcohol-related crashes in Central Otago, Waitaki and Queenstown Lakes districts. As alcohol-related crashes rarely cause serious or fatal injury in Dunedin City, they are not a major concern there. This may because the speeds involved are lower.

4.2. Comments on data collection

This scientific analysis of road-safety issues in Otago-Southland demonstrated clearly the benefits of using all available sets of data – CAS, ACC and hospitalisation data – to determine the issues upon which the efforts to reduce road-safety trauma should focus. Use of CAS data alone fails to properly evaluate evidence of serious injuries suffered by vulnerable road users (motorcyclists, pedestrians and cyclists) and over-emphasises crashes involving cars, trucks and similar vehicles.

Because of the usefulness of analysing multiple data sets, the combined Otago Southland Regional Advisory Group (transport staff advising the regional transport committees) has recommended that better ways of aligning CAS, ACC and hospitalisation data need to be investigated, including further assessment of the information contained within the ACC and hospitalisation datasets, to strengthen the robustness of future road-safety priority setting.

4.3. Concluding comments

The findings set out in this report will assist the organisations involved with road safety in southern New Zealand — the regional transport committees of Otago and Southland, NZTA, TLAs, NZ Police and the ACC — to review their approach to road safety in their districts, to determine where and how to focus interventions to reduce the level of serious road trauma substantially. In particular, the report provides scientifically robust information for setting road-safety priorities in each district when undertaking strategic planning, business case and asset management planning.

The results for each district contain information needed to design effective intervention programmes (crash characteristic and causes, infrastructure characteristics and behaviours associated with fatal and serious road crashes), plus information needed to determine when to undertake interventions (weather and environmental conditions, timing of fatal and serious road crashes). The report also contains the information needed for districts to identify issues they share with other districts, to allow joint / common programmes to be developed and delivered efficiently.

Appendix

Results of analyses of ACC data, by district

Note that reference to a district or city refers to all that district or city's local roads and state highways, not just to the roads managed by a district or city council.

Table 5 Factors common in motor vehicle crashes in each district 2010-2013 inclusive (ACC claims, Motor Vehicle Account)

Note that unusual patterns are shown in bold text.

District	Activity prior to crash	Direct cause of clients' injury	Injury-contact point	Clients' road-user type
Central Otago District	Majority of clients were driving or riding; otherwise usually travelling as passenger	Most frequent single cause of injury was loss-of-control of vehicle, with a collision (primarily with another vehicle) in second place. **Very few in collision category, relative to other districts**	Most frequent cause of injury was a collision (with moving object or road user); second-most-frequent cause was hitting vehicle/ground while in vehicle (i.e. striking a non-moving vehicle or experiencing single-vehicle, run-off-road crash without hitting object). **Few in 'collision' category**	Majority of clients were car drivers and passengers. Second-most-frequent category involves motorcycle riders or motorcycle passengers
Clutha District	Majority of clients were driving or riding; otherwise usually travelling as a passenger	Most frequent single cause of injury was loss-of-control of vehicle, with a collision (primarily with another vehicle) in second place	Most frequent single cause of injury was a collision (with moving object or road user); second-most-frequent single cause was hitting vehicle/ground while in vehicle (i.e. either striking a non-moving vehicle or experiencing a single-vehicle, run-off-road crash, without hitting object)	Majority of clients were car drivers and passengers. Second-most-frequent category involves drivers or passengers of an '*Other*' category (typically heavy-vehicle drivers or passengers, namely buses and trucks)

District	Activity prior to crash	Direct cause of clients' injury	Injury-contact point	Clients' road-user type
Dunedin City	Majority of clients were driving or riding; otherwise usually travelling as passenger. Relative to other districts, **high proportion were walking or running**	Most frequent single cause of injury was a collision (usually with another vehicle); second-largest single cause of injury was loss-of -control of vehicle. **Very few in loss-of-control category, relative to other districts**	Most frequent single cause of injury was a collision (with moving object or road user); second-largest single cause of injury was impacting with non-moving object	Majority of clients were car drivers and passengers. **Second-most-frequent category involves pedestrians who were struck by a moving vehicle**
Gore District	Majority of clients were driving or riding; otherwise usually travelling as passenger	Most frequent single cause of injury was loss-of-control of vehicle, with a collision (primarily with another vehicle) in second place	Most frequent single cause of injury was a collision (with moving object or road user); second-most-frequent single cause was hitting vehicle/ground while in vehicle (i.e. either striking a non-moving vehicle or experiencing a single-vehicle, run-off-road crash, without hitting object)	Majority of clients were car drivers and passengers. Second-most-frequent category involves drivers or passengers of an '*Other*' category (typically heavy-vehicle drivers or passengers, namely buses and trucks)
Invercargill City	Majority of clients were driving or riding; otherwise usually travelling as passenger	Most frequent single cause of injury was a collision (usually with another vehicle); second-largest single cause of injury was loss-of -control of vehicle	Most frequent single cause of injury was a collision (with moving object or road user); second-most-frequent single cause was hitting vehicle/ground while in vehicle (i.e. either striking a non-moving vehicle or experiencing a single-vehicle, run-off-road crash, without hitting object)	Majority of clients were car drivers and passengers. Second-most-frequent category involves motorcycle riders or motorcycle passengers

District	Activity prior to crash	Direct cause of clients' injury	Injury-contact point	Clients' road-user type
Queenstown Lakes District	Majority of clients were driving or riding; otherwise usually travelling as passenger	Most frequent single cause of injury was a collision (usually with another vehicle); second-largest single cause of injury was loss-of -control of vehicle	Most frequent single cause of injury was a collision (with moving object or road user); second-most-frequent single cause was hitting vehicle/ground while in vehicle (i.e. either striking a non-moving vehicle or experiencing a single-vehicle, run-off-road crash, without hitting object)	Majority of clients were car drivers and passengers. Second-most-frequent category involves motorcycle riders or motorcycle passengers
Southland District	Majority of clients were driving or riding; otherwise usually travelling as passenger. Relative to other districts, **low proportion were walking or running**	Most frequent single cause of injury was loss-of-control of vehicle, with a collision (primarily with another vehicle) in second place	Most frequent cause of injury was a collision (with moving object or road user); second-most-frequent cause was hitting vehicle/ground while in vehicle (striking non-moving vehicle or experiencing single-vehicle, run-off-road crash without hitting object). **Many claims in '*Other*' category (i.e. involving rollovers)**	Majority of clients were car drivers and passengers. Second-most-frequent category involves motorcycle riders or motorcycle passengers. **Very few clients were cycling before the crash**

District	Activity prior to crash	Direct cause of clients' injury	Injury-contact point	Clients' road-user type
Waitaki District	Majority of clients were driving or riding; otherwise usually travelling as passenger	Most frequent single cause of injury was a collision (usually with another vehicle); second-largest single cause of injury was loss-of-control of vehicle	Most frequent single cause of injury was a collision (with moving object or road user); second-most-frequent single cause was hitting vehicle/ground while in vehicle (i.e. either striking a non-moving vehicle or experiencing a single-vehicle, run-off-road crash, without hitting object)	Majority of clients were car drivers and passengers. Second-most-frequent category involves motorcycle riders or motorcycle passengers

Table ?? Factors common in-road, non-motor-vehicle accidents in each district, 2010-2013 inclusive (ACC claims)

Note that unusual patterns are shown in bold text

District	Activity prior to accident	Direct cause of clients' injury	Injury contact point	External agency involved in the incident
Central Otago District	Most common activity that clients were engaged in before the accident was walking or running on the road or roadside. **Second-most-common category was recreational and/or sporting activity on road or roadside – very frequent in Central Otago, relative to other districts**	Most common cause of injury was a loss of balance and/or personal control. Second-most-common cause of injury was tripping or stumbling	Most common injury contact point involves contacting the ground/floor following the incident. Second-most-common injury contact point involves contacting an object	Most common external agency involved in the incident is the ground/path. Second-most-common external agency is the '*Other'* category, including situations where the client struck broken glass; a live animal [excluding dogs]; and a plant, bush or tree
Clutha District	Most common activity that clients were engaged in before the accident was walking or running on the road or roadside. Second-most-common category was recreational and/or sporting activity on road or roadside	Most common cause of injury was a loss of balance and/or personal control. Second-most-common cause of injury was tripping or stumbling	Most common injury contact point involves contacting the ground/floor following the incident. Second-most-common injury contact point involves contacting an object	Most common external agency involved in the incident is the ground/path. Second-most-common external agency is the '*Other'* category, including situations where the client struck broken glass; a live animal [excluding dogs]; or a plant, bush or tree

District	Activity prior to accident	Direct cause of clients' injury	Injury contact point	External agency involved in the incident
Dunedin City	Most common activity that clients were engaged in before the accident was walking or running on the road or roadside. Second-most-common category was recreational and/or sporting activity on road or roadside	Most common cause of injury was a loss of balance and/or personal control. Second-most-common cause of injury was tripping or stumbling	Most common injury contact point involves contacting the ground/floor following the incident. Second-most-common injury contact point involves contacting an object	Most common external agency involved in the incident is the ground/path. Second-most-common external agency is the '*Other'* category, including situations where the client struck broken glass; a live animal [excluding dogs]; and a plant, bush or tree
Gore District	Most common activity that clients were engaged in before the accident was walking or running on the road or roadside. Second-most-common category was recreational and/or sporting activity on road or roadside	Most common cause of injury was a loss of balance and/or personal control. Second-most-common cause of injury was tripping or stumbling	Most common injury contact point involves contacting the ground/floor following the incident. Second-most-common injury contact point involves contacting an object	Most common external agency involved in the incident is the ground/path. Second-most-common external agency is the '*Other'* category, including situations where the client struck broken glass; a live animal [excluding dogs]; or a plant, bush or tree
Invercargill City	Most common activity that clients were engaged in before the accident was walking or running on the road or roadside. Second-most-common category was recreational and/or sporting activity on road or roadside	Most common cause of injury was a loss of balance and/or personal control. Second-most-common cause of injury was being struck by a person or animal.	Most common injury contact point involves contacting the ground/floor following the incident. Second-most-common injury contact point involves contacting an object	Most common external agency involved in the incident is the ground/path. Second-most-common external agency is the '*Other'* category, including situations where the client struck broken glass; a live animal [excluding dogs]; or a plant, bush or tree

District	Activity prior to accident	Direct cause of clients' injury	Injury contact point	External agency involved in the incident
Queenstown Lakes District	Most common activity that clients were engaged in before the accident was walking or running on the road or roadside. Second-most-common category was recreational and/or sporting activity on road or roadside	Most common cause of injury was a loss of balance and/or personal control. **Second-most-common cause of injury was slipping or skidding on foot**	Most common injury contact point involves contacting the ground/floor following the incident. Second-most-common injury contact point involves contacting an object	Most common agency involved in the incident is the ground/path Second-most-common agency is '*Other'*, including situations where the client struck broken glass; live animal [excluding dogs]; or a plant, bush or tree. High number of claims involving **clients who were affected by wind, snow and/or ice**
Southland District	Most common activity that clients were engaged in was walking or running on road or roadside. Second-most-common was recreational and/or sporting activity. High number of claims involving clients who were **performing employment activities on road or roadside**	Most common cause of injury was a loss of balance and/or personal control. Second-most-common cause of injury was being struck by a person or animal	Most common injury contact point involves contacting the ground/floor following the incident. Second-most-common injury contact point involves contacting an object. High number of claims involving clients who were **kicked, butted or bitten by an animal**	Most common external agency involved in the incident is the ground/path. Second-most-common external agency is the '*Other'* category, including situations where the client struck broken glass; a live animal [excluding dogs]; or a plant, bush or tree.
Waitaki District	Most common activity that clients were engaged in was walking/running on the road or roadside. Second-most-common was '*Other/No Activity*'	Most common cause of injury was a loss of balance and/or personal control. Second-most-common cause of injury was '*Other cause/Unclear cause'*	Most common contact point involves contacting the ground/floor. Second-most-common injury contact point involves contacting object	Most common external agency is ground/path. Second-most-common agency is the '*Other'* category, including situations where client struck broken glass; live animal [excluding dogs]; or a plant, bush or tree