# FINAL REPORT

Project Title: R53: Identifying Higher Risk State-controlled Roads for Speed-Related Crashes 2016/17

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# SUMMARY



Speeding remains a significant contributing factor in fatal and serious injury crashes. The social cost of speed-related fatal and serious injury (FSI) crashes in Queensland is estimated at $283 million per year.

The aims of the study were to: conduct a literature review and crash analysis to identify the causes and contributing factors of speed-related crashes; identify the relationship between road features and speed-related crashes, if any; identify high-risk state-controlled roads for speed-related crashes; and propose treatment options to reduce the risk of speed-related crashes occurring.

The indicative findings from the crash analysis include the following:

- Five per cent of FSI crashes and 18% of fatal crashes on Queensland's State-controlled roads were classified as speed-related. This confirms other research findings suggesting that extreme behaviour contributes more strongly to fatalities.
- The relative proportion of speed-related crashes that resulted in a fatality increased with speed limit ranging from 10% in 50 km/h or less zones to 18% in 100-110 km/h zones.
- The relative proportion of fatal FSIs was higher for speed-related crashes than for non-speed-related crashes.
- Speeding-related crashes were more likely to have occurred on mid-block road sections.
- The majority of speed-related FSI crashes involved single-vehicles: 72% of the speed-related FSIs involved single vehicles compared to 40% for non-speed-related FSI crashes.
- Speed-related FSI crashes into roadside objects were over-represented, regardless of speed environment. The majority of speed-related FSI crashes involved hit-object (50%), double the proportion of the non-speed-related FSI crashes.
- Speed-related head-on and overturning FSI crashes were more common on high-speed roads, as expected in high-energy road departures.
- Speed-related crashes were over-represented on curves, with 54% of speed-related FSIs occurring on curves compared to 28% of non-speed-related crashes.
- Speed-related crashes were over-represented on grade, i.e. non-level road sections (risk ratio of 1.6).
- The main road-user crash factors for speed-related FSI crashes were 'disobey road rules' (22%) followed by 'controller condition' (18%), 'young adult (16-24 years)' (11%), 'alcohol-related' (10%), and 'distracted/inattentive' (8%).
- Speed-related crashes which were over-represented in crashes involving unlicensed drivers, 'controller condition', alcohol-related and motorcyclists compared to non-speed-related. For example, unlicensed drivers were 2.3 times more likely to be speeding when involved in FSI crashes.

The speed-related crash data was linked to 100 m long sections of AusRAP data to enable the road features at the location of these crashes to be examined and high-risk sites to be identified.

The speed-related crashes were not concentrated but spread across the network. This made it difficult to identify high-risk sections.

The top 20 high-risk State-controlled road sections with the highest number of speed-related FSI crashes were identified. An examination of the data suggested that risk of speed-related FSI crashes – compared with non-speed-related crashes – when travelling along the road was higher:

- for single-lane roads
- for very sharp curves
- for undivided roads
- where there is no shoulder or a narrow shoulder less than 1.0 m wide
- for roads where the clear zone on the passenger side is >10.0 m.

Road safety treatments which may be implemented to reduce the risk of speed-related crashes on the State-controlled network include the setting of speed limits and speed management, engineering road treatments and non-infrastructure treatments. These treatments have been reported in Sections 3.2 and 3.3.

The crash analysis was limited by the availability of operating speed data and the recording of speed-related crashes in the crash database. The definition of a speed-related crash is based on the Police report indicating speed as a contributing factor for at least one vehicle involved in a crash. The subjective nature of this assessment may result in the under-reporting of speed-related crashes.

There was no method available to differentiate between the two types of speed-related crashes – those resulting from driving faster than the posted speed limit and those driving too fast for the prevailing road conditions. Further development of the definition and capturing of speed-related crashes in the crash database would provide a more detailed understanding of the speed problem, allowing tailored treatment options to reduce the risk of the two types of speed-related crashes.

As technology is rapidly changing, and data capturing, and its management, is evolving, it is recommended that other data sources (e.g. Probe data) be explored that would enable the assessment of actual operating speeds of vehicles on the network in relation to where crashes are occurring. This would provide a better understanding of speed-related crashes on the network.

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# 1 INTRODUCTION

## 1.1 Background

Speeding is a significant contributing factor in fatal and serious injury crashes. A recent Queensland Department of Transport and Main Roads (TMR 2016) review found that fatalities attributed to speed represented 26% of the road toll in Queensland in 2014/15 and trending upwards. The social cost of speed-related fatal and serious injury (FSI) crashes in Queensland is estimated at $283 million per year.

A key finding from an Austroads project (Austroads 2014a) on speed limit setting in the Safe System context was that severe crash risk is high where there is a gap between travel speeds and the safety level of the road infrastructure. The report also concluded that speed limits should be compatible with road use (e.g. AADT, presence of pedestrians and cyclists), road users and existing speeds. It was recommended that high-risk crash sections on the state-controlled road network that had speed-related issues be identified and the linkages between speed-related crashes and the characteristics of the road infrastructure be investigated.

The project sought to address the following gaps in knowledge:

- the relationship between the road environment, the posted speed limit and the risk of fatalities and hospitalisation
- common features of sites at high-risk locations and the concentration of crashes
- how countermeasures could be developed to reduce the risk of speed-related crashes.

The identification of treatment options would assist TMR to reduce speed-related crashes and therefore the road toll.

## 1.1 Objectives

The aim of the project was to obtain a better understanding of speed-related crashes and to identify ways to reduce their occurrence and severity. This was achieved using AusRAP and road crash data to identify roads on the State-controlled road network where the posted speed limit has been found to be a contributing factor in fatal and hospitalisation crashes. Specific objectives included:

- identify those locations which had the highest risk of speed-related crashes
- identify possible treatments that could be applied at these locations
- provide recommendations to improve management practice and mitigate the risk of speed as an important contributing factor to road crashes.

## 1.2 Scope

The project scope included the following tasks:

- A literature review addressing the impact of speed on crashes, the factors that contribute to speed-related crashes, current treatments being implemented or adopted by road agencies, both nationally and internationally, to reduce the risk of speed-related crashes and gaps in current knowledge.
- Analyse AusRAP and road crash data and identify the locations of high-risk locations on the State-controlled network and correlate these locations with the number of speed-related crashes.

- Investigate the common factors involved in speed-related crashes, and what road features increase the risk of speed-related crashes. An improved knowledge of these factors will provide a greater understanding of what is contributing to speed-related crashes and allow appropriate countermeasures to be developed to assist TMR to manage and mitigate the risk of speed as a contributing factor in road crashes. Treatment options to address the problem of speeding and inappropriate speed choice may include engineering treatments, speed management and driver education.
- Prepare a report, including recommended treatments and improvements to deal with high-risk locations.

## 1.3 Definition of a speed related crash

There were two elements to consider when defining a speed-related crash:

- driving faster than the posted speed limit
- driving too fast for the prevailing weather, light, traffic and road conditions without taking full regard of vehicle condition and driver skills and experience.

No information was available in TMR's crash database to enable a differentiation to be made between the two types of speed issues, namely driving too fast for the conditions and driving faster than the posted speed limit. Therefore, for this study, a speed-related crash was defined as a crash where the Police report has indicated that speed was a contributing factor for at least one vehicle involved in a crash.

# 2 METHODOLOGY

The methodology used in this project was as follows.

## 2.1 Literature Review

### *2.1.1 Search method*

In order to identify relevant research, a literature review was conducted using the resources of ARRB's MG Lay Library. These resources included the Library's own comprehensive collection of technical land transport literature and information retrieval specialists with extensive experience in the transport field, as well as access to the collections and expertise of other transport-related libraries throughout Australia and internationally.

Used specifically in this literature search were the Australian Transport Index (ATRI) and Transportation Research Information Documentation (TRID) databases. The use of these databases ensured wide coverage of research material within the subject area from both national and international sources.

### *2.1.2 Background research*

Significant national and international research in relation to speed-related crashes has been undertaken in recent years. This includes research sponsored by Austroads which provides guidance for the setting of speed limits and various treatment options to reduce vehicle speeds in rural, urban and high-speed environments.

The outcomes of this research were particularly relevant to this study and provided a significant input into the literature review. This was supplemented by published papers and internet search results. The relevant Austroads reports include:

- *Infrastructure/speed limit relationship in relation to road safety outcomes* (Austroads 2010)
- *Model national guidelines for setting speed limits at high-risk locations* (Austroads 2014a)
- *Methods for reducing speeds on rural roads compendium of good practice* (Austroads 2014b)
- *Achieving safe system speeds on urban arterial roads: compendium of good practice* (Austroads 2016a)
- *Speed reduction treatments for high-speed environments* (Austroads 2016b).

## 2.2 Data Analysis

The data analysis involved the following data sets:

- fatal and serious injury (FSI) crash data sourced from TMR – eight-year period (2008-2015)
- AADT and speed limit data – sourced from the TMR ARMIS database
- AusRAP data – road features coded at 100 m intervals based on a 2015 video survey of the road network.

### *2.2.1 Fatal and serious crash data analysis*

The latest available FSI crash data (2008-2015) sourced from TMR for state-controlled roads included both urban and rural roads. This data was analysed to identify any trends and factors contributing to speed-related crashes. The analysis included an assessment of:

- Which crash types were commonly involved in speed-related crashes according to DCA code?

- Where were they occurring, e.g. on curves or straights, intersections, rural or urban roads, sealed or unsealed roads?
- When were they occurring, e.g. night or day, wet or dry?
- What was the impact of speed limit?
- Who was involved in speed-related crashes, e.g. driver age and gender, which road users (motorcyclists, heavy vehicles, pedestrians, cyclists, etc.), single or multiple vehicles, impaired drivers (fatigue, alcohol/drugs, distraction, etc.)?

Exploratory, descriptive univariate analysis of crash data patterns was carried out to identify potential risk factors.

#### 2.2.2 Identification of high-risk sites

The speed-related crash data was linked to 100 m long sections of AusRAP data. The chainage (TDist) from the crash data and the distance field in the AusRAP data were linked to combine the two data sets. This combined data was then used to determine those road sections on the network which had the highest number of speed-related crashes.

A review of the crash locations indicated that the speed-related crashes were not concentrated, but rather spread across the network. Therefore, the 100 m long sections were grouped into 3 km long sections for the purpose of identifying high-risk sections. A high-risk section was defined as where three or more speed-related FSI crashes had occurred within the 3 km section.

#### 2.2.3 Investigation of relationship between crash relationships and road infrastructure

The speed-related crash data was linked to 100 m sections of AusRAP data and compared to non-speed-related crashes to identify whether the two measures of risk were geographically correlated, i.e. have similar characteristics, or whether particular road features were over-represented in speed-related crash sections compared against all crash types. The aim of this analysis was to improve understanding of the factors that would assist in the identification of high-risk speed-related crash sections in the future, and to develop treatment options to reduce the risk of speed-related crashes.

Descriptive, exploratory analysis of the relationships was part of the project scope. More in depth multivariate analysis was not conducted due to the limited data available.

## 2.3 Identification and Selection of Treatments

Based on the literature review and the findings of the data analysis, possible treatments were identified to reduce the risk of speed-related crashes on the State-controlled network. Specific recommendations should feed into TMR standards and practices (for example: speed limit setting and input into future revisions of the Manual of Uniform Traffic Control Devices, Part 4 and the Crash Reduction Factors matrix).

# 3 LITERATURE REVIEW

As already discussed, the focus of the literature review was to identify the causes and contributing factors of speed-related crashes and to identify current treatment options that could be adopted to reduce the risk of speed-related crashes. The review covers the definition and limitations of the recording of speed-related crashes by the Police in the crash database.

## 3.1 Speed and its Impact on Crashes

### *3.1.1 Definition of a speed-related crash*

According to TMR (2014), there are two elements to consider when defining a speed-related crash:

- *'violation – exceeding speed limit'* – driving faster than the posted speed limit
- *'violation – excessive speed for circumstances'* – driving too fast for the prevailing weather, light, traffic and road conditions without full regard for the vehicle condition and driver skills and experience. The driver may not necessarily be exceeding the speed limit.

The Queensland crash database does not distinguish between crashes that resulted from these two types of speed violations. They are both recorded as a speed-related crash, making it impossible to differentiate between the two types of speed issues.

In a fatal crash, 'exceeding the speed limit violation' may be determined by extensive investigation by the Forensic Crash Unit (FCU), but generally the assessment as to whether a crash is speed-related is based on the investigating Police officer's judgement and witness accounts of what occurred. As it is a subjective assessment, speed-related crashes may not be accurately captured in the crash database, i.e. they are likely to be under-reported.

For this study, a speed-related crash was limited to a crash where the Police report has indicated speed as a contributing factor for at least one vehicle involved in a crash. Despite the limitation, this approach is consistent with other speed-related crash studies (Liu & Chen 2009; Austroads 2010 and 2014b).

Liu & Chen (2009) highlights the importance of differentiating between speed-related crashes involving 'driving too fast for the conditions' and 'in excess of the posted speed limit', particularly for the development of targeted countermeasures. Six states in the USA specify whether a driver was travelling too fast for the conditions or exceeding the posted speed limit in their data system. Liu & Chen examined this data to determine how these two factors contributed to speed-related crashes and found that:

- 55% of all speed-related fatal crashes were due to 'exceeding the posted speed limit' compared to 45% for 'driving too fast for the conditions'
- 26% of all speed-related injury crashes were due to 'exceeding the posted speed limit' compared to 74% 'driving too fast for the conditions'
- 18% of all speed-related property damage only crashes were due to 'exceeding the posted speed limit' compared to 82% 'driving too fast for the conditions'.

The findings imply crashes due to travelling above the speed limit resulted in more severe injury outcomes compared to driving too fast for the road conditions.

Gavin et al. (2010) examined the impact of speed differential above the speed limit on the road toll in NSW. Using 2008 speed survey data and crash data from 2006 to 2008, they estimated crash risk based on the power model developed by Kloeden et al. (1997), Kloeden, Ponte & McLean (2001) and Elvik (2009). They demonstrated that travelling up to 10 km/h over the speed limit contributed to around 43-67% of speed-related fatal crashes and that travelling up to 20 km/h over the speed limit contributed to around 74-92% of speed-related fatal crashes.

Analysis of the speed data indicated that a large proportion of drivers were exceeding the speed limit by a small margin with less than 5% found to be exceeding the speed limit by more than 20 km/h (Gavin et al. 2010).

When Gavin et al. (2010) combined the speed data with the relative risk of speeding model, it became apparent that the number of low-level speeders contributed to a large proportion of the risk associated with speeding. Similarly, Alavi, Keleher & Nieuwesteeg (2014), found that 79% of speeding-related casualty crashes could be attributed to low-level speeding (driving up to 10 km/h above the speed limit) with excessive speeding (≥21 km/h above the speed limit) likely to contribute to around 4% of speeding-related casualty crashes in Victoria.

### 3.1.2 Safe speeds and Safe System approach

The aim of the Queensland Road Safety Strategy, which is based on the Safe System approach, is to reduce fatalities by 30% in support of the Australian National Road Safety Strategy. The Safe System approach to road safety takes into account human error and human physical tolerance; it provides a forgiving road system with the aim of preventing serious injury or death in the event of a crash.

A report by Austroads (2005) summarised the biomechanical tolerances of humans for different crash types. The findings are presented in Table 3.1. They show approximate impact speed thresholds for fatality risk (10% probability) citing Wramborg (2005). Similar approximate figures are presented for the FSI threshold (also 10% probability), based on more recent evidence (Austroads 2015a).

**Table 3.1: Biomechanical tolerances of humans to severe injury**

| Crash type | Fatality threshold impact speed (km/h) | FSI threshold impact speed (km/h) |
|---|---|---|
| Car/pedestrian | 20-30 | 20 |
| Car/motorcyclist | 20-30 | 20 |
| Car/tree or pole | 30-40 | Not available |
| Car/car (side impact) | 50 | 30 |
| Car/car (head-on) | 70* | 30 |
| Car/car (rear-end into stationary) | Not available | 55 |

* Unclear if this refers to closing speed or individual vehicle speed.

Source: Austroads (2005) citing Wramborg (2005), Austroads (2015a).

Safe speed is one of the four pillars of the Safe System approach to road safety (Figure 3.1). It involves effective speed management through safer and more accepted speed limits that consider the risks on different parts of the road system. It requires more responsive setting and notification of speed limits for locations based on crash risk. In areas with large numbers of vulnerable road users or substantial collision risk, speed management, supplemented by road and roadside treatments, is a key strategy for limiting crashes.

**Figure 3.1: Safe System approach to road safety**


Source: Ministry of Transport (2013).

### *3.1.3 Speed and crash risk*

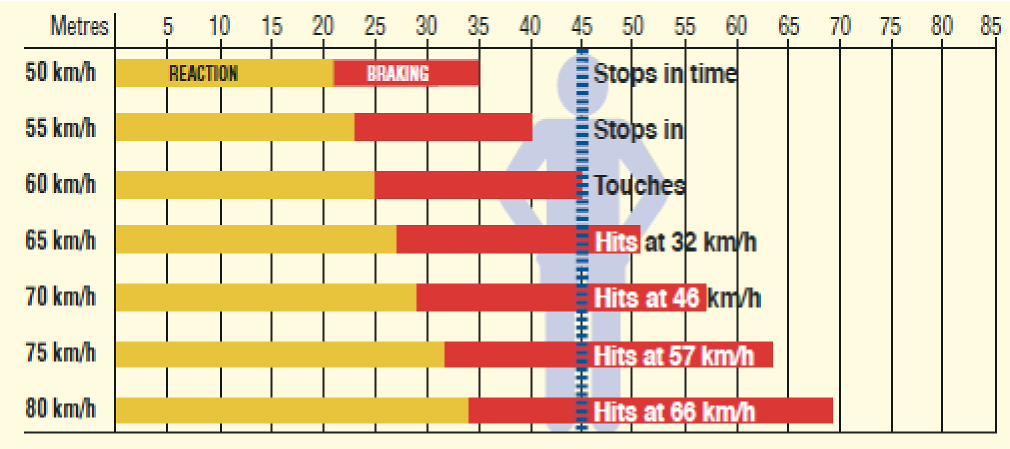
Speeding, whether it be driving faster than the posted speed limit or travelling too fast for the road conditions, is a significant factor in crashes. It contributes to both crash occurrence and severity. According to the OECD (2006), speed is a factor in up to one-third of fatal crashes in high income countries. The higher the speed, the higher the likelihood of a crash occurring and the greater the outcome of the crash severity (Patterson, Frith and Small 2000). Vehicle speed directly affects the force of impact during a collision. An increase in speed leads to an increase in the following factors and, in turn, an associated increase in the risk of crash (Paterson et al. 2000):

- stopping distance – both the distance travelled during the reaction time and the distance travelled after the brakes are applied
- the probability of exceeding the critical speed on a curve
- the chance of other road users misjudging how fast the speeding driver is travelling
- the probability of a rear-end crash if the driver has not accounted for the increased speed by increasing the following distance.

The combined effects of reaction and braking times on overall stopping distance are shown in Figure 3.2.

The relationship between speed and safety is outlined in SMOV (2012). They discuss two pillars, the first being the relationship between collision speed and the severity of a crash. Higher driving speeds lead to higher collision speeds and thus to more severe injury. The second pillar is the relationship between speed and the risk of a crash. The higher the speed, the higher the risk of being involved in a crash. Higher speeds also provide less time to react and therefore the breaking distance is longer.

**Figure 3.2: Impact of speed on the combined effect of reaction and braking distance (overall stopping distance)**



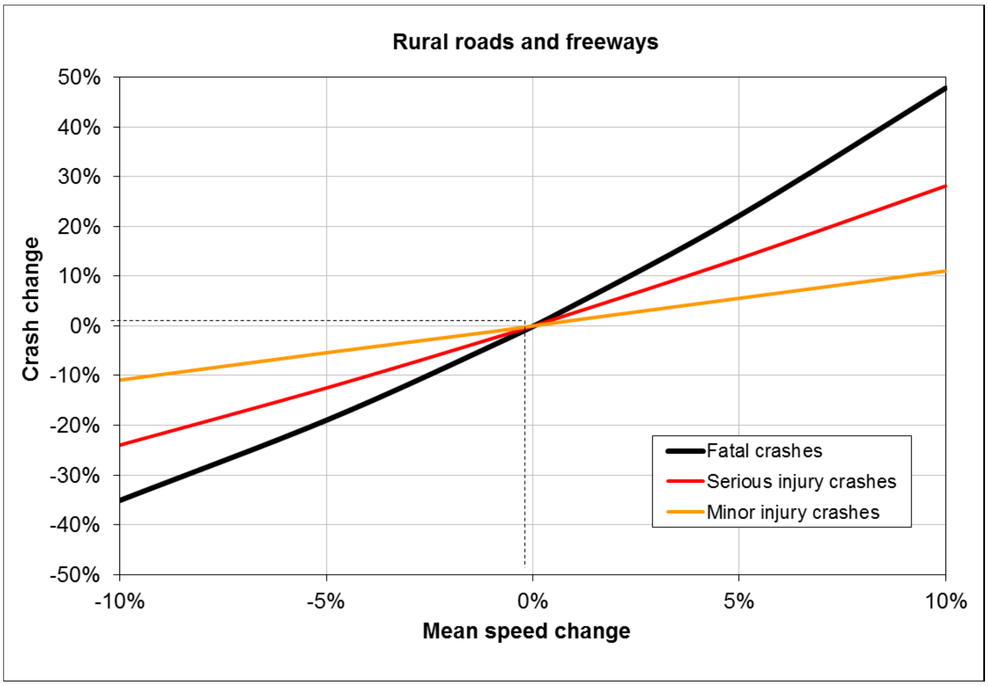

Source: Australian Transport Safety Bureau (2004).

Austroads (2014b) reported that speed contributes to around 28% of all fatal rural crashes in Australia, and 31% in New Zealand. On urban roads, speed accounted for 38% of fatal and serious injury crashes (Austroads 2015b).

The results of an analysis of serious injury and fatal crashes in Australia and New Zealand from 2001 to 2010 were reported in Austroads (2015b). Of those crashes determined as speed-related, almost half resulted in fatalities and serious injury in Australia and approximately 30% in New Zealand.

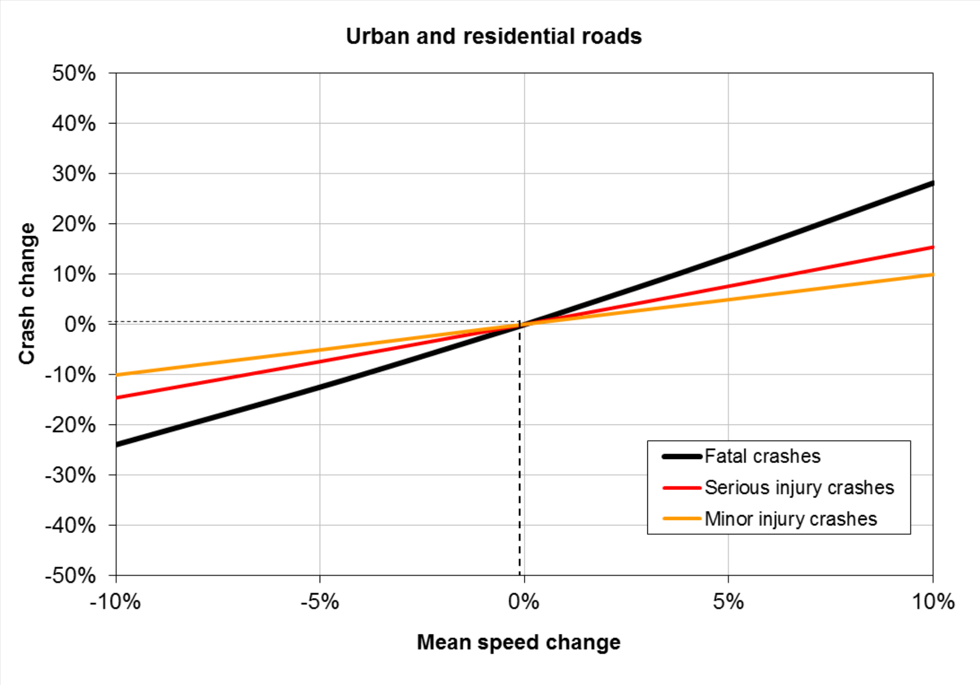
Nilsson (1982, 2004), Elvik, Christensen & Amundsen (2004) and Elvik (2009) examined the relationship between speed and safety. They reported that the relationship can best be described as a power function, meaning the crash rate increases more rapidly when the speed increases and vice versa. Small reductions in mean speeds can result in substantial decreases in fatal and serious injury crashes (Austroads 2016a). The relationship between mean speed change and safety outcomes is presented in Figure 3.3 and Figure 3.4 (Elvik 2009 cited in Austroads 2014a).

**Figure 3.3: Mean speed changes versus expected crash changes for rural roads and freeways**



Source: Austroads (2014a).

**Figure 3.4: Mean speed changes versus expected crash changes for urban and residential roads**




Source: Austroads (2014a).

A number of studies relating the effects of varying free vehicle speeds on crash outcomes were identified in Austroads (2010), including issues of speeding or driving below the average speed. The key findings included the following:

- Individual drivers travelling slower than the average speed were not at higher risk of casualty crashes.
- Free-flow speeds lower than the average somewhat reduced the risk of casualty crash involvement.
- Free-flow speeds higher than the average dramatically increased the risk (risk approximately doubles every 5 km/h above the average in urban areas).
- The same amount of uniform reduction in free speeds on rural roads was expected to produce a higher percentage reduction in casualty crashes than on urban roads.
- In collective terms, minor speeding was a greater burden on the community than excessive speeding. The cumulative effect of a small additional risk multiplied by a high number of drivers resulted in more casualties than the cumulative effect of a few drivers who speed by a large margin (who carry a much greater individual risk of a crash).

### *3.1.4 Factors associated with speed-related crashes*

Austroads (2014b) examined rural crashes and found that a higher proportion of speed-related crashes occur:

- at night or in the early morning
- on curved roads
- at mid-block sections (as opposed to intersections)
- on hilly roads
- on wet roads.

Also, a higher proportion of rural speed related crashes involved:

- not wearing a seat belt
- alcohol or drugs
- motorists aged 17-24 years
- motorcycles.

Federal Highway Administration (2010) examined crash data to help define crash, vehicle, and driver characteristics that seemed to result in a higher probability of speed-related crashes. It was found that a higher percentage of speed-related crashes:

- involved single-vehicle, run-off-road crashes compared to multi-vehicle crashes
- increased with the speed limit
- occurred on curves
- occurred at night
- involved:
  - motorcycle operators (two to four times higher than for car drivers)
  - younger drivers (21–25 year-olds)
  - males
  - non-users of restraints
  - drivers under the influence of alcohol (i.e. two to four times higher than drivers not under the influence of alcohol)
  - drivers with prior speeding convictions
  - drivers with no license or invalid license
  - distracted drivers.

Liu & Chen (2009) examined how speed-related crashes were affected by the road environment. The main findings of their review were as follows:

- A higher proportion of speed-related crashes due to driving too fast for the conditions occurred on adverse road surface conditions during cooler months. This same seasonal distribution was not as prevalent for speed-related crashes resulting from exceeding the posted speed limit.
- The relative proportion of crashes that occurred on curved sections of road was much higher for both types of speed-related crashes.
- Speed-related crashes were more likely to have occurred on mid-block sections for both speed-related crash types.

### *3.1.5 Factors influencing speed choice*

It was noted in Austroads (2014) that the following factors influence driver speed choice:

- Behavioural issues including:
  - self-image
  - influence of passengers
  - perception of enforcement, trip purpose, attitudes to safety including crash history
  - comparison with other drivers.

- Traffic-related factors:
  - volume of other vehicles and pedestrians
  - speed of other vehicles
  - presence of parked vehicles (this may be related to road width).
- Road environment:
  - road layout including lane width and shoulder width
  - roadside development
  - hazards and activity
  - presence of medians
  - number of access points
  - horizontal alignment
  - sight distance
  - road smoothness/roughness.

The road environment factors had a greater influence in combination rather than individually (Austroads 2014).

## 3.2 Engineering Treatments for Managing Speed

A comprehensive review of treatments to achieve Safe System speeds was reported by Austroads (2014, 2016a, 2016b). These treatments – which have been adopted both nationally and internationally to reduce the risk of speed-related crashes – are summarised in Table 3.2 to Table 3.8. Treatment options have been categorised into intersections, mid-block, curves, approaches to towns, school zones, railway level crossings and roadworks.

The crash modification factors presented are for casualty crashes, with the speed reduction values reflecting changes in mean and 85$^{th}$ percentile speed. Although the individual treatments are listed, in practice a combination of treatments may be applied.

### Table 3.2: Summary of intersection treatments

| Treatment type | Brief description | Crash modification factor (CMF)(1) | Speed reduction (1) | Usage | Cost | Treatment life |
|---|---|---|---|---|---|---|
| Vehicle-activated signs (VAS) | Used to warn drivers of changes in road conditions/emerging hazards. They are mainly installed in locations with an existing crash history or where the use of standard static warning signs has not been effective in altering driver behaviour. | 0.40 for rural | 5 km/h 85th percentile speed and 2 km/h mean speed for rural roads | Shows promise | Medium | 10 years+ |
| Roundabouts | Intersection control measure implemented to reduce speeds and reduce road user conflict points. | 0.25 | 10 km/h 85th percentile speed | Well established | High | 20 years+ |
| Signalised roundabout (2) | Entry into the roundabout is gated by signals or movements are controlled by signal phasing. Signal operation can be full-time or part-time, e.g. in peak times only. | 0.72 | Unknown | Emerging | High | 20 years+ |
| Turbo roundabout | Multi-lane roundabouts where vehicles are required to enter the roundabout in specific lanes depending on which exit they wish to take. | 0.30 | Unknown | Shows promise | High | 20 years+ |
| Raised intersections | Either the entire intersection is raised, acting as a type of speed platform, or raised sections can be placed in advance of the intersection (sometimes referred to as raised stop bars). | 0.60 | 8 km/h 85th percentile speed 3 km/h mean speed | Shows promise | Medium – high | 20 years+ |
| Horizontal deflection on approaches | Installation of kerb extensions, medians and/or pedestrian refuge islands to alter the physical layout of the intersection approach. The treatments are designed to slow vehicles to a safe intersection speed. | Up to 0.65 | 5 km/h 85th percentile speed | Emerging | Medium | 10 years+ |
| Perceptual countermeasures | Manipulations of the road environment to influence drivers' speed behaviour on intersection approach, e.g. transverse bars or linemarking, enhanced edge-post spacing. | 0.40 for rural | 8 km/h 85th percentile speed for rural roads | Shows promise | Low | 1–5 years |
| Transverse rumble strips | Lines or sections of profiled road markings placed across the carriageway to cause noise and vibration in the vehicle to alert the driver to the presence of an intersection. | 0.80 for rural | 5 km/h 85th percentile speed for rural roads | Shows promise | Low | 1–5 years |
| Reduce excessive sight distance | Involves reducing 'excess' sight visibility at the intersection (particularly roundabouts) so that drivers do not anticipate gaps in traffic too far in advance. | 0.60 (roundabouts) | 18 km/h 85th percentile speed (roundabouts) | Shows promise | Low | 5–10 years |
| Lower speed limits | Involves lowering the mandatory (posted) speed limit on the approaches to the intersection. | Unknown | Unknown | Emerging | Low | 10 years+ |
| Variable speed limits (VSL) | Dynamic speed limit signs that activate based on changing traffic speed, traffic volume, weather, and road surface conditions. Some activate a lower speed limit for through traffic when vehicles approach the intersection from a side road. (3) | 0.92 for rural | 17 km/h 85th percentile speed for rural | Emerging | Low – medium | 10 years+ |

| | | | | | | |
|---|---|---|---|---|---|---|
| Lane narrowing | Narrowing lane width on approach or at intersections through perceptual and physical measures, e.g. kerb extensions, wide medians or shoulders. | 0.70 | 7 km/h 85th percentile speed | Emerging | Low – medium | 15 years |
| Signals: green wave | Local coordination of adjacent traffic signals or linking several signals at intersections along a particular route on major urban arterial roads such that a vehicle travelling at a recommended speed will be rewarded with consecutive green lights. | Unknown | Unknown | Well established | Low | 1–5 years |
| Signals: dwell on red | An all red phase is displayed when there is no traffic or pedestrian demand. The red signal is displayed until the system is activated by a vehicle (via detection) or pedestrian (when manually activated). Used where there is high night-time pedestrian activity. | 0.55 | 11 km/h 85th percentile speed | Emerging | Low | 1–5 years |
| Advance warning signs | Used in advance of intersections to raise attention level and slow down motorists. | 0.7 | Unknown | Well established | Low | 5-10 years |
| Increasing the prominence of the intersection | Markings to make the intersection more prominent. | Unknown | 10 km/h mean speed | Untested | Low | 1-5 years |

Source: Austroads (2014b), Austroads (2016a), Austroads (2016b).

1 Suggested maximum values will differ based on factors such as the road environment and design of the treatment.

2 Effectiveness over and above roundabout effect.

3. A recent New Zealand study by Mackie et al. (2017) showed rural VSL sites had FSI CMF of 0.21 and all-crashes CMF of 0.49.

### Table 3.3: Summary of mid-block treatments

| Treatment type | Brief description | Crash modification factor (CMF)(1) | Speed reduction (1) | Usage | Cost | Treatment life |
|---|---|---|---|---|---|---|
| Humps/platforms (2) | Vertical deflection treatments used to control speed, with various forms of speed humps available for different road types. | 0.60 | Up to 25 km/h 85th percentile speed<br>25 km/h mean speed | Shows promise | Medium – high | 10 years+ |
| Vehicle-activated signs (VAS) | Dynamic signs displaying speed or hazard warnings when an approaching vehicle exceeds the threshold speed. | 0.65 for rural | 10 km/h 85th percentile speed for rural | Emerging | Medium | 5–10 years |
| Raised pedestrian crossings/wombat crossings | Similar profile and speed reduction effect as flat-top speed humps but differ by giving priority to pedestrians rather than motorists. | 0.60 | 9 km/h 85th percentile speed<br>8 km/h mean speed | Emerging | Medium – high | 10 years+ |
| Road diet | Road narrowing measure typically involving the conversion of a four-lane road (two each way) into a road with only one lane in each direction, and a central two-way right-turn lane. | 0.65 | 4 km/h 85th percentile speed<br>5 km/h mean speed | Emerging | Low – medium | 1–5 years |
| Pedestrian refuge | Raised median island in the middle of the road with at-grade space provided for pedestrians to wait until a gap in traffic allows them to cross the road. | 0.75 | Unknown | Well established | Low – medium | 20 years+ |
| Medians | Involves separation of opposing traffic streams, and typically the narrowing of existing lanes. | 0.85 for flush median<br>0.54 for raised median | Mixed results | Well established | Medium – high | Up to 10 years+ |
| Gateway treatments | Use of signs with other techniques to create a threshold or gateway between high and low speed environments. | up to 0.60 for rural | Unknown for urban<br>25 km/h 85th percentile speed<br>15 km/h mean speed for rural | Shows promise (well established for rural) | Low – medium | 5–20 years |
| Transverse rumble strips | Audio-tactile treatments applied transversely or across the driving lane to warn of approaching hazards. | Unknown<br>up to 0.64 for rural | Unknown | Emerging | Low | 1–5 years |
| Shared spaces/naked roads | Urban design concept where the priority for users is shifted from vehicles towards pedestrians and cyclists, complemented by a speed limit reduction. | Mixed results | 13 km/h mean speed | Emerging | Medium – high | 10 years+ |
| Lower speed limits | Involves managing posted speed limits, revising them towards Safe System levels. | 0.75 for urban | 6 km/h 85th percentile speed | Well established | Low | 10 years+ |
| Variable speed limits (VSL) | Dynamic signs displaying variable statutory speed limits depending on prevailing traffic, weather and road conditions. | 0.92 | Unknown | Well established | Low | 10 years+ |
| Variable message sign (VMS) | Traffic control device used for warning drivers of changing conditions and for traffic management and routing. | 0.90 | Up to 2 km/h mean speed | Well established | Low– medium | 10 years+ |
| Repeater signs | Speed restriction sign used to reinforce the posted speed limit that applies to the speed zone or speed limit in a specific area. The signs are smaller than the speed limit sign. | Unknown | Up to 4 km/h mean speed | Well established | Low | 5–10 years |
| Speed limits | Setting an appropriate rural speed limit. | Unknown | 4 km/h mean speed | Emerging treatment | Low | 5-10 years |

| Treatment type | Brief description | Crash modification factor (CMF)(1) | Speed reduction (1) | Usage | Cost | Treatment life |
|---|---|---|---|---|---|---|
| Road narrowing | Road narrowing to reduce speeds, using physical or perceptual measures, or a combination of both. | Unknown | 5 km/h mean speed | Shows promise | Low–medium | 5–10 years |
| Weather activated speed limit signs | Use of dynamic message signs to inform drivers of adverse weather conditions (e.g. fog, wind, snow) and static signs to inform of changes in speeds when these conditions are present. | Unknown | 5 km/h mean speed | Shows promise | Low–medium | 5–10 years |

Source: Austroads (2016a), Austroads (2014b).

1 Suggested maximum value. This will differ based on factors such as the road environment and design of the treatment.

### Table 3.4: Summary of treatments at curves

| Treatment type | Brief description | Crash modification factor (CMF) | Speed reduction | Usage | Cost | Treatment Life |
|---|---|---|---|---|---|---|
| Advance warning signs | Used in advance of curves to raise attention level and slow motorists. | 0.75 | Unknown | Well established | Low | 5-10 years |
| Chevron alignment markers (CAMs) | Used to indicate presence and severity of curves. | 0.70 | 3.5 km/h | Well established | Low | 5-10 years |
| Speed advisory signs | Sometimes used to help indicate the comfortable travelling speed (and hence the severity) of a curve. | 0.60 | Unknown | Well established | Low | 5-10 years |
| Vehicle-activated signs | Once triggered by approaching speed exceeding threshold speed limit, sign displays the hazard. | 0.65 | 6 km/h | Emerging treatment | Medium | 5-10 years |
| Other delineation devices | Includes guide posts, linemarking, pavement markers, etc. to provide additional guidance for safe roadway negotiation. | 0.8 to 0.95 | May increase | Well established | Low | 1-5 years |
| Transverse rumble strips | Audio-tactile treatments applied transversely or across the driving lane to warn of approaching curves. | Unknown | 5 km/h | Shows promise | Low | 1-5 years |
| Perceptual countermeasures | Changing the motorists' perception of the environment to improve safety, e.g. creating an illusion that a curve is tighter than it is. | Unknown | 10 km/h | Shows promise | Low – medium | 1-5 years |
| Route-based curve treatments | Consistent application of curve treatment(s) along a route. | Unknown | Unknown | Untested | Low – medium | Up to 10 years |
| Slow markings | Road markings in advance of a curve to indicate the need to slow down. | Unknown | 5% | Untested | Low | 5-10 years |

Source: Austroads (2014b).

**Table 3.5: Summary of treatments at the approaches to towns**

| Treatment type | Brief description | Crash modification factor (CMF) | Speed reduction | Usage | Cost | Treatment life |
|---|---|---|---|---|---|---|
| Advance warning | Signage warning of a lower speed environment ahead. | Minimal | Minimal | Well established | Low | 5-10 years |
| Buffer zones | A short length of speed zone used to provide a stepped change between adjacent sections of road that have different speed limits. | Minimal | Minimal | Well established | Low | 5-10 years |
| Count-down signs | Count-down signs in advance of towns displaying a decreasing number of diagonal marks until a new speed limit comes into force. | Minimal | Minimal | Untested | Low | 5-10 years |
| Rural thresholds / gateway treatments | Use of signs with other techniques to create a rural threshold or gateway between high and low speed environments. | 0.65 | 25 km/h | Well established (NZ only) | Low-Medium | 5-20 years (depends on treatment used) |
| Vehicle-activated traffic signals | Signs are triggered by approaching vehicles that exceed a threshold speed. | Unknown | Unknown | Untested | Medium | 5-10 years |

Source: Austroads (2014b).

**Table 3.6: Summary of rural treatments at railway level crossings**

| Treatment type | Brief description | Crash reduction | Speed reduction | Usage |
|---|---|---|---|---|
| Transverse rumble strips | Audio-tactile treatments applied transversely (across the traffic lane) in advance of rail level crossings. | Unknown | 5 km/h | Shows promise |
| Speed limits | Regulatory speed limit signs to reduce speeds at railway level crossings. | Unknown | 10 km/h | Shows promise |

Source: Austroads (2014b).

### Table 3.7: Summary of school zone treatments

| Treatment type | Brief description | Road user effect | Speed reduction | Usage |
|---|---|---|---|---|
| Flashing lights | Flashing beacon/lights added to a school zone sign to indicate operation of the zone and to increase sign conspicuity. | ▪ Increases awareness of school zone | 10 km/h mean speed | Well established |
| Static speed limit signs | Static signs displaying reduced school zone speed limits and when these are applicable. | ▪ Slight increases in compliance, however, the magnitude of this effect is not available | 6 km/h 85th percentile speed | Well established |
| Variable speed limit signs (VSL) | Dynamic road signs displaying variable school zone speed limits. | ▪ Increases driver awareness<br>▪ Increased compliance | 10 km/h 85th percentile speed<br>9 km/h mean speed | Well established |
| Vehicle-activated signs (VAS) | Dynamic signs displaying speed when an approaching vehicle exceeds the threshold speed. | ▪ Increased compliance | 16 km/h 85th percentile speed<br>12 km/h mean speed | Well established |
| Wombat crossing | Similar profile and speed reduction effect as flat-top speed humps but they differ in that they give priority to pedestrians rather than motorists. | ▪ Increases pedestrian visibility | 4 km/h 85th percentile speed | Well established |
| Advance warning sign | Static warning sign on approach to a school zone. | ▪ Increases awareness of school zone | 8 km/h 85th percentile speed | Well established |

Source: Austroads (2016a).

### Table 3.8: Summary of roadworks treatments

| Treatment type | Brief description | Road user effect | Speed reduction | Usage |
|---|---|---|---|---|
| Vehicle activated signs (VAS) | Dynamic signs displaying speed limit in the work zone when an approaching vehicle exceeds the threshold speed. | ▪ Increased compliance<br>▪ Increases driver awareness | Up to 19 km/h mean speed | Well established |
| Variable message signs (VMS) | Traffic control device used to warn drivers of changed or real-time work zone conditions. | ▪ Increased compliance<br>▪ Increased vehicle speeds towards the end of the work zone<br>▪ Increased traffic flow in work zones, with reduced delays<br>▪ More effective when used with speed recording device | Up to 18 km/h 85th percentile speed<br>Up to 6.4 km/h mean speed | Well established |
| Variable speed limit signs (VSL) | Dynamic road signs displaying variable work zone speed limits. | ▪ Reductions in travel time through the work zone<br>▪ Reduced speed variability near the activity area of the work zone | 12 km/h mean speed | Well established |
| Speed limit sign | Static sign displaying work zone speed limits. | ▪ Increased compliance levels where the speed limit sign was associated with a speed limit reduction | Unknown | Well established |
| Lane narrowing | Reduction of lane width through a work zone. | ▪ Unknown | Up to 16 km/h mean speed | Well established |
| Portable rumble strips | Portable audio-tactile strips applied across the driving lane to warn of work zone. | ▪ Drivers may manoeuvre around the rumble strips | 3 km/h mean speed | Emerging |

Source: Austroads (2016a).

## 3.3 Non-infrastructure Treatments

The focus of the literature review was to identify engineering treatments; however, some non-engineering treatments have also been successful in reducing vehicle speeds. These are discussed in the following sections.

### *3.3.1 Enforcement and penalties*

Allsop (2010) conducted a review on the effectiveness of speed cameras and their contribution to road safety in Great Britain. There were a number of key findings from this assessment including appreciable reductions in speeds and significant reductions in fatal and serious injury crashes which have persisted over time.

Newstead and Cameron (2003) analysed the effectiveness of the Queensland speed camera program from when first introduced in 1997 to 2001. It was estimated to have produced a reduction in fatal crashes of around 45% in areas within 2 km of speed camera sites.

Newstead, Budd & Cameron (2014) examined the performance of the Queensland Camera Detected Offence Program (CDOP) from 2009 to 2012. It was estimated that CDOP was associated with an overall reduction in all Police-reported crashes of between 23% and 26% over this period with reductions being similar for different crash severity levels.

***Fixed speed cameras***

Fixed speed cameras are permanently installed at high-risk locations, the aim being to reduce vehicle speeds and subsequently fatal and serious injury crashes.

The effectiveness of fixed speed cameras has been assessed both nationally and internationally. They have been found to reduce vehicle speeds, the proportion of drivers exceeding the speed limit, and the number of crashes. Transport for NSW (2015) conducted their annual speed camera review and found that, overall, when comparing five years of crash data before and after the fixed speed cameras were installed there had been a:

- 38% reduction in the number of injury crashes
- 91% reduction in fatalities
- 42% reduction in injuries.

***Mobile speed cameras***

Mobile speed cameras are similar to fixed speed cameras but they can be moved from location to location, allowing speed enforcement to be targeted given specific conditions. The unpredictability of their location also contributes to speed reductions.

The Centre for Road Safety (CRS), Transport for NSW (2015) assessed the annual performance of their mobile speed cameras and found that there had been reductions in road fatalities and speeds. It was therefore concluded that the mobile speed camera program was delivering positive road safety benefits.

***Point-to-point speed cameras***

Point-to-point speed cameras use pairs of cameras to determine an average speed along a known distance between cameras.

CRS (2015) analysed the performance of point-to-point speed enforcement data. They found that there had been a reduction in the number of heavy vehicle crashes since camera operation. Infringement data for average speed offences in point-to-point enforcement lengths showed a high level of compliance and a low number of infringements. Note, however, that, in New South Wales, point-to-point cameras are only used to measure the speeds of heavy vehicles.

After reviewing a range of sources, it was reported in Austroads (2012) that fatal serious injury crashes typically had reduced by 33-85% following the introduction of point-to-point speed limit enforcement. The reported effectiveness range was broad because the reviewed studies varied in size, length of follow-up time and robustness. Nevertheless, the finding points to substantial safety benefits associated with this treatment.

#### *Red light cameras*

CRS (2015) analysed the performance of the red-light speed camera program and reported the following crash reductions due to changes in driver behaviour:

- 34% reduction in casualty crashes
- 39% reduction in total casualties
- 55% reduction in fatalities
- 32% reduction in serious injuries
- 45% reduction in moderate injuries
- 36% reduction in minor/other injuries
- 44% reduction in pedestrian casualties.

Red light/speed cameras involve a combination of enforcement cameras at high-risk signalised intersections. The camera is triggered either when the speed limit is exceeded, or the red light is violated, or both. Budd, Scully and Newstead (2011) evaluated Victorian application of this treatment and found that there was a 44% reduction in adjacent and opposing-turning severe crashes following the installation of the cameras.

#### *Feedback signs (Speed Advisory Checks)*

Feedback signs are a mobile form of vehicle-activated sign used to encourage a greater speed compliance. They provide feedback to the driver relative to the posted speed limit.

#### *Penalties*

Drivers are discouraged from speeding by the use of penalties which include monetary fines, loss of demerit points, impounding of vehicles and/or loss of licence.

Job et al. (2001) examined how penalties influence speeding behaviour. They indicated that for penalties to be effective:

- the perceived probability of detection is high
- the penalty is known
- the penalty is a sufficient deterrent but not seen as unreasonable
- the alternate behaviours are known and viable.

### *3.3.2 Education, training and publicity*

Education, training and publicity are key elements to speed management. Education and training programs help to communicate the risk of speeding to all roads users as well as targeting specific road user groups. It plays a key role in bridging the gap between current practice in speed management and speed zone setting and the adoption of Safe System speeds.

Healy and Corben (2009) examined the challenges involved in the adoption of a Safe System approach to speeding. They suggested that one of the key successes in bridging the gap was communication. They recommend the use of evidence-based research and development and the use of demonstration projects to provide material which could be communicated to specific target groups including decision -makers, road safety professionals and the general community.

### *3.3.3 Vehicle technology*

A range of technologies available that assist the driver to comply with speed limits and reduce crashes was reported in Austroads (2016a and 2014b). These are as follows.

***In-vehicle technology***

- Intelligent speed adaption whereby the vehicle uses GPS or satellite navigation technology to compare the speed of the vehicle to the posted speed limit. The driver is alerted when the speed limit is exceeded.
- In-vehicle warning or avoidance systems including forward collision avoidance systems, adaptive cruise control, autonomous braking, and curve speed warnings.
- Severity reducing features such as tightening seat belts or adjusting head restraints.
- Other in-vehicle technologies that may reduce severity or the likelihood of crashes, including lane departure warning, adaptive head lights, side view assist, electronic stability control, emergency brake assist and anti-lock brakes.

***Vehicle-to-vehicle technology***

- Vehicle-to-vehicle (V2V) technology – which allows communication between vehicles in a traffic stream – is currently being developed and trialled. Sensors in the vehicles detect abnormal driving activity such as deceleration exceeding a certain threshold, change of direction, or major mechanical failure. A message can be sent to other surrounding vehicles via the V2V communication system. For example, in the case of an emergency and if one vehicle brakes suddenly it will notify other vehicles travelling on the same section of road, the aim being to give vehicles more reaction time.

***Vehicle-to-infrastructure technology***

- Other vehicle ITS systems have emerged as a result on V2V communication research which includes vehicle-to-infrastructure technology. Research and trials have been conducted in the US, Europe and Japan (Austroads 2014b).

## 3.4 Summary of Findings

The main findings of the review are as follows.

- Speed is a significant contributor to crashes. It impacts on both the likelihood and severity of a crash.
- Speed-related crashes can result from drivers exceeding the posted speed limit or driving too fast for the road conditions. These two speed factors are not differentiated in the Queensland crash database, making it difficult to determine the contribution that these two factors have on speed-related crashes. In addition, the reliability and consistency of the application of the speed-related variable cannot be guaranteed. The Police do not know the pre-crash speed of vehicles involved in a crash. Hence the definition of a crash as speed-related is based on the Police officer's judgement, witness statements, or simply on the high severity of the crash.

- Further development of the definition and capturing of speed-related crashes in the crash database would provide a more detailed understanding of speed problem, allowing tailored treatment options to reduce the risk of the two types of speed-related crashes – over-speeding and driving too fast for the prevailing conditions.
- A large proportion of drivers who are speeding exceed the speed limit by a small margin (up to 10 km/h). These 'low-level' speeders contribute to a large proportion of the risk associated with speeding. Education campaigns can be targeted to highlight the risk associated with low-level speeding to the community.
- A range of engineering treatments have been successfully implemented to reduce the levels of speeding and improve road safety.
- Enforcement and penalties continues to be a major tool in encouraging reduced operating speed.
- Education, training and publicity play an important role in speed management; it communicates the safe speed approach that is required to achieve a reduction in the risk and road trauma related to speeding.
- Vehicle technologies incorporated into vehicle standards will play an increasing role in reducing speed-related crashes.

# 4 CRASH ANALYSIS

## 4.1 Annual Distribution

The eight-year (2008-15) fatal and serious injury (FSI) crash data on Queensland's State-controlled roads was analysed. A total of 48 076 injury crashes were recorded, of which 20 967 (44%) crashes resulted in a fatal or serious injury (FSI) (Table 4.1). The highest number of FSI crashes occurred in 2013, though all-injury crashes peaked in 2008 with a downward trend since then. Visual appraisal of the severe-crash data in Figure 4.1 did not suggest a time trend over the past eight years.

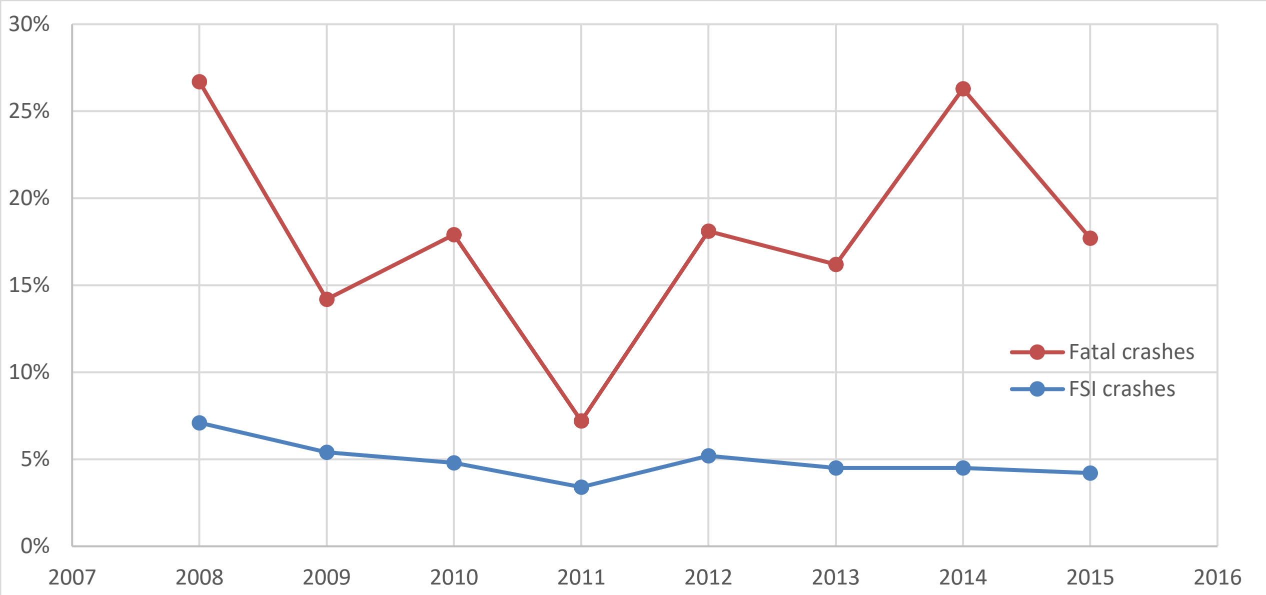
Approximately 5% of all FSI crashes were classified as a speed-related crash, whilst 18% of all fatal crashes were classified as speed-related (Table 4.1). The number of FSI and fatal crashes classified as speed-related both peaked in 2008 at 187 and 47 respectively.

Speed-related crashes appear to be over-represented among fatal crashes rather than FSI crashes (Figure 4.1). This is consistent with previous research by Wundersitz et al. (2011) which showed that extreme driver behaviour was much more strongly present in fatal crashes than injury crashes.

**Table 4.1: Annual proportion of crashes on Queensland state-controlled roads**

| Year | FSI by all injury crashes | | | FSI crashes | | Fatal crashes | | |
|---|---|---|---|---|---|---|---|---|
| | FSI crashes | All injury crashes | Proportion of FSI crashes | Speed-related FSI crashes | Proportion of speed-related FSI crashes | Speed-related fatal crashes | All fatal crashes | Proportion of speed-related fatal crashes |
| 2008 | 2616 | 6537 | 40.0% | 187 | 7.1% | 47 | 176 | 26.7% |
| 2009 | 2656 | 6418 | 41.4% | 143 | 5.4% | 24 | 169 | 14.2% |
| 2010 | 2516 | 6136 | 41.0% | 122 | 4.8% | 24 | 134 | 17.9% |
| 2011 | 2538 | 5845 | 43.4% | 86 | 3.4% | 10 | 139 | 7.2% |
| 2012 | 2695 | 5938 | 45.4% | 139 | 5.2% | 30 | 166 | 18.1% |
| 2013 | 2797 | 5898 | 47.4% | 125 | 4.5% | 24 | 148 | 16.2% |
| 2014 | 2675 | 5806 | 46.1% | 121 | 4.5% | 35 | 133 | 26.3% |
| 2015 | 2474 | 5498 | 45.0% | 104 | 4.2% | 23 | 130 | 17.7% |
| **Total** | **20 967** | **48 076** | **43.6%** | **1027** | **4.9%** | **217** | **1195** | **18.2%** |

**Figure 4.1: Proportion of speed-related severe crashes on State-controlled roads (2008-2015)**




## 4.2 Spatial Distribution of Speed-related FSI Crashes

The spatial distribution of speed-related FSI crashes is shown in Figure 4.2, whilst the spatial distribution of speed-related FSI crashes in South East Queensland is shown in Figure 4.3. It can be seen that the majority of the crashes occurred in the South-East Queensland and on the Bruce Highway, especially around the large urban centres, whilst speed-related crashes were clustered along high-volume roads.

**Figure 4.2: Spatial distribution of speed-related FSI crashes on State-controlled roads (2008-15)**

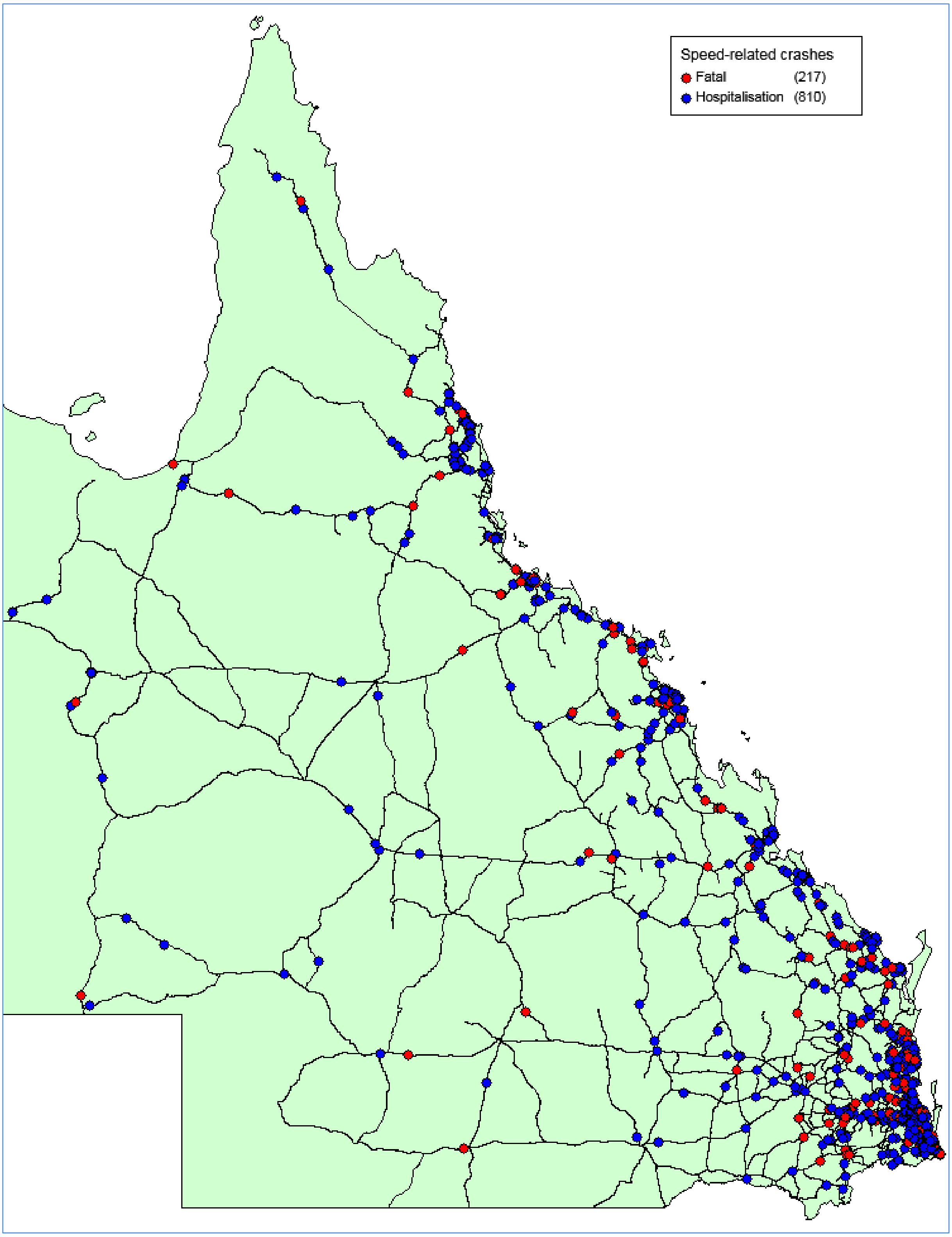
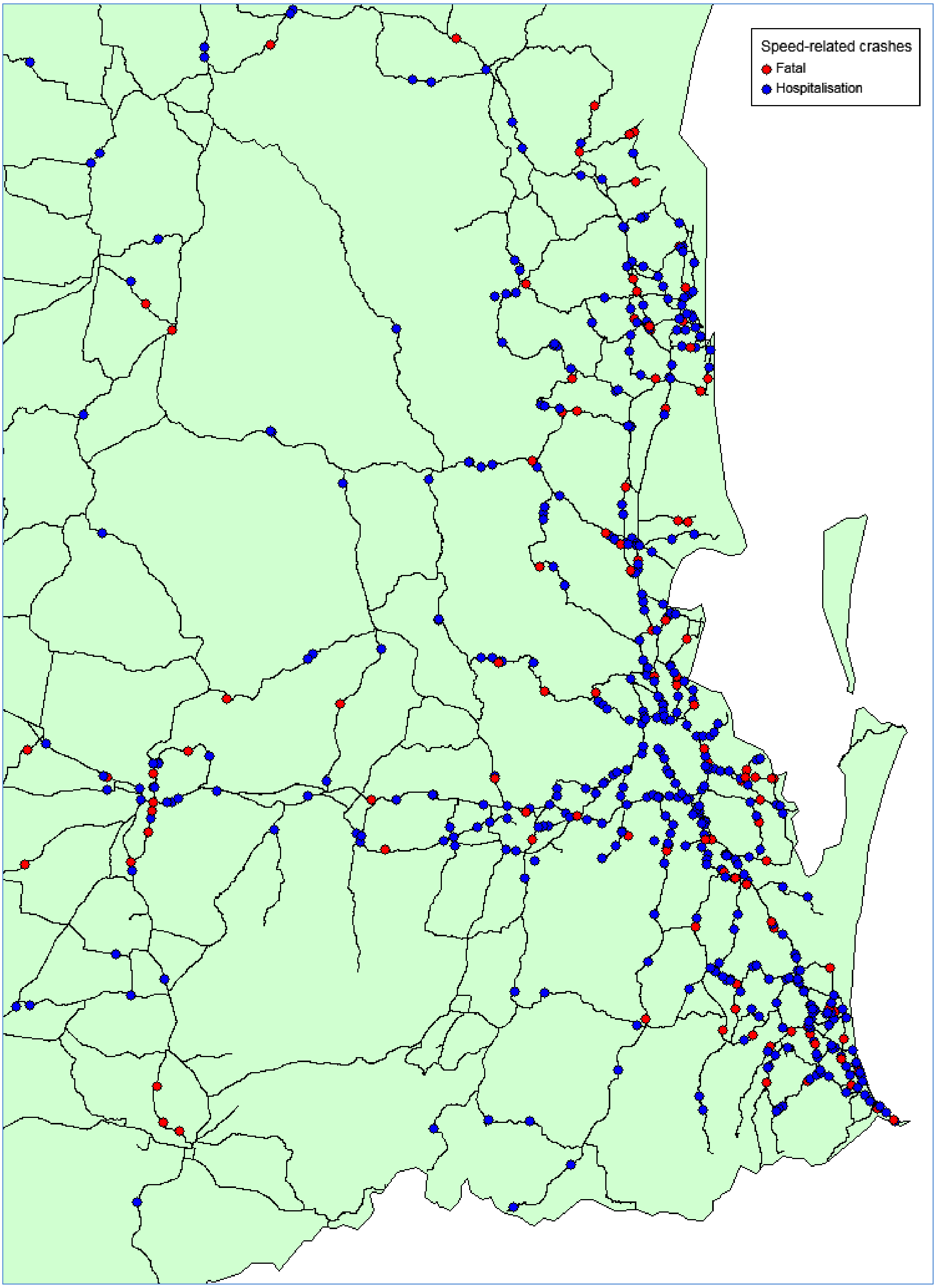


Figure 4.3: Spatial distribution of speed-related FSI crashes – South East Queensland (2008-15)

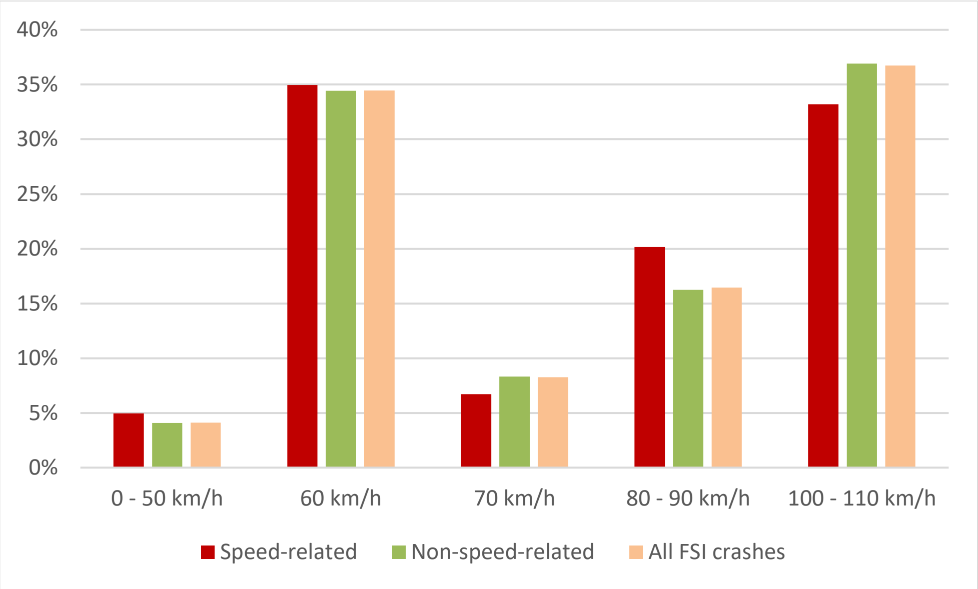


## 4.3 FSI Crashes and Speed Limits

This section provides a descriptive analysis of speed-related crash data patterns to inform further consideration of risk factors for this crash category.

The proportion of FSI crashes according to speed limit is shown in Figure 4.4. The majority of all FSI crashes occurred in the 60 km/h and 100 km/h-110 km/h zones. This is expected since these speed zones make up the largest proportion of the network. Thus, speed is not necessarily correlated with an increased proportion of FSI crashes.

**Figure 4.4: FSI crashes by speed limit (2008-2015)**




Both the individual risk (crashes per vehicle-km of travel (VKT) (see Figure 4.5) and collective risk (crashes per km (see Figure 4.6)) were observed to be higher for the 50–60 km/h speeds zones and lower for the ≥ 70 km/h speed zones (Figure 4.5). This observation was true for both speed- and non-speed-related FSI crashes. Note, however, that there are very few sections of State-controlled roads with a 50 km/h speed limit; therefore the result cannot be considered robust.

**Figure 4.5: FSI crash rate per VKT by speed limit zones (2008-2015)**

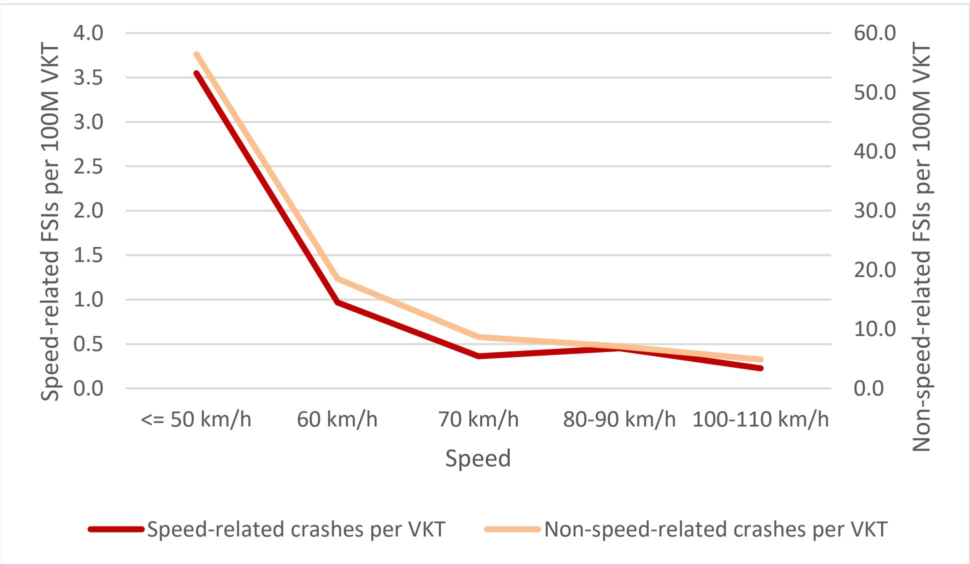
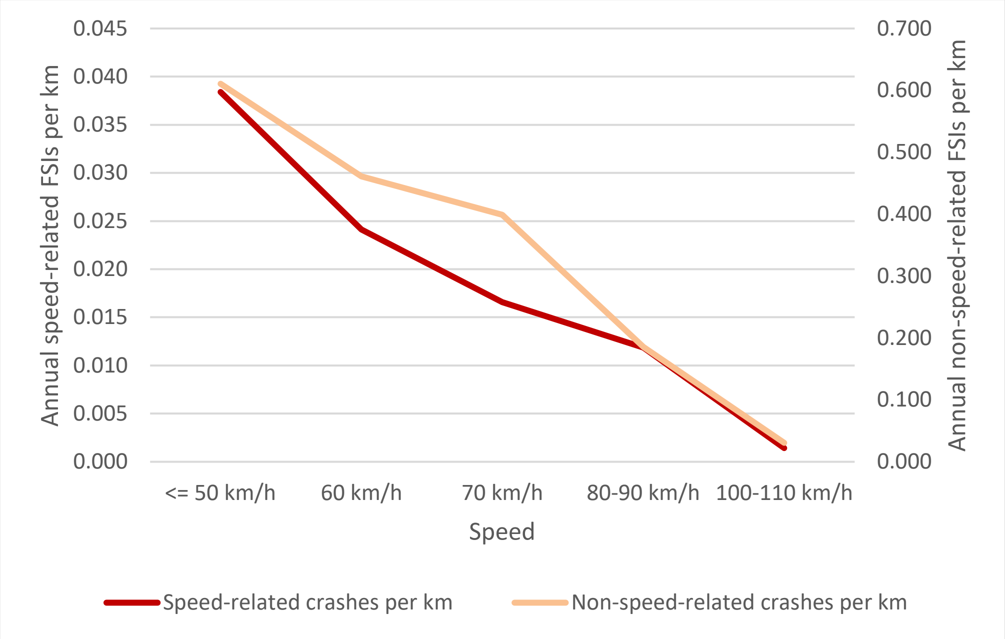


Figure 4.6: FSI crashes per km by speed limit zones (2008-2015)




As expected, average crash severity generally increased with the speed limit for both speed-related and non-speed-related crashes (Figure 4.7 and Figure 4.8 ). However, the relative proportion of fatal crashes was higher for speed-related crashes. About 28% of speed-related FSI crashes resulted in a fatality in the 100–110km/h zone compared to 9% for non-speed-related crashes (Figure 4.7).

Figure 4.7: Speed-related FSI crashes by speed limit zones by severity (2008-2015)

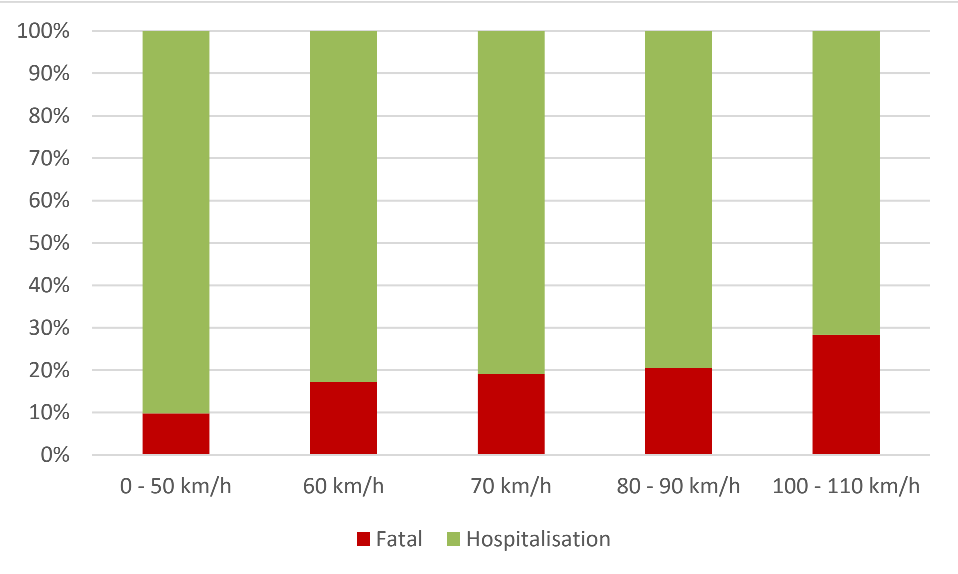
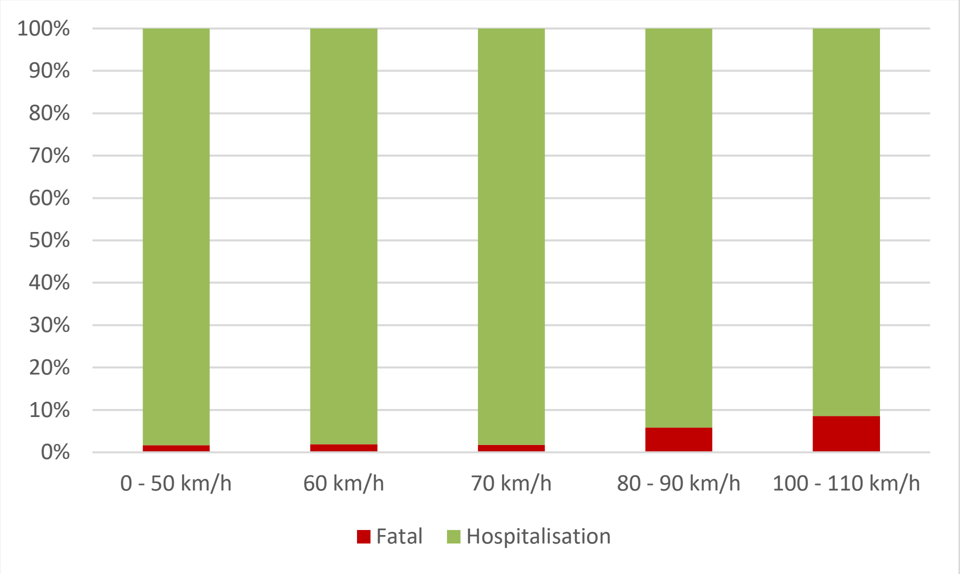


Figure 4.8: Non-speed-related FSI crashes by speed limit zones by severity (2008-2015)




Statisitical modelling (e.g. binary logistic) may provide more robust quantification of the observed effect of the speed zone on fatality patterns.

## 4.4 FSI Crashes According to Crash Type

Speed-related FSI crashes occurred mainly in single-vehicle crashes (72%). This was far higher than the proportion of non-speed related and all FSI crashes (Figure 4.9). Approximately 70% of speed-related FSI crashes on low-speed roads and 74% on high-speed roads involved single vehicles (Figure 4.10). Thus, single vehicle crashes are over-represented in speed-related FSI crashes on State-controlled roads. Notably, only a very small proportion of pedestrian crashes were speed-related, with only seven out of the 813 crashes involving pedestrians. However, whilst the likelihood of speed-related pedestrian crashes is low, the severity would be high.

Figure 4.9: Crash types (2008-2015)

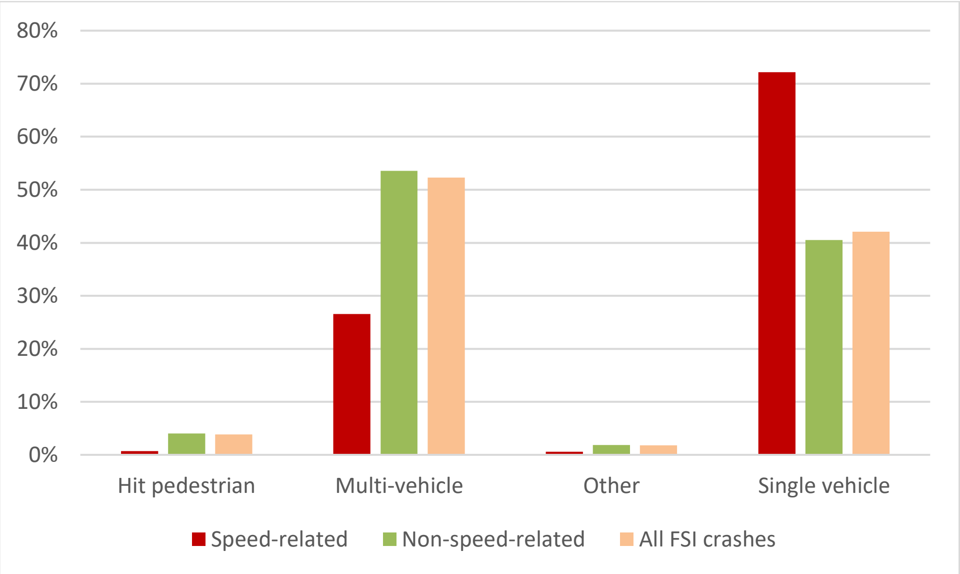
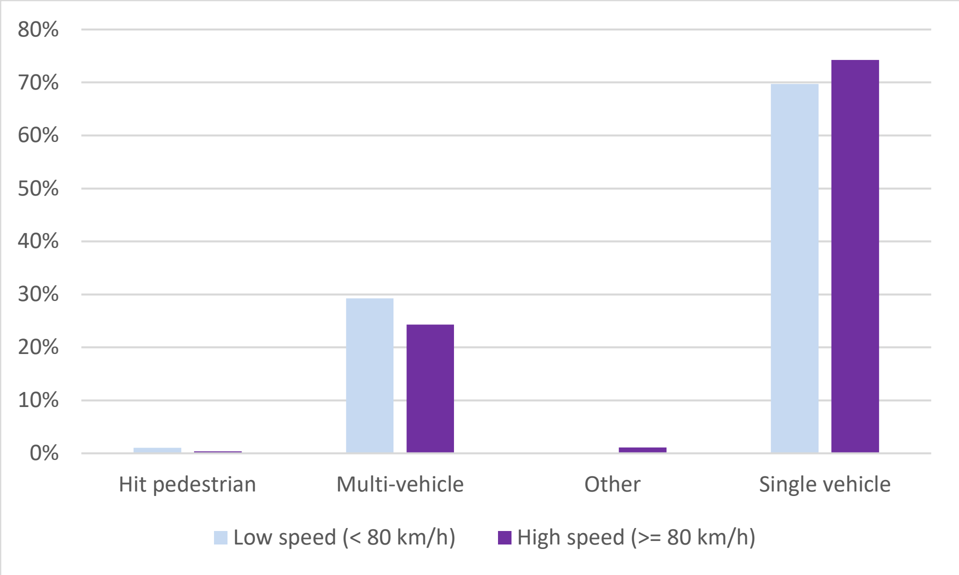
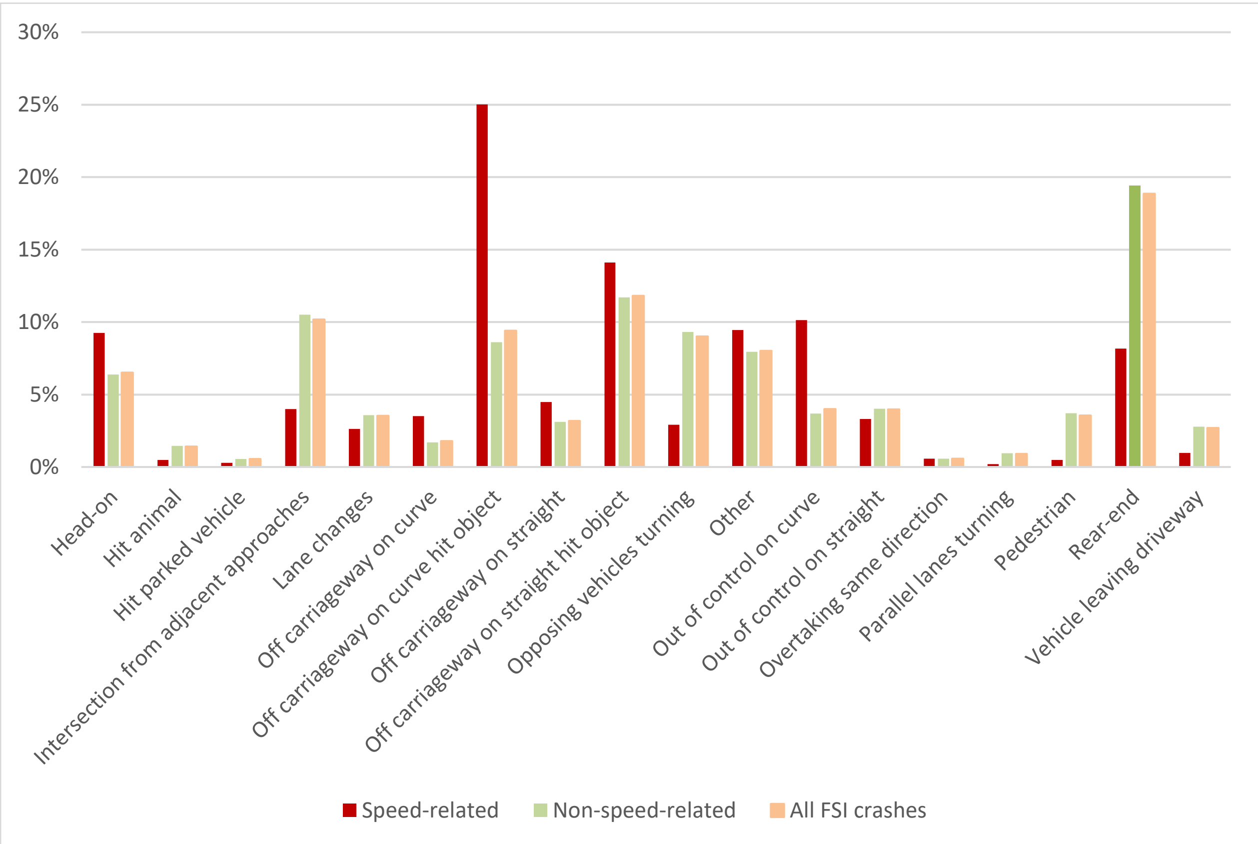


Figure 4.10: Speed-related FSI crashes by type and speed environment (2008-2015)




Data patterns suggest that the highest proportion of speed-related FSI crashes involved hitting an object off the carriageways (either straight or curved) (Figure 4.11). Overall, the relative proportion of speed-related FSI crashes on curved sections was far higher than for non-speed-related crashes. Speed-related crashes were under-represented in intersection (adjacent direction, opposing-turning), rear-end and pedestrian crashes.

Figure 4.11: FSI crashes by DCA Code (2008-2015)



Speed-related crashes were over-represented in hit-object, head-on and overturned vehicle crashes compared to non-speed-related crashes (Figure 4.12). Half of all the speed-related FSIs involved hitting an object compared to 26% for non-speed-related FSIs.

**Figure 4.12: FSI crashes by crash collision type (2008-2015)**

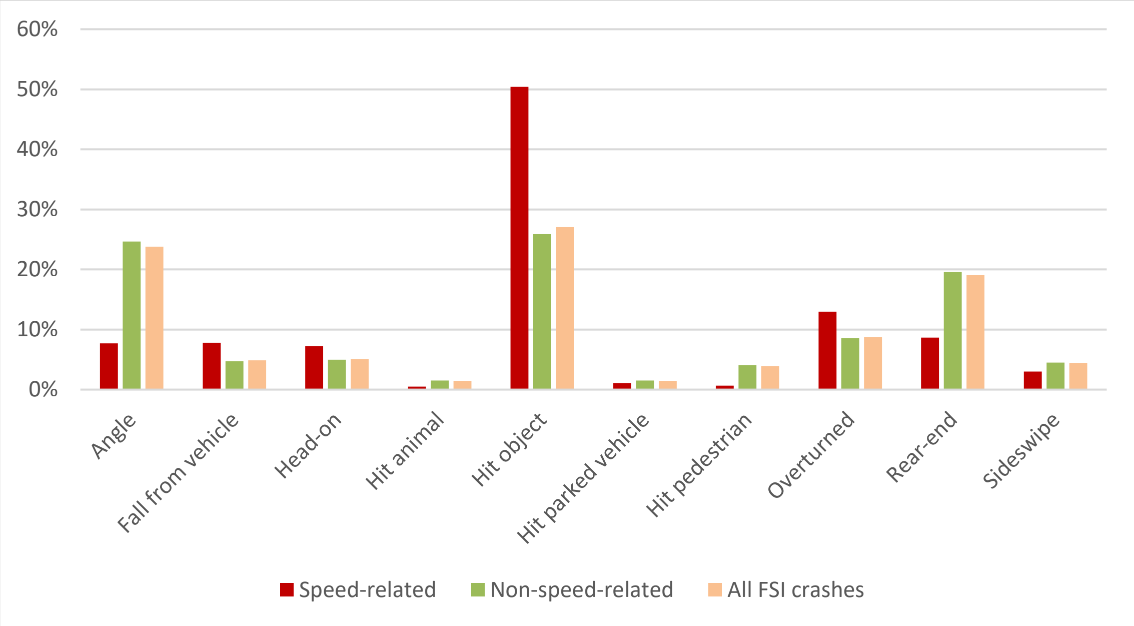
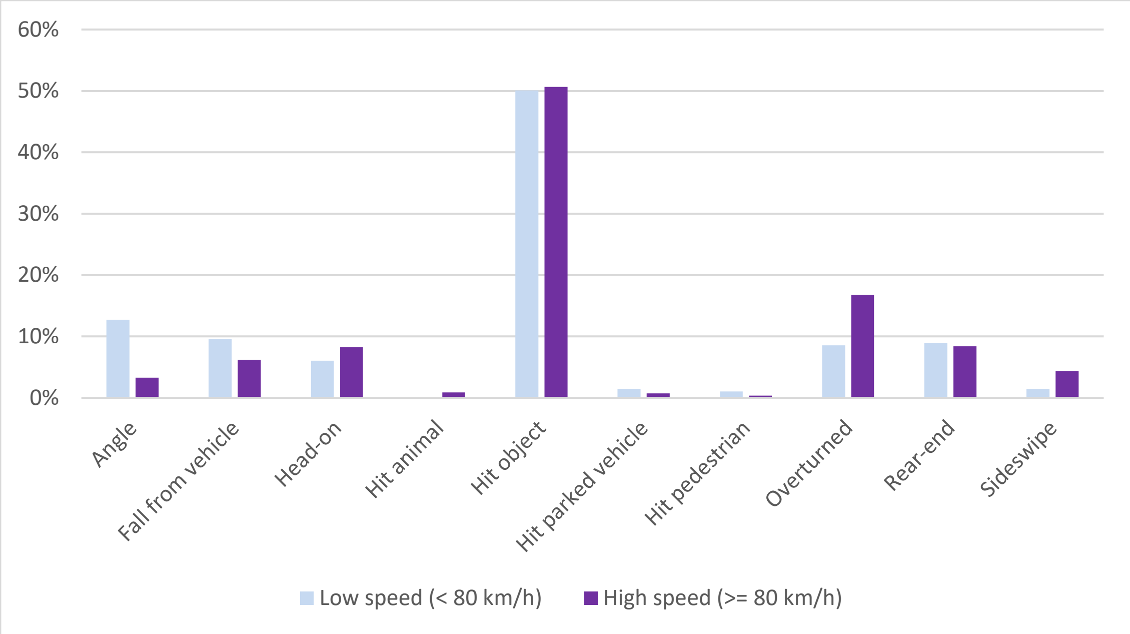



Figure 4.13 shows the distribution of speed-related crashes by crash type and speed environment. The main crash type in the low-speed environment was hit-object (50%), followed by angle collisions (13%), fall from vehicle (10%) and rear-end crashes (9%). In high-speed environments, the main crash type was also hit-object (50%), followed by overturned vehicle (17%), rear-end (8%) and head-on crashes (8%).

Speed-related FSI crashes into roadside objects were over-represented, regardless of speed environment. Speed-related head-on and overturning FSI outcomes were more common on high-speed roads, as expected in high-energy road departures.

Inferential analysis could provide further insights into the significance of these observations.

**Figure 4.13: Speed-related FSI crashes by crash collision type by speed environment (2008-2015)**




## 4.5 FSI Crashes and Road Feature Type

An analysis of visual data patterns showed that approximately 67% of speed-related FSI crashes occurred at mid-block sections, slightly higher than non-speed-related FSI crashes (60%) (Figure 4.14). The relative proportion of speed-related FSIs at mid-block sections was lower in low-speed zones compared to high-speed zones (Figure 4.15). Confirming earlier observations, intersection locations were relatively under-represented. Notably, speed-related crashes were slightly over-represented at roundabouts, especially in high-speed environments.

**Figure 4.14: FSI crashes by road feature type (2008-2015)**

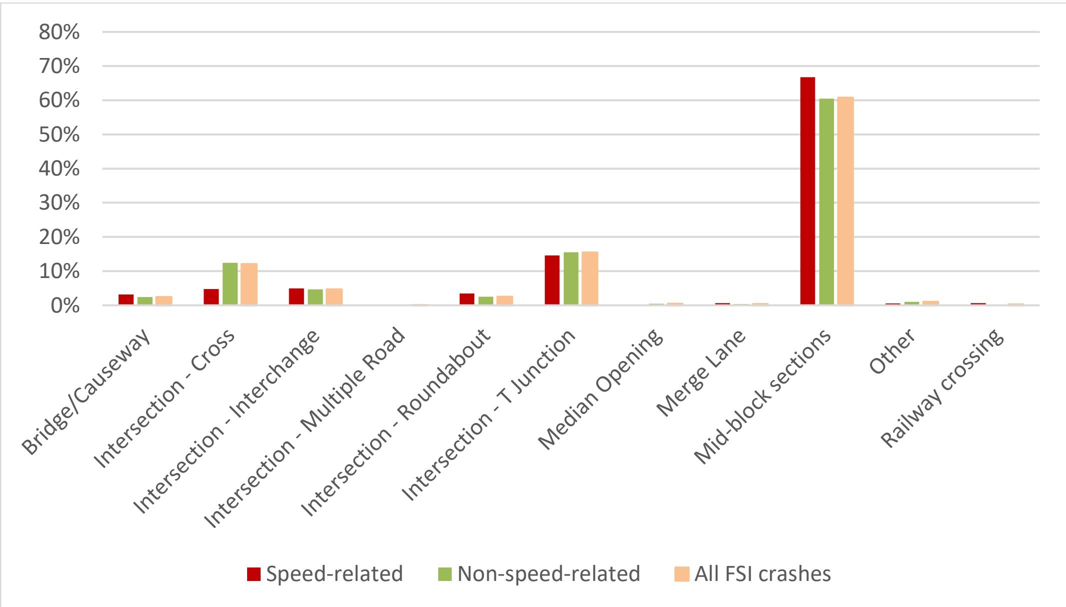
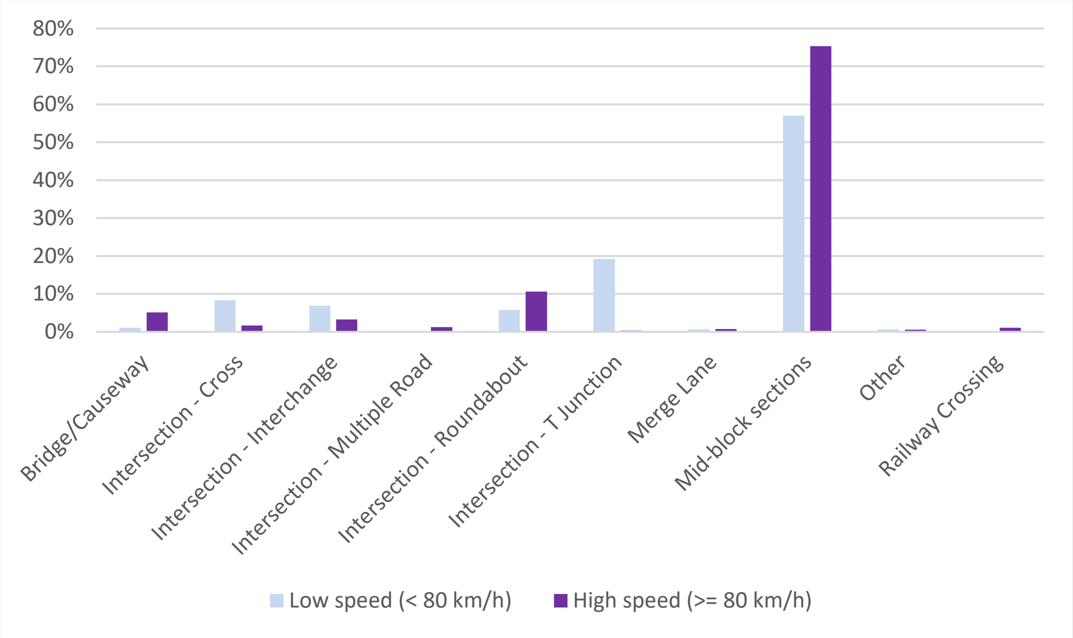


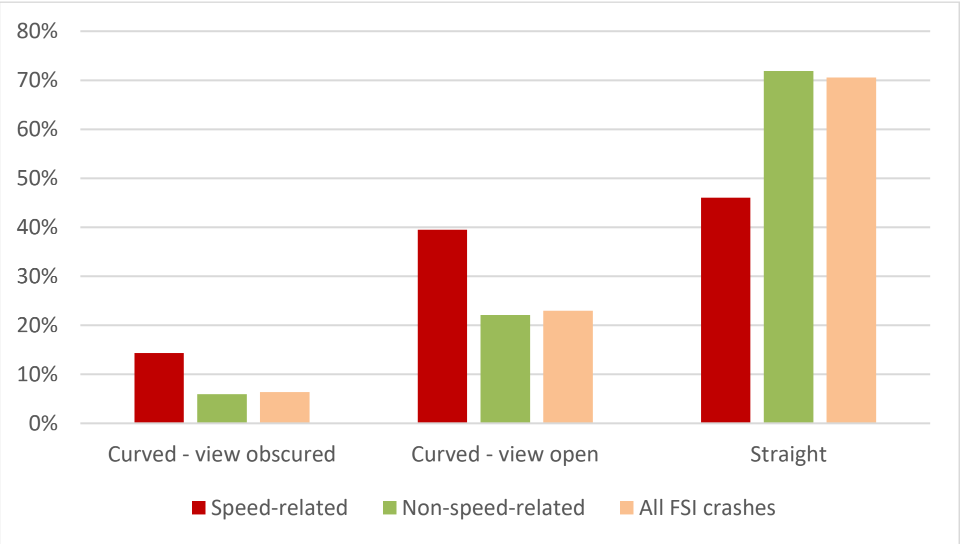
Figure 4.15: Speed-related FSI crashes by road feature by speed zone (2008-2015)




## 4.6 FSI Crashes and Horizontal Alignment

The distribution of FSI crashes according to horizontal alignment is shown in Figure 4.16. Most of the FSI crashes occurred on straight road sections. However, comparatively the relative proportion of speed-related FSI crashes was higher on curves; as a result, speed-related crashes could be considered over-represented on curves. Further analysis of exposure would be needed to quantify this risk factor.

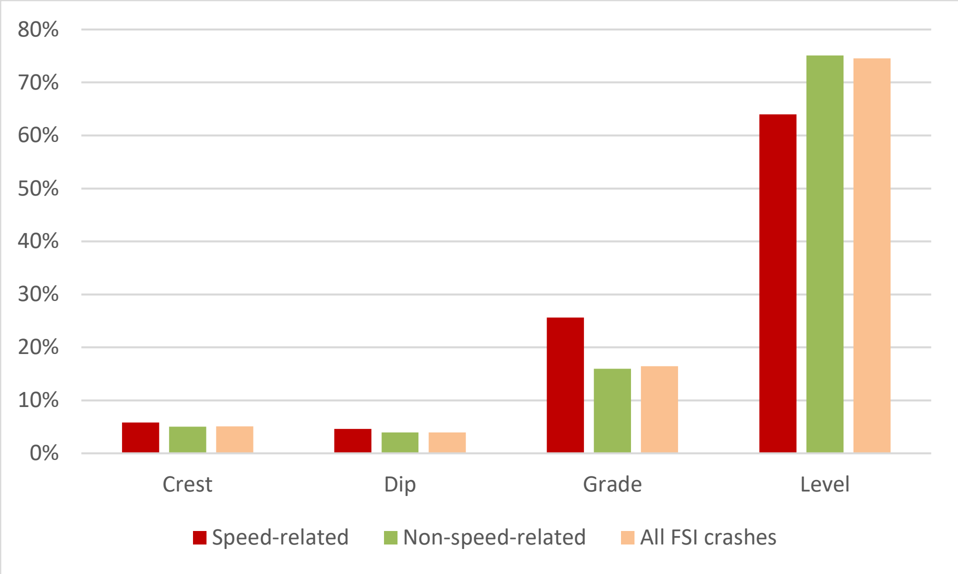
Figure 4.16: Horizontal alignments (2008-2015)




## 4.7 FSI Crashes and Vertical Alignment

While the majority of FSI crashes occurred on level (flat) roads, speed-related crashes were somewhat over-represented on grade (Figure 4.17). This observation would require further analysis for covariance with other factors (e.g. curvature) to quantify the effect of grade.

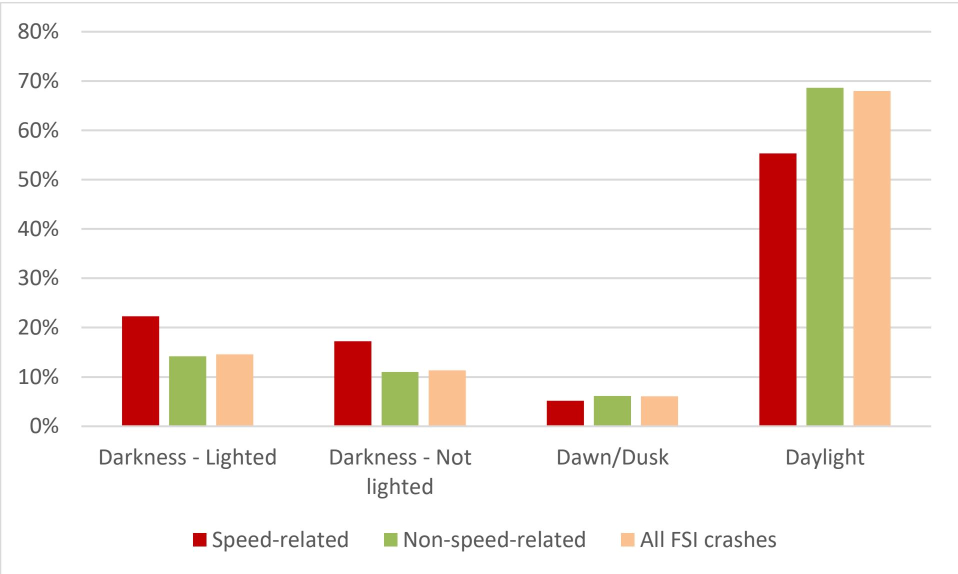
Figure 4.17: FSI crashes by vertical alignment (2008-2015)




## 4.8 FSI Crashes and Lighting Conditions

Majority of FSI crashes occurred during daylight hours (Figure 4.18). However, speed-related crashes were over-represented during the night (darkness- lighted and not-lighted). Further statistical analysis would provide more robust answer on the significance of this risk factor.

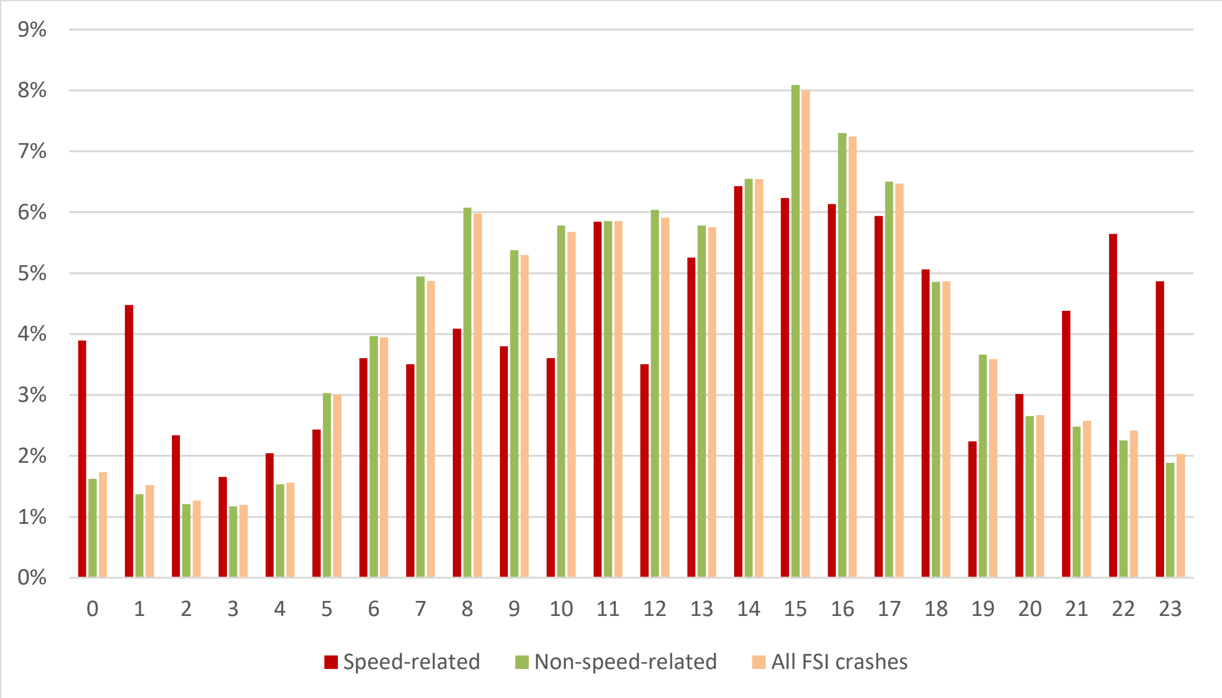
Figure 4.18: FSI crashes by lighting condition (2008-2015)




## 4.9 FSI Crashes and Time of Day

The majority of FSI crashes (speed-related and non-speed-related) occurred between 2 pm and 5 pm (Figure 4.19). However, compared to the proportion of all FSIs, speed-related crashes appeared to be over-represented between 9 pm and 4 am.

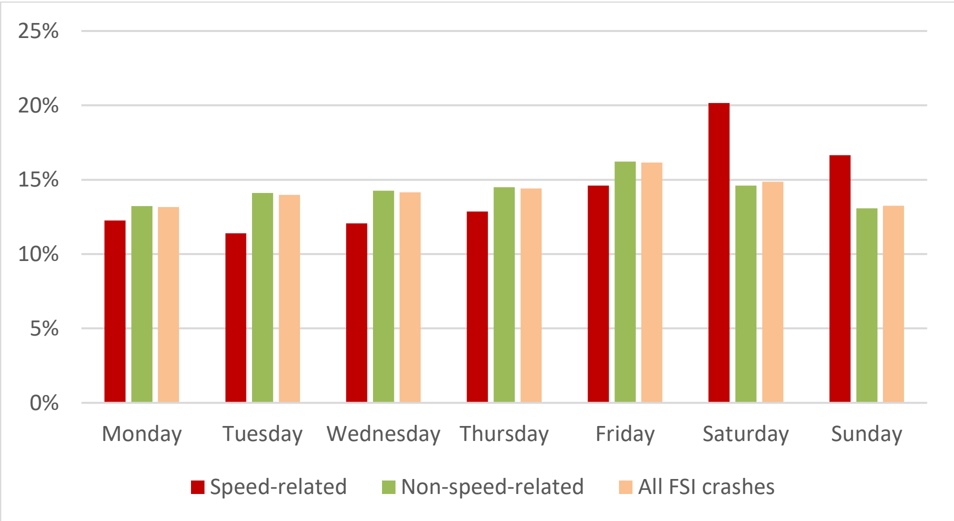
Figure 4.19: FSI crashes by time of day (2008-2015)




## 4.10 FSI Crashes and Weekday

The highest proportion of speed-related crashes occurred on Saturday followed by Sunday (Figure 4.20).

Figure 4.20: FSI crashes by Day of the week (2008-2015)

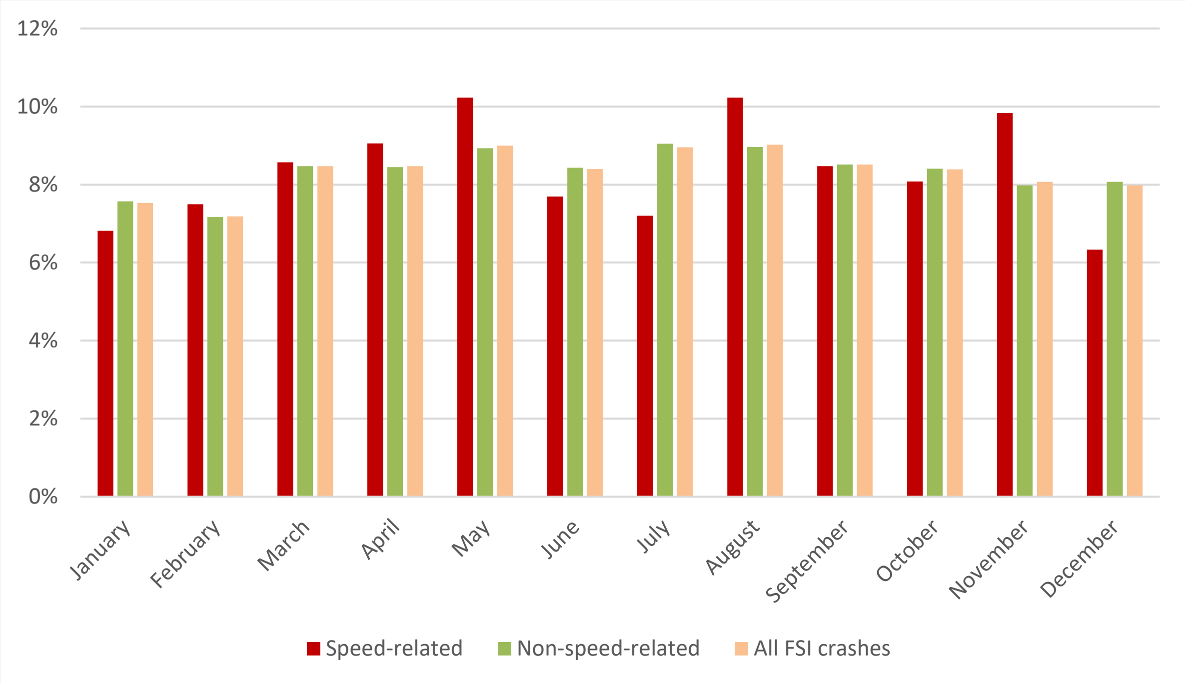



Combined with the time of day analysis in Figure 4.19, this observation suggests a correlation with ‘alcohol hours’, i.e. times with greater prevalence of drink- and drug-driving.

## 4.11 FSI Crashes and Month

The highest proportion of speed-related crashes occurred in May, August and November (Figure 4.21). There was no overall pattern observed in the data.

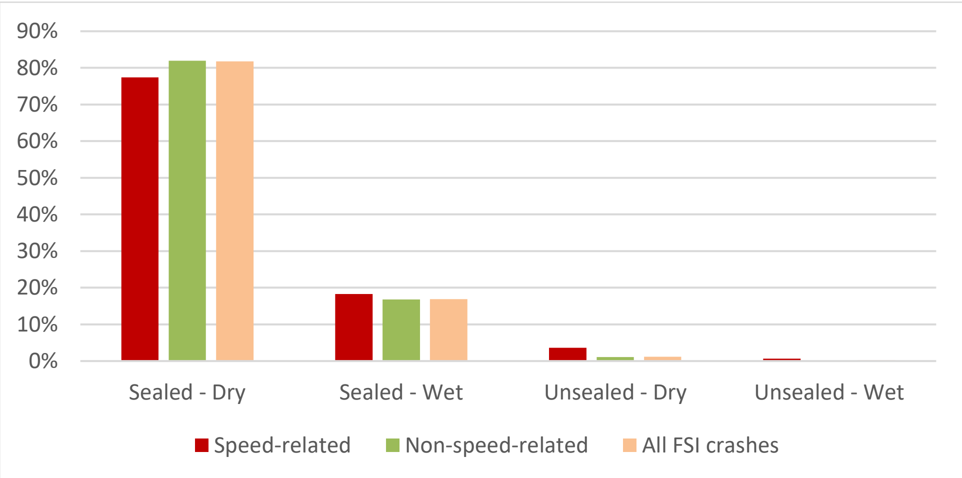
Figure 4.21: FSI crashes by month (2008-2015)




## 4.12 FSI Crashes and Road Surface Condition

Over 80% of all FSI crashes occurred on sealed surfacings (Figure 4.22). FSI crashes on unsealed-wet roads were negligible due to the low traffic volumes and the low proportion of unsealed roads on the State-controlled network.

Figure 4.22: FSI crashes by road surface conditions (2008-2015)




The distribution of FSI crashes by month and road surface condition was similar for both speed-related and non-speed-related FSI crashes as shown in Figure 4.23 and Figure 4.24 respectively. Speed-related crashes on unsealed dry roads were somewhat over-represented. This may point to further statistical analysis to check if the speed problem is over-represented on unsealed roads (possible driver behaviour issues or driving too fast for conditions).

Figure 4.23: Speed-related FSIs by road surface condition by month (2008-2015)

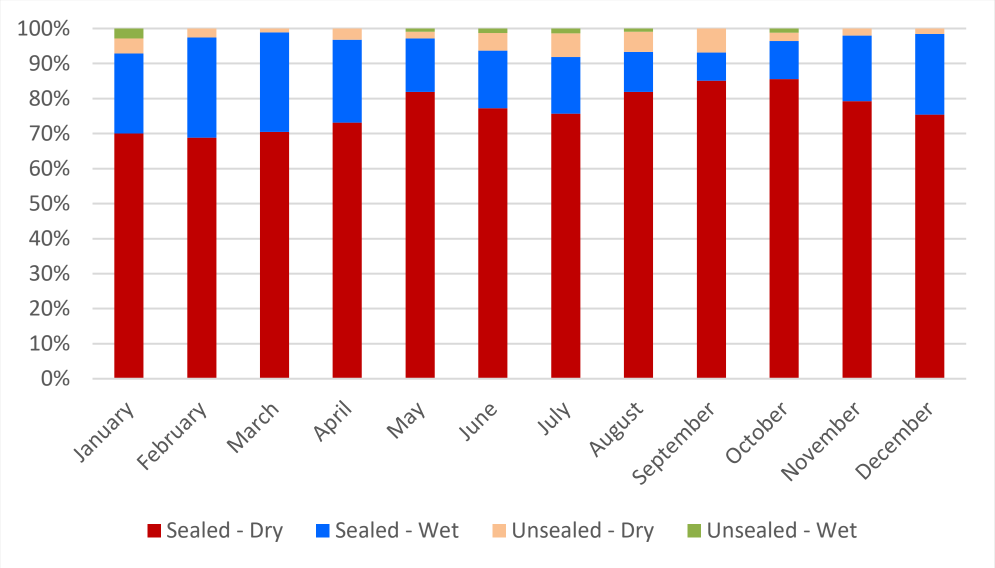
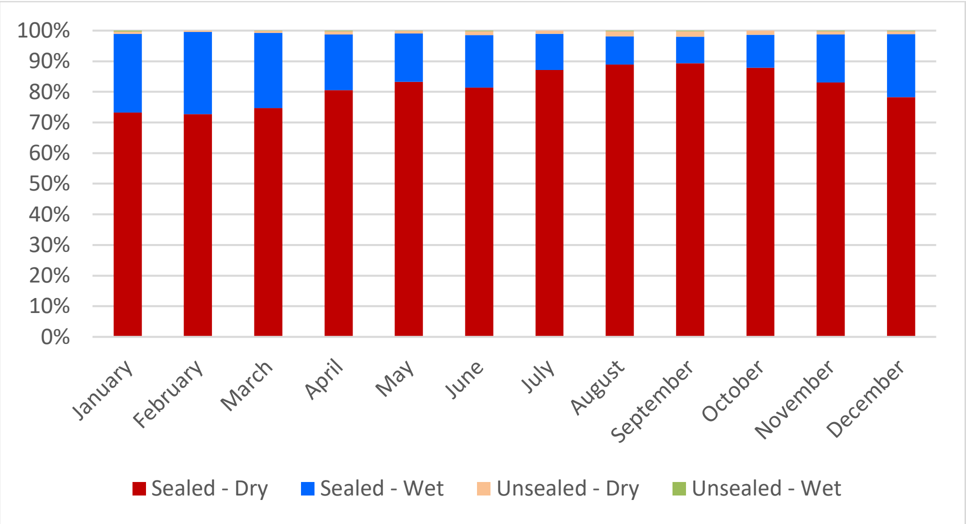



Figure 4.24: Non-speed-related FSIs by road surface condition by month (2008-2015)




## 4.13 Crash Contributing Factors

Table 4.2 presents a summary of the factors contributing to speed-related and non-speed-related crashes. The results are exploratory only, as there was no control for other influencing factors such as crash type or road environment (see previous sections), or any significance testing.

It can be seen from the Table that disobeying road rules (22%) accounted for the highest number of speed-related FSI crashes followed by controller condition (18%), young adults 16-24 years (11%), alcohol-related (10%) and distracted/inattentive (8%). The main factors for non-speed-related crashes were also disobey road rules (27%), followed by young adults (16-24 years) (11%), controller condition (9%), distracted/inattentive (8%) and senior adult (60+ years) (7%).

**Table 4.2: Crash contributing factors**

| | Speed-related FSIs | | Non-speed-related FSIs | | Relative risk |
|---|---|---|---|---|---|
| **Factors** | **Count** | **%** | **Count** | **%** | |
| **Alcohol-related** | **346** | **9.5%** | **2674** | **6.0%** | **1.6** |
| Atmospheric condition | 18 | 0.5% | 379 | 0.9% | 0.6 |
| Bus | 8 | 0.2% | 151 | 0.3% | 0.7 |
| **Controller condition** | **652** | **17.9%** | **4094** | **9.2%** | **1.9** |
| Disobey road rules | 781 | 21.5% | 12126 | 27.4% | 0.8 |
| Distraction/Inattentive | 299 | 8.2% | 3684 | 8.3% | 1.0 |
| Fatigued-related | 118 | 3.2% | 2248 | 5.1% | 0.6 |
| Heavy vehicle | 59 | 1.6% | 1505 | 3.4% | 0.5 |
| Lighting condition | 17 | 0.5% | 612 | 1.4% | 0.4 |
| **Motorcycle/moped** | **248** | **6.8%** | **2215** | **5.0%** | **1.4** |
| **Non-restraint** | **80** | **2.2%** | **490** | **1.1%** | **2.0** |
| Road condition | 176 | 4.8% | 2415 | 5.4% | 0.9 |
| Road surface condition | 122 | 3.4% | 1644 | 3.7% | 0.9 |
| Senior adult (60+) | 59 | 1.6% | 3215 | 7.3% | 0.2 |
| **Unlicensed driver** | **181** | **5.0%** | **986** | **2.2%** | **2.3** |
| **Unregistered vehicle** | **66** | **1.8%** | **404** | **0.9%** | **2.0** |
| Vehicle defect | 23 | 0.6% | 571 | 1.3% | 0.5 |
| Young adult (16-24 years) | 385 | 10.6% | 4912 | 11.1% | 1.0 |
| Total | 3638 | 100.0% | 44325 | 100.0% | 1.0 |

Compared to non-speed-related crashes, unlicensed drivers, controller condition, alcohol-related, non-restraint and motorcyclists were over-represented in speed-related crashes. Unlicensed drivers were 2.3 times more likely to be speeding when involved in an FSI crashes. The corresponding relative risk for drivers under the influence and motorcyclists were 1.6 and 1.4 times respectively. Senior adults (60+ years), heavy vehicles, lighting condition and fatigue-related were found to be under-represented and less likely to be involved in speed-related crashes.

### *4.13.1 Alcohol-related*

A total of 3 020 FSI crashes were attributed to drivers under the influence of alcohol; of these, 13% were speed-related (Figure 4.25). Speed-related crashes appeared to be strongly corelated with the influence of alcohol. Thirty per cent of all speed-related crashes involving alcohol resulted in fatalities (Figure 4.26). This percentage was much lower if alcohol was not involved, or if the crash was non-speed-related (Figure 4.27, Figure 4.28). Further statistical analysis could quantify and determine the significance of these observations.

Figure 4.25: FSI crashes by alcohol-related factor (2008-2015)

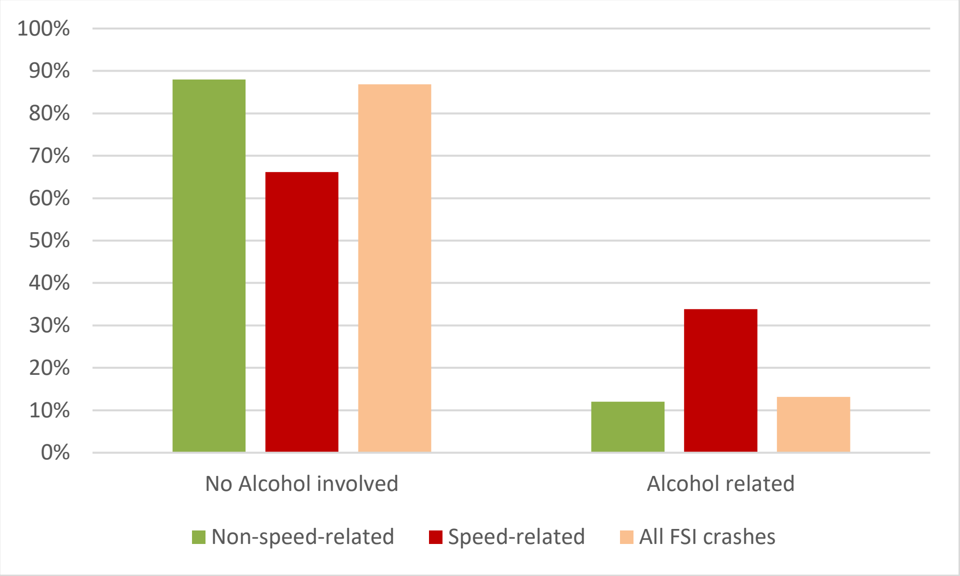



Figure 4.26: Speed-related FSI crashes by alcohol-related factor (2008-2015)


Figure 4.27: Non-speed-related FSI crashes by alcohol-related factor (2008-2015)

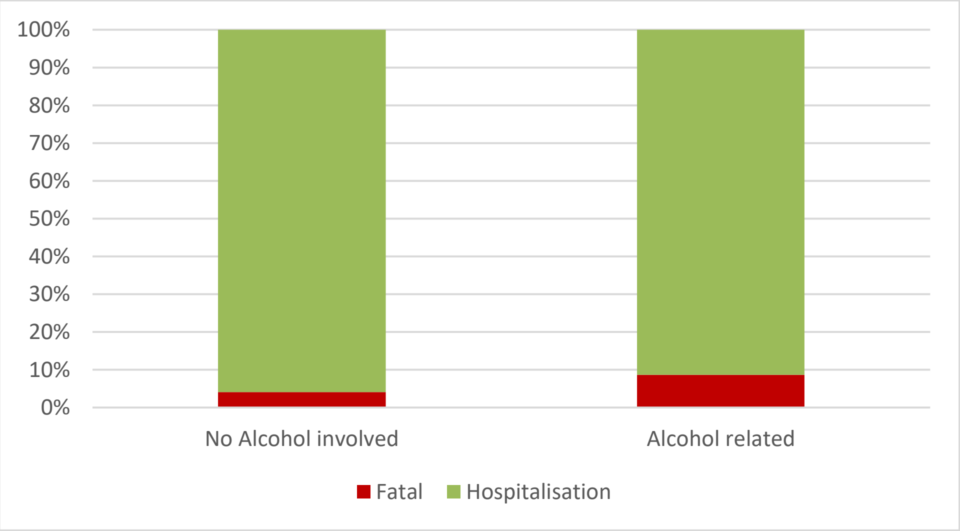


Figure 4.28: FSI crashes by alcohol-related factor (2008-2015)


### 4.13.2 *Distraction*

Distracted drivers contributed to 18% of all FSI crashes (Figure 4.29). The relative proportion of speed-related crashes due to distraction was higher than non-speed-related crashes. The proportion of fatal crashes appeared higher when drivers were distracted compared to when they were not distracted (Figure 4.30 to Figure 4.32).

Figure 4.29: FSI crashes by distraction (2008-2015)

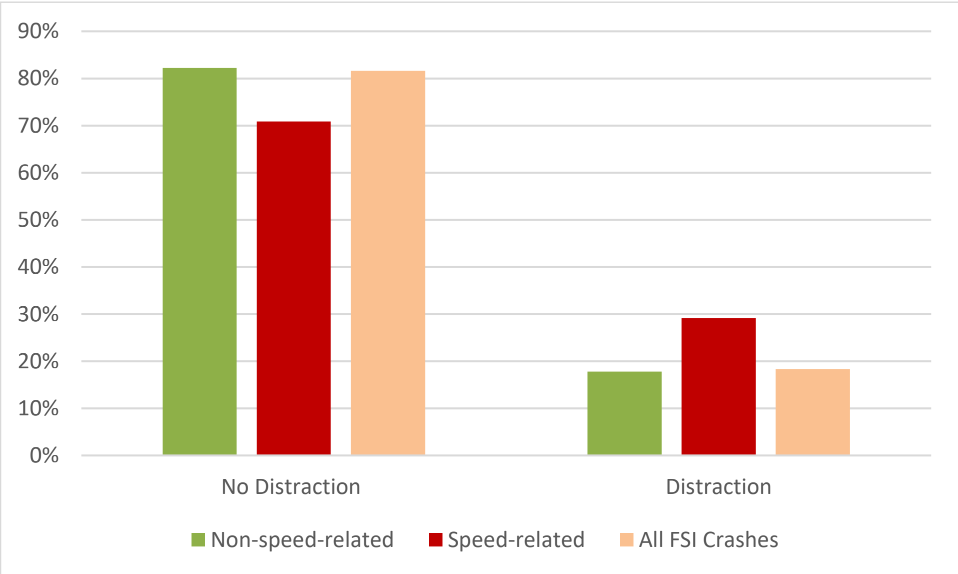


Figure 4.30: Speed-related FSI crashes by distraction (2008-2015)


Figure 4.31: Non-speed-related FSI crashes by distraction (2008-2015)

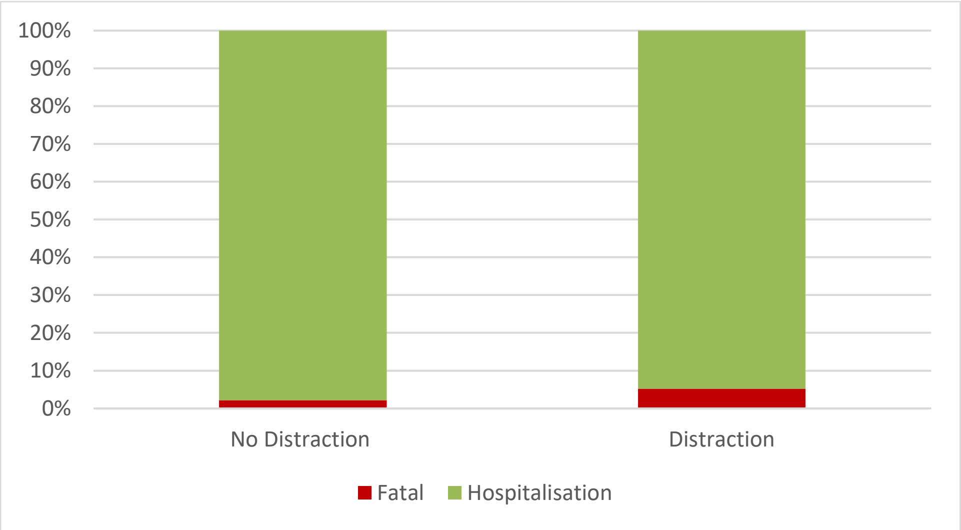
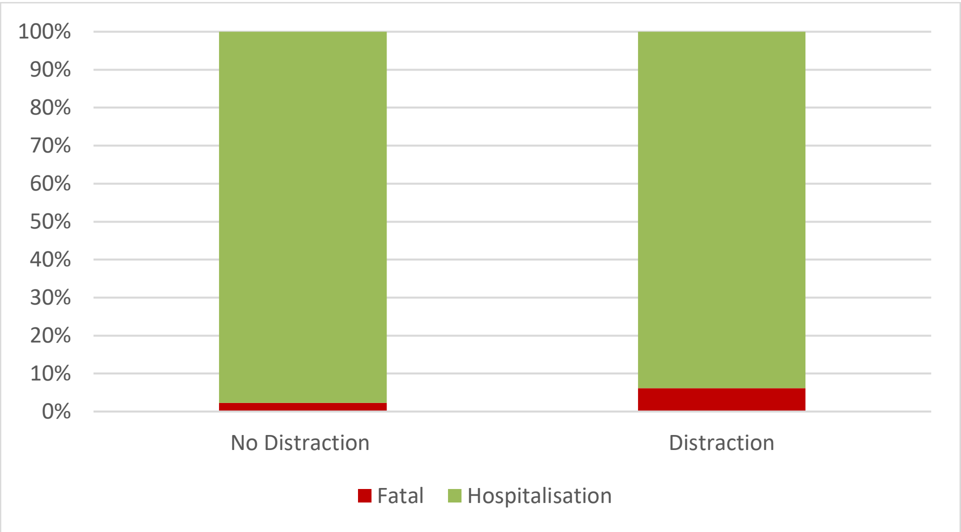



Figure 4.32: All FSI crashes by distraction (2008-2015)



## 4.14 Driver Characteristics

### *4.14.1 Driver age*

Driver age groups from 16 to 39 years were over-represented in speed-related crashes compared to non-speeding-related crashes (Figure 4.33). The under-24 years groups were most strongly over-represented. The very young and old (i.e. 0-4 years and ≥75 years) were over-represented in fatal crashes, but there was no speed-related difference (Figure 4.34 to Figure 4.35).

Figure 4.33: Driver age groups (2008-2015)

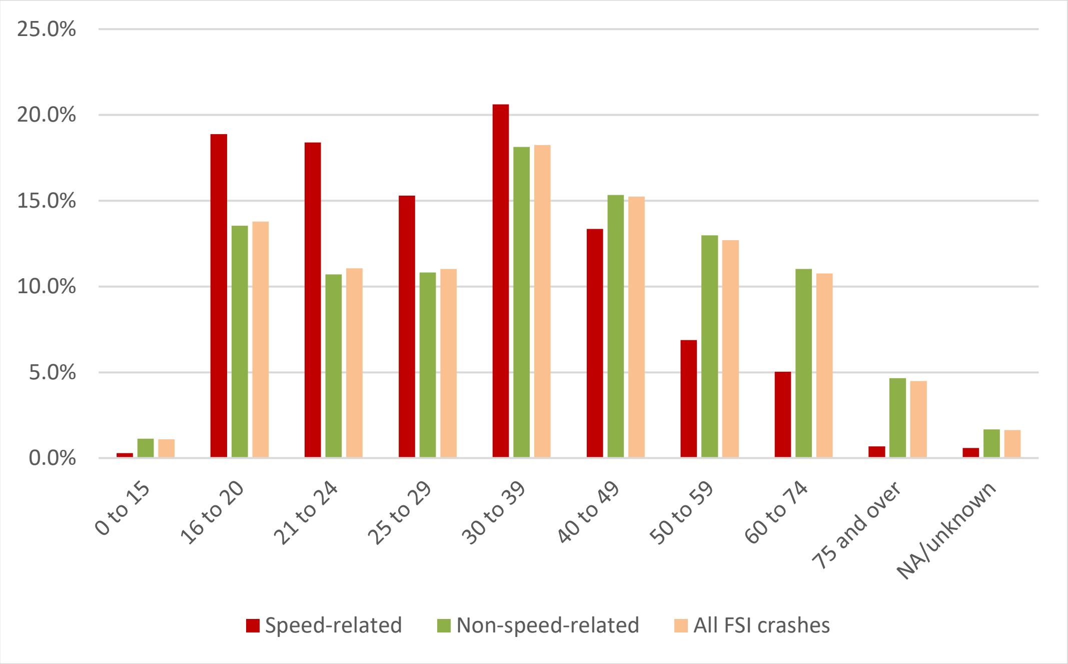



Figure 4.34: Severity of speed-related FSI crashes by age group (2008-2015)

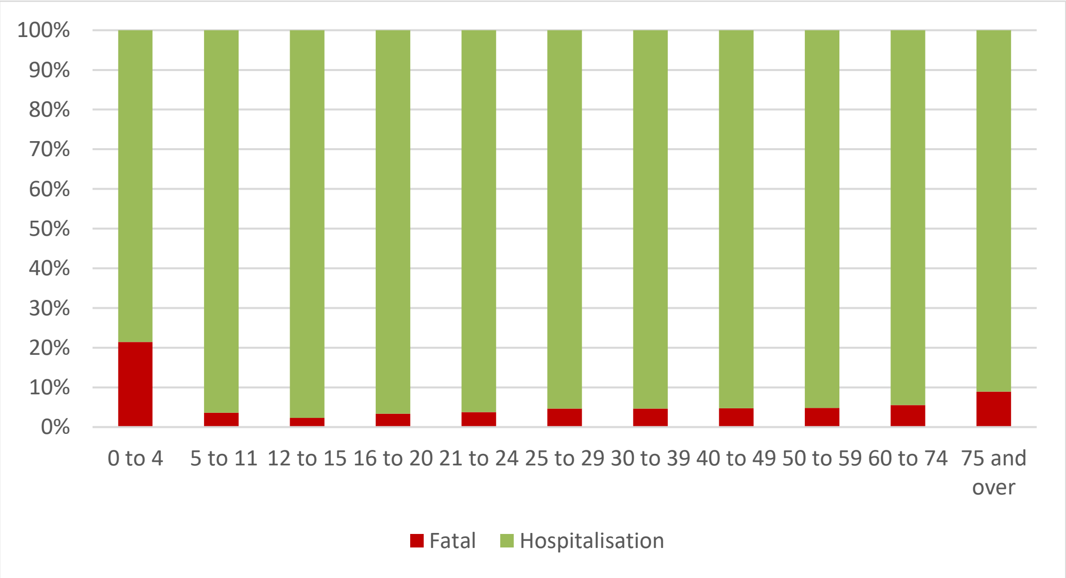
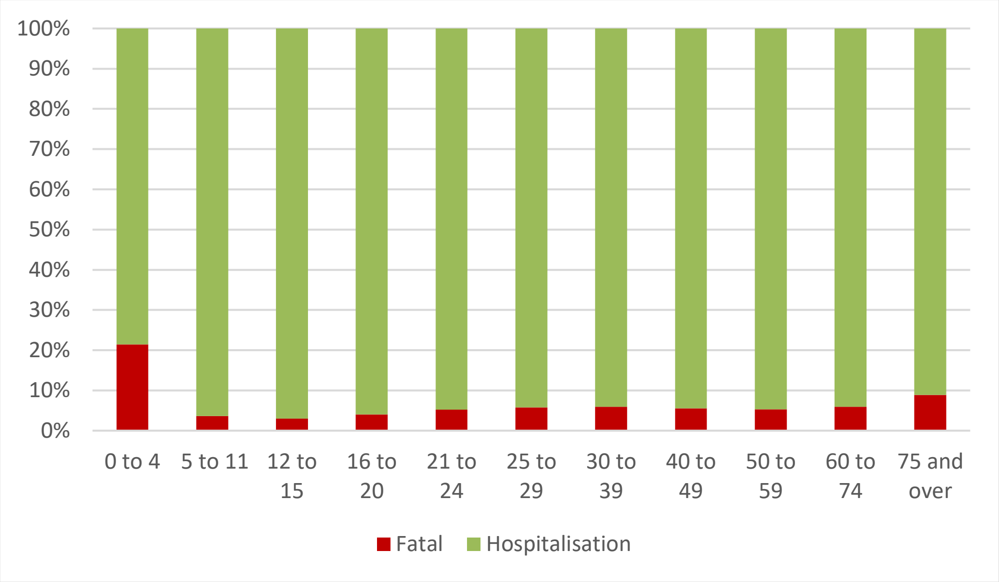


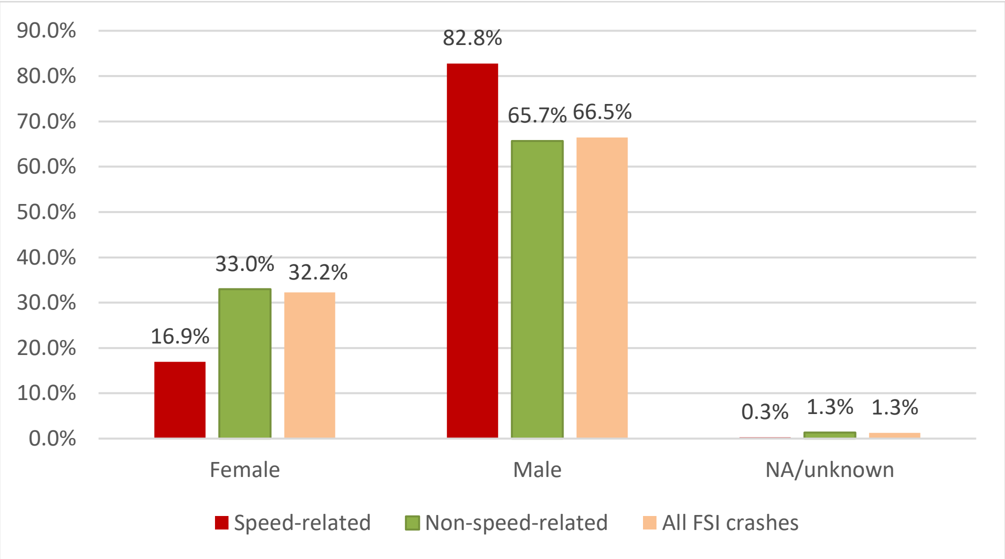
Figure 4.35: FSI crashes by age group (2008-2015)




### 4.14.2 *Driver gender*

Male drivers were involved in 83% of speed-related crashes, approximately five times more than female drivers (Figure 4.36). Male drivers are thus over-represented in speed-related crashes (83%) compared to female drivers (17%) and to non-speed-related crashes involving male drivers (66%).

Figure 4.36: Gender (2008-2015)




### 4.14.3 *Gender and driver age*

Generally, the relative proportion of male drivers involved in FSI crashes was higher than female drivers in the 25-59 years age bracket (Table 4.3). Female drivers aged less than 20 years were over-represented in speed-related crashes. Both male and female drivers in the 16-39 years age bracket were over-represented in speed-related FSI crashes compared to non-speed-related crashes.

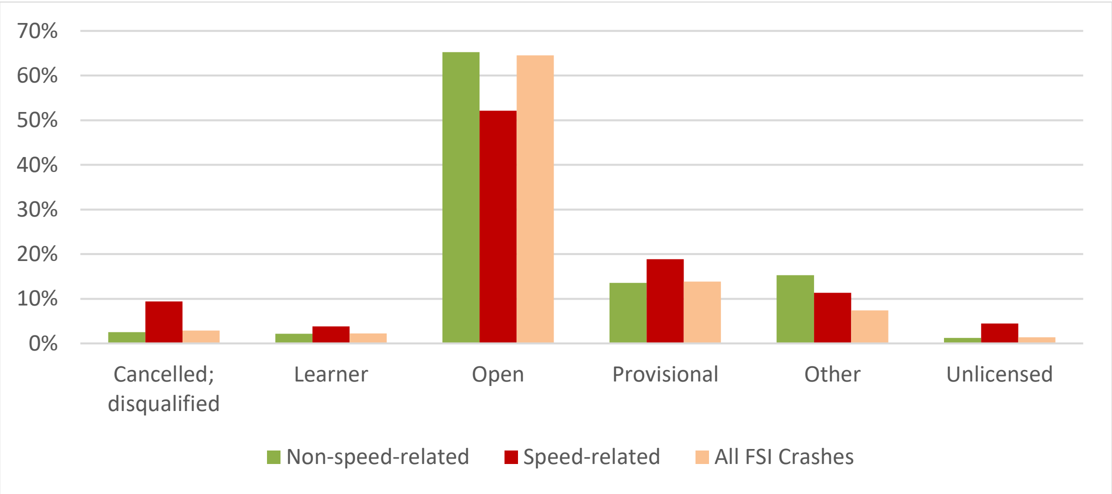
Table 4.3: FSI crashes by driver age and gender (2008-2015)

| Controller Age | Speed-related crashes | | | | Non-speed-related crashes | | | |
|---|---|---|---|---|---|---|---|---|
| | Female | Male | Female (%) | Male (%) | Female | Male | Female (%) | Male (%) |
| 0 to 15 | 1 | 2 | 0.6% | 0.2% | 64 | 177 | 0.9% | 1.3% |
| 16 to 20 | 45 | 150 | 25.7% | 17.5% | 1160 | 1739 | 16.4% | 12.4% |
| 21 to 24 | 29 | 161 | 16.6% | 18.8% | 802 | 1489 | 11.4% | 10.6% |
| 25 to 29 | 24 | 134 | 13.7% | 15.7% | 755 | 1558 | 10.7% | 11.1% |
| 30 to 39 | 37 | 176 | 21.1% | 20.6% | 1274 | 2604 | 18.0% | 18.5% |
| 40 to 49 | 18 | 120 | 10.3% | 14.0% | 1039 | 2243 | 14.7% | 16.0% |
| 50 to 59 | 12 | 59 | 6.9% | 6.9% | 877 | 1899 | 12.4% | 13.5% |
| 60 to 74 | 8 | 44 | 4.6% | 5.1% | 762 | 1598 | 10.8% | 11.4% |
| 75 and over | 1 | 6 | 0.6% | 0.7% | 311 | 687 | 4.4% | 4.9% |
| Unknown | 0 | 3 | 0.0% | 0.4% | 16 | 64 | 0.2% | 0.5% |
| **Total** | **175** | **855** | **100.0%** | **100.0%** | **7 060** | **14 058** | **100.0%** | **100.0%** |

### *4.14.4 Driver licence type*

Figure 4.37 suggests that, while the majority of drivers in FSI crashes held open licences, the cancelled/disqualified and provisional licence categories were over-represented.

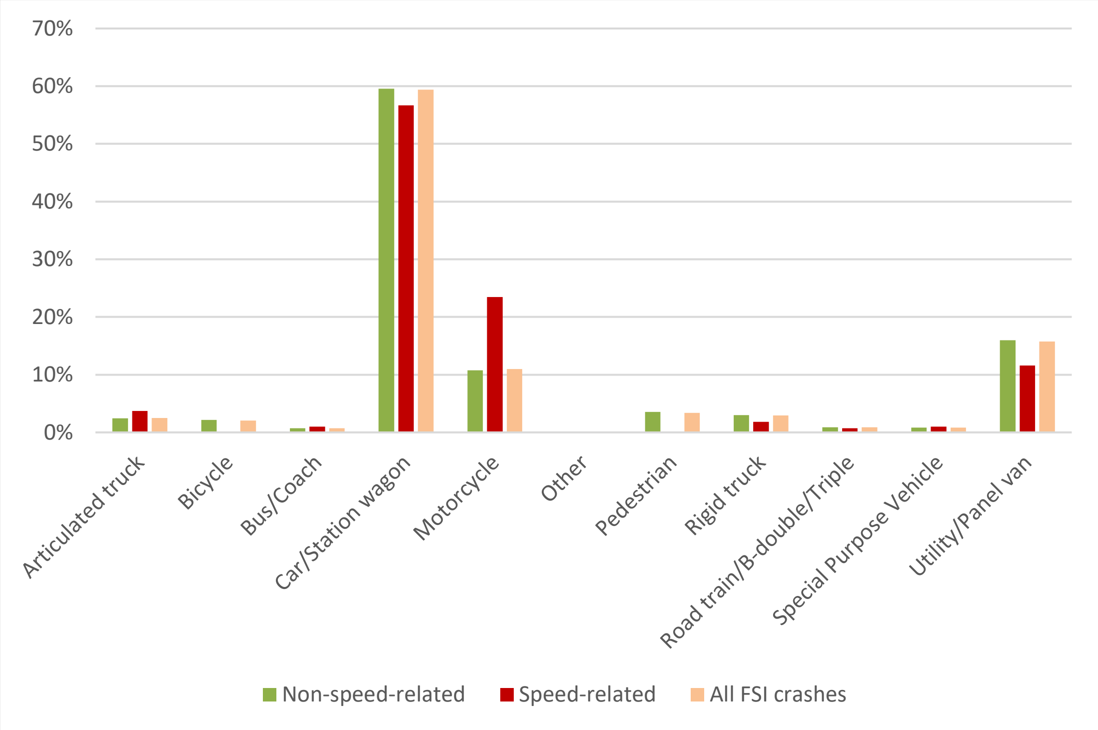
Figure 4.37: FSI crashes by driver licence type (2008-2015)




### *4.14.5 Vehicle type*

Cars, station wagons, motorcycles, utility and panel vans comprised 86% of all FSI crashes (Figure 4.38). Motorcyclists were strongly over-represented in speed-related crashes compared to non-speeding crashes (relative risk of 2.1).

**Figure 4.38: FSI crashes by vehicle type (2008-2015)**




## 4.15 Summary of Findings

The findings of the crash analysis suggest the following:

- Five per cent of FSI crashes and 18% of fatal crashes on Queensland's State-controlled roads were classified as speed-related. This confirms other research findings suggesting that extreme behaviour contributes more strongly to fatalities.
- The relative proportion of speed-related crashes that resulted in a fatality increased with the speed limit, ranging from 10% in 50 km/h or less zones to 18% in 100-110 km/h zones.
- The relative proportion of fatal FSIs was higher for speed-related crashes than for non-speed-related crashes.
- Speeding-related crashes were more likely to have occurred on mid-block road sections.
- The majority of speed-related FSI crashes involved single-vehicles: 72% of the speed-related FSIs involved single vehicles compared to 40% for non-speed related FSI crashes.
- Overall, speed environment did not have a strong influence on the proportion of speed-related FSI crashes.
- Speed-related FSI crashes into roadside objects were over-represented, regardless of speed environment. The majority of speed-related FSI crashes involved hit-object (50%), double the proportion of the non-speed-related FSI crashes.
- Speed-related head-on and overturning FSI crashes were more common on high-speed roads, as expected in high-energy road departures.
- Speed-related crashes were over-represented on curves, with 54% of speed-related FSIs occurring on curves compared to 28% of non-speed-related crashes.
- Speed-related crashes were over-represented on grades, i.e. non-level road sections (risk ratio of 1.6).

- On average, a higher proportion of speed-related crashes occurred on weekends compared to weekdays.
- The main road user crash factors for speed-related FSI crashes were ‘disobey road rules’ (22%) followed by ‘controller condition’ (18%), ‘young adult (16-24 years)’ (11%), ‘alcohol-related’ (10%), and ‘distracted/inattentive’ (8%).
- Speed-related crashes were over-represented in crashes involving unlicensed drivers, ‘controller condition’, alcohol-related and motorcyclists compared to non-speed-related crashes. For example, unlicensed drivers were 2.3 times more likely to be speeding when involved in FSI crashes.
- The relative proportion of drivers with non-open licences was slightly higher for speed-related crashes than non-speed-related crashes.

# 5 ROAD CHARACTERISTICS AND SPEED-RELATED CRASHES

## 5.1 Linking Crash and AusRAP Data

The speed-related FSI crash data was linked to the AusRAP data to enable the road features at the location of these crashes to be examined as described in Section 2.2.3. Approximately 96% (977) of the FSI speed-related crashes were linked. The remaining 50 FSI crashes were unable to be assigned to the appropriate carriageway, i.e. the gazetted and anti-gazetted carriageways of divided roads. These crashes have been given labels A, B, C, D, etc. under the 'Crash_Road Section_Carriageway' field in the crash database. These crashes, some of which occurred on the ramps, have been excluded from the analysis (ramp data is not included in AusRAP).

## 5.2 High-Risk State-controlled Roads (Speed-related FSI Crashes)

The top 20 road sections with the highest number of speed-related FSI crashes and for all FSI crashes are shown in Figure 5.1 and Figure 5.2 respectively. The Pacific Highway (12A) recorded the highest number of FSIs in both cases. The other road sections including Peaks Down Highway (32A) and Bruce Highway 10A in the top 20 for speed-related FSIs also appear in the top 20 roads for all FSI crashes, but not in the same position. The top 50 high-risk speed-related crash road sections are provided in Appendix A.

**Figure 5.1: Top 20 road sections with highest numbers of speed-related FSI crashes by severity (2008-15)**

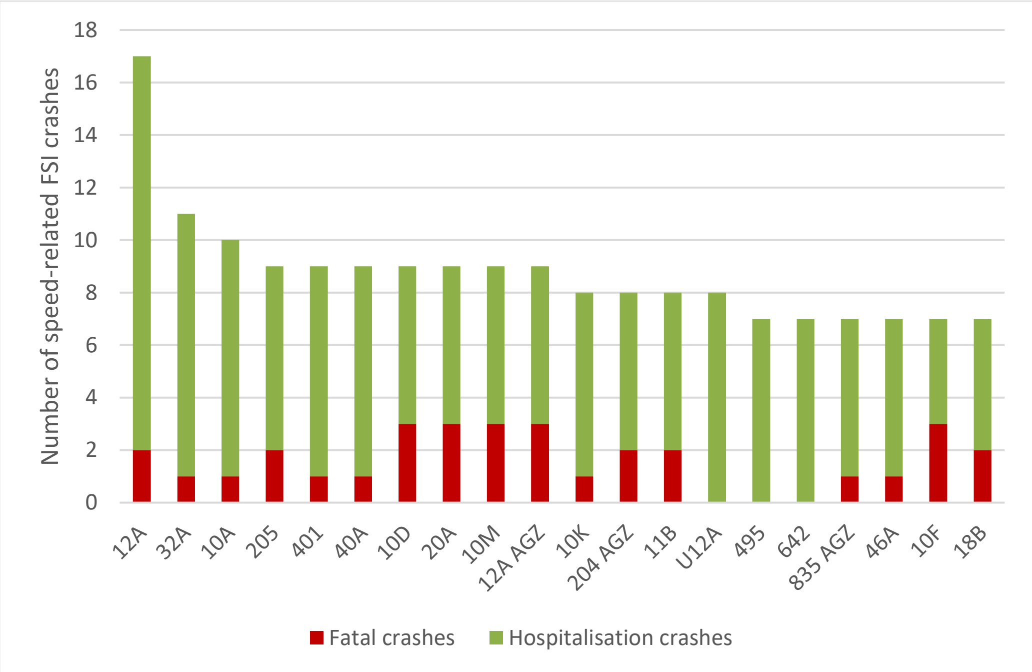
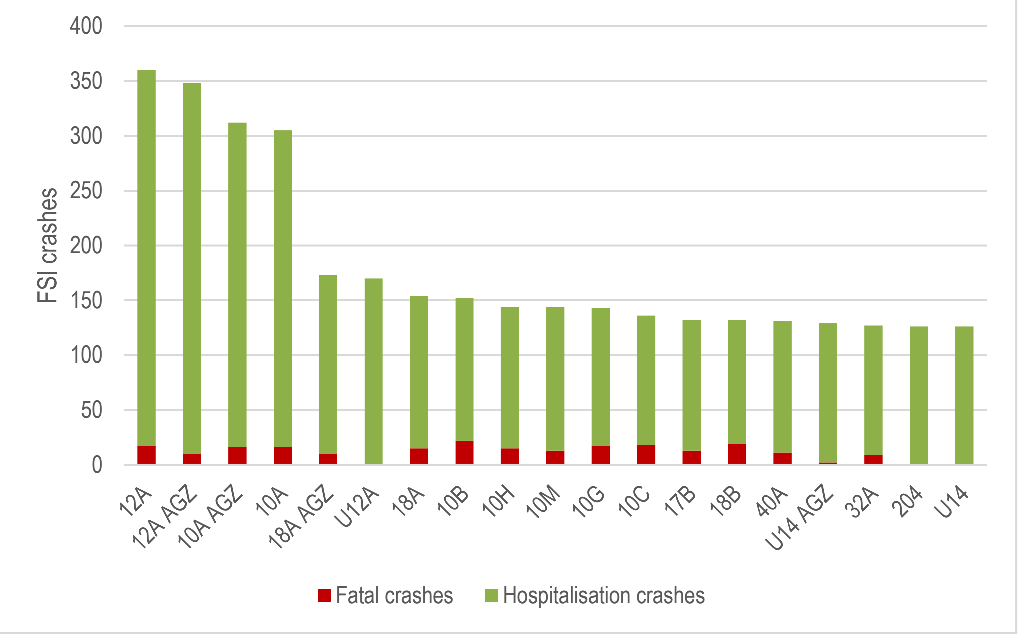


Figure 5.2: Top 20 road sections with highest numbers of all FSI crashes by severity (2008-15)




The top 20 road sections with the highest speed-related FSI crashes per kilometre and crash rate per 100M VKT respectively are shown in Table 5.1 and Table 5.2.

Table 5.1: Top 20 road sections with the highest speed-related FSI crashes per kilometre (2008-15)

| Road Section ID | Length (km) | M VKT | Fatal crashes | Hospitalisation crashes | FSI crashes | Annual crashes per km | Annual crashes per 100M VKT |
|---|---|---|---|---|---|---|---|
| 492 AGZ | 0.7 | 1.49 | 0 | 2 | 2 | 0.36 | 16.76 |
| 17D AGZ | 0.7 | 0.40 | 0 | 1 | 1 | 0.18 | 31.54 |
| 906 | 1.6 | 6.65 | 0 | 2 | 2 | 0.16 | 3.76 |
| 1720 | 1.8 | 1.77 | 0 | 2 | 2 | 0.14 | 14.16 |
| 915 | 2.1 | 7.50 | 0 | 2 | 2 | 0.12 | 3.33 |
| 831 AGZ | 1.1 | 3.13 | 0 | 1 | 1 | 0.11 | 3.99 |
| 174 AGZ | 1.3 | 4.93 | 0 | 1 | 1 | 0.10 | 2.54 |
| 10E AGZ | 4.1 | 17.78 | 1 | 2 | 3 | 0.09 | 2.11 |
| 835 AGZ | 10.9 | 52.16 | 1 | 6 | 7 | 0.08 | 1.68 |
| 851 AGZ | 1.6 | 4.82 | 0 | 1 | 1 | 0.08 | 2.59 |
| 407 | 6.7 | 27.04 | 0 | 4 | 4 | 0.07 | 1.85 |
| 118 AGZ | 1.7 | 6.49 | 0 | 1 | 1 | 0.07 | 1.93 |
| 840 | 5.5 | 30.04 | 2 | 1 | 3 | 0.07 | 1.25 |
| 101 | 7.5 | 73.85 | 1 | 3 | 4 | 0.07 | 0.68 |
| 116 AGZ | 9.7 | 49.34 | 1 | 4 | 5 | 0.06 | 1.27 |
| 163 AGZ | 3.9 | 13.33 | 0 | 2 | 2 | 0.06 | 1.88 |
| 136 | 10 | 44.25 | 0 | 5 | 5 | 0.06 | 1.41 |
| 117 | 2 | 11.64 | 0 | 1 | 1 | 0.06 | 1.07 |
| 200 AGZ | 4.2 | 14.34 | 1 | 1 | 2 | 0.06 | 1.74 |
| U12A | 17.4 | 349.36 | 0 | 8 | 8 | 0.06 | 0.29 |

Table 5.2: Top 20 road sections with highest annual speed-related FSI crashes per 100M VKT (2008-15)

| Road Section ID | Sum of length | M VKT | Fatal crashes | Hospitalisation crashes | FSI crashes | Annual crashes per km | Annual crashes per 100M VKT |
|---|---|---|---|---|---|---|---|
| 8554 | 11.3 | 0.98 | 0 | 3 | 3 | 0.03 | 38.20 |
| 17D AGZ | 0.7 | 0.40 | 0 | 1 | 1 | 0.18 | 31.54 |
| 3401 | 21.1 | 0.49 | 0 | 1 | 1 | 0.01 | 25.76 |
| 4023 | 26.9 | 3.63 | 1 | 5 | 6 | 0.03 | 20.68 |
| 717 | 102.8 | 0.68 | 0 | 1 | 1 | 0.00 | 18.51 |
| 481 | 14.3 | 2.97 | 0 | 4 | 4 | 0.03 | 16.81 |
| 492 AGZ | 0.7 | 1.49 | 0 | 2 | 2 | 0.36 | 16.76 |
| 1720 | 1.8 | 1.77 | 0 | 2 | 2 | 0.14 | 14.16 |
| 6801 | 219.4 | 3.21 | 0 | 3 | 3 | 0.00 | 11.68 |
| 534 | 22.9 | 2.25 | 1 | 1 | 2 | 0.01 | 11.11 |
| 493 | 20.4 | 7.31 | 2 | 4 | 6 | 0.04 | 10.27 |
| 487 | 54.3 | 3.24 | 0 | 2 | 2 | 0.00 | 7.72 |
| 93C | 390.8 | 3.32 | 0 | 2 | 2 | 0.00 | 7.54 |
| 81A | 164.1 | 1.74 | 1 | 0 | 1 | 0.00 | 7.20 |
| 476 | 59 | 5.62 | 1 | 2 | 3 | 0.01 | 6.67 |
| 2050 | 10.9 | 6.79 | 0 | 3 | 3 | 0.03 | 5.52 |
| 8506 | 10 | 4.93 | 0 | 2 | 2 | 0.03 | 5.07 |
| 436 | 36.4 | 5.08 | 0 | 2 | 2 | 0.01 | 4.93 |
| 5501 | 11 | 2.57 | 1 | 0 | 1 | 0.01 | 4.86 |
| 914 | 10.6 | 2.59 | 0 | 1 | 1 | 0.01 | 4.82 |

## 5.3 High-Risk Sections (Speed-related FSI Crashes and AusRAP)

### *5.3.1 High-risk sections – 3 km long sections*

A review of the crash location indicated that speed-related crashes were not concentrated, but rather spread across the network. Hence, in order to define high-risk sections, crashes that occurred within 3 km long sections were computed. This process identified 743 sections that recorded at least one speed-related FSI crash within a 3 km section. The number of speed-related FSI crashes per 3 km section ranged from one to five, as summarised in Table 5.3. Sections that recorded three or more FSI crashes have been classified as high-risk sections. These 38 high-risk sections are shown in Table 5.4.

Table 5.3: 3 km road sections and number of speed-related crashes

| Speed-related FSI crashes within 3 km | Number of sections |
|---|---|
| 1 | 562 |
| 2 | 143 |
| 3 | 25 |
| 4 | 11 |
| 5 | 2 |
| Total | 743 |

**Table 5.4: High-risk sections that recorded three or more speed-related FSI crashes (2008-15)**

| Road Section ID | Start (km) | End (km) | M VKT | Posted Speed Limit | No. of intersec-tions | Speed-related crashes | | | | Non-speed-related FSI crashes | Total FSI | Percent speed-related FSI crashes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Fatal | Hospitalised crashes | FSI | Crash rate per 100M VKT | | | |
| 414 | 15.50 | 18.50 | 1.26 | 80 | 1 | 1 | 4 | 5 | 49.72 | 5 | 10 | 50% |
| 11B | 2.21 | 5.21 | 35.24 | 60/70 | 0 | 1 | 4 | 5 | 1.77 | 11 | 16 | 31% |
| 136 | 7.01 | 10.12 | 24.94 | 60 | 11 | 0 | 4 | 4 | 2.00 | 8 | 12 | 33% |
| 205 | 4.60 | 7.60 | 3.84 | 60 | 0 | 1 | 3 | 4 | 13.02 | 3 | 7 | 57% |
| 301 | 5.20 | 8.20 | 26.76 | 60 | 21 | 0 | 4 | 4 | 1.87 | 40 | 44 | 9% |
| 401 | 53.70 | 56.70 | 0.91 | 100 | 1 | 0 | 4 | 4 | 55.01 | 13 | 17 | 24% |
| 407 | 2.90 | 5.90 | 12.11 | 70 | 3 | 0 | 4 | 4 | 4.13 | 19 | 23 | 17% |
| 116 AGZ | 1.21 | 4.21 | 30.23 | 70/80 | 0 | 1 | 3 | 4 | 1.65 | 16 | 20 | 20% |
| 12A | 41.20 | 44.20 | 158.07 | 100 | 0 | 0 | 4 | 4 | 0.32 | 11 | 15 | 27% |
| 32A | 3.00 | 5.51 | 7.30 | 60/70 | 0 | 0 | 4 | 4 | 6.85 | 14 | 18 | 22% |
| 32A | 6.51 | 9.52 | 8.76 | 60 | 0 | 0 | 4 | 4 | 5.71 | 17 | 21 | 19% |
| 835 AGZ | 3.00 | 6.00 | 30.30 | 60/70 | 0 | 1 | 3 | 4 | 1.65 | 23 | 27 | 15% |
| U12A | 2.20 | 5.20 | 139.38 | 90 | 0 | 0 | 4 | 4 | 0.36 | 39 | 43 | 9% |
| 101 | 4.50 | 7.50 | 66.18 | 100/90 | 2 | 0 | 3 | 3 | 0.57 | 9 | 12 | 25% |
| 104 | 5.43 | 8.43 | 0.94 | 60/70 | 6 | 1 | 2 | 3 | 39.96 | 10 | 13 | 23% |
| 120 | 8.00 | 11.00 | 35.45 | 80/60/70 | 3 | 1 | 2 | 3 | 1.06 | 12 | 15 | 20% |
| 163 | 38.70 | 41.71 | 19.09 | 60 | 15 | 0 | 3 | 3 | 1.96 | 17 | 20 | 15% |
| 201 | 10.20 | 13.20 | 1.65 | 80 | 1 | 1 | 2 | 3 | 22.79 | 6 | 9 | 33% |
| 213 | 30.30 | 33.30 | 0.59 | 100/80/60 | 1 | 0 | 3 | 3 | 63.42 | 3 | 6 | 50% |
| 406 | 0.00 | 3.00 | 20.57 | 60/80/70 | 8 | 2 | 1 | 3 | 1.82 | 30 | 33 | 9% |
| 481 | 4.20 | 7.20 | 0.57 | 100 | 0 | 0 | 3 | 3 | 65.61 | 2 | 5 | 60% |
| 493 | 13.60 | 16.60 | 0.73 | 100 | 1 | 0 | 3 | 3 | 51.08 | 9 | 12 | 25% |
| 495 | 7.60 | 10.60 | 2.01 | 80/100 | 3 | 0 | 3 | 3 | 18.70 | 3 | 6 | 50% |
| 647 | 4.91 | 7.90 | 32.92 | 80 | 4 | 1 | 2 | 3 | 1.14 | 6 | 9 | 33% |
| 840 | 2.09 | 5.08 | 30.57 | 60/70 | 17 | 2 | 1 | 3 | 1.23 | 27 | 30 | 10% |
| 4023 | 16.70 | 19.70 | 0.30 | 80 | 0 | 1 | 2 | 3 | 124.53 | 8 | 11 | 27% |
| 4032 | 9.80 | 12.80 | 10.03 | 60/80/50 | 12 | 1 | 2 | 3 | 3.74 | 12 | 15 | 20% |
| 10D | 98.00 | 101.00 | 6.14 | 100 | 0 | 0 | 3 | 3 | 6.11 | 0 | 3 | 100% |
| 10E AGZ | 117.34 | 120.34 | 25.89 | 60/70 | 0 | 1 | 2 | 3 | 1.45 | 11 | 14 | 21% |
| 10P AGZ | 73.27 | 76.27 | 31.62 | 80 | 0 | 2 | 1 | 3 | 1.19 | 10 | 13 | 23% |
| 12A | 55.20 | 58.20 | 102.97 | 100 | 0 | 1 | 2 | 3 | 0.36 | 11 | 14 | 21% |
| 18A AGZ | 87.23 | 90.23 | 23.50 | 100/80 | 0 | 1 | 2 | 3 | 1.60 | 12 | 15 | 20% |
| 20A | 29.70 | 32.71 | 6.42 | 80/100 | 0 | 2 | 1 | 3 | 5.84 | 12 | 15 | 20% |
| 40A | 42.91 | 45.91 | 7.65 | 100 | 0 | 0 | 3 | 3 | 4.90 | 5 | 8 | 38% |
| 46A | 0.10 | 3.09 | 22.12 | 60 | 0 | 1 | 2 | 3 | 1.70 | 11 | 14 | 21% |
| U14 | 3.30 | 5.80 | 74.60 | 60/70 | 0 | 0 | 3 | 3 | 0.50 | 16 | 19 | 16% |
| U88 | 4.70 | 7.70 | 45.62 | 70 | 0 | 2 | 1 | 3 | 0.82 | 23 | 26 | 12% |
| N239 | 8.81 | 11.81 | 80.84 | 100 | 0 | 1 | 2 | 3 | 0.46 | 6 | 9 | 33% |

The total number of speed-related FSI crashes within high-risk sections was 129. This represents 13% of the 977 speed-related FSI crashes able to be linked to AusRAP data. This further demonstrates that speed-related FSI crashes are not concentrated at specific locations but are randomly distributed across the network. Due to the small crash numbers, only descriptive statistics have been provided for the road attributes at the defined high-risk sections.

Descriptive analysis of observed correlations between high-risk road sections and road infrastructure design categories is presented in the following sections. Further analysis of these observations, using statistical modelling methods, would identify and quantify the road design and operation factors associated with high-risk of speed-related crashes.

### *5.3.2 High-risk sections and speed limit*

Table 5.5 highlights the pattern of distribution of high-risk sections (speed-related FSI crashes) across different speed zones. For the high-risk sites the highest number of speed-related FSI crashes occurred in the 60 km/h speed zone (34%), followed by the 100-110 km/h speed zone (27%), then the 80-90 km/h speed zone (24%) and the 70 km/h speed zone (15%). The 60 km/h road sections represent only 5% of the total length of State-controlled roads and 15% of VKT, indicating that the speed-related crashes are more concentrated in 60 km/h speed zones. Comparison of the attributes at high-risk sites with the entire network is provided in Appendix B.

**Table 5.5: High-risk sites and speed limit (2008-15)**

| Speed limit (km/h) | High-risk sections: speed-related FSIs | | Entire state-controlled roads | |
|---|---|---|---|---|
| | FSI speed-related | % FSI | % length | % VKT |
| <= 50 | 0 | 0 | 0.5 | 0.6 |
| 60 | 44 | 34 | 5.4 | 14.6 |
| 70 | 19 | 15 | 1.5 | 7.5 |
| 80-90 | 31 | 24 | 6.3 | 18.0 |
| 100-110 | 35 | 27 | 86.4 | 59.4 |
| Total | 129 | 100 | 100 | 100 |

### *5.3.3 High-risk sections and number of lanes*

Most of the speed-related FSI crashes at high-risk sites occurred on single lane roads (46%) followed by two lane roads (37%). Note, however, that more than 95% of the network length consists of single lane roads.

**Table 5.6: High-risk sites and number of lanes (2008-15)**

| Number of lanes | High-risk sections: speed-related FSIs | |
|---|---|---|
| | FSI speed-related | % FSI |
| 1 | 59 | 46 |
| 2 | 48 | 37 |
| 3 | 14 | 11 |
| 4 or more | 6 | 5 |
| 2+1 | 2 | 2 |
| Total | 129 | 100 |

### 5.3.4 High-risk sections and horizontal curvature

Half of the speed-related FSI crashes on high-risk sections occurred on horizontal curves, including one-third on sharp curves. This implies that sharp curves were over-represented in these speed-related high-risk sites compared to the proportion of the entire network that is curved (approx. 10%).

**Table 5.7: High-risk sites and curvature (2008-15)**

| Curvature | High-risk sections: speed-related FSIs | |
|---|---|---|
| | FSI speed-related | % FSI |
| Straight & gently curving | 64 | 50 |
| Moderate curve | 19 | 15 |
| Sharp curve | 43 | 33 |
| Very sharp curve | 3 | 2 |
| Total | 129 | 100 |

Note: Very sharp curve – can be driven at speed <40 km/h or curve radius < 200 m.
Sharp curve – can be driven at speeds between 40 km/h and 70 km/h or curve radius 200 m to 5 0m.
Moderate curve – can be driven at speeds between 0 km/h and 100 km/h or curve radius 500 m to 900 m.
Straight or gently curve – road contains curves which can be driven at 100 km/h or more or curve radius >900 m.

### 5.3.5 High-risk sections and median

It can be seen from Table 5.8 that half of the speed-related FSI crashes at high-risk sections occurred on undivided roads while the other half occurred on roads with safety barriers (16%), physical median greater than 5 m wide (17%) and where there was a physical median less than 5 m wide (16%).

**Table 5.8: High-risk sites and median separation (2008-15)**

| Median separation | High-risk sections: speed-related FSIs | |
|---|---|---|
| | FSI speed-related | % FSI |
| Safety barrier | 21 | 16 |
| Physical median > 5 m | 22 | 17 |
| Physical median <= 5 m | 21 | 16 |
| Undivided | 65 | 50 |
| Total | 129 | 100 |

### 5.3.6 High-risk sections and lane width

It can be seen from Table 5.9 that the majority (74%) of speed-related FSI crashes at high-risk sections occurred on road sections with wide lane widths (3.25 m or more), with the remainder (26%) occurring on roads with lane widths of 2.75 to 3.25 m. Note that majority of the network (70% of road length and 91% of VKT) consists of lane widths greater than 3.25 m.

**Table 5.9: High-risk sites and lane width (2008-15)**

| Lane width | High-risk sections; speed-related FSIs | |
|---|---|---|
| | FSI speed-related | % FSI |
| >= 3.25 m | 96 | 74 |
| 2.75 to 3.25 m | 33 | 26 |
| < 2.75 m | 0 | 0.0 |
| Total | 129 | 100 |

### 5.3.7 High-risk sections and sealed shoulder width – passenger side

It can be seen from Table 5.10 that the highest proportion of speed-related FSI crashes at high-risk sections occurred where the passenger side sealed shoulder width was less than 1.0 m (40%), and 6% of the crashes on sections with no sealed shoulders. Note, roads with sealed shoulder width less than 1 m and none represent 28% and 6% of the network in terms of VKT, respectively. The higher speed-related crash risk on these road sections may be due to the lack of adequate shoulder width for drivers to recover after making an error when driving above the speed limit or appropriate for the road condition.

Table 5.10: High-risk sites and sealed shoulder width – passenger side (2008-15)

| Sealed shoulder width | High-risk sections: speed-related FSIs | |
|---|---|---|
| | FSI speed-related | % FSI |
| > 2.4 m | 21 | 16 |
| 1 to 2.4 m | 48 | 37 |
| < 1.0 m | 52 | 40 |
| None | 8 | 6 |
| Total | 129 | 100 |

### 5.3.8 High-risk sections and sealed shoulder width – driver side

It can be seen from Table 5.11 that the highest proportion of speed-related FSI crashes at high-risk sections occurred when the width of the driver side sealed shoulder was less than 1.0 m (65%), followed by a sealed shoulder width of 1.0 to 2.4 m (25%), and then where there was no shoulder (9%). Note that roads with a width of sealed shoulder less than 1 m, or with no sealed shoulder, none represent 55% and 7% of the network respectively in terms of VKT. Similarly, and as stated earlier, the higher speed-related crash risk on these road sections may be due to the lack of adequate shoulder width for drivers to recover after making an error when driving above the speed limit or in a way appropriate for the road condition.

Table 5.11: High-risk sites and sealed shoulder width – driver side (2008-15)

| Sealed shoulder width | High-risk sections: speed-related FSIs | |
|---|---|---|
| | FSI speed-related | % FSI |
| > 2.4 m | 1 | 1 |
| 1 to 2.4 m | 32 | 25 |
| < 1.0 m | 84 | 65 |
| None | 12 | 9 |
| Total | 129 | 100 |

### 5.3.9 High-risk sections by delineation

Table 5.12 shows that delineation was not a factor involved in speed-related FSI crashes at the high-risk sites, with only 3% of crash sites having poor delineation. Most of the network has good delineation.

**Table 5.12: High-risk sites and delineation (2008-15)**

| Delineation | High-risk sections: speed-related FSIs | |
|---|---|---|
| | FSI speed-related | % FSI |
| Adequate | 125 | 97 |
| Poor | 4 | 3 |
| Total | 129 | 100 |

Note: Delineation is a combination of factors including centrelines, edge lines, guideposts/ delineator road studs and hazard markers, and signage. Adequate delineation is where signs warning of sever hazards and centre and edge markings are generally present and visible. For unsealed roads guidepost are to be present.

### *5.3.10 High-risk sections and object distance – passenger side*

The highest proportion of speed-related FSI crashes at high-risk sections occurred where the distance from the travel lane to a hazard on the passenger side (clear zone width) was 1 to 5 m (74%), followed by 5 to 10 m (18%).

**Table 5.13: High-risk sites and clear zone – passenger side (2008-15)**

| Object distance | High-risk sections; speed-related FSIs | |
|---|---|---|
| | FSI speed-related | % FSI |
| < 1 m | 6 | 5 |
| 1 to 5 m | 96 | 74 |
| 5 to 10 m | 23 | 18 |
| >= 10 m | 4 | 3 |
| Total | 129 | 100 |

### *5.3.11 High-risk sections and object distance – driver side*

The highest proportion of speed-related FSI crashes at high-risk sites occurred when the width of the driver side clear zone was 1 to 5 m (73%), followed by 5 to 10 m (12%).

**Table 5.14: High-risk sites and clear zone – driver side (2008-15)**

| Object distance | High-risk sections; speed-related FSIs | |
|---|---|---|
| | FSI speed-related | % FSI |
| < 1 m | 10 | 8 |
| 1 to 5 m | 94 | 73 |
| 5 to 10 m | 16 | 12 |
| >= 10 m | 9 | 7 |
| Total | 129 | 100 |

## 5.4 Road Attributes at Locations of Speed-related Crashes

This section summarises the road attributes of the 100 m long road sections (locations) where speed-related FSI crashes have occurred compared to non-speed related FSI crashes. The purpose was to identify those characteristics of the road attributes that were more strongly associated with speed-related crashes. Factors investigated included the number of lanes, lane width, sealed shoulder width, curvature, intersection type, delineation, and roadside clear zones.

The results presented in the following sections are data observations based on univariate analysis. They are indicative of where relationships may exist. Further analysis using appropriate statistical modelling techniques would identify and quantify the strength of any relationships.

### 5.4.1 FSI crashes and number of lanes

A higher percentage of speed-related FSI crashes (62%) occurred on sections of road with a single traffic lane (each way) compared to 52% for non-speed-related FSI crashes, as shown in Table 5.15. This was reflected in the highest crash rate of 83 FSI crashes per 100M VKT (individual risk) on single traffic lane roads (i.e. two-lane, two-way).

**Table 5.15: FSI crashes and number of lanes (2008-15)**

| Number of lanes | % road length | Speed-related FSI crashes | | | | | Non-speed-related FSI crashes | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % FSI crashes | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % FSI crashes |
| 1 | 92.3 | 603 | 58.9 | 1.3 | 83.0 | 61.7 | 9830 | 823 | 1.5 | 80.0 | 51.8 |
| 2 | 5.5 | 269 | 26.0 | 1.3 | 22.5 | 27.5 | 6573 | 406 | 2.0 | 34.6 | 34.6 |
| 3 | 1.0 | 76 | 7.3 | 1.3 | 10.8 | 7.8 | 1824 | 105 | 2.2 | 17.0 | 9.6 |
| 4 or more | 0.3 | 18 | 1.8 | 1.3 | 5.7 | 1.8 | 440 | 33 | 1.7 | 7.3 | 2.3 |
| 2+1 | 0.9 | 11 | 1.1 | 1.3 | 50.7 | 1.1 | 306 | 25 | 1.5 | 59.2 | 1.6 |
| Total: 34 783 km | | 977 | 95.1 | 1.3 | 33.0 | 100 | 18973 | 1393 | 1.7 | 39.1 | 100 |

### 5.4.2 FSI crashes and horizontal curvature

Although the majority of the road network consists of straight sections, a higher percentage of speed-related FSI crashes (35%) occurred on curves compared to non-speed-related FSI crashes (21%), indicating that there is a higher risk of speed-related crashes on curves (Table 5.16). This is particularly noted for sharp and very sharp curves, which make up only approximately 2% of the network but account for 17% of the speed-related FSI crashes compared to 7% of non-speed-related FSI crashes. The higher speed-related crash risk on these curves is due to the reduced ability of drivers to recover from an error when speeding or not driving to the road conditions compared to not speeding.

**Table 5.16: FSI crashes and horizontal curvature (2008-15)**

| Curvature | % road length | Speed-related FSI crashes | | | | | Non-speed-related FSI crashes | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % crashes | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % crashes |
| Straight | 91.2 | 634 | 62.3 | 1.3 | 27.5 | 64.9 | 15016 | 1116.9 | 1.7 | 36.2 | 79.1 |
| Moderate curve | 6.6 | 180 | 17.5 | 1.3 | 43.3 | 18.4 | 2677 | 183.9 | 1.8 | 49.3 | 14.1 |
| Sharp curve | 2.0 | 146 | 13.8 | 1.3 | 64.3 | 14.9 | 1153 | 82.1 | 1.8 | 72.8 | 6.1 |
| Very sharp curve | 0.2 | 17 | 1.5 | 1.4 | 163.6 | 1.7 | 127 | 10.4 | 1.5 | 151.0 | 0.7 |
| Total: 34 783 km | | 977 | 95.1 | 1.3 | 33.0 | 100 | 18973 | 1393.3 | 1.7 | 39.1 | 100 |

Note: Very sharp curve – can be driven at speed <40 km/h or curve radius < 200 m.
Sharp curve – can be driven at speeds between 40 km/h and 70 km/h or curve radius 200 m to 500 m.
Moderate curve – can be driven at speeds between 70 km/h and 100 km/h or curve radius 500 m to 900 m.
Straight or gently curve – road contains curves which can be driven at 100 km/h or more or curve radius >900 m.

### 5.4.3 FSI crashes and lane width

There are more speed-related FSI crashes (18%) occurring on road sections with a lane width less than 3.25 m compared to non-speed-related FSI crashes (12%). The individual risk (crashes per VKT) is highest on road sections with lane widths less than of 2.75 m for both non-speed-related and speed-related crashes, most probably due to low traffic volume.

**Table 5.17: FSI crashes and lane width (2008-15)**

| Lane width | % road length | Speed-related FSI crashes | | | | | Non-speed-related FSI crashes | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % crashes | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % crashes |
| > 3.25 m | 67.6 | 803 | 78.6 | 1.3 | 28.7 | 82.2 | 16761 | 1205 | 1.7 | 36.4 | 88.3 |
| 2.75 to 3.25 m | 22.5 | 162 | 15.3 | 1.3 | 102.0 | 16.6 | 2069 | 183.9 | 1.5 | 83.3 | 10.9 |
| < 2.75 m | 9.9 | 12 | 1.2 | 1.3 | 764.6 | 1.2 | 143 | 82.1 | 1.3 | 997.3 | 0.8 |
| Total: 34 783 km | | 977 | 95.1 | 1.3 | 33.0 | 100 | 18973 | 10.4 | 1.7 | 39.1 | 100 |

### 5.4.4 FSI crashes and median type

It can be seen from Table 5.18 that a higher percentage of speed-related FSI crashes occurred on undivided roads (62%) compared to non-speed-related FSI crashes (53%). There is also a higher individual risk to road users traveling along undivided carriageways with the highest crash rate per VKT (76 crashes per 100M VKT).

**Table 5.18: FSI crashes by median type (2008-15)**

| Median | % road length | Speed-related FSI crashes | | | | | Non-speed-related FSI crashes | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % crashes | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % crashes |
| Safety barrier | 2.2 | 98 | 9.5 | 1.3 | 10.1 | 10.0 | 1925 | 150.0 | 1.6 | 11.7 | 10.1 |
| Physical median > 5 m | 2.7 | 119 | 11.4 | 1.3 | 20.2 | 12.2 | 2755 | 177.5 | 1.9 | 28.9 | 14.5 |
| Physical median <= 5 m | 2.2 | 152 | 14.7 | 1.3 | 25.3 | 15.6 | 4148 | 225.0 | 2.3 | 45.4 | 21.9 |
| Undivided | 92.9 | 608 | 59.5 | 1.3 | 76.0 | 62.2 | 10145 | 840.8 | 1.5 | 75.7 | 53.5 |
| Total: 34 783 km | | 977 | 95.1 | 1.3 | 33.0 | 100 | 18973 | 1393.3 | 1.7 | 39.1 | 100 |

### 5.4.5 FSI crashes and sealed shoulder width – passenger side

It can be seen from Table 5.19 that more speed-related FSI crashes occurred on road sections with a sealed shoulder width (passenger side) less than 1.0 m (40%) and where there was no shoulder (14%) compared to non-speed-related FSI crashes (34% and 10% respectively). The higher speed-related crash risk on these road sections may be due to the lack of adequate shoulder width for drivers to recover after making an error when driving above the speed limit or appropriate for the road condition.

Table 5.19: FSI crashes and sealed shoulder width – passenger side (2008-15)

| Sealed shoulder width (m) | % road length | Speed-related FSI crashes | | | | | Non-speed-related FSI crashes | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % crashes | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % crashes |
| > 2.4 | 2.6 | 109 | 10.7 | 1.3 | 15.1 | 11.2 | 2816 | 191.0 | 1.8 | 26.9 | 14.8 |
| 1.0–2.4 | 15.5 | 350 | 34.1 | 1.3 | 25.5 | 35.8 | 7835 | 570.4 | 1.7 | 31.1 | 41.3 |
| < 1.0 | 35.0 | 386 | 37.3 | 1.3 | 54.2 | 39.5 | 6397 | 486.7 | 1.6 | 60.2 | 33.7 |
| None | 46.9 | 132 | 13.0 | 1.3 | 84.7 | 13.5 | 1925 | 145.2 | 1.7 | 85.9 | 10.1 |
| Total: 34 783 km | | 977 | 95.1 | 1.3 | 33.0 | 100 | 18973 | 1393.3 | 1.7 | 39.1 | 100 |

### 5.4.6 FSI crashes and sealed shoulder width – driver side

The percentage of speed-related FSI crashes for the different sealed shoulder widths (driver side), presented in Table 5.20, are similar to non-speed-related FSI crashes. The percentage of speed related FSI crashes where there was no sealed shoulder (15%) was slightly higher compared to non-speed-related FSI crashes (12%). The individual risk is higher for speed-related crash on roads with no shoulder, followed by a shoulder width of less than 1.0 m.

Table 5.20: FSI crashes and sealed shoulder width – driver side (2008-15)

| Sealed shoulder width (m) | % road length (km) | Speed-related FSI crashes | | | | | Non-speed-related FSI crashes | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % crashes | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % crashes |
| > 2.4 | 0.8 | 25 | 2.3 | 1.4 | 12.7 | 2.6 | 593 | 45.7 | 1.6 | 23.9 | 3.1 |
| 1.0–2.4 | 10.1 | 213 | 21.0 | 1.3 | 12.5 | 21.8 | 4322 | 341.8 | 1.6 | 26.5 | 22.8 |
| < 1.0 | 41.9 | 590 | 57.1 | 1.3 | 20.5 | 60.4 | 11781 | 838.8 | 1.8 | 43.7 | 62.1 |
| None | 47.2 | 149 | 14.7 | 1.3 | 49.0 | 15.3 | 2277 | 167.0 | 1.7 | 81.7 | 12.0 |
| Total: 34 783 km | | 977 | 95.1 | 1.3 | 19.2 | 100.0 | 18973 | 1393.3 | 1.7 | 39.1 | 100.0 |

### 5.4.7 FSI crashes and object distance – passenger side

It can be seen from Table 5.21 that the percentage crashes for speed-related FSI crashes by roadside clear zones on the passenger side are similar to those for non-speed-related FSI crashes. Speed-related FSI crashes were slightly higher where there was a clear zone >10.0 m (17%) compared to non-speed-related crashes (14%). However, the individual risk was similar (57 and 58 crashes per VKT).

Table 5.21: FSI crashes and object distance – passenger side (2008-15)

| Lane width (m) | %road length | Speed-related FSI crashes | | | | | Non-speed-related FSI crashes | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % crashes | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % crashes |
| < 1 | 2.4 | 44 | 4.3 | 1.3 | 35.0 | 4.5 | 682 | 47.2 | 1.8 | 33.6 | 3.6 |
| 1–5 | 27.5 | 585 | 56.4 | 1.3 | 28.1 | 59.9 | 11997 | 817.2 | 1.8 | 35.3 | 63.2 |
| 5–10 | 25.1 | 183 | 18.1 | 1.3 | 39.1 | 18.7 | 3626 | 293.8 | 1.5 | 45.7 | 19.1 |
| > 10 | 45.0 | 165 | 16.3 | 1.3 | 57.0 | 16.9 | 2668 | 235.1 | 1.4 | 58.3 | 14.1 |
| Total: 34 783 km | | 977 | 95.1 | 1.3 | 33.0 | 100 | 18973 | 1393.3 | 1.7 | 39.1 | 100 |

### 5.4.8 FSI crashes and object distance – driver side

The percentage crashes for speed-related FSI crashes by roadside clear zones on the driver side are similar to those for non-speed-related FSI crashes. Speed related FSI crashes where there is a clear zone 5.0 to 10.0 m and <1.0 m (18% and 8% respectively) are slightly higher compared to non-speed-related FSI crashes (15% and 6% respectively). Clear zone width of 5.0 to 10.0 m had the highest crash rate (44 crashes per VKT).

**Table 5.22: FSI crashes and object distance – driver side (2008-15)**

| Object distance | % road length | Speed-related FSI crashes | | | | | Non-speed-related FSI crashes | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % crashes | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % crashes |
| < 1 m | 3.1 | 77 | 7.5 | 1.3 | 21.3 | 7.9 | 1221 | 83.7 | 1.8 | 23.2 | 6.4 |
| 1 m to 5 m | 30.0 | 543 | 52.8 | 1.3 | 28.9 | 55.6 | 11479 | 795.0 | 1.8 | 36.1 | 60.5 |
| 5 m to 10 m | 29.1 | 173 | 16.7 | 1.3 | 59.2 | 17.7 | 2797 | 239.6 | 1.5 | 70.4 | 14.7 |
| > 10 m | 37.7 | 184 | 18.1 | 1.3 | 43.1 | 18.8 | 3476 | 275.0 | 1.6 | 46.3 | 18.3 |
| Total (km) | 34 783 | 977 | 95.1 | 1.3 | 33.0 | 100 | 18973 | 1393.3 | 1.7 | 39.1 | 100 |

### 5.4.9 FSI crashes and delineation

A higher percentage of speed-related FSI crashes (11%) occurred on road sections with inadequate delineation compared to non-speed-related FSI crashes (7%). Individual risk of a speed-related crash in terms of crash rate per VKT was higher for road sections with inadequate delineation. However, the majority of speed-related crashes occurred where delineation was adequate. This may reflect drivers driving too fast for the conditions or the road environment not encouraging drivers to drive at a safe speed.

**Table 5.23: FSI crashes and delineation (2008-15)**

| Delineation | %road length | Speed-related FSI crashes | | | | | Non-speed-related FSI crashes | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | % crashes | FSI crashes | Length (km) | Annual crashes per km | Crashes per 100M VKT | %t crashes |
| Adequate | 56.5 | 866 | 84.3 | 1.3 | 29.7 | 88.6 | 17669 | 1274.3 | 1.7 | 36.9 | 93.1 |
| Poor | 43.5 | 111 | 10.8 | 1.3 | 220.1 | 11.4 | 1304 | 119.0 | 1.4 | 197.3 | 6.9 |
| Total: 34 783 km | | 977 | 95.1 | 1.3 | 33.0 | 100 | 18973 | 1393.3 | 1.7 | 39.1 | 100 |

Note: Delineation is a combination of factors including centrelines, edge lines, guideposts/ delineator road studs and hazard markers, and signage.
Adequate delineation is where signs warning of sever hazards and centre and edge markings are generally present and visible.
For unsealed roads guidepost are to be present.

## 5.5 Summary of Findings

The speed-related FSI crash data was linked to the AusRAP data to enable the road features at the location of these crashes to be examined. A total of 977 of the FSI speed-related crashes were linked, this equates to 96% success rate.

The top 20 high-risk State-controlled road sections with the highest number of speed-related FSI crashes were identified and are presented in Table 5.1 and Table 5.2.

An attempt was made to identify high-risk sections for speed-related crashes on the road network. A total of 38 sections over 3 km length recorded three or more speed-related FSI crashes across the State-controlled road network. Speed-related crashes within these sections accounted for 13% (129) of the 977 speed-related crashes linked to AusRAP data, indicating that the majority of speed-related crashes occurred randomly across the road network. The 129 crashes were analysed, and the results presented. However, due to the low crash numbers it was difficult to observe any strong correlations between potential risk factors, draw conclusions or make recommendations.

Potential speed-related issues and comparative analysis based on the road attributes at the 100 m section level and FSI crashes have been provided. Compared to non-speed-related FSI crashes, more speed-related FSI crashes occurred:

- on single lane roads (i.e. two-lane, two-way) (62% for speed-related FSI crashes compared to 52% for non-speed-related FSI crashes)
- on curves (35% for speed-related FSI crashes compared to 21% for non-speed-related FSI crashes)
- on lane widths less than 3.25 m (18% for speed-related FSI crashes compared to 12% all FSI crashes
- undivided roads (62% speed related FSI crashes compared to 53% all FSI crashes)
- where the sealed shoulder on the passenger side was <1.0 m or none (54% for speed related FSI crashes compared to 44% for non-speed-related crashes)
- where there is inadequate delineation (11% of speed-related FSI crashes occurred on road sections with inadequate delineation compared to non-speed-related FSI crashes (7%).

# 6 TREATMENT OPTIONS

This section provides a list of treatments that may reduce the risk of speed-related crashes on the State-controlled network on the basis of the findings of the literature review and data analysis.

## 6.1 Setting of speed limits and speed management

The crash data shows that crash severity generally increased with the speed limit for both speed-related and non-speed related crashes. However, the relative proportion of fatal crashes was higher for speed-related crashes. Treatment options for reducing speed limits include the following:

- Lowering speed limits – which involves managing posted speed limits and moving towards Safe System levels. This is a widely applied speed management measure aimed at producing lower vehicle speeds, and crash and injury severity reductions.
- Variable speed limits (VSL) – dynamic signs display variable statutory speed limits depending on the prevailing traffic, weather and road conditions, thereby helping drivers adjust to the conditions. There are three main types of VSL: speed harmonisation, speed buffering and speed reduction. Speed harmonisation VSL reduces speed differentiation between vehicles and lanes; speed buffering VSL produces gradual reduced speed zones and are mainly applied in cases of downstream congestion; speed reduction VSL reduces, or lowers, speeds to match prevailing conditions (weather, road and traffic, e.g. congestion) (Austroads 2016a).

## 6.2 Engineering Treatments and Road Design to Support Safe Speeds

### *6.2.1 Curve treatments*

The crash analysis and assessment of road attributes indicated that speed-related crashes were over-represented on curves. It was also identified that a driver was at a greater risk of a speed-related crash on a curve.

This highlights the importance and need to provide curves with good, clear curve delineation with appropriate advanced warning signs to allow road users to predict the road alignment and adjust their approach speeds accordingly.

Speed has a major impact on crash severity, so measures to provide safe travel speeds will lead to improve safety at curves. Measures to reduce and manage operating speeds on curves for low and high-speed environments include:

- Advanced warning signs to raise attention level of hazards and slow motorists on curves.
- Chevron alignment markers (CAMS) to indicate the presence and severity of curves.
- Advisory speed signs –to aid. A warning message is displayed to alert the driver to the hazard. hopefully leading to a change in driving behaviour (e.g. speed reduction).
- Adequate delineation including signs, linemarking, and guidepost to direct motorists safely around curve.
- Rumble strips – audio-tactile treatment applied transverse or across the travel lane to warn of approaching curve.
- Innovative road pavement markings, additional marker posts, and other perceptual countermeasures that may be useful to highlight deceptive corners and may aid motorists in adjusting their speed prior to entering the curve.
- Consistent application of curve design and treatments along a route.

### 6.2.2 Roadside hazard management

The crash data analysis showed that a high proportion of speed-related crashes involved vehicles hitting an object. Therefore, it is important to provide a forgiving roadside in the event of a vehicle leaving the road. Where possible, roadside hazards should be removed, particularly on curves.

If the hazard is unable to be removed, then road users should be shielded from it by a safety barrier. Barriers should be used where the potential damage caused by the hazard is greater than that of the barrier itself.

However, it is also worth noting that, when assessing road attributes, the wider clear zones appear to be over-represented in speed-related crashes; this suggests that open spaces may encourage speeding.

### 6.2.3 Shoulder treatments

The provision of a sealed and unsealed shoulder provides an area whereby a vehicle may successfully recover during an off-road event. The data analysis indicated a higher risk of speed-related FSI crashes where there was little or no sealed shoulder. The provision of wide sealed shoulder may reduce the risk of speed-related FSI crashes.

### 6.2.4 Lane widths

Lane width can influence travel speeds. Typically, the use of wide lanes, combined with other features such as good delineation and wide shoulders, may provide a safer road environment. However, where speed has been identified as an issue, lane narrowing treatments using physical narrowing of the roadway, road markings and wide painted medians may be used to encourage speed reductions.

### 6.2.5 Delineation

The crash data analysis indicated that speed-related crashes occurred on road sections where there was inadequate delineation. Centre and edge delineation treatments provide guidance to drivers as they drive along the roadway. They provide advice about conditions ahead, particularly when visibility can become poor (for example, due to rain, fog or darkness) and on sharp curves. Good delineation communicates the roadway features to the driver, encouraging safer speeds, and reducing the risk of speed related crashes. Delineation may include linemarking, pavement marking, signs, RRPMs and guideposts.

### 6.2.6 Perceptual countermeasures

Perceptual countermeasures are used to alter the drivers' perception of the road environment. Methods may consist of making a road appear narrower or a curve appear more severe. By altering the driver's perception, it is hoped that the driver will slow down to match the perceived conditions rather than the actual ones.

Perceptual countermeasures to reduce operating speeds include:

- transverse pavement markings including lines, chevrons or bars, to alert drivers to slow down on approaches to curves, intersections and high-speed roundabouts, bridges etc.
- perceptual guide post treatments
- road narrowing and wide centreline treatments.

### 6.2.7 Gateway treatments

Gateways are a type of treatment that have been applied to reduce speeds where a vehicle is travelling from a higher-speed environment to a lower-speed environment. The treatment may include traffic islands, lane narrowing, coloured pavements, road markings and vertical elements (e.g. planting of trees or shrubs) to create a threshold or gateway between the high and low speed environments. Crash data analysis indicated that speed-related FSI crashes mostly occurred at 60 km/h speed zones. Gateway treatments may assist in alerting drivers to reduce their speed when entering the 60 km/hr speed zone.

#### *6.2.8 Intersection treatments*

Intersection locations were relatively under-represented. Notably, speed-related crashes were slightly over-represented at roundabouts, and especially in high-speed environments.

Reductions in speed-related crashes at roundabouts can be achieved by managing speeds on approaches, both upon entry and within roundabouts. This can be achieved using horizontal deflections (reverse curves) on the approaches to roundabouts, long median islands, kerb build-outs, large warning signs, or rumble strips. Vertical deflection treatments in the form of Wombat crossings, speed humps or platforms, speed cushions, or elevated roundabouts may also reduce vehicle speeds.

There are a number of other treatments designed to reduce vehicle speeds on the approaches to and through intersections. These have been listed in Table 3.2.

## 6.3 Non-infrastructure Treatments

The analysis found that alcohol-related, disqualified and provisional licence holders were over-represented in speed-related crashes. To deal with these the following non-engineering treatments are proposed.

#### *6.3.1 Enforcement and penalties*

Enforcement and penalties are an important measure to encourage drivers to make suitable speed choices when driving on the road network. Speed cameras (including fixed, mobile and point-to-point), red light cameras, and penalties have been successful in reducing vehicle speeds and reducing crashes and will continue to be a factor in controlling driver behaviour.

#### *6.3.2 Education, training and publicity*

Education, training and publicity are key elements to speed management. Education and training programs help to communicate the risk of speeding to all roads users as well as targeting specific road user groups. Based on the crash analysis education campaigns to reduce speeding should target:

- young adults 16-24
- male drivers
- non-open licence holders
- drink driving
- driver inattention
- motorcyclists.

The literature review identified that a large proportion of drivers exceed the speed limit by a small margin (up to 10 km/h) and that these low-level speeders contribute to a large proportion of the risk associated with speeding. Education campaigns can be targeted to highlight the risk associated with low-level speeding to the community.

### 6.3.3 Vehicle technology

Speed-related crashes are mostly associated with human-related factors. Hence vehicle technology and design improvements that help reduce the likelihood of driver error occurring would help reduce crashes. As more and more vehicle technologies are developed and incorporated into vehicle standards they will play an increasing role in reducing speed-related crashes. The range of technologies available that assist the driver to comply with speed limits and reduce crashes are summarised in Section 3.3.3.

# 7 CONCLUSIONS AND RECOMMENDATIONS

## 7.1 Discussion

The crash analysis was limited by the availability of operating speed data and the recording of speed-related crashes in the crash database. The definition of a speed-related crash is based on the Police report indicating speed as a contributing factor for at least one vehicle involved in a crash. The subjective nature of this assessment may result in the under-reporting of speed-related crashes.

There was no method available to differentiate between the two types of speed-related crashes – those resulting from driving faster than the posted speed limit and those driving too fast for the prevailing road conditions. Further development of the definition and capturing of speed-related crashes in the crash database would provide a more detailed understanding of speed problem, allowing tailored treatment options to reduce the risk of the two types of speed-related crashes.

## 7.2 Conclusions

This study has assessed the characteristics of speed-related FSI crashes on State-controlled roads. The crashes classified as speed-related were as defined in Queensland crash records. The findings include the following:

- Five per cent of FSI crashes and 18% of fatal crashes on State-controlled roads were classified as speed-related. This supports other research findings suggesting that extreme behaviour contributes more strongly to fatalities.
- The relative proportion of speed-related crashes that resulted in a fatality increased with speed limit, ranging from 10% in 50 km/h or less zones to 18% in the 100-110 km/h zone.
- The relative proportion of FSIs that were fatal was higher for speed-related crashes than for non-speed-related crashes.
- Speeding-related crashes were more likely to have occurred on mid-block road sections and involved single-vehicle crashes.
- Speed-related FSI crashes into roadside objects were over-represented, regardless of speed environment. The majority of speed-related FSI crashes involved hit-object (50%), double the proportion of the non-speed-related FSI crashes.
- Speed-related crashes were over-represented on curves; 54% of speed-related FSIs occurred on curves compared to 28% for non-speed-related crashes.
- The main road user crash factors for speed-related FSI crashes were ‘disobey road rules’ (22%) followed by ‘controller condition’ (18%), ‘young adult (16-24 years)’ (11%), ‘alcohol-related’ (10%), and ‘distracted/inattentive’ (8%).
- Speed-related crashes were over-represented in crashes involving unlicensed drivers, ‘controller condition’, alcohol-related and motorcyclists compared to non-speed-related, e.g. unlicensed drivers were 2.3 times more likely to be speeding when involved in an FSI crash.

Further analysis indicates that speed-related crashes were not concentrated but spread across the network, making it difficult to identify high-risk sections.

The risk of a speed-related FSI crash when travelling along the road was higher when compared with non-speed-related crashes:

- for single lane roads
- for very sharp curves

- for undivided roads
- where there was no shoulder or a narrow shoulder less than 1.0 m wide
- for roads where the clear zone on the passenger side was >10.0 m.

A list of recommended treatments has been presented which may be implemented to reduce the risk of speed-related crashes on the State-controlled network. As vehicle technology, including in vehicle, vehicle-to-vehicle, and vehicle-to-infrastructure is further developed and incorporated into vehicle standards it will play an important role in the prevention and reduction of speed-related crashes on the road network.

## 7.3 Recommendations

As technology is rapidly changing, and data capturing, and its management, is evolving, it is recommended that other data sources (e.g. Probe data) be explored that would enable the assessment of actual operating speeds of vehicles on the network in relation to where crashes are occurring. This would provide a better understanding of speed-related crashes on the network.

For improvement in speed related crash outcomes TMR Land Transport Safety Branch should:

- Consider opportunities to improve road infrastructure to address speed related crashes, with particular focus on application of treatments identified in section 3.2 to higher risk road sections identified in sections 5.2 and 5.3.
- Consider opportunities to apply non-infrastructure treatments to address speed related crashes as identified in section 3.3.
- Consider opportunities for statewide road infrastructure improvements to address speed related crashes. For example, a higher incidence of speed related crashes occurred where there is inadequate delineation (section 5.4). Improving delineation across the network should help to reduce the number of speed related FSIs.

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# APPENDIX A SPEED-RELATED CRASHES BY ROAD SECTION

### Table A 1: Top 50 high-risk roads

| Road Section ID | Length (km) | M VKT | Fatal crashes | Hospitalisation crashes | FSI crashes | Annual crashes per km | Annual crashes per 100M VKT |
|---|---|---|---|---|---|---|---|
| 12A | 79.3 | 1663.35 | 2 | 15 | 17 | 0.03 | 0.13 |
| 32A | 48.8 | 114.29 | 1 | 10 | 11 | 0.03 | 1.20 |
| 10A | 145.4 | 1280.23 | 1 | 9 | 10 | 0.01 | 0.10 |
| 10D | 146.2 | 237.20 | 3 | 6 | 9 | 0.01 | 0.47 |
| 10M | 121.8 | 362.11 | 3 | 6 | 9 | 0.01 | 0.31 |
| 12A AGZ | 79.3 | 1661.58 | 3 | 6 | 9 | 0.01 | 0.07 |
| 20A | 75.3 | 248.69 | 3 | 6 | 9 | 0.01 | 0.45 |
| 205 | 24.1 | 26.77 | 2 | 7 | 9 | 0.05 | 4.20 |
| 401 | 60.5 | 93.45 | 1 | 8 | 9 | 0.02 | 1.20 |
| 40A | 50.6 | 160.45 | 1 | 8 | 9 | 0.02 | 0.70 |
| 11B | 18.6 | 109.46 | 2 | 6 | 8 | 0.05 | 0.91 |
| 204 AGZ | 19.3 | 108.52 | 2 | 6 | 8 | 0.05 | 0.92 |
| 10K | 112.1 | 152.74 | 1 | 7 | 8 | 0.01 | 0.65 |
| U12A | 17.4 | 349.36 | 0 | 8 | 8 | 0.06 | 0.29 |
| 10F | 178 | 219.32 | 3 | 4 | 7 | 0.00 | 0.40 |
| 18A AGZ | 92 | 400.41 | 2 | 5 | 7 | 0.01 | 0.22 |
| 18B | 84.3 | 240.40 | 2 | 5 | 7 | 0.01 | 0.36 |
| 25A | 41.7 | 245.66 | 2 | 5 | 7 | 0.02 | 0.36 |
| 46A | 120.1 | 126.22 | 1 | 6 | 7 | 0.01 | 0.69 |
| 835 AGZ | 10.9 | 52.16 | 1 | 6 | 7 | 0.08 | 1.68 |
| 495 | 40.7 | 21.94 | 0 | 7 | 7 | 0.02 | 3.99 |
| 642 | 55.7 | 57.31 | 0 | 7 | 7 | 0.02 | 1.53 |
| 202 | 52.2 | 102.25 | 4 | 2 | 6 | 0.01 | 0.73 |
| 10A AGZ | 116.4 | 1107.34 | 3 | 3 | 6 | 0.01 | 0.07 |
| 22B | 69.5 | 124.73 | 3 | 3 | 6 | 0.01 | 0.60 |
| 171 | 51.9 | 69.80 | 2 | 4 | 6 | 0.01 | 1.07 |
| 414 | 45.8 | 20.02 | 2 | 4 | 6 | 0.02 | 3.75 |
| 493 | 20.4 | 7.31 | 2 | 4 | 6 | 0.04 | 10.27 |
| 33B | 88 | 165.46 | 2 | 4 | 6 | 0.01 | 0.45 |
| 104 | 30.4 | 27.31 | 1 | 5 | 6 | 0.02 | 2.75 |
| 647 | 14.1 | 89.38 | 1 | 5 | 6 | 0.05 | 0.84 |
| 4023 | 26.9 | 3.63 | 1 | 5 | 6 | 0.03 | 20.68 |
| 18A | 95.3 | 418.98 | 0 | 6 | 6 | 0.01 | 0.18 |
| 32B | 81.9 | 101.17 | 0 | 6 | 6 | 0.01 | 0.74 |
| 83A | 125.1 | 47.10 | 3 | 2 | 5 | 0.00 | 1.33 |
| 120 | 17.9 | 111.58 | 2 | 3 | 5 | 0.03 | 0.56 |
| 10N | 147.4 | 215.77 | 2 | 3 | 5 | 0.00 | 0.29 |
| 163 | 44.5 | 165.20 | 1 | 4 | 5 | 0.01 | 0.38 |
| 194 | 44.2 | 73.73 | 1 | 4 | 5 | 0.01 | 0.85 |

| Road Section ID | Length (km) | M VKT | Fatal crashes | Hospitalisation crashes | FSI crashes | Annual crashes per km | Annual crashes per 100M VKT |
|---|---|---|---|---|---|---|---|
| 301 | 14.8 | 77.17 | 1 | 4 | 5 | 0.04 | 0.81 |
| 10H | 123.2 | 240.25 | 1 | 4 | 5 | 0.01 | 0.26 |
| 116 AGZ | 9.7 | 49.34 | 1 | 4 | 5 | 0.06 | 1.27 |
| 150B | 25.8 | 202.66 | 1 | 4 | 5 | 0.02 | 0.31 |
| 22A | 118 | 142.21 | 1 | 4 | 5 | 0.01 | 0.44 |
| N239 | 23.2 | 306.28 | 1 | 4 | 5 | 0.03 | 0.20 |
| 136 | 10 | 44.25 | 0 | 5 | 5 | 0.06 | 1.41 |
| 203 | 35.5 | 88.25 | 0 | 5 | 5 | 0.02 | 0.71 |
| 206 | 22.2 | 49.58 | 0 | 5 | 5 | 0.03 | 1.26 |
| 213 | 46.5 | 13.59 | 0 | 5 | 5 | 0.01 | 4.60 |
| 532 | 69.9 | 73.73 | 0 | 5 | 5 | 0.01 | 0.85 |

# APPENDIX B COMPARING ATTIBUTES AT HIGH-RISK SITES WITH THE WHOLE NETWORK

### Table B 1: High-risk sites and speed limit (2008-15)

| Speed limit (km/h) | High-risk sections: speed-related FSIs | | Whole network | | |
|---|---|---|---|---|---|
| | FSI speed-related | % FSI | FSI | % all FSIs | % VKT |
| <= 50 | 0 | 0 | 282 | 1% | 1 |
| 60 | 44 | 34 | 5949 | 30% | 15 |
| 70 | 19 | 15 | 2288 | 11% | 8 |
| 80-90 | 31 | 24 | 3402 | 17% | 18 |
| 100-110 | 35 | 27 | 8029 | 40% | 59 |
| Total | 129 | 100 | 19 950 | 100% | 100 |

### Table B 2: High-risk sites and number of lanes (2008-15)

| Number of lanes | High-risk sections: speed-related FSIs | | Whole network | | |
|---|---|---|---|---|---|
| | FSI speed-related | % FSI | FSI | % all FSIs | % VKT |
| 1 | 59 | 46 | 10 433 | 52 | 44 |
| 2 | 48 | 37 | 6842 | 34 | 32 |
| 3 | 14 | 11 | 1900 | 10 | 13 |
| 4 or more | 6 | 5 | 458 | 2 | 8 |
| 2+1 | 2 | 2 | 317 | 2 | 2 |
| Total | 129 | 100 | 19 950 | 100 | 100 |

### Table B 3: High-risk sites and curvature (2008-15)

| Curvature | High-risk sections: speed-related FSIs | | Whole network | | |
|---|---|---|---|---|---|
| | FSI speed-related | % FSI | FSI | % all FSIs | % VKT |
| Straight & gently curving | 64 | 50 | 15 650 | 78.4 | 88.3 |
| Moderate curve | 19 | 15 | 2857 | 14.3 | 9.4 |
| Sharp curve | 43 | 33 | 1299 | 6.5 | 2.1 |
| Very sharp curve | 3 | 2 | 144 | 0.7 | 0.2 |
| Total | 129 | 100 | 19 950 | 100 | 100% |

### Table B 4: High-risk sites and median separation (2008-15)

| Median separation | High-risk sections: speed-related FSIs | | Whole network | | |
|---|---|---|---|---|---|
| | FSI speed-related | % FSI | FSI | % all FSIs | % VKT |
| Safety barrier | 21 | 16% | 2023 | 10% | 26% |
| Physical median > 5 m | 22 | 17% | 2874 | 14% | 17% |
| Physical median <= 5 m | 21 | 16% | 4300 | 22% | 11% |
| Undivided | 65 | 50% | 10753 | 54% | 46% |
| Total | 129 | 100% | 19950 | 100% | 100% |

### Table B 5: High-risk sites and lane width (2008-15)

| Lane width (m) | High-risk sections; speed-related FSIs | | Whole network | | |
|---|---|---|---|---|---|
| | FSI speed-related | % FSI | FSI | % all FSIs | %t VKT |
| >= 3.25 | 96 | 74.4 | 17 564 | 88 | 91 |
| 2.75 to 3.25 | 33 | 25.6 | 2231 | 11.2 | 8.4 |
| < 2.75 | 0 | 0 | 155 | 0.8 | 0.6 |
| Total | 129 | 100 | 19 950 | 100 | 100 |

### Table B 6: High-risk sites and sealed shoulder width – passenger side (2008-15)

| Sealed shoulder width (m) | High-risk sections: speed-related FSIs | | Whole network | | |
|---|---|---|---|---|---|
| | FSI Speed-related | % FSI | FSI | % all FSIs | % VKT |
| > 2.4 | 21 | 16 | 2925 | 15 | 16 |
| 1 to 2.4m | 48 | 37 | 8185 | 41 | 50 |
| < 1.0 | 52 | 40 | 6783 | 34 | 28 |
| None | 8 | 6 | 2057 | 10 | 6 |
| Total | 129 | 100 | 19 950 | 100 | 100 |

### Table B 7: High-risk sites and sealed shoulder width – driver side (2008-15)

| Sealed shoulder width (m) | High-risk sections: speed-related FSIs | | Whole network | | |
|---|---|---|---|---|---|
| | FSI speed-related | % FSI | FSI | % all FSIs | % VKT |
| > 2.4 | 1 | 1 | 618 | 3 | 4 |
| 1 to 2.4 | 32 | 25 | 4535 | 23 | 34 |
| < 1.0 | 84 | 65 | 12 371 | 62 | 55 |
| None | 12 | 9 | 2426 | 12 | 7 |
| Total | 129 | 100 | 19 950 | 100 | 100 |

### Table B 8: High-risk sites and delineation (2008-15)

| Delineation | High-risk sections: speed-related FSIs | | Whole network | | |
|---|---|---|---|---|---|
| | FSI speed-related | % FSI | FSI | % all FSIs | % VKT |
| Adequate | 125 | 97 | 18 535 | 93 | 95 |
| Poor | 4 | 3 | 1415 | 7 | 5 |
| Total | 129 | 100 | 19 950 | 100 | 100 |

### Table B 9: High-risk sites and clear zone – passenger side (2008-15)

| Object distance (m) | High-risk sections: speed-related FSIs | | Whole network | | |
|---|---|---|---|---|---|
| | FSI speed-related | % FSI | FSI | % all FSIs | % VKT |
| < 1 | 6 | 5 | 726 | 4 | 3 |
| 1 to 5 | 96 | 74 | 12 582 | 63 | 57 |
| 5 to 10 | 23 | 18 | 3809 | 19 | 22 |
| >= 10 | 4 | 3 | 2833 | 14 | 18 |
| Total | 129 | 100 | 19 950 | 100 | 100 |

### Table B 10: High-risk sites and clear zone – driver side (2008-15)

| Object distance | High-risk sections: speed-related FSIs | | Whole network | | |
|---|---|---|---|---|---|
| | FSI Speed-related | % FSI | FSI | % all FSIs | % VKT |
| < 1 m | 10 | 8 | 1298 | 7 | 7 |
| 1 to 5 m | 94 | 73 | 12 022 | 60 | 57 |
| 5 to 10 m | 16 | 12 | 2970 | 15 | 15 |
| >= 10m | 9 | 7 | 3660 | 18 | 21 |
| Total | 129 | 10% | 19 950 | 100 | 100 |