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Profiling head on crashes in South Australia

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CASR REPORT SERIES

CASR175

February 2023

Report documentation

REPORT NO.	DATE	PAGES	ISBN	ISSN
CASR175	February 2023	23	978-1-925971-08-8	1449-2237

TITLE

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PERFORMING ORGANISATION

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FUNDING

This research was funded via a deed with the South Australian Government

AVAILABLE FROM

Centre for Automotive Safety Research
http://casr.adelaide.edu.au/publications/list

ABSTRACT

This report provides a profile of head on crashes in South Australia using police-reported crash data from the Traffic Accident Reporting System (TARS) and data from the Centre for Automotive Safety Research (CASR) at-scene in-depth crash investigations. TARS data revealed that head on crashes are: ten times more likely to be fatal, about 2.5 times more likely to occur in a 100 or 110 km/h zones, four times more likely to occur on a curve, and more likely to involve a truck or a motorcycle than all crashes. Only 5% of head on crashes occurred as a result of a vehicle overtaking. CASR's at-scene in-depth crash investigations of 24 head on crashes revealed further insights. These including identifying the top contributing factors as a medical condition, fatigue, drugs and speed; the top mitigating interventions as centre barriers, speed limit reductions and wide centre medians; and the top prevention interventions as lane keep assist, wide centre medians and ESC. The higher injury severity associated with head on crashes highlights the need to better understand these crashes and to develop and implement effective interventions to mitigate and prevent these crash types and associated injuries.

KEYWORDS

Head on crash, Data analysis, Crash investigation

Summary

Recent research that examined the risk of serious injury relative to impact speed found that head on impacts had the highest risk at a given speed (Doecke, Baldock, Kloeden & Dutschke, 2020). The risk of serious injury in head on impacts was also quite high even at low speeds. The aim of this present report is to provide a profile of head on crashes in South Australia using data from the Traffic Accident Reporting System (TARS) that uses data from police reports and the Centre for Automotive Safety Research's (CASRs) at-scene in-depth crash investigations.

TARS data revealed that head on crashes are:

- Almost ten times more likely to be fatal than all crashes
- About 2.5 times more likely to occur in a 100 or 110 km/h zones than all crashes
- Four times more likely to occur on a curve than all crashes
- More likely to involve a truck or a motorcycle
- Rarely due to an overtaking manoeuvre (only 5%)

Mapping the locations of the head on crashes in TARS revealed some locations on major highways where there were no head on crashes. This may be due to wide medians, centre barriers and wide centreline treatments, but this requires further investigation before it can be confirmed.

CASR's at-scene in-depth crash investigations of 24 head on crashes revealed these further insights:

- Just under half of head on crashes are preceded by a vehicle losing control
- Side impacts occurred in 20% of head on crashes
- More than half of the frontal impacts involve a low overlap (less than 25% overlap)
- Serious and fatal injuries can occur in five-star vehicles on high-speed roads
- Truck drivers can be seriously injured in head on crashes with light vehicles
- Motorcycles were involved in head on crashes on tight corners on winding roads
- The top contributing factors were:
  - A medical condition
  - Fatigue
  - Drugs
  - Speed
- The top mitigating interventions were
  - Centre barriers
  - Speed limit reduction
  - Wide centre median
- The top prevention interventions were
  - Lane keep assist
  - Wide centre median
  - ESC

The higher injury severity associated with head on crashes highlights the need to better understand these crashes and to develop and implement effective interventions to mitigate and prevent these crash types and associated injuries.

Contents

1 Introduction

Recent research that examined the risk of serious injury relative to impact speed found that head on impacts had the highest risk at a given speed (Doecke, Baldock, Kloeden & Dutschke, 2020). The risk of serious injury in head on impacts was also quite high even at low speeds, reaching 10% at just 53 km/h, 50% at 76 km/h and 90% at 99 km/h.

The aim of this present report is to provide a profile of head on crashes in South Australia using data from the Traffic Accident Reporting System (TARS) that uses data from police reports and the Centre for Automotive Safety Research (CASR) at-scene in-depth crash investigations.

Note that this report was substantially completed in December 2020 and does not consider developments after that date.

2 Method

TARS data for head on crashes from 2013 to 2018 was analysed and compared to all crashes in TARS to provide a profile of head on crashes and to compare and contrast this to the profile of all police reported crashes. Head on crashes were identified by the relevant DCA (Definition for Coding Accidents) codes, 120 and 150. To compare head on crashes to all crashes the proportion of head on crashes within a given category was divided by the proportion of all crashes in the same category. This is referred to as the ratio in the results. For example, if 20% of head on crashes occur in 100 km/h and 10% of all crashes occur in 100 km/h zones the ratio would 2.0 (20 divided by 10). The ratio of 2.0 can be interpreted as head on crashes being twice as likely to occur in a 100 km/h zone as all crashes.

Head on crashes investigated as part of the current series of CASR's at-scene in-depth crash investigations between October 2014 and September 2020 were analysed. These investigations involve detailed data collection at the scene of the crash, interviews with the crash participants, crash reconstructions and detailed case reviews where contributing factors and mitigating and prevention treatments are identified. At-scene crash investigations only occur within 100 km of Adelaide to enable the investigators to arrive at the scene while the vehicles and other crash evidence remains. For more detail on the methodology see Doecke, Thompson and Stokes (2020).

3 Results

3.1 TARS data

Table 3.1 shows the injury severity and location characteristics of the TARS data for head on crashes. Head on crashes are rare, making up only 1.7% of all crashes. However, they are almost 10 times more likely to be fatal than all crashes, 3.3 times more likely to involve hospital admission, and 1.4 times more likely to involve hospital treatment. While head on crashes were most likely to occur in 60 km/h zones they are more than twice as likely to occur in 100 and 110 km/h zones than all crashes, and just under half occurred in rural areas (44%).

It is interesting to note that head on crashes were 1.8 times more likely than all crashes to involve driving under the influence (DUI), though this was only a factor in 5.7% of crashes. DUI can refer to either driving under the influence of alcohol or drugs.

The road geometry and surface for head on crashes differed quite a lot from all crashes. Head on crashes were 4 times more likely to occur on a curve than all crashes, with just under half occurring on a curve. TARS data does not specify which direction the road was curving. They are also more than twice as likely to occur on a slope, at the crest of a hill or at the bottom of a hill. The direction of the slope (up or down) is not specified in TARS. Head on crashes were also 2.5 times more likely to occur on an unsealed road and were 1.4 times more likely to occur on a wet road.

The vehicle and occupant characteristics of head on crashes are shown in Table 3.2, as well as the corresponding characteristics of all crashes. Head on crashes were more likely to have multiple occupants in the involved vehicles and were much more likely to involve a motorcycle or a truck. Of the drivers that had their Blood Alcohol Concentration (BAC) measured, 7.6% of those involved in a head on crash had a level above zero, similar to all crashes, but were more likely to have a BAC below 0.05, the legal limit for most drivers. Of the three proscribed drugs tested, methamphetamine was more common in head on crashes than all crashes while MDMA was very rare, appearing in only one head on crash. It should be noted that only 27% of drivers in head on crashes had known results for BAC and drugs in TARS, though this is higher than for all crashes which had only 11% recorded. Drivers in head on crashes were more likely to be male and over 40 years old than in all crashes.

Table 3.1
Injury severity and location characteristics of South Australian head on crashes compared to all crashes (TARS, 2013-2018)

	Head on		All Crashes		Ratio
	Number	Percentage	Number	Percentage	
Severity					
PDO	757	47.8%	59859	65.1%	0.73
Doctor	65	4.1%	8668	9.4%	0.43
Treated	476	30.1%	19318	21.0%	1.43
Admitted	198	12.5%	3509	3.8%	3.27
Fatal	88	5.6%	526	0.6%	9.70
Speed					
<50	17	1.1%	1724	1.9%	0.57
50	346	21.8%	24593	26.8%	0.82
60	407	25.7%	43595	47.4%	0.54
70-90	404	25.5%	12541	13.6%	1.87
100	246	15.5%	5479	6.0%	2.60
110	164	10.4%	3948	4.3%	2.41
Area					
City (Adelaide CBD)	16	1.0%	4904	5.3%	0.19
Metropolitan	873	55.1%	69083	75.2%	0.73
Rural	695	43.9%	17888	19.5%	2.25
Horizontal alignment					
Straight	801	50.6%	80436	87.5%	0.58
Curve	782	49.4%	11368	12.4%	3.99
Vertical alignment					
Bottom of Hill	42	2.7%	1137	1.2%	2.14
Crest of Hill	97	6.1%	1545	1.7%	3.64
Level	981	61.9%	78793	85.8%	0.72
Slope	458	28.9%	10172	11.1%	2.61
Surface					
Sealed	1474	93.1%	89342	97.2%	0.96
Unsealed	110	6.9%	2531	2.8%	2.52
Road moisture					
Dry	1290	81.4%	79553	86.6%	0.94
Wet	290	18.3%	12150	13.2%	1.38
Lighting					
Daylight	1262	79.7%	70940	77.2%	1.03
Night	322	20.3%	20940	22.8%	0.89
Total	1584	100.0%	91880	100.0%	1.00

	Head on		All Crashes		Ratio
	Number	Percentage	Number	Percentage	
Motorcycles					
0	1431	90.3%	87025	94.7%	0.94
1+	153	9.7%	4855	5.3%	1.80
Trucks					
0	1384	87.4%	85721	93.3%	0.94
1	182	11.5%	5924	6.4%	1.78
2+	18	1.1%	235	0.3%	4.44
Total	1584	100.0%	91880	100.0%	1.00

Table 3.2
Occupant and driver characteristics of South Australian head on crashes compared to all crashes (TARS, 2013-2018)

	Head on		All Crashes		Ratio
	Number	**Percentage**	**Number**	**Percentage**	
Number of Occupants					
1	2347	70.7%	123824	74.5%	0.95
2	650	19.6%	28979	17.4%	1.12
3+	322	9.7%	13460	8.1%	1.20
BAC					
0	836	92.4%	17666	92.2%	1.00
0.001-0.049	16	1.8%	194	1.0%	1.75
0.050-0.079	5	0.6%	155	0.8%	0.68
0.080-0.149	16	1.8%	500	2.6%	0.68
0.150+	32	3.5%	651	3.4%	1.04
Drugs					
Meth	46	5.3%	658	3.9%	1.36
THC	45	5.2%	800	4.7%	1.09
MDMA	1	0.1%	57	0.3%	0.34
Driver Age					
<16	10	0.3%	411	0.3%	1.19
16-25	678	21.5%	37328	24.2%	0.89
26-40	840	26.6%	46889	30.3%	0.88
41-65	1273	40.3%	54831	35.5%	1.14
66-80	302	9.6%	12038	7.8%	1.23
80+	52	1.6%	3067	2.0%	0.83
Driver Sex					
Female	996	31.0%	61943	38.9%	0.80
Male	2213	69.0%	97381	61.1%	1.13
Total	3347	100.0%	173456	100.0%	1.00

Note: Percentages shown are percentages of knowns within a given category

TARS main error

TARS also contains a field for the main error attributed to drivers in the crash. The top five errors, which represent 99.5% of all errors, are shown in Table 3.3. This field does not provide much insight as the vast majority of errors are simply listed as "fail to keep left". Just under 6% are attributed to driving under the influence (DUI) which can include both alcohol and drugs. There is also no category purely for fatigue, with being asleep at the wheel grouped with having a medical episode while driving. Less than 1% were attributed to a vehicle fault.

Table 3.3
Main errors in head on crashes (TARS, 2013-2018)

Main error	Number	Percentage
Fail to keep left	1293	82.1%
DUI	91	5.8%
Inattention	90	5.7%
Overtake without due care	48	3.0%
Died, sick or asleep at wheel	30	1.9%
Vehicle fault	14	0.9%
Total at fault	1574	99.5%

Overtaking

The DCA codes that define crash type in TARS contain two distinct codes for a head on crash that differentiate between a vehicle overtaking (DCA 150) and one that is not (DCA 120). Only 5% of the head on crashes in TARS are coded as being due to a vehicle overtaking.

Crash locations

The locations of head on crashes in South Australia are shown in Figures 3.1 to 3.4. Areas of high traffic volumes appear to account for a large proportion of the head on crashes. There is an obvious cluster in the metropolitan area, as over half of all head on crashes occur there. Lines of crashes can also be seen on the major highways, particularly the Dukes highway between Murray Bridge and Keith, the Riddoch Highway between Keith and Mt Gambier, and the Sturt Highway.

There are also some sections of major highways that are conspicuous by the absence of head on crashes. There are no head on crashes on a large section of Port Wakefield Highway starting just north of Two Wells and continuing to just south of Port Wakefield. The South Eastern Freeway is another major road that has no head on crashes. It also appears that there are no head on crashes on the Dukes Highway between Keith and the Victorian border. The absence of head on crashes on the South Eastern Freeway and Port Wakefield Highway is mostly likely due to these roads being divided, with wide medians and sections of barriers. Trees on these wide medians also reduces the chances of a head on crash, though they increase the chance of a hit-fixed-object crash. The section of the Dukes Highway between Keith and the Victorian border is not divided but a wide centreline treatment was completed in late 2012. The absence of head on crashes on sections of major highways appears to be due to wide medians, centre barriers and wide centreline treatments, but more detailed investigation into these roads (and control roads) would be necessary to confirm this.

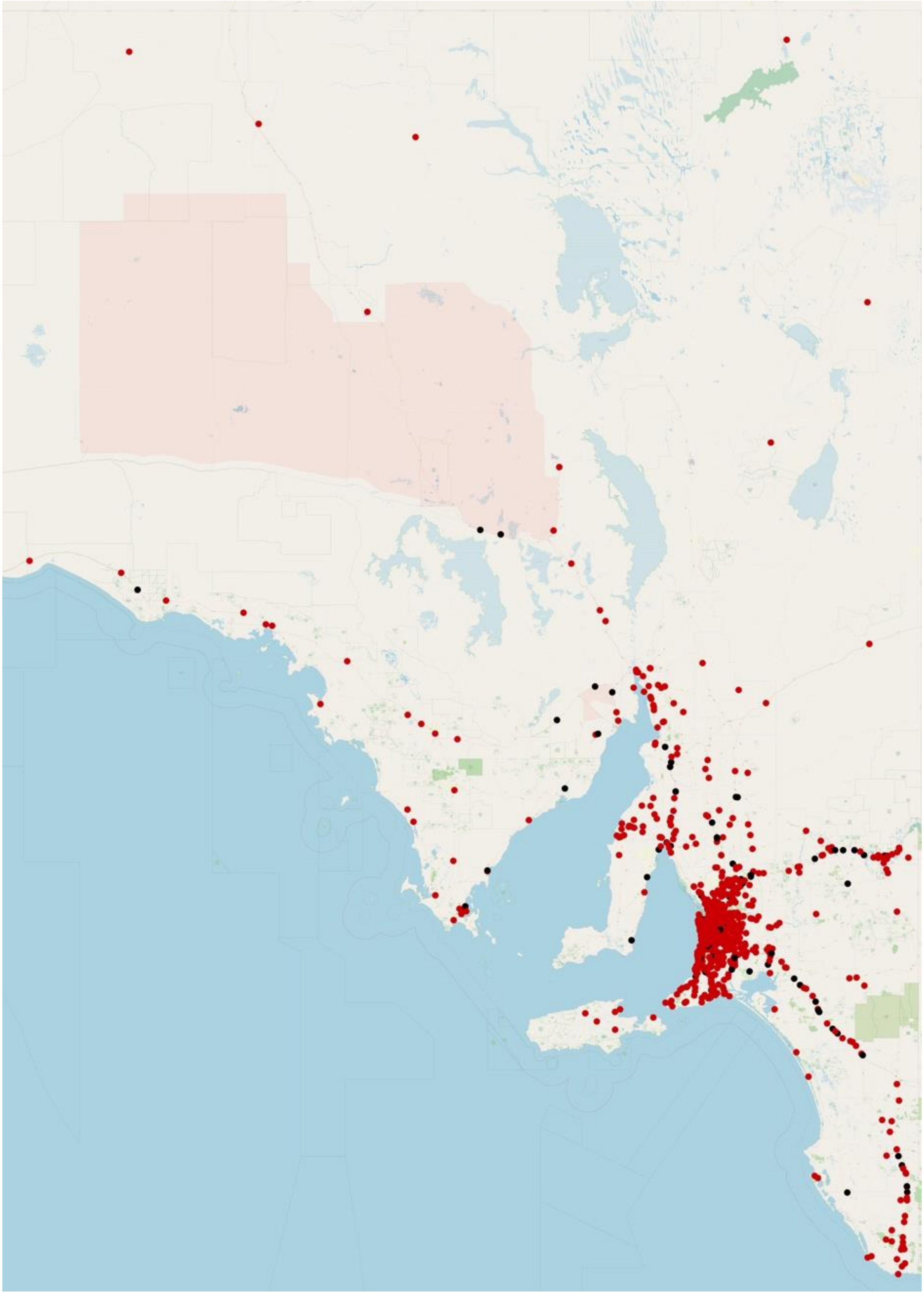

Figure 3.1
Locations of head on crashes in South Australia with fatal crashes shown in black (TARS, 2013-2018)

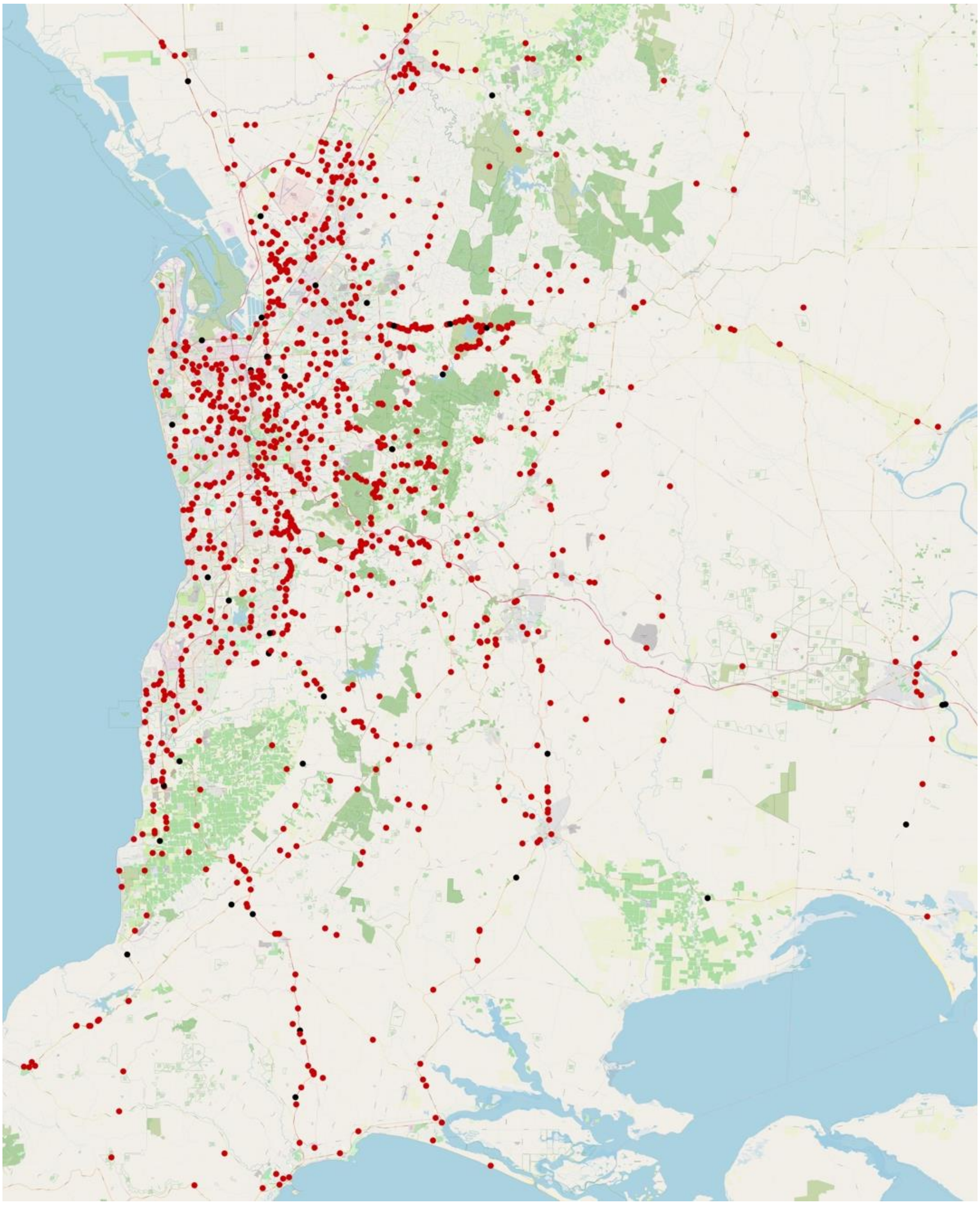

Figure 3.2
Zoomed view of locations of head on crashes in South Australia with fatal crashes shown in black (TARS, 2013-2018)

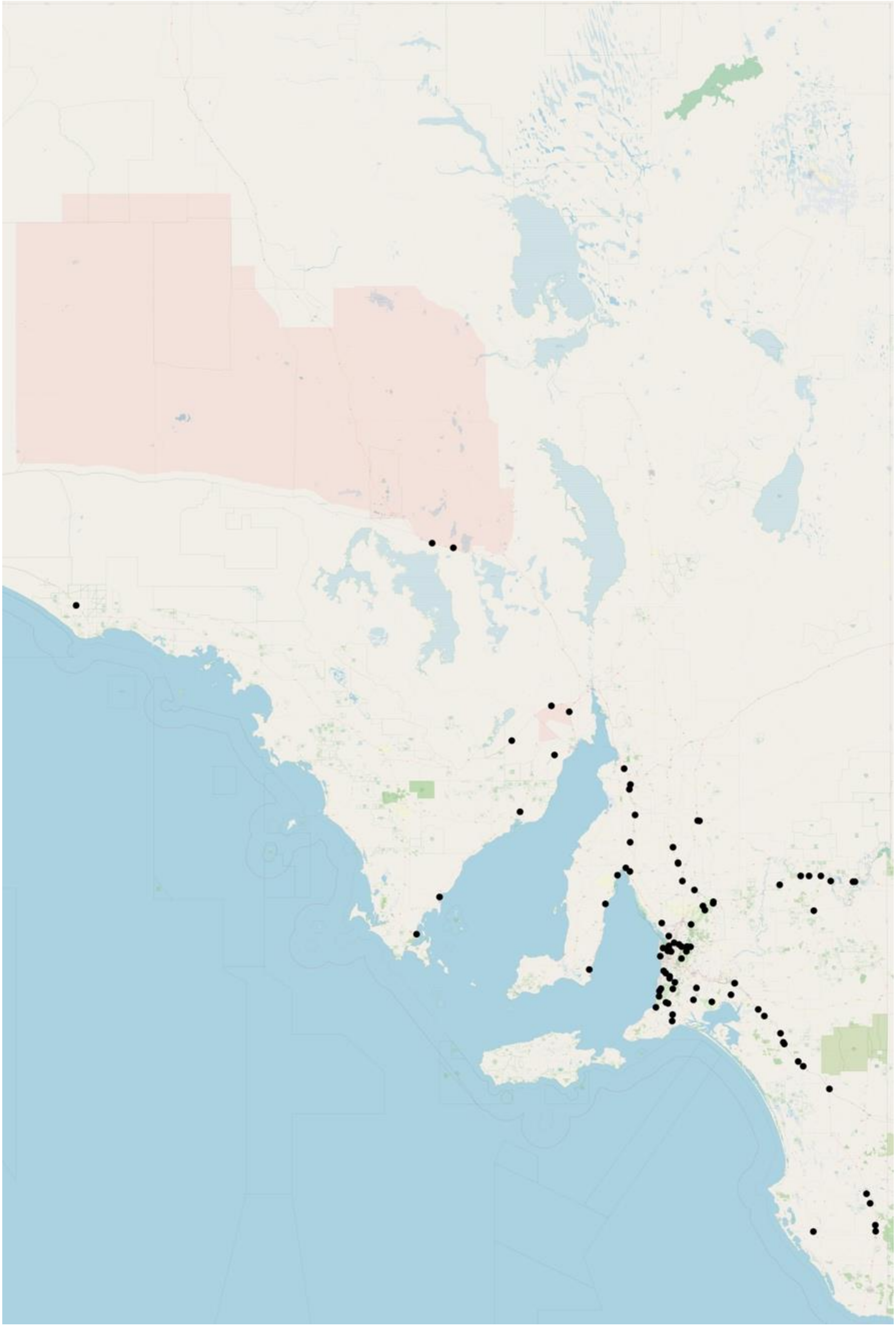

Figure 3.3
Locations of fatal head on crashes in South Australia (TARS, 2013-2018)

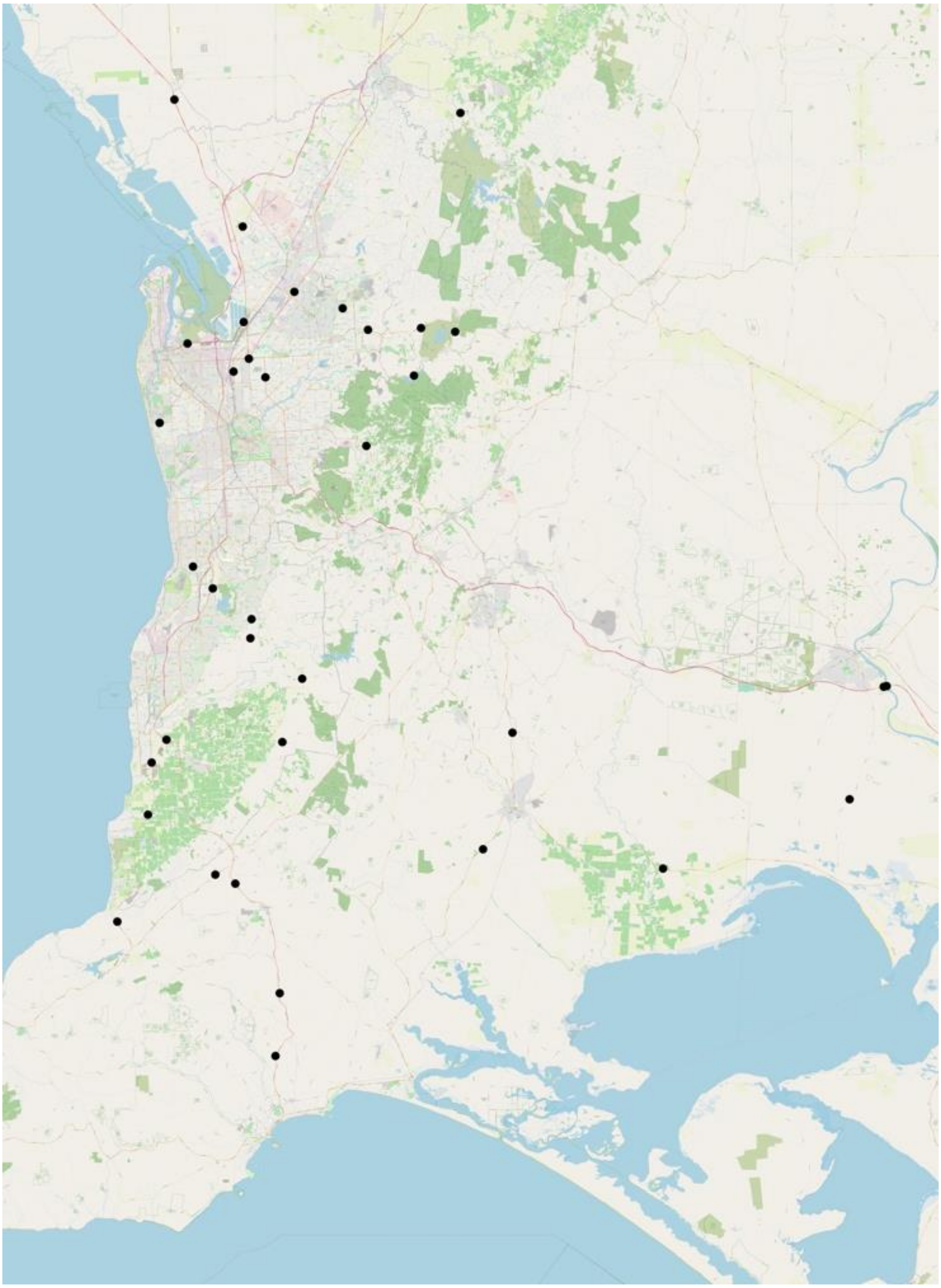

Figure 3.4
Zoomed view of locations of fatal head on crashes in South Australia (TARS, 2013-2018)

3.2 In-depth crash investigations

There were 24 head on crashes in the most recent sample of CASR's at-scene in-depth crash investigations that began in late 2014. These crashes are discussed in the following section to provide further insights into the nature of head on crashes.

Type of lane departure

Four head-on crash types have been defined based on observations from the in-depth crash investigations: drift into oncoming lane, loss of control, overtaking, and travel wrong way.

A drift into oncoming lane type lane departure involves a driver slowly moving into the oncoming lane. This may be as a result of fatigue, a medical condition, distraction or other reasons. Such departure types typically result in a frontal collision between the two vehicles, offset by 50% or less. A diagram from a drift off type departure is shown in Figure 3.5, with the resulting damage to one of the vehicles shown in Figure 3.6. Twelve of the 24 head on crashes were drift into oncoming lane type departures.

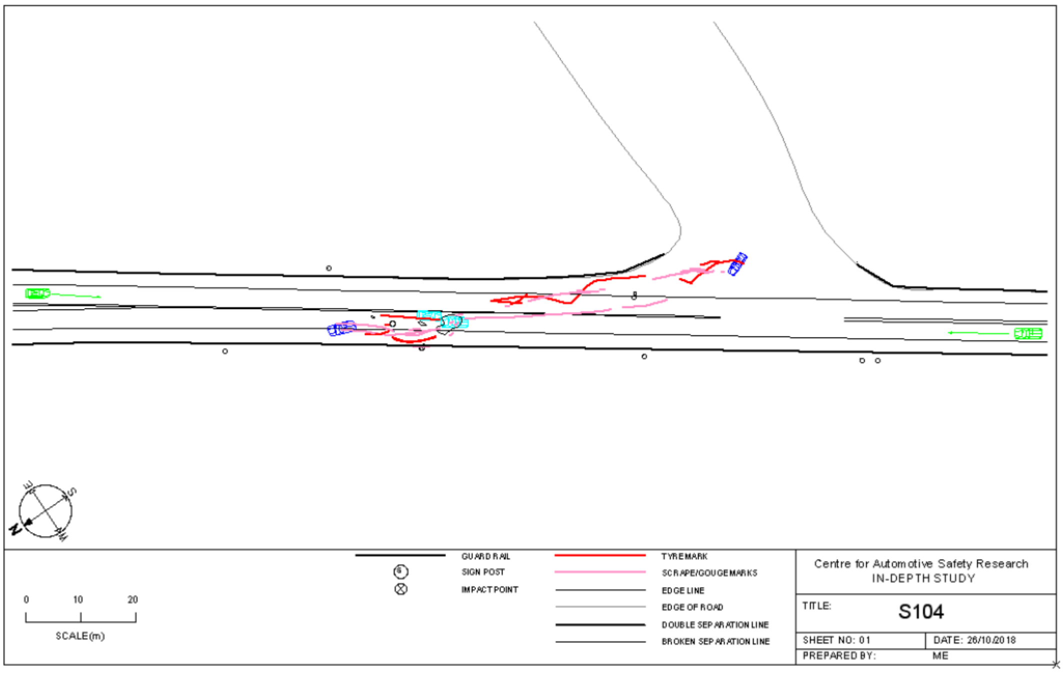

Figure 3.5
Site diagram from drift into oncoming lane type head on crash.

A loss of control lane departure involves the driver first losing control of the vehicle before entering the oncoming traffic lane. The loss of control may be due to initially departing their lane to the left before overcorrecting and losing control, or it may be due to entering a curve at an inappropriate speed. The loss of control can cause the vehicle to develop a side slip angle and be struck in the side by the oncoming vehicle, an area which has less crumple zone available to absorb energy before the intrusion into the occupant compartment begins. Loss of control type lane departures also include motorcyclists who have lost control of the motorcycle, either through a riding mistake or due to the road surface, and have entered the oncoming lane upright or having already fallen from the motorcycle. Figure 3.7 shows a site diagram from of a loss of control type lane departure, and Figure 3.8 shows the extreme deformation that can result in a head on crash the involves a side impact for one of the vehicles. There were 11 crashes that involved a loss of control type lane departure in the 24 cases.

Figure 3.6
Typical damage suffered in a drift into oncoming lane head on crash on a high-speed road.

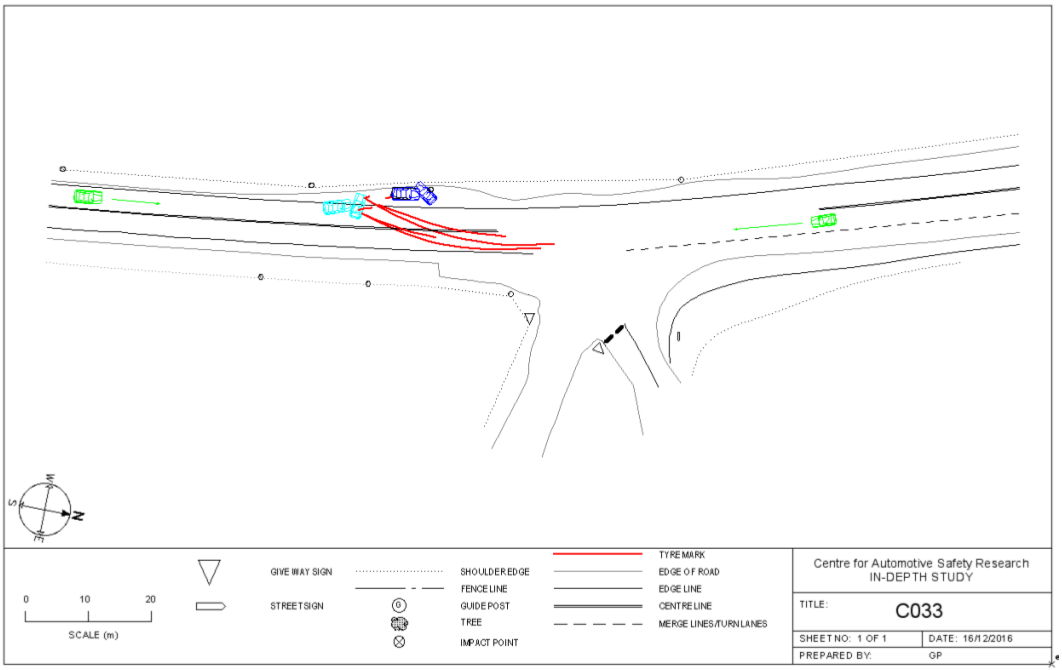

Figure 3.7
Site diagram of loss of control type of head on crash

Figure 3.8
Typical side impact damage from loss of control type head on crash

The overtaking type of head-on crash is an intentional maneuver for the purpose of overtaking. There were no crashes of this type in the 26 head-on crashes.

The final type of head-on crash, travel wrong way, involves a vehicle travelling in the wrong direction on either a divided road or a one-way street. There was one case investigated by CASR that involved this type of head-on crash.

Impact configuration

It is sometimes assumed that head-on crashes always involve a front-to-front impact configuration, as this might be implied by the term “head-on”. When considering the impact configuration for head-on crashes that did not involve a motorcycle (n=20), most were a frontal impact (n=13), but some involved side impacts (n=4), or a side swipe (n=3).

Of the front-to-front impact configuration crashes, more than half (n=7) involved a small overlap of less than 25% of the width of the vehicle. An example of the damage sustained in a small overlap head-on impact is shown in Figure 3.6.

Current NCAP tests conduct frontal impact tests at a 40% overlap, but this is soon to be increased to 50% with the introduction of the mobile progressive deformable barrier test. Only the consumer testing in the United States (IIHS tests) conduct a low overlap crash test, with an overlap of 25%. Low overlap crashes test the vehicle structure in a different manner, and a vehicle that performs well in a 50% overlap crash may not perform well in a 25% overlap crash. It is, therefore, important that crash tests represent the types of impact that are occurring in actual crashes.

The limits of five-star vehicles

Head on crashes on South Australian roads can involve a much more severe impact than occurs in the tests undertaken by ANCAP. The current ANCAP testing protocols include a frontal test that represents a head on impact with a vehicle of the same mass at 64 km/h. This is soon to be modified to represent a head on impact with a vehicle weighing 1,400 kg at 50 km/h. On South Australian roads it is possible to have a head on impact with another vehicle at 110 km/h without a vehicle exceeding the speed limit, more than twice the speed of what will soon be the ANCAP test speed. If the other vehicle is an SUV or work utility it could weigh over 2,000 kg, much heavier than the representation of the other vehicle in the new ANCAP test. Safety in a 5-star vehicle is therefore not guaranteed in a head on crash on a high-speed road.

In-depth cases have provided examples of serious or fatal injuries in vehicles rated five-stars by ANCAP that were involved in a head on crash. The vehicle shown in Figure 3.6 above is a 2015 Mitsubishi ASX that was involved in a head on crash in a 100 km/h zone. The driver of the ASX received serious injuries (MAIS 4, ISS 21) that may have severe lifelong consequences. The other driver involved in the crash, who was driving a 1996 Mazda Bravo, was killed, suggesting some benefit of the 5-star rated vehicle. Both drivers were of similar age. Another crash involved a 2016 Mitsubishi Triton that had a head on crash on a 110 km/h road (Figure 3.9). Despite the Triton having a 5-star rating the driver was killed, as was the driver of the other vehicle, a 2000 Toyota Camry with a 3-star rating.

Figure 3.9
A five-star vehicle (right) involved in a head on crash where the driver was fatally injured

Head on crashes involving trucks

Four of the 24 crashes involved a truck. Collisions with trucks tend to be severe, and this is especially the case for head on crashes. Two of these four resulted in an occupant of the light vehicle being killed. It is also possible for the driver of the truck to be seriously injured in a head on crash. Both the truck drivers from the fatal crashes were admitted to hospital, with one having to be pulled from his truck which had caught fire (see Figure 3.10). In all four of these crashes the light vehicle was the one who had departed their lane and moved into the oncoming lane that the truck was travelling in. Figure 3.11 provides an example of the massive amount of damage that a light vehicle can sustain in a head on impact with a truck.

Figure 3.10
The damage to a truck involved in a head on crash

Figure 3.11
The massive amount of damage inflicted upon a light vehicle in a head on crash with a truck

Head on crashes involving motorcycles

Four on the 24 crashes involved a motorcycle. In all four of these crashes the motorcycle had lost control and had entered the oncoming traffic lane. All of these cases also occurred on winding roads in the Adelaide hills with the motorcycle losing control when attempting to navigate a curve. The advisory speeds for the curves ranged from 35 to 55 km/h. In two of the cases the riders were still on their motorcycles when they struck the oncoming vehicle, while two had already come off their motorcycles, only one of which was struck by the oncoming vehicle.

One motorcycle rider involved in a head on crash was killed. The potential for a rider to be seriously injured or killed in a head on crash is high, whether they stay on the motorcycle, or are struck while on the ground. That the other three crashes were not fatal is likely due to their travel speeds being around 60 km/h or less before losing control, and the low travel speeds of the oncoming vehicles on the winding roads. The rider who was killed was travelling at around 120 km/h prior to losing control. One rider avoided the potential of serious injury because they were not struck by the oncoming vehicle (only the motorcycle was struck). An example of a head on crash involving a motorcycle is pictured in Figure 3.12.

Figure 3.12
A head on crash involving a motorcycle

Contributing factors

The factors that contributed to a crash occurring are identified as part of the CASR crash investigation case review process. Multiple contributing factors can be identified for each crash. Fourteen of the in-depth cases had been reviewed and contributing factors identified.

The top contributing factors are shown in Table 3.4. The most common contributing factor was a medical condition, followed by fatigue, and drugs. Of the drivers that had a medical condition that contributed to the crash, only one was over 65 years old. Two of the four were related to seizures, with both of these drivers being in their 20's. Of the cases where a drug was judged to be a contributing factor two were positive for methamphetamine and one for THC (cannabis). It is worth noting that fatigue is difficult to conclusively identify in some crashes, therefore there could be even more crashes in the sample where fatigue was a contributing factor.

Three cases involved speed as a contributing factor, either exceeding the speed limit or travelling at an inappropriate speed for the conditions. All these crashes occurred on winding roads through the Adelaide hills. Two involved motorcycles, including one that was travelling at 120 km/h in an 80 km/h zone, then lost control on a curve and collided head on with an approaching vehicle. The other involved a vehicle approaching a curve with a 35 km/h advisory at 60 km/h when the road was wet, entering the oncoming lane as a result.

In two of the speed related crashes the horizontal alignment of the road was found to have contributed to the crash occurring. In both these cases a curve in the road tightened suddenly, which contributed to the driver or rider entering that section of the curve too fast and consequently travelling into the oncoming lane.

Table 3.4
Top contributing factors

Contributing factor	Number	Percentage
Medical condition	4	29%
Fatigue	3	21%
Drugs	3	21%
Speed too high for conditions	2	14%
Horizontal alignment	2	14%
Exceeding the speed limit	1	7%
Total cases reviewed	14	100%

Interventions for mitigation and prevention

Interventions or treatments that would either mitigate the outcome of the crash or prevent it from occurring are also nominated as part of the case review process. This process and a full list of all the interventions can be found in Doecke, Thompson and Stokes (2020). There were 29 mitigation and 43 prevention interventions nominated for the 14 cases that have been reviewed, meaning an average of just over two mitigation and three prevention interventions were nominated per crash.

The top mitigation interventions are shown in Table 3.5. Unsurprisingly, centre barriers were the top mitigation intervention, followed by a reduction in speed limit and a wide centre median. Frontal intrusion protection refers to improved design of the vehicle structure to prevent intrusion into the occupant compartment, especially for low overlap crashes where the front wheel can be pushed backwards into the footwell.

Table 3.5
Top mitigation interventions

Intervention	Number	Percentage
Centre barrier	9	64%
Speed limit reduction	4	29%
Wide centre median	3	21%
Front intrusion protection	2	14%
Total cases reviewed	14	100%

The top prevention interventions are shown in Table 3.6. Vehicle technologies featured prominently with lane keep assist and ESC combined preventing nine of the 14 cases. Wide centre medians were the top infrastructure based intervention to prevent head on crashes. Apprehension for a drink or drug driving offence prior to the crash would have prevented three of the crashes.

Table 3.6
Top prevention interventions

Intervention	Number	Percentage
Lane keep assist	5	36%
Wide centre median	5	36%
ESC	4	29%
Apprehension for drink/drug driving offence	3	21%
Total cases reviewed	14	100%

4 Key findings

The results revealed that head on crashes, while not common, are 10 times more likely to be fatal than all crashes. The higher injury severity associated with head on crashes highlights the need to better understand these crashes and to develop and implement effective interventions to mitigate and prevent these crash types and associated injuries.

TARS data revealed that head on crashes are:

- About 2.5 times more likely to occur in a 100 or 110 km/h zones than all crashes
- Four times more likely to occur on a curve than all crashes
- More likely to be involve a truck or a motorcycle
- Rarely due to an overtaking manoeuvre (only 5%)

Interestingly, mapping the locations of the head on crashes in TARS revealed some locations on major highways where there were no head on crashes. This may be due to wide medians, centre barriers and wide centreline treatments, but requires further investigation before it can be confirmed.

CASR's at-scene in-depth crash investigations of 24 head on crashes revealed these further insights;

- Just under half of head on crashes are preceded by a vehicle losing control
- Side impacts occurred in 20% of head on crashes
- More than half of the frontal impacts involve a low overlap (less than 25% overlap)
- Serious and fatal injuries can occur in five-star vehicles on high-speed roads
- Truck drivers can be seriously injured in head on crashes with light vehicles
- Motorcycles were involved in head on crashes on tight corners on winding roads.
- The top contributing factors were:
  - A medical condition
  - Fatigue
  - Drugs
  - Speed
- The top mitigating interventions were
  - Centre barriers
  - Speed limit reduction
  - Wide centre median
- The top prevention interventions were
  - Lane keep assist
  - Wide centre median
  - ESC

Acknowledgements

This research was funded via a deed with the South Australian Government.

The authors would also like to thank Sally Edwards for her work on conducting interviews for at-scene in-depth crash investigations.

The views expressed in this report are those of the author and do not necessarily represent those of the University of Adelaide or the funding organisation.

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