CENTRE FOR
AUTOMOTIVE
SAFETY RESEARCH

THE UNIVERSITY
of ADELAIDE

Prevention and mitigation of fatal crashes in regional and remote areas

LN Wundersitz, SA Edwards, JP Thompson

CASR REPORT SERIES
CASR193
October 2021

Report documentation

REPORT NO.	DATE	PAGES	ISBN	ISSN
CASR193	October 2021	56	978-1-925971-27-9	1449-2237

TITLE

Prevention and mitigation of fatal crashes in regional and remote areas

AUTHORS

LN Wundersitz, SA Edwards, JP Thompson

PERFORMING ORGANISATION

Centre for Automotive Safety Research
The University of Adelaide
South Australia 5005
AUSTRALIA

SPONSORED BY

Department for Infrastructure and Transport
GPO Box 1533
Adelaide SA 5001
AUSTRALIA

AVAILABLE FROM

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

ABSTRACT

Road users in regional and remote areas have a higher risk of death and serious injuries than those in metropolitan areas. This study used a Safe Systems based approach to investigate the potential of different types of interventions to prevent fatal crashes or mitigate the level of injury severity in regional/remote areas. Coroner's case reports investigating 111 fatal road crashes in South Australia from 2014 to 2015 that occurred on regional or remote roads in South Australia were examined. A case-by-case analysis was conducted to determine the circumstances surrounding, and the factors contributing to, the crash, as well as potential preventative measures under each of the Safe System pillars. The findings showed that while road user behaviour is a large contributor to fatal crashes in regional/remote areas, it is vehicle and road based countermeasures that provide the greatest potential to prevent these crashes and mitigate related injuries. Investment in safe roadside infrastructure, particularly to protect road users in road departure crashes, and the use of policies and incentives to accelerate the uptake of newer vehicles with safe vehicle technologies (i.e. lane keeping technology, electronic stability control, autonomous emergency braking) hold the most promise. These interventions should also be coupled with the most effective enforcement strategies to deter unsafe driver behaviours and increase the perceived risk of detection; speed management, such as lower speed limits to match the quality of the road and infrastructure; and measures to ensure restraint use compliance. The findings provide those responsible for designing, managing and monitoring the road system with evidence-based guidance for establishing future priorities in order to more effectively prevent road trauma in regional/remote areas.

KEYWORDS

Rural, crash, fatal, countermeasures, Safe System

Summary

Road users in regional and remote areas face a greater risk of death and serious injury than those in major cities. The fatality rate in regional and remote areas of South Australia is almost four times higher than in the Adelaide metropolitan area. To improve road safety on regional and remote roads, this study investigated the circumstances surrounding, and the factors contributing to, fatal crashes on regional/remote South Australian roads. By identifying gaps in the wider road transport system that were contributing to the crashes, the potential for different types of interventions to prevent fatal crashes or mitigate the injury severity was determined using a systems-based approach. The findings from this study provide those responsible for designing, managing and monitoring the road system with evidence-based guidance for establishing future priorities to eliminate harm more effectively on regional and remote roads.

A total of 111 road crashes reported to the State Coroner resulting in at least one fatality from 2014 to 2015 that occurred in regional or remote areas in South Australia were examined. A case-by-case analysis of Coroner's case reports was conducted to determine the circumstances associated with, and the factors contributing to, the crash, as well as potential preventative measures under each of the Safe System pillars.

Some characteristics associated with regional and remote crashes and fatalities include:

- Single vehicle crashes were the most common crash type (54%) followed by head on crashes (17%).
- Almost 80% of crashes occurred on high speed roads with a speed limit of 100 or 110 km/h.
- Road users culpable for the fatal crash were more likely to live in regional/remote South Australia than non-culpable road users (62% vs 53%).
- Almost a third of fatally injured vehicle occupants were unrestrained. Males and those aged 25-34 years were most likely to be unrestrained. Unrestrained fatalities were more likely than restrained fatalities to crash in remote areas, on unsealed roads, involve a rollover, be positive for illicit drugs, and have a positive BAC.
- More fatalities tested positive for an illicit drug than recorded an illegal BAC, with THC being the most common drug type.
- For 28.3% of fatalities there was some indication that they were experiencing a mental health condition.
- Vehicles driven by culpable drivers in a fatal crash were more likely to be older than vehicles driven by non-culpable drivers.

The most common gaps in the road transport system, or factors identified as contributing to regional/remote crashes (or injury severity), centred around risky driving behaviours, including lack of restraint use (24.3%), speeding (23.4%), drug use (22.5%), alcohol use (19.8%) and driver inattention (19%). In all crashes, at least one intervention could have prevented the crash or mitigated injury severity. This finding may suggest that all crashes were preventable, but it does not mean that the nominated interventions are all cost effective or easy to implement.

While risky driving behaviours are clearly large contributors to fatal crashes in regional/remote areas, the findings indicated that it is road and vehicle-based interventions that have the greatest potential to prevent these crashes or mitigate related injuries (94.6%, 93.7%, respectively). Investment in safe roadside infrastructure, particularly to protect road users in road departure crashes (i.e. roadside and

median barriers, audio tactile line marking), and the use of policies and incentives to accelerate the uptake of newer vehicles with safe vehicle technologies such as lane keeping technology, electronic stability control and autonomous emergency braking hold the most promise in the challenging regional/remote environment. These interventions should also be coupled with the most effective enforcement strategies to deter unsafe driver behaviours (i.e. drugs, alcohol) and increase the perceived risk of detection; speed management, such as lower speed limits to match the quality of the road and infrastructure; and measures to ensure restraint use compliance. A number of organisations and agencies can make a significant impact by implementing and managing these countermeasures and therefore creating a safer transport system which will improve road safety in regional/remote areas.

Contents

This page intentionally left blank

1 Background

Drivers and riders in regional and remote areas face an unacceptably greater risk of death and serious injury than those in major cities. On a national level, approximately one third of Australians live in regional or remote areas, as defined by the Australian Statistical Geography Standards (ASGS) remoteness areas (Australian Bureau of Statistics (ABS), 2018a), but two thirds of road crash deaths occur in these areas (Wundersitz et al., 2019). The disproportionate representation of road deaths in regional and remote areas is also evident in South Australia, as seen in Table 1.1. On average, from 2014 to 2018, 59% of fatalities in South Australia recorded in the Traffic Accident Recording System (TARS) were in regional/remote areas. In 2019, 65 fatalities in regional/remote areas were recorded, a 16% increase from the five year average. In addition, 44% of serious injuries occur in regional and remote areas (Department for Infrastructure and Transport, 2019).

Table 1.1
Fatal crashes and fatalities reported in TARS by location, 2014-2019

TARS	2014	2015	2016	2017	2018	Average 2014-2018	2019
Fatal crashes (total)	96	96	77	93	75	87	110
Rural crashes	**59**	**53**	**45**	**39**	**51**	**49**	**61**
Metro crashes	37	43	32	54	24	38	49
Fatalities (total)	108	102	86	100	80	95	114
Rural fatalities	**70**	**59**	**52**	**44**	**56**	**56**	**65**
Metro fatalities	38	43	34	56	24	39	49

When considering the rate of deaths relative to population, presented in Figure 1.1, the difference between metropolitan Adelaide and South Australian regional and remote areas is stark. In 2019, the fatality rate in regional and remote areas was 14.1 deaths per 100,000 population compared to 3.8 deaths per 100,000 population in the metropolitan area (3.7 times higher). Of concern is that the fatality rate in regional and remote areas has increased in recent years.

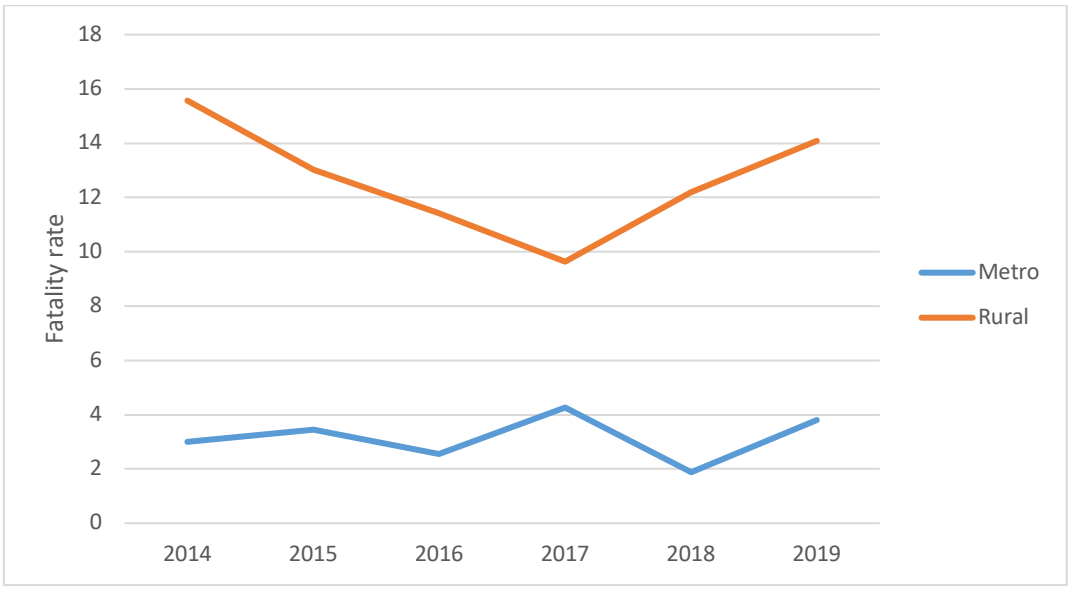

Figure 1.1
Fatality rate per 100,000 population by location (based on ASGS remoteness areas) in South Australia, 2014-2019

As South Australia works towards the strategic target of zero serious injuries and fatalities, regional and remote road safety presents some serious challenges including, but not limited to, the need to travel over vast distances to reach regional/remote towns and cities, varying terrain, lower quality roads, numerous roadside hazards and wildlife, higher speed roads, a large road network, a complex mix of vehicle types, different road user perceptions of risk, low population density, and limited resources and funding.

In order to eliminate harm on regional and remote roads in South Australia, there is a need to investigate the context and circumstances surrounding these crashes, which can be influenced by many factors, organisations and individuals. This can be achieved by using a systems-based approach that considers the complex relationships and interactions between actors and components within the road transport system.

The Safe System approach aims to eliminate deaths and serious injuries on the road network. It involves a holistic view of the road transport system and the interactions among roads and roadsides, vehicles, travel speeds and road users. The underlying principle of the approach is the acceptance that people make mistakes and that some crashes are inevitable. The system should be planned and designed to accommodate human error so that, if one part of the system fails, the other parts will still protect road users. Parts of the system should not be viewed in isolation as the solution to a problem in one part of the system may lie in another part. A key element of the safe system approach is being proactive by identifying risks and preventing crashes before they occur. Using a holistic Safe Systems approach to examine regional and remote crashes will improve and extend limited existing knowledge regarding which countermeasures are required to mitigate or prevent crash outcomes in these areas.

Aims

This current study aims to:

- Investigate the context and circumstances associated with fatal crashes in regional and remote areas in South Australia.
- Identify gaps in the wider road transport system that are contributing to road deaths on regional and remote areas
- Determine how fatal crashes in regional and remote areas might be prevented, using a systems-based approach.

The findings from this study will provide an estimate of the potential of different types of Safe System interventions to prevent fatal crashes or mitigate injury severity in South Australian regional/remote areas and afford those responsible for designing, managing and monitoring the road system with evidence-based guidance for establishing future priorities to more effectively eliminate harm on regional and remote roads.

2 Method

2.1 Coroners case reports

In the state of South Australia all deaths resulting from road crashes are legally required to be reported to the state Coroner for investigation (South Australia Coroner's Act, 2003). Through this routine investigation, the state Coroner obtains detailed information about the circumstances surrounding a fatal crash. Case reports typically include a detailed report compiled by the investigating police officer (including interviews with surviving participants and witnesses), a forensic autopsy report detailing injuries, a forensic toxicology report (i.e. alcohol and drugs), and a summary of the Coroner's findings relating to the cause of death. The police report generally includes photographs and a map of the scene, interviews with surviving participants and witnesses, a mechanical inspection report for all vehicles involved in the crash, details of any charges against individuals involved in the crash and any other relevant information. The systematic examination of contributing factors means that Coroner's case reports are one of very few data sources that can provide comprehensive information regarding the circumstances surrounding a crash.

This study examined all motor vehicle crashes reported to the State Coroner resulting in at least one fatality (i.e. vehicle occupants, motorcycle riders, cyclists, pedestrians) from 2014 to 2015 that occurred on regional or remote roads in South Australia. The location of the crash was defined according to the Australian Statistical Geography Standard (ASGS) classification of Remoteness Areas across Australia which uses five categories (ABS, 2018a). Relative remoteness is measured in an objective way using the Accessibility and Remoteness Index of Australia (ARIA+). The ARIA+ is derived by measuring the road distance from a point to the nearest Urban Centres and Localities (ABS, 2018a). Regional areas were defined by combining the ASGS categories of inner regional and outer regional. Remote areas were defined by combining the categories remote and very remote. Overall, regional/remote areas were defined by combining the four categories (inner regional, outer regional, remote and very remote). Note that this definition of regional/remote varies slightly from the definition adopted by the Department for Infrastructure and Transport (DIT); however, it is objective and uses a consistent process for classifying Remoteness Areas allowing comparisons of data published over time and across Australia. This classification is also currently used for national road trauma statistical summaries produced by the federal Bureau of Infrastructure, Transport and Regional Economics (BITRE).

All Coroner's case reports included in the study were completed or 'closed' reports that were no longer under investigation. Cases were excluded if they did not occur on a public road, if the crash was judged to be intentional (i.e. suicide) or if the fatality resulted from natural causes (i.e. a pre-existing condition such as a myocardial infarction).

Of the 185 closed Coroner's case reports obtained for analysis from 2014 to 2015, 120 crashes (65%) occurred on regional or remote roads. There were 9 cases which did not meet the study inclusion criteria, resulting in a final sample size of N=111.

It is acknowledged that the number of fatal crashes in regional/remote areas for 2014-15 included in this study is likely to differ slightly from that recorded by the Department due to the different classifications used to define rural areas, and the use of 'closed' Coroner's files. Coroner's case files for crashes that are still open for investigation were not included in this sample.

2.2 Procedure

Three road safety experts with extensive crash investigation experience independently reviewed and analysed each case to determine the factors contributing to the crash and potential preventative measures using a systems-based approach. The conceptual framework developed to examine each crash is presented in Figure 2.1. For each individual crash, all factors contributing to the crash were identified objectively during the case review (see list of all contributing factors in Appendix A) by considering the following questions: 1) What was the combination of factors that led to the crash and 2) What led to the fatality? Sufficient evidence was required to demonstrate that an issue was a contributing factor. The mere presence of an unsafe road factor did not mean it was identified as contributing. Multiple contributing factors could be identified for each crash and there was no limit to the number of contributing factors.

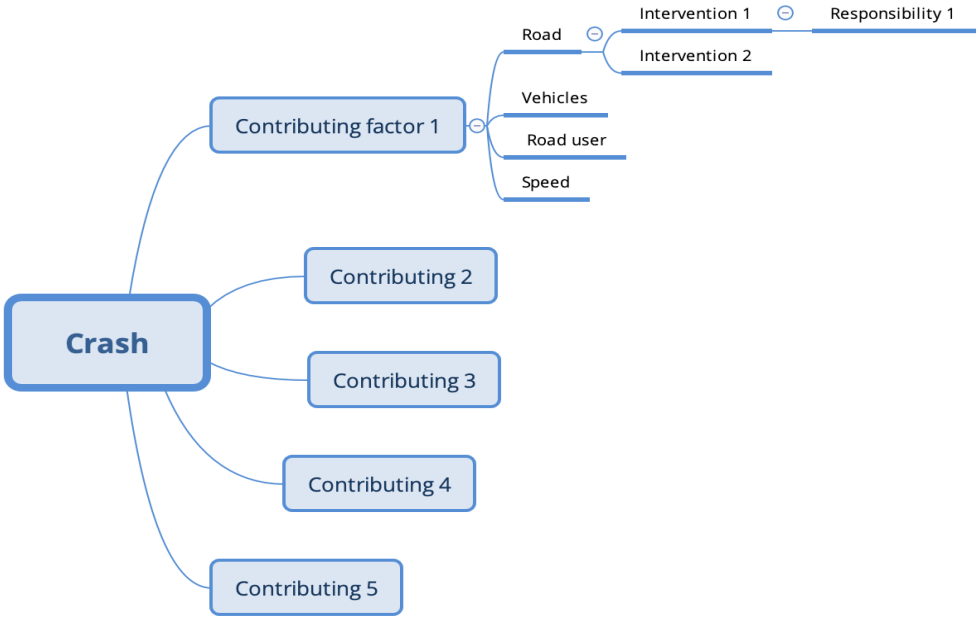

Figure 2.1
Conceptual framework for individual crash analysis

Following this, interventions that might have either prevented or mitigated the crash or injuries were considered under each of the Safe System pillars (roads, vehicles, road users, speed). The list of potential interventions, as seen in Appendix B, were derived by the CASR multidisciplinary in-depth crash investigation review team (see Doecke, Thompson & Stokes, 2020). The interventions considered are all currently defined with some evidence in the research literature indicating their potential benefits. However, in some instances (e.g. vehicle technologies) the countermeasure may not be fully developed or may not yet operate at an optimum level. Automated and connected vehicles were not considered as their operation in specific crash-related situations is still largely unknown. Limited consideration was given to the cost or practicality of a given intervention as the focus of the study was on the potential of interventions. Each intervention was carefully considered as to whether it would have worked effectively in each given crash. For example, in a crash where a vehicle departed from the road, lane keeping technology would only be considered as an intervention if the road was sealed and had painted edge lines. Multiple interventions could be selected for each crash but each intervention was considered on its own merits. Interactions between interventions were not considered. Finally, the agency or organisation who shares responsibility for implementing each intervention was recorded.

For each crash, routinely recorded information included time of day, day of week, crash type, location of crash, speed limit, road features (type, alignment, surface, edge lines, shoulders, roadside and median barriers), environmental conditions (weather, lighting) and a crash description. In some cases, computer aided reconstructions of the crashes were undertaken to determine vehicle speeds or data from the air bag module of a vehicle were analysed.

Detailed data were also collected on the crash participants (driver and deceased) including age, sex, location of residence (regional/remote/metro), wearing of a seat belt, BAC level recorded, the presence of drugs (licit and illicit) and injury severity. The BAC level for a deceased driver and any other drivers involved in a fatal crash are routinely recorded in the autopsy forensic toxicology report. The report contains the outcomes of alcohol and drug testing with interpretation of the findings in terms of likely impairment. The forensic testing for the Coroner covers a wide range of licit and illicit drugs and is conducted by Forensic Science SA. In addition, crash-involved drivers, riders, vehicle occupants and pedestrians over the age of 14 years who present to hospital are required to undergo mandatory testing for blood alcohol concentration in South Australia. This legislation requires a blood sample to be taken by hospital medical personnel within eight hours of being involved in the collision, with most occurring within the first one to two hours following the crash.

While not a requirement, in some cases, Indigenous status was mentioned within the files. Likewise, mental health is not required to be reported but in many instances general practitioners or family members commented on issues or prescribed medication or there was evidence of medications typically prescribed for mental health in the forensic toxicology report. Researchers also recorded information on the crash involved vehicles such as vehicle type, vehicle age and the presence of vehicle technologies (e.g. airbags, ABS, ESC).

All variables of interest were entered into a Filemaker Pro database. Statistical analyses (chi-square tests, T-tests) were undertaken using SPSS.

The analysis was limited in some cases by the extent and quality of the information available in Coroner's files which can vary from case to case. Nevertheless, the information contained in Coroner's files has greater detail than regular crash reports and, for most of the crashes, the information provided a good understanding of the contributing factors and, therefore, potential interventions.

3 Results

The first part of this results section provides an overview of the profile of the sample of fatal crashes in regional/remote South Australia. Specifically, it describes the sample of crashes in terms of the characteristics of the crash, the characteristics of the road on which it occurred, and the behaviour of the road users involved. This is followed by a description of driver characteristics by driver culpability, an analysis of those fatally injured in the crashes, and an examination of the age of the vehicle fleet involved in the crashes. Finally, factors contributing to the crashes and potential interventions or countermeasures that could prevent the crash or mitigate the injury severity are considered.

3.1 Profile of regional/remote crashes

3.1.1 Crash characteristics

Of the total sample of 111 fatal crashes in regional/remote areas of South Australia in 2014 and 2015, 88 (79.3%) were in regional areas and 23 (20.7%) were in remote areas, as defined by the ASGS classification of Remoteness Areas (ABS, 2018a). The location of the crashes are mapped in Figure 3.1.

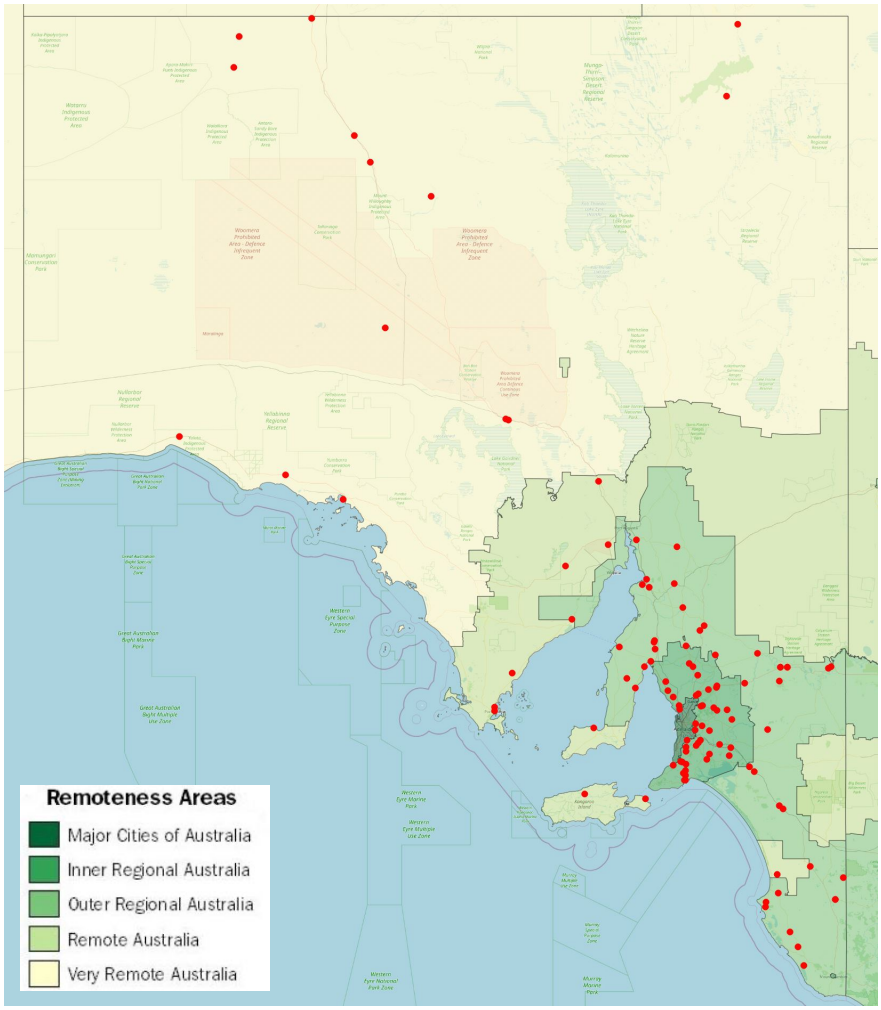

Figure 3.1
Location of fatal crashes in South Australia by remoteness areas (ASGS), 2014-2015

Characteristics related to the crashes are presented in Table 3.1. The most common types of crashes that occurred were single vehicle crashes (54.1%), followed by head on crashes (17.1%). The circumstances of both single vehicle and head on crashes would be similar, in that they would both be precipitated by a vehicle departing its lane and either hitting a roadside object such as a tree (single vehicle), rolling over (single vehicle), or hitting another vehicle in the opposite lane (head on). After single vehicle crashes (54.1%), multi-vehicle midblock crashes (28.8%) were the second most common crash category. Head on crashes accounted for 18 of the 32 multi-vehicle midblock crashes. There was a smaller proportion of multi-vehicle intersection crashes (12.6%), most likely due to the low number of intersections in regional/remote areas (in comparison to metropolitan areas).

Crash types were also examined separately for regional and remote areas to determine whether they differed. Of the 88 regional crashes, 43 were single vehicle, 17 were head on, 10 were right angle/right turn, seven were side swipe, four were 'other', three were pedestrian, two were rear end and two were entering or leaving road. In comparison, almost three quarters of remote crashes were single vehicle (n=17), with two head on, two involving pedestrians, one a side swipe and one involving entering or leaving the road. Therefore, single vehicle and head on crashes account for a somewhat larger proportion of crashes in remote areas compared to regional areas (82.6% versus 68.2%).

Table 3.1
Characteristics of fatal crashes in regional/remote South Australia, 2014-2015

Crash characteristic		Number (N=111)	%
Crash type	Single vehicle	60	54.1
	Head on	19	17.1
	Right angle/right turn	10	9.0
	Side swipe	8	7.2
	Pedestrian	5	4.5
	Other	4	3.6
	Entering or leaving road	3	2.7
	Rear end	2	1.8
Crash category	Single vehicle	60	54.1
	Multi-vehicle midblock	32	28.8
	Multi-vehicle intersection	14	12.6
	Pedestrian	5	4.5
Weather conditions	Fine	95	85.6
	Overcast	6	5.4
	Unknown	5	4.5
	Heavy rain	3	2.7
	Light rain	2	1.8
Lighting conditions	Daylight	75	67.6
	Night without street lighting	30	27.0
	Night with street lighting	6	5.4

With regard to the weather conditions at the time of the crash, most of the crashes (85.6%) occurred in fine weather. Two-thirds of the crashes occurred during daylight, although one-quarter occurred at night-time on roads where there was no street lighting. To some extent, this is expected given the nature of many rural driving environments in which there are fewer streetlights. The tendency for the crashes to occur during the hours of daylight is also demonstrated in Figure 3.2, which presents the crashes by the hour of the day in which they occurred. Most (73.0%) occurred between 9:00 am and 7:59 pm, when there would be most traffic on the roads.

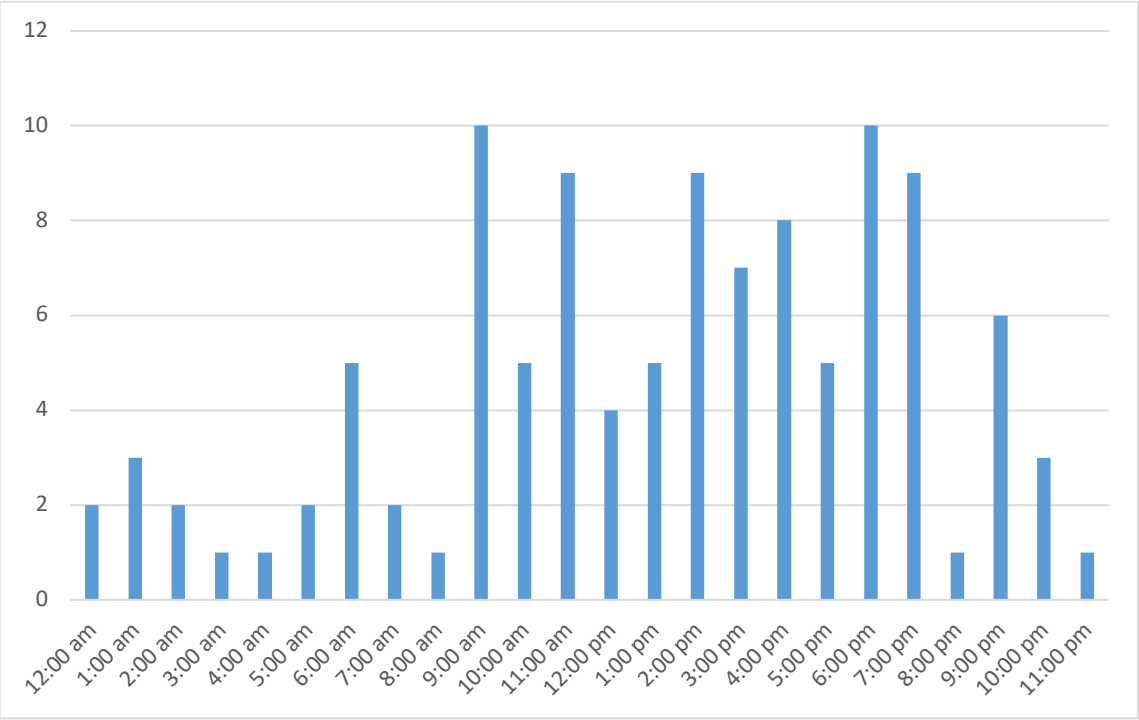

Figure 3.2
Fatal crashes in regional/remote South Australia by hour of the day, 2014-2015

In terms of the months of the year in which the crashes occurred (see Figure 3.3), there was no strong pattern, although slightly more crashes occurred in later months of the year (59.2% occurred during July to December). Similarly, there was no identifiable pattern in the days of the week (see Figure 3.4), with crashes evenly distributed, except for a low number on Wednesdays (only accounted for 7.2% of the sample of crashes).

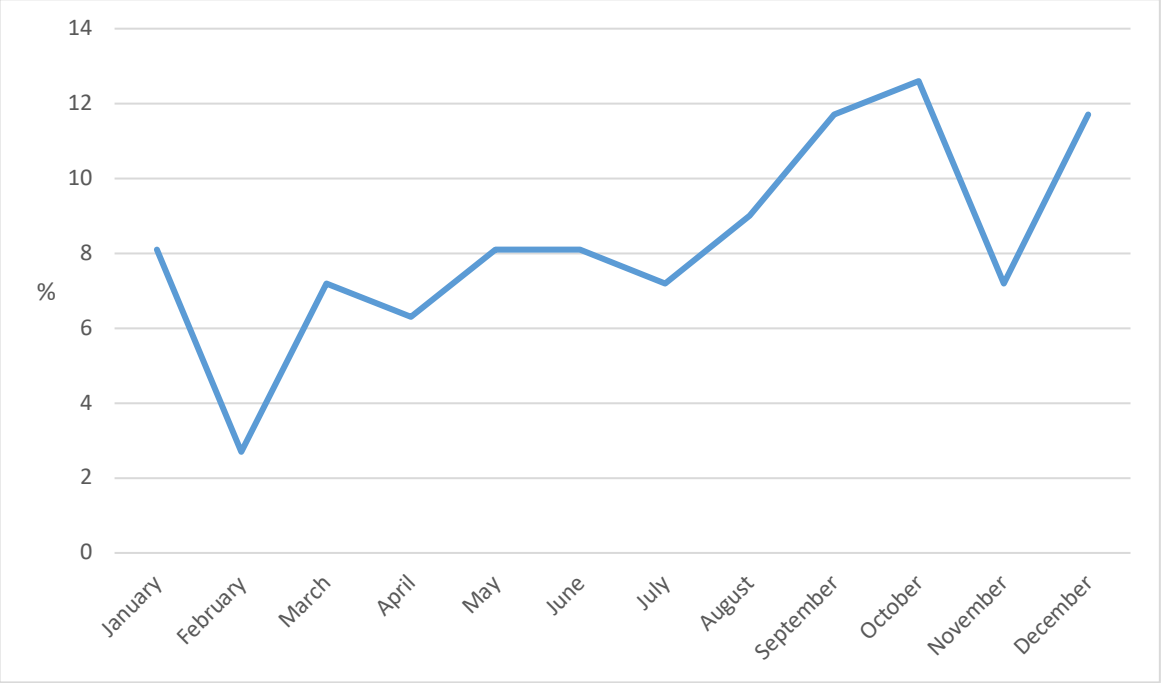

Figure 3.3
Fatal crashes in regional/remote South Australia by month of the year, 2014-2015

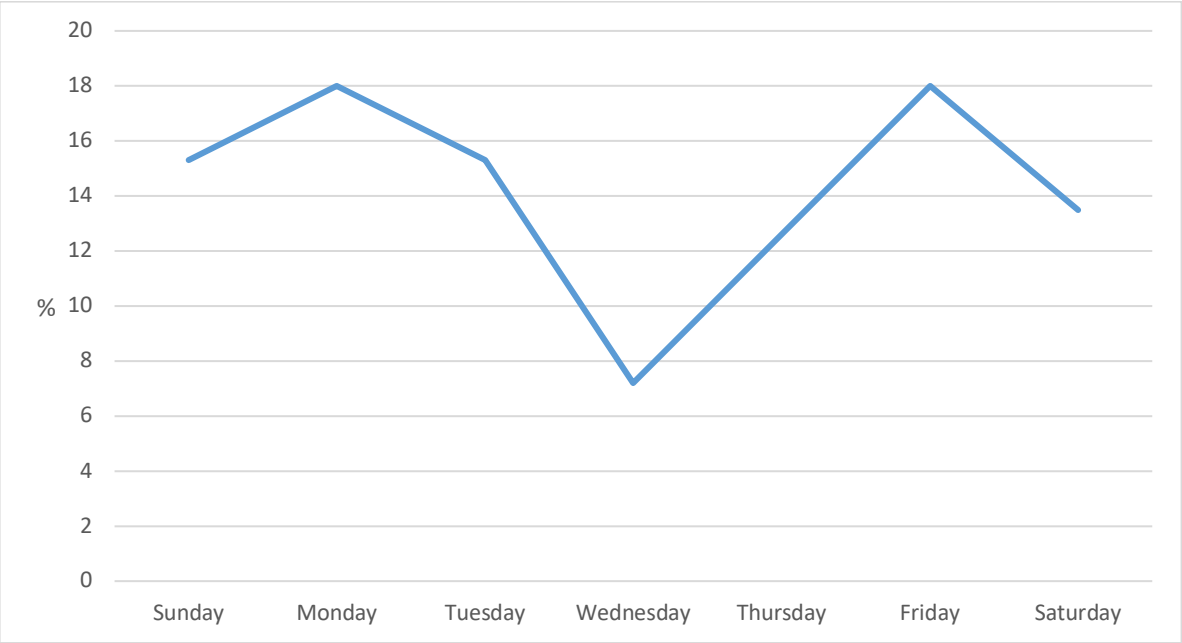

Figure 3.4
Fatal crashes in regional/remote South Australia by day of the week, 2014-2015

3.1.2 Road characteristics

Characteristics related to the road on which the crashes occurred are presented in Table 3.2. The highest number of crashes occurred on highways (37.8%) followed by collector roads (28.8%). Seventeen crashes (15.3%) occurred on unsealed roads, of which seven were collector roads, seven were local roads, two were arterial roads and one was a highway. A majority of crashes also occurred on straight roads (60.4%), level roads (74.8%), roads with unsealed shoulders (54.1%), roads with edge lining (69.4%), and on undivided roads (93.7%). Almost 80% of crashes occurred on high speed roads with a speed limit of 100 or 110 km/h. This is not surprising as there are many roads in regional/remote areas with these higher speed limits and crashes at these speeds would more likely be fatal.

Table 3.2
Characteristics of the roads for fatal crashes in regional/remote South Australia, 2014-2015

Road characteristic		Number (N=111)	%
Class of road	Highway	42	37.8
	Collector	32	28.8
	Arterial	25	22.5
	Local	12	10.8
Road surface	Bitumen	94	84.7
	Unsealed	17	15.3
Horizontal alignment	Straight	67	60.4
	Left bend	25	22.5
	Right bend	16	14.4
	S bend	3	2.7
Vertical alignment	Level	83	74.8
	Slope down	15	13.5
	Slope up	9	8.1
	Crest	4	3.6
Shoulders	Unsealed	61	55.0
	Bitumen	35	31.5
	No shoulder	12	10.8
	Concrete	3	2.7
Edge lining	Yes	77	69.4
	No	34	30.6
Speed limit	110	44	39.6
	100	44	39.6
	90	1	0.9
	80	11	9.9
	60	5	4.5
	50	6	5.4
Divided road	No	104	93.7
	Yes	7	6.3

The classes of the roads on which the crashes occurred were further explored by the types of the crashes, presented in Table 3.3. Single vehicle crashes were the most common crash type for each class of road in regional/remote areas, and, while they were most prevalent on highways, they comprised the greatest proportion of all crash types on local roads. Head on crashes were the second most common crash type for highways and arterial roads. The second most common crash type for collector roads was right angle crashes, and for local roads it was pedestrian crashes.

Table 3.3
Class of road and crash type for fatal crashes in regional/remote South Australia, 2014-2015

Class of road	Crash type	Number	%
Highway	Single vehicle	21	50.0
	Head on	10	23.8
	Other	3	7.1
	Rear end	2	4.8
	Right angle	2	4.8
	Side swipe	2	4.8
	Pedestrian	1	2.4
	Entering or leaving road	1	2.4
Arterial	Single vehicle	12	48.0
	Head on	7	28.0
	Side swipe	2	8.0
	Right turn	2	8.0
	Pedestrian	1	4.0
	Other	1	4.0
Collector	Single vehicle	19	59.4
	Right angle/right turn	5	15.6
	Side swipe	3	9.4
	Head on	2	6.3
	Entering or leaving road	2	6.3
	Pedestrian	1	3.1
Local	Single vehicle	8	66.7
	Pedestrian	2	16.7
	Right angle	1	8.3
	Side swipe	1	8.3

3.1.3 Road user behaviour

The prevalence of risky or illegal road user behaviours in fatal crashes occurring in regional/remote areas is presented in Table 3.4. Overall, 68.5% of crashes involved at least one of the listed road user behaviours and 41.4% of crashes involved more than one road user behaviour.

Table 3.4
Road user behaviour in fatal crashes in regional/remote South Australia, 2014-2015

Road user behaviour	Regional		Remote		Total	
	(n=88)	%	(n=23)	%	(N=111)	%
Restraint non-use	23	26.1	11	47.8	34	30.6
Exceed speed limit / too high for conditions	20	22.7	6	26.1	26	23.4
Drugs	20	22.7	5	21.7	25	22.5
Illegal BAC	19	21.6	3	13.0	22	19.8
Distraction / inattention	17	19.3	4	17.4	21	18.9
Fatigue	14	15.9	4	17.4	18	16.2
Unlicensed	3	3.4	3	13.0	6	5.4

A lack of restraint use was the most common behaviour reported in regional/remote areas with 30.6% of crashes involving a vehicle occupant not wearing an available seatbelt. This behaviour was most problematic in remote areas where almost half of the crashes (47.8%) involved non-restraint use by a vehicle occupant. Speed, defined as either exceeding the speed limit or travelling at a speed deemed too high for the conditions, was identified in 23.4% of all crashes. There were slightly more crashes involving a driver testing positive to an illicit drug than a driver recording an illegal blood alcohol

concentration (22.5%,19.8% respectively). Crashes involving an illegal BAC were more frequent in regional areas than remote areas. Driver distraction/inattention was involved in 18.9% of crashes while driver fatigue was involved in 16.2%. Around 5% of crashes involved an unlicensed driver, with this being most notable in remote areas, where 13% of crashes involved an unlicensed driver.

3.2 Culpability

3.2.1 Demographics

Of the 168 drivers/riders involved in a fatal crash, 107 individuals were deemed by police as being culpable for the crash, and 72.9% (n=78) of those deemed culpable were fatally injured. Notably, 56 of these crashes were single vehicle and thus culpability was automatically assigned to that driver, with the exception of four crashes which were attributed to causes external to the individual (i.e., vehicle faults, environmental conditions and an animal on the road). The type of road user by culpability status for regional/remote fatal crashes can be seen in Table 3.5. Culpable road users, in comparison to non-culpable road users, were more likely to be drivers of passenger vehicles (84.1% vs 47.5%, χ^2=25.15, df=1, *p*<.001) and less likely to be heavy vehicle drivers (2.8% vs 39.3%, χ^2=38.46, df=1, *p*<.001).

Table 3.5
Road user by culpability status in regional/remote South Australia, 2014-2015

	Culpable		Non-culpable		Total	
Road user	N=107	%	N=61	%	N=168	%
Driver (passenger vehicle)	90	84.1	29	47.5	119	70.8
Motorcyclist	10	9.3	3	4.9	13	7.7
Heavy vehicle driver	3	2.8	24	39.3	27	16.1
Cyclist	2	1.9	2	3.3	4	2.4
Pedestrian	2	1.9	3	4.9	5	3.0

The mean age of culpable road users was 42.2 years (SD = 19.1; range 17 - 90 years) compared to 45.7 years (SD = 16.7; range 18 – 88 years; one participant's age was unknown) for non-culpable road users indicating there was little difference in age by driver culpability. Culpability status by age group can be observed graphically in Figure 3.5. Around 46% of culpable road users were aged under 35 years, and the majority of those culpable were male (71%; n=76). However, chi square analysis indicated there were no statistically significant differences between gender and culpability status (χ^2= 2.48, df=1, *p*=.115 ns.).

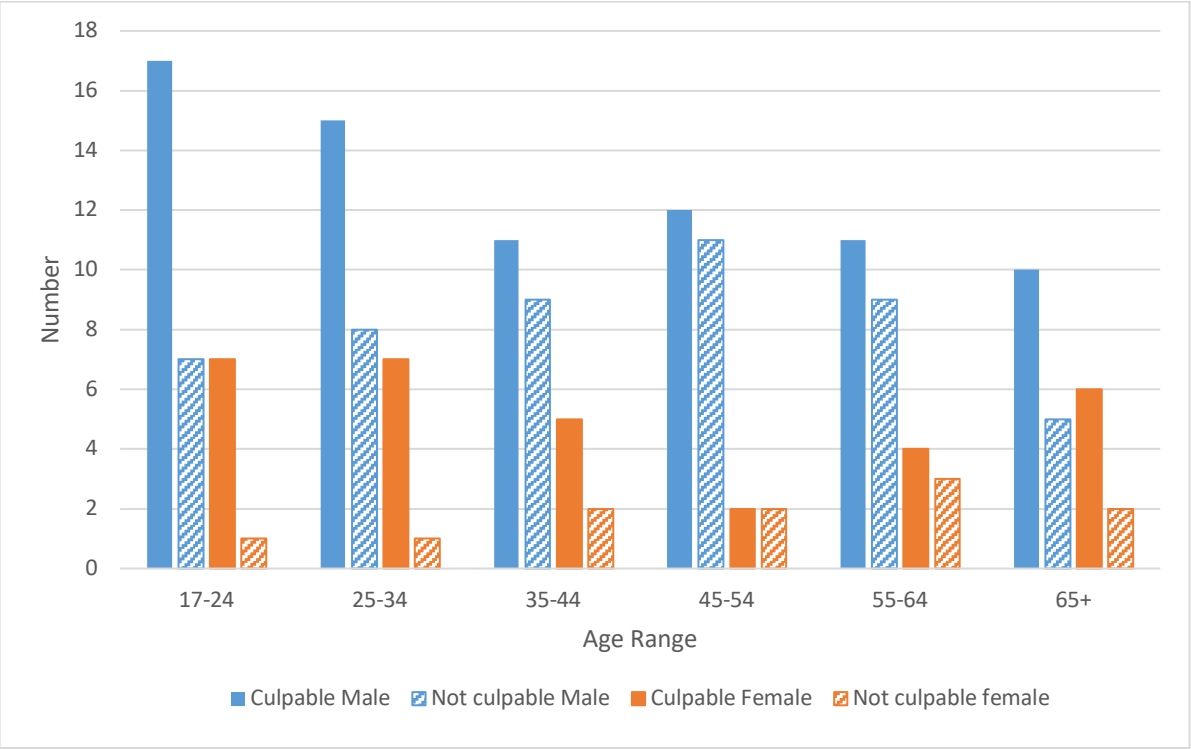

Figure 3.5
Culpable road users by age group for fatal crashes in regional/remote South Australia, 2014-15

The location of culpable and non-culpable road users involved in the fatal crash is presented in Figure 3.6. The majority 61.7% (n=66) of culpable road users in the fatal crash lived in regional/remote South Australia, with less than a quarter residing in the Adelaide metropolitan area and the remainder from interstate or overseas. In comparison to culpable drivers, non-culpable drivers were less likely to live in regional/remote areas and more likely to live interstate. This difference was statistically significant (χ^2=9.56, df=3, *p*=.023 excluding unknown cases).

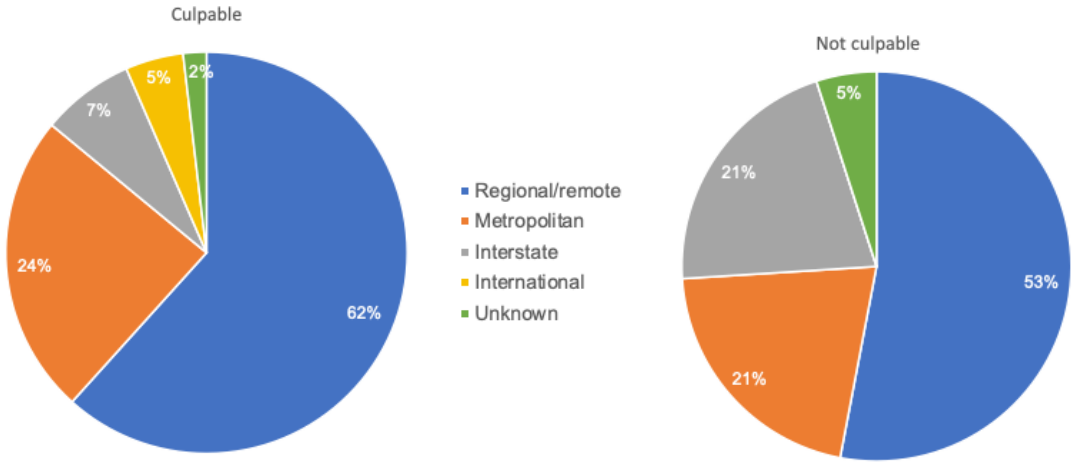

Figure 3.6
Location of residency for culpable and non-culpable road users in fatal crashes in regional/remote South Australia, 2014-2015

In regard to cultural identity, 4.7% of culpable road users were identified as Indigenous (n=5) but cultural identity was unknown for 36.4% (n=39) of culpable road users.

3.2.2 BAC

The individual BACs for culpable road users with a BAC above zero (n=25) is shown in Figure 3.7. There were 18.7% (n=20) of culpable road users who had an illegal BAC (0.05g/100ml or greater), with individuals aged between 20 and 67 years. Most of those with an illegal BAC were drivers of motor vehicles but there was one pedestrian (BAC 0.014) and two motorcycle riders (BAC 0.067 and 0.146). The BAC for two drivers was unknown. In contrast to the culpable road users, non-culpable road users (drivers, riders, cyclists and pedestrians) all had a zero BAC (n=61).

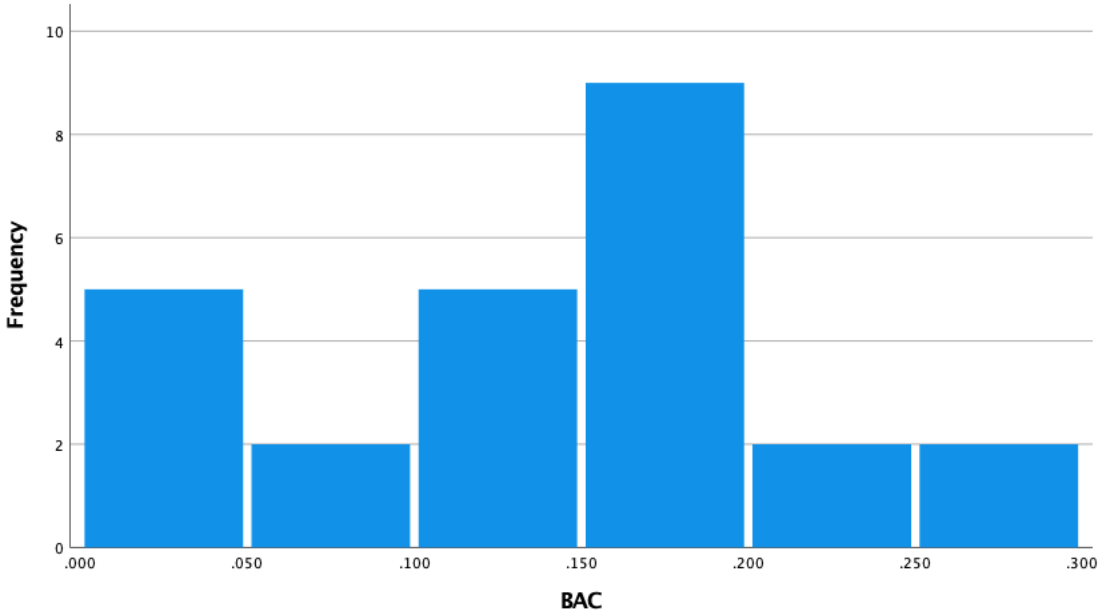

Figure 3.7
Positive BACs for culpable road users in regional/remote South Australia, 2014-2015

3.2.3 Illicit drugs

Of the culpable road users, 23.4% (n=25) tested positive for an illicit drug and they were aged between 19 and 56 years. The illicit drug types are presented in Table 3.6. Twenty three of the 25 road users who tested positive for an illicit drug were fatally injured. The most common illicit drug detected in culpable road users was tetrahydrocannabinol (THC or cannabis) at 13.1%, followed by 3.7% for a combination of both THC and methamphetamine (3.7%) and 3.7% for methamphetamine only. By contrast, only two of the non-culpable participants recorded a positive illicit drug result, one for THC and the other for methamphetamine (the drug toxicology for six non-culpable participants was unknown).

Table 3.6
Drug toxicology for culpable road users in regional/remote South Australia, 2014-2015

Drug status/type	N	%
Drug negative	80	74.8
THC	14	13.1
THC & Methamphetamine	4	3.7
Methamphetamine	4	3.7
MDMA positive & THC	1	0.9
Methylamphetamine	1	0.9
Cocaine	1	0.9
Unknown	2	1.9
Total	107	100.0

3.2.4 Mental health

For 30.8% of the culpable road users (n=33, 22 males and 11 females) there was some indication that they were experiencing a mental health condition including difficulties in their emotional functioning (report by self, General Practitioner, or a family member) and/or were taking medication that is typically prescribed for the management of a mental health condition (i.e., psychotropic medication). Note that none of the cases were suicides. Moreover, as seen in Table 3.7, 45.5% of those with a suspected mental health condition were also found to be positive for an illicit drug and/or an illegal BAC. The majority (87.9%) of the culpable individuals who likely had a mental health condition were fatally injured (n=29). By contrast, only three (4.9%) of the non-culpable road users had a suspected mental health condition. Two of these were negative for illicit drugs or BAC, and toxicology was unknown for the other.

Table 3.7
Comorbid illicit drug and alcohol use in culpable road users with mental health conditions in regional/remote South Australia, 2014-2015

Mental health condition/Illegal BAC/Illicit drugs	N	%
Mental health condition only	17*	51.5
Mental health condition & illegal BAC	3	9.1
Mental health condition & illicit drugs	6	18.2
Mental health condition, illegal BAC & illicit drugs	6**	18.2
Mental health condition – BAC and drug status unknown	1	3.0
Total	33	100.0

*Three of these individuals were not fatally injured
**One of these individuals was not fatally injured

3.3 Fatalities

3.3.1 Demographics

In the overall sample of 111 crashes, a total of 127 individuals were fatally injured, comprising 87 males (68.5%) and 40 females (31.5%). Overall, in 61.4% (n=78) of all fatal injuries, the deceased was deemed culpable for the crash (as delineated above). Drivers were the most likely to be fatally injured (56.7%, n=72; note that 66 of these drivers were also culpable), followed by other motor vehicle occupants (27.6%, n=35), motorcycle riders (8.7%, n=11, 8 were also culpable), pedestrians (3.9%, n=5, 2 were also culpable) and cyclists (3.2%, n=4, 2 were culpable).

The mean age of those who were fatally injured was 42.4 years (SD = 22.0, range 2-90 years). There were 15 children fatally injured under the age of 18 years. Around 4.7% of the fatally injured were reported to be Indigenous (n=6) with cultural identity not reported for 17.3% of fatal participants (n=22).

With respect to residency, the majority (63.8%) of those fatally injured lived in regional/remote South Australia (n=81), 22.1% lived in the Adelaide metropolitan area (n=28), 10.2% were from interstate (n=13) and 3.9% resided overseas (n=5).

3.3.2 Restraint use

The frequency of restraint use for fatally injured vehicle occupants is presented in Table 3.8 delineated by gender and age (riders and pedestrians excluded). There were 32.7% (n=35) of fatalities who were unrestrained at the time of the crash, despite restraints being available to them (except for one case in which the deceased was seated in the lap of a passenger). In four cases, there was insufficient information to determine restraint use for the fatally injured vehicle occupant. Males (36.6%, n=26) were more frequently unrestrained that females (25%, n=9). As depicted in Figure 3.8 those aged 25 to 34 years were the most frequently unrestrained, compared to all other age groups, with two thirds (66.7%, n=14) of fatalities unrestrained.

There were six children who were fatally injured, of whom two (aged 5 years and 15 years) were unrestrained, while one five year old was restrained by an adult seatbelt (contravening child restraint legislation that a 5 year old must be restrained in a child safety seat or booster seat). The three remaining fatally injured children (all aged two years) were restrained using appropriate forward-facing child restraints.

Of the 35 unrestrained fatally injured vehicle occupants, 62.9% (n=22) were drivers and 62.9% were ejected from the vehicle (including 4 partial ejections). The majority (68.6%) of unrestrained fatally injured vehicle occupants resided in regional/remote areas while 8.6% resided in the Adelaide metropolitan area, 14.3% resided interstate and 8.6% were from overseas.

Unrestrained fatalities were statistically significantly more likely than restrained fatalities to have an illegal BAC (34.3% vs 9.8%, χ^2=8.73, df=1, p=.003) and test positive for illicit drugs: THC, methamphetamines, or cocaine (34.3% vs 15%, χ^2=4.77, df=1, p=.029). There were five unrestrained fatalities who tested positive for both alcohol and drugs.

Table 3.8
Restraint use by age and gender for fatalities in regional/remote South Australia, 2014-2015

	Male			Female		
Age Group	Seatbelt	No Seatbelt	Unknown	Seatbelt	No Seatbelt	Unknown
0-15	4	2	0	4	0	0
16-24	11	4	0	4	1	0
25-34	5	9	0	2	5	0
35-44	5	2	0	3	1	0
45-54	5	4	0	2	1	0
55-64	4	3	1	3	0	1
65+	9	2	1	7	1	1
Total	43	26	2	25	9	2

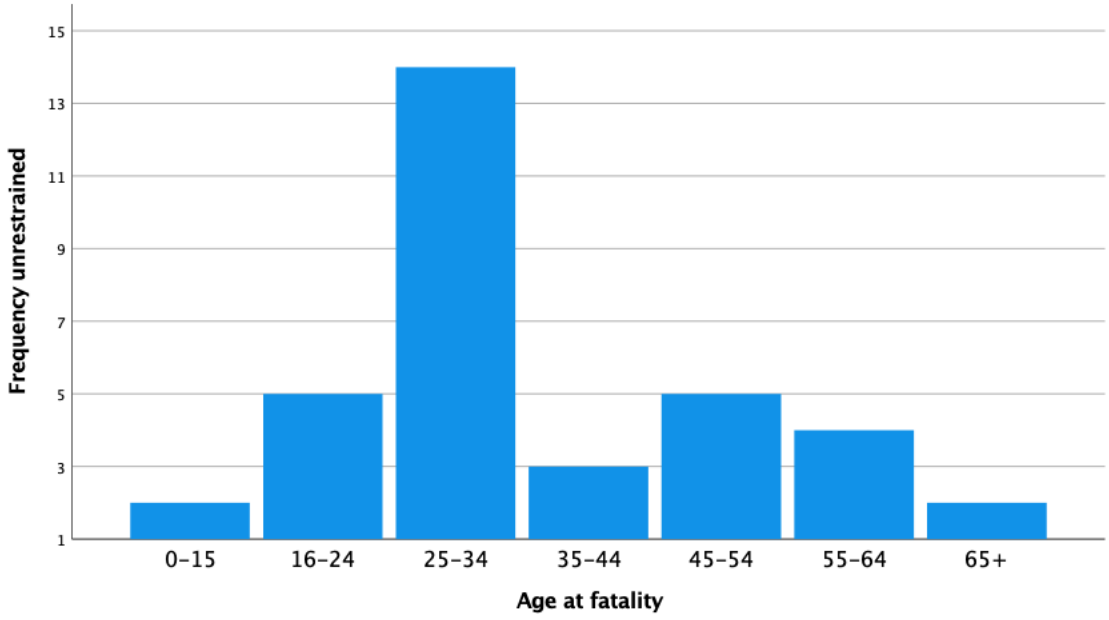

Figure 3.8
Unrestrained fatally injured vehicle occupants by age group in regional/remote South Australia, 2014-2015

A series of chi square test for independence were conducted to determine differences in restraint use for fatally injured vehicle occupants as a function of crash characteristics, with the results presented in Table 3.9. Statistically significant differences in restraint use were observed for location of crash (χ^2=5.27, p=.021), road surface (χ^2=5.60, df=1, p=.018) and rollover crash type (χ^2=13.83, df=1, p<.001) . While the greatest number of unrestrained fatalities were in regional areas, in remote areas fatalities were more likely to be unrestrained (54.5%) than restrained. On unsealed roads, a greater proportion of fatalities were unrestrained (58.8%) than restrained. Three quarters of unrestrained fatalities were involved in a rollover.

Table 3.9
Restraint use by crash characteristics for fatally injured vehicle occupants in regional/remote South Australia, 2014-2015

Crash characteristics	Unrestrained fatality		Restrained fatality	
	n=35	%	n=68	%
Location of crash*				
Regional	23	65.7	58	85.3
Remote	12	34.3	10	14.7
Speed zone				
100-110	32	91.4	58	85.3
60-90	3	8.6	10	14.7
Road surface*				
Bitumen	25	71.4	61	89.7
Unsealed	10	28.6	7	10.3
Rollover[a**]				
Yes	26	76.4	25	37.3
No	8	23.6	42	62.7

[a] 2 unknown
*p<.05, **p<.001

Table 3.10 shows the proportion of unrestrained fatalities for each vehicle type (percentages add up to 100% horizontally). The greatest number of unrestrained fatalities were in cars. However, examination of each vehicle type indicates that the proportion of unrestrained fatalities, compared to unrestrained fatalities, was highest in vans (66.7%) and in utilities (42.9%) and lowest in heavy vehicles (25%).

Table 3.10
Restraint use by vehicle type for fatally injured vehicle occupants in regional/remote South Australia, 2014-2015

Vehicle type	Unrestrained fatality		Restrained fatality		Total by vehicle type
	n=35	%	n=68	%	N=103
Car	18	32.1	38	67.9	56
Utility	6	42.9	8	57.1	14
Van	4	66.7	2	33.3	6
Heavy vehicle	4	25.0	12	75.0	16
4wd/SUV	3	27.3	8	72.7	11

3.3.3 BAC

There were 20.5% (n=26) of all fatally injured vehicle occupants who recorded a positive BAC, ranging from 0.014 to 0.299, in individuals aged 15 to 67 years. Of the positive BACs, 20 were greater than 0.05 (15.7% of fatalities). BAC levels were unknown for four fatally injured adults and five fatally injured children were not tested.

In addition to the culpable road users described in Section 3.2 above, there were only three more individuals with positive BACs (0.034; 0.180; and 0.211), who were deemed non-culpable (motor vehicle passengers) and who were fatally injured. The remaining BACs for fatally injured drivers were deemed the culpable drivers and are therefore presented in Figure 3.8 above.

3.3.4 Illicit drugs

For 20.5% (n=26) of those fatally injured (n=127), a positive illicit drug test was recorded, in individuals aged 19 to 56 years. The majority of these individuals (n=23) were also considered to have been deemed culpable for the crash and have therefore been discussed in the culpability section above. There were an additional three fatally injured individuals who were not culpable for the crash and who tested positive for illicit drugs. One of these had both an illegal BAC (0.211) and tested positive for THC; another had tested positive for illicit drug use (THC & Methamphetamine) with a zero BAC, and the third person had a zero BAC but tested positive for THC.

3.3.5 Mental health

For 28.3% (n=36) of those fatally injured (n=127) there was some indication that they were experiencing a mental health condition (report by self, General Practitioner, or a family member) and/or taking medication (i.e., psychotropic medication) that is typically prescribed for the management of a mental health condition. The majority of these individuals (n=29) were also considered to have been deemed culpable for the crash and have therefore been discussed in the culpability section above. There were an additional seven fatally injured individuals who were not culpable for the crash and met the aforementioned inclusion criteria for a mental health condition. One of these had both an illegal BAC (0.211) and was positive for THC; another was positive for illicit drugs (THC & methamphetamine) with a zero BAC, three were drug and BAC negative and one had unknown drug toxicology.

3.4 Vehicles

There were a total of 163 vehicles involved in the overall fatal regional/remote crash sample, with the most commonly involved vehicles being passenger vehicles, making up 73% (n=119) of the overall crash sample. Passenger vehicles included the following vehicle types: sedan, hatchback, 4WD, SUV, coupe, station wagon, utility and van. Prime movers comprised 10.4% (n=17) of the overall sample; motorcycles 8% (n=13); bicycles 2.5% (n=4); other trucks 5.5% (n=9) and tractors 0.6% (n=1). The four bicycles were excluded from the following vehicle age-related analyses, reducing the overall sample to 159.

The resulting 159 vehicles had a mean age of 11 years (SD=7.8). This was slightly lower than the average age of the South Australian motor vehicle fleet for 2014 and 2015 which was 11.3 years (ABS, 2015), as seen in Table 3.11. There were 27.7% (n= 44) of fatal crash involved vehicles aged over 15 years.

When considering only those vehicles in which the fatalities occurred (n=108), passenger vehicles made up 83.3% of the sample (n=90), motorcycles accounted for 10.2% (n=11), bicycles 3.7% (n=4), and heavy vehicles accounted for 2.8% (n= 1 light truck; n=1 rigid truck; n=1 prime mover). When excluding the four bicycles from the vehicle age-related analyses, of the resulting 104 vehicles in which the fatalities occurred, the overall sample had a mean age of 11.6 years (SD=8.1) which was slightly older than the average vehicle fleet. Around 30.8% (n=32) of vehicles involving fatalities were aged over 15 years.

Regarding vehicles in which the driver or rider was deemed culpable (n=103) the mean vehicle age (12.1 years, SD=7.7) was higher than all other vehicle samples in Table 3.11. In comparison, the mean age of non-culpable vehicles was 9.0 years (SD=7.7). An independent-samples t-test was conducted to compare the age of the vehicles for culpable and non-culpable vehicles. There was a statistically significantly difference, such that culpable vehicles were likely to be older than non-culpable vehicles ($t(157)=2.47$, $p=.015$). One third (33%, n=34) of vehicles driven by culpable drivers were aged over 15 years compared to 17.9% (n=10) of vehicles driven by non-culpable drivers.

Table 3.11
Average age of vehicle, standard deviation and range for selected vehicle samples, 2014-2015

Vehicle samples	Mean age	SD	Range	Total (N)
Vehicle fleet in SA	11.3	N/A	N/A	N/A
Regional/remote fatal crash involved vehicles	11.0	7.8	0-33	159
Regional/remote fatalities (vehicle)	11.6	8.1	0-32	104
Regional/remote culpable driver/rider vehicle	12.1	7.7	0-32	103
Regional/remote non-culpable driver/rider vehicles	9.0	7.7	0-33	56

3.5 Summary of the characteristics of regional/remote crashes

To better understand the context in which fatal crashes occur in regional/remote areas of South Australia, analysis of the 111 fatal crashes that occurred in 2014 and 2015 uncovered a number of characteristics associated with the crashes, the roads on which they occurred, the behaviour of the road users involved and the vehicles they were travelling in. Characteristics associated with road user culpability and factors associated with the fatality were also considered. The findings are summarised here.

Crashes

- Single vehicle crashes were the most common crash type (54%) followed by head on crashes (17%). Together, single vehicle and head on crashes accounted for a larger proportion of crashes in remote areas compared to regional areas (82.6% versus 68.2%).

Roads

- Crashes in regional/remote areas most frequently occurred on highways (37.8%). 15% of crashes were on unsealed roads.
- The majority of regional/remote crashes were on roads with unsealed shoulders (54.1%), roads that did have edge lining (69.4%), and on undivided roads (93.7%).
- Almost 80% of crashes occurred on high speed roads with a speed limit of 100 or 110 km/h.

Road users

- Crashes often involved more than one risky road user behaviour (41.4%).
- 30.6% of crashes involved a vehicle occupant not wearing an available seatbelt, increasing to 47.8% in remote areas.
- Speed, defined as either exceeding the speed limit or travelling at a speed deemed too high for the conditions, was identified in 23.4% of all crashes
- Around 5% of crashes involved an unlicensed driver, with this being more prevalent in remote areas (13%).
- Crashes involving an illegal BAC (19.8%) were more frequent in regional areas (21.6%) than remote areas (13.0%). Drug driving was involved in 22.5% of crashes, with THC the most common drug type.

Culpability

- Road users culpable for the fatal crash were more likely to live in regional/remote South Australia than non-culpable road users (62% vs 53%).
- Culpable drivers were more likely than non-culpable drivers to be drivers of passenger vehicles and less likely to be drivers of heavy vehicles.
- 18.7% of culpable road users had an illegal BAC (over 0.05) and 23.4% of culpable road users were positive for an illicit drug, with THC being the most common drug type.
- For 30.8% of the culpable road users, there was some indication that they were experiencing a mental health condition and 45.5% of these were also positive for an illicit drug or an illegal BAC.

Fatalities

- Fatally injured vehicle occupants in regional/remote areas (n=127) were predominantly male (69%), 11.8% were children, 4.7% were known to be Indigenous and 63.8% lived in regional/remote areas.
- Almost a third (32.7%) of fatalities were unrestrained. Males and vehicle occupants aged 25-34 years were most likely to be unrestrained.
- Unrestrained fatalities were more likely than restrained fatalities to crash in remote areas, on unsealed roads, involve a rollover, be positive for illicit drugs and have a positive BAC.

- There were 20.5% of fatalities who tested positive for an illicit drug and 15.7% of fatalities who recorded an illegal BAC.
- For 28.3% of fatalities there was some indication that they were experiencing a mental health condition.

Vehicles

- Around 31% of vehicles involving a fatality were aged over 15 years.
- Vehicles driven by culpable drivers in a fatal crash were more likely to be older than vehicles driven by non-culpable drivers.

3.6 Contributing factors

Common factors identified as *contributing* to the regional/remote crash or injury severity are listed in Table 3.12 (for the complete list, see Appendix C). Multiple factors could be attributed to each crash and so the total number of factors (N=248) exceeds the number of crashes (N=111). Overall, the analysis indicated that the greatest contributing factor was restraint non-use; in 24.3% of crashes a lack of restraint use contributed to the fatal injuries. There were six additional crashes in which a vehicle occupant was not wearing a seatbelt but the severity of the impact was so great that the use of a seatbelt would not have made a difference to the injury severity. Consequently, these crashes were not counted in Table 3.12 as the lack of restraint use did not contribute to the injury outcome. Lack of restraint use contributed to a much greater proportion of injury severity in crashes in remote areas (39.1%) in comparison to regional areas (20.5%).

Drugs and alcohol contributed to 22.5% and 19.8% of regional/remote crashes, respectively. While drug driving contributed to a similar proportion of crashes in both regional and remote areas, drink driving contributed to more crashes in regional than in remote areas (21.6% vs 13%).

Fatigue was identified as a contributing factor in 16.2% of regional/remote crashes. Distraction, a subtype of inattention, defined as the driver's attention being diverted away from activities critical for safe driving toward a competing activity (i.e. cognitive, physical, visual, or auditory distraction), was identified as a contributing factor in 14.4% of crashes. In addition, 4.5% of crashes had a form of inattention, defined as insufficient attention to activities critical to safe driving (i.e. competing demands for attention or attention unspecified) as a contributing factor (see Appendix C). Therefore, in 18.9% of crashes, inattention was a contributing factor, with similar proportions in regional (19.3%) and remote (17.3%) areas.

Speed was a contributing factor in 23.4% of crashes: in 13.5% of crashes the vehicle travelling speed exceeded the speed limit, and in 9.9% of crashes the travel speed was too high for the conditions (e.g. unsealed road n=8, curve n=8, weather n=2 with some being multiple factors). Of interest, while the overall proportion of speed related crashes in regional (22.7%) and in remote areas was similar (25%), exceeding the speed limit was more prevalent in regional areas while speed too high for conditions was more prevalent in remote areas. Overall, crashes in which speed was a contributing factor predominantly involved a single vehicle (73.1%, n=19) and were most likely to occur on roads with a 100km/h speed limit (65.6%, n=17). However, vehicle speed was not known for all vehicles; of the 163 vehicles involved in a fatal crash, in 43 cases (26.4%) the vehicle speed was unknown.

Loss of control (typically single vehicle crashes) and fail to keep left (typically head on crashes) were identified as contributing factors in 17.1% and 13.5% of crashes respectively. In these crashes, the reason for the loss of control or deviation from the traffic lane could not be substantiated from the available evidence. It is likely that in some cases, a contributing factor may have been fatigue,

distraction or a medical issue but there was no clear evidence or witnesses to confirm. Consequently, there would be more crashes that involved loss of control or a failure to keep left but in this instance they reflect this type of crash where the reason as to why this happened could not be determined (i.e. reason unknown). Fail to keep left crashes were more prevalent in regional areas (14.8%) than in remote areas (8.7%).

While cabin intrusion is not a factor that contributes to a crash occurring, it was a significant factor in contributing to the fatal injury in 10.8% of crashes. All of these crashes occurred on high speed roads (100/110km/h) and involved high velocity impacts. In these crashes, the cabin intrusion was caused by impact with trees (n=2), vehicles (truck n=2, utility=2, van=1), rollover (n=1) and a combination of a rollover and impact with trees (n=4).

Table 3.12
Factors contributing to fatal crashes in regional/remote South Australia, 2014-2015

	Regional		Remote		Total	
Contributing factor	N=88	%	N=23	%	N=111	%
Restraint use	18	20.5	9	39.1	27	24.3
Drugs	20	22.7	5	21.7	25	22.5
Alcohol	19	21.6	3	13.0	22	19.8
Loss of control (reason unknown)	15	17.0	4	17.4	19	17.1
Fatigue	14	15.9	4	17.4	18	16.2
Distraction	13	14.8	3	13.0	16	14.4
Fail to keep left (reason unknown)	13	14.8	2	8.7	15	13.5
Speed exceeds limit	14	15.9	1	4.3	15	13.5
Cabin intrusion	10	11.4	2	8.7	12	10.8
Speed too high for conditions	6	6.8	5	21.7	11	9.9
Fail to give way	9	10.2	0	0.0	9	8.1
Inexperience	4	4.5	2	8.7	6	5.4
Medical condition	5	5.7	1	4.3	6	5.4
Unlicensed/disqualified driver	3	3.4	3	13.0	6	5.4
Visibility	5	5.7	1	4.3	6	5.4
Fail to check for traffic	3	3.4	2	8.7	5	4.5
Road surface	3	3.4	2	8.7	5	4.5
Unsealed road	2	2.3	3	13.0	5	4.5
Overcrowded vehicle	1	1.1	3	13.0	4	3.6
Inexperience with vehicle	2	2.3	2	8.7	4	3.6
Old vehicle	3	3.4	1	4.3	4	3.6
Unsafe overtaking	4	4.5	0	0.0	4	3.6
Unsealed shoulder	3	3.4	1	4.3	4	3.6

3.7 Interventions

Interventions that could either prevent a fatal crash or reduce the injury severity, the associated safe system pillars, and the organisation responsible for implementing such an intervention are presented in Table 3.13 for the top 20 interventions (see Appendix D for a complete list). Multiple interventions could be applied to each crash and so the total number (N=561) exceeds the number of crashes (N=111). Note also that each intervention should be considered separately as adding multiple interventions may result in a crash being counted twice.

Of all the interventions, barriers on the side of the road could have prevented or mitigated 42.3% of regional/remote crashes, lane keep assist (LKA) 37.8%, centre barriers 36% and electronic stability control (ESC) 31.5%. These top four interventions are most effective for preventing single vehicle crashes (e.g. loss of control, run off road) and head on crashes. The vehicle-based interventions are measures designed to keep the vehicle from deviating out of the traffic lane (i.e. LKA) or maintain control of the vehicle to keep it on the road (i.e. ESC) while the road-based measures prevent the vehicle from either striking roadside hazards or other vehicles.

Interventions to increase seat belt use (e.g. seat belt interlocks and enforcement) could have prevented or mitigated around 25.2% of regional/remote crashes.

Speed limit reductions were identified as an intervention for 23.4% (n=26) of regional/remote crashes. In 23 of these crashes, the speed limit was 100 or 110km/h and in nine crashes the road was unsealed.

Other interventions within the top ten include autonomous emergency braking (21.6%), lane departure warning (19.8%) and enforcement of drug driving (20.7%) and drink driving (18.9%). Half of the top ten interventions were vehicle based.

Table 3.13
Interventions for fatal crashes in regional/remote South Australia, 2014-2015

Safe System	Intervention	Responsibility	Number (N=111)	% of crashes
Road	Side barrier	Road authority	47	42.3
Vehicle	Lane keep assist	Vehicle manufacturers	42	37.8
Road	Centre barrier	Road authority	40	36.0
Vehicle	Electronic stability control	Vehicle manufacturers	35	31.5
Vehicle	Seatbelt interlock	Vehicle manufacturers	28	25.2
Road user	Apprehension for seatbelt offence	Police	28	25.2
Speed	Speed limit reduction	Road authority	26	23.4
Vehicle	Autonomous emergency braking	Vehicle manufacturers	24	21.6
Road user	Apprehension for drug driving offence	Police	23	20.7
Vehicle	Lane departure warning	Vehicle manufacturers	22	19.8
Road user	Apprehension for drink driving offence	Police	21	18.9
Vehicle	Alcohol interlock in all vehicles	Vehicle manufacturers	20	18.0
Road	Audio tactile centre lines	Road authority	19	17.1
Vehicle	Collision warning	Vehicle manufacturers	19	17.1
Vehicle	Drowsiness detection/warning	Vehicle manufacturers	18	16.2
Road	Sealed shoulders	Road authority	18	16.2
Vehicle	Rollover structural integrity	Vehicle manufacturers	17	15.3
Road	Audio tactile edge line	Road authority	14	12.6
Vehicle	Frontal impact intrusion protection	Vehicle manufacturers	13	11.7
Speed	Apprehension for speed offence	Police	13	11.7
Road user	Alternative transport options	Road authority /driver	12	10.8
Vehicle	Intelligent speed adaption - limiting	Vehicle manufacturers	12	10.8
Vehicle	Side airbag	Vehicle manufacturers	11	9.9
Vehicle	Curtain airbag	Vehicle manufacturers	10	9.0
Road user	Drug use treatment program	Health	10	9.0
Road user	Mental health treatment	Health	10	9.0
Road	Seal road	Road authority	9	8.1

Interventions for fatal crashes in regional areas only is shown in Table 3.14 and for remote areas only in Table 3.15 (for complete lists see Tables D2-3 in Appendix D). The first ten interventions to prevent or mitigate regional crashes are similar to those listed in Table 3.13 above, although in a slightly different order with the addition of collision warning, alcohol interlocks, audio tactile centre lines and drowsiness detection/warning. However, in remote areas the three interventions that could prevent or mitigate the most crashes and injuries were seat belt interlocks, seat belt enforcement and electronic stability control (43.5%). This reflects seat belt non-use in fatal crashes being much higher in remote (47.8%) than in regional areas (26.1%) (see Table 3.4). Other interventions that featured more prominently in remote areas were rollover structural integrity (26.1%) (to counteract cabin intrusion during a rollover), sealing of roads (26.1%) and sealing of shoulders (21.7%).

Table 3.14
Interventions for fatal crashes in regional South Australia, 2014-2015

Safe System	Intervention	Responsibility	Number (n=88)	% of crashes
Road	Side barrier	Road authority	38	43.2
Vehicle	Lane keep assist	Vehicle manufacturers	36	40.9
Road	Centre barrier	Road authority	36	40.9
Vehicle	Electronic stability control	Vehicle manufacturers	25	28.4
Vehicle	Autonomous emergency braking	Vehicle manufacturers	22	25.0
Speed	Speed limit reduction	Road authority	20	22.7
Road user	Apprehension for drug driving offence	Police	19	21.6
Road user	Apprehension for seatbelt offence	Police	18	20.5
Vehicle	Lane departure warning	Vehicle manufacturers	18	20.5
Vehicle	Seatbelt interlock	Vehicle manufacturers	18	20.5
Road user	Apprehension for drink driving offence	Police	18	20.5
Vehicle	Collision warning	Vehicle manufacturers	17	19.3
Vehicle	Alcohol interlock in all vehicles	Vehicle manufacturers	17	19.3
Road	Audio tactile centre lines	Road authority	15	17.0
Vehicle	Drowsiness detection/warning	Vehicle manufacturers	14	15.9

Table 3.15
Interventions for fatal crashes in remote South Australia, 2014-2015

Safe System	Intervention	Responsibility	Number (n=23)	% of crashes
Vehicle	Seatbelt interlock	Vehicle manufacturers	10	43.5
Road user	Apprehension for seatbelt offence	Police	10	43.5
Vehicle	Electronic stability control	Vehicle manufacturers	10	43.5
Road	Side barrier	Road authority	9	39.1
Vehicle	Lane keep assist	Vehicle manufacturers	6	26.1
Speed	Speed limit reduction	Road authority	6	26.1
Road	Seal road	Road authority	6	26.1
Vehicle	Rollover structural integrity	Vehicle manufacturers	6	26.1
Road	Sealed shoulders	Road authority	5	21.7
Vehicle	Automatic crash notification	Vehicle manufacturers	4	17.4
Road	Audio tactile centre lines	Road authority	4	17.4
Vehicle	Drowsiness detection / warning	Vehicle manufacturers	4	17.4
Road user	Apprehension for drug driving offence	Police	4	17.4
Road	Centre barrier	Road authority	4	17.4
Vehicle	Lane departure warning	Vehicle manufacturers	4	17.4

Safe system pillars

When considering the Safe System approach and the four pillars of the Safe System:

- road-based interventions could have prevented or mitigated 94.6% of regional/remote crashes (n=105)
- vehicle-related interventions could have prevented or mitigated 93.7% of regional/remote crashes (n=104)
- road user-based interventions could have prevented or mitigated 65.8% of regional/remote crashes (n=73)
- speed-related interventions could have prevented or mitigated 36.9% of regional/remote crashes (n=41).

Responsibility

For the interventions identified as preventing or mitigating the fatal crashes or injury severity in regional/remote areas, a number of organisations, agencies or individuals share responsibility for implementing such interventions and improving road safety on regional/remote roads.

- The road transport authority could implement infrastructure programs and interventions that prevent or mitigate 93.7% of regional/remote crashes (n=104)
- Vehicle manufacturers could implement technology that prevent or mitigate 92.8% of regional/remote crashes (n=103)
- Police enforcement could prevent or mitigate 45.9% of regional/remote crashes (n=51)
- Health interventions or programs could prevent or mitigate 18.9% of regional/remote crashes (n=21)
- Driver/rider (n=33) and pedestrian (n=2) actions could prevent or mitigate 31.5% of regional/remote crashes
- Employer programs could prevent or mitigate 0.9% of regional/remote crashes (n=1).

4 Discussion

This study used a holistic Safe System-based approach to investigate the potential of different types of interventions to prevent fatal crashes or mitigate the injury severity in regional/remote areas. The findings provide those responsible for designing, managing and monitoring the road system (such as road authorities, vehicle manufacturers and police) with evidence-based guidance for establishing future priorities in order to more effectively prevent fatal crashes in regional/remote areas.

4.1 Gaps in the regional/remote system: contributing factors

Within this sample of 111 fatal crashes in regional/remote South Australia, a number of gaps in the wider transport system were identified. These gaps or factors identified as contributing to regional/remote crashes or injury severity were numerous and varied but the most common factors centred around risky driving behaviours, including lack of restraint use, drug use, alcohol use and speeding. This finding, while uniquely specific to regional/remote areas, was consistent with other recent studies from Australia and New Zealand where road user non-compliance was found to be a greater contributor to fatal and injury crashes than vehicle or road factors (Baldock, Unpublished; Mackie et al., 2017). While many gaps in the regional/remote system were identified in this study (see Table 3.12), the most significant gaps or greatest contributing factors are discussed here.

Failure to wear restraints is one of the most significant factors in regional/remote fatal crashes. As mentioned above, 33% of fatalities were unrestrained and a lack of restraint use contributed to 24.3% of the fatal injuries sustained in crashes (in a small number of cases the crash was so severe that wearing a seat belt would not have prevented the fatal injuries). Lack of restraint use was more evident in fatalities in remote areas (54.5% unrestrained) than in regional areas (28.4%). Of concern, the rates for unrestrained fatalities in South Australia are higher than those reported for the respective areas Australia wide (35% unrestrained in remote areas, 16% in regional areas in 2016) and much higher than major cities in Australia (8% unrestrained) (Wundersitz et al., 2019). Non-restraint use for fatalities was associated with males, people aged 25-34 years, an illegal BAC, positive for an illicit drug, rollover crash type and unsealed roads, consistent with previous research (Austroads, 2009).

Drugs and alcohol contributed to 22.5% and 19.8% of regional/remote crashes, respectively. Other research has confirmed that drug driving is now more prevalent than drink driving in injury crashes in South Australia (Baldock & Lindsay, 2020). The study found 15.2% of drivers/riders hospitalised following a crash were positive for at least one proscribed drug compared to 9.3% of drivers/riders who had a BAC above the legal limit of 0.05. A recent study by the Australian Institute of Health and Welfare (AIHW, 2019a) reported alcohol consumption is significantly higher in regional and remote areas of Australia compared to major cities and people living in regional and remote areas are more likely to drink frequently or at harmful levels. Alcohol consumption per capita and alcohol-related harms increased with remoteness. Levels of drug use are similar between regional/remote areas and major cities but the type of drug use varies. The most recent wastewater analysis indicates that cannabis use is more prevalent in regional South Australia than the Adelaide metropolitan area and while methylamphetamines are also very prevalent in regional areas, they are higher in the metropolitan area (Australian Criminal Intelligence Commission, 2020). Factors contributing to alcohol and drug use and dependency in regional/remote areas include the social acceptability of alcohol and its role in social events, social isolation, rates of youth unemployment and lower educational attainment (AIHW, 2019a; Allan, Clifford, Ball, Alston & Meister, 2012). People in regional/remote areas also have further to travel to access treatment for substance dependency.

Seminal research has shown that there is a greater than exponential increase in the risk of a casualty crash for vehicles travelling above the mean traffic speed on regional and remote roads with a speed

limit of 80 km/h or more (Kloeden et al., 2001). Speed was a contributing factor in 23.4% of fatal crashes with the majority of these crashes involving a single vehicle (run off road) and on roads with a speed limit of 100km/h. In this study, speeding referred to exceeding the speed limit and travelling too fast for the conditions. Even with this wider definition, the prevalence of speed in crashes may be underestimated. To determine vehicle speed, police used evidence to reconstruct the crash, airbag module data, witness estimates and examined the extent of the vehicle damage. However, in 26% of cases, there was limited or no evidence to estimate vehicle speed.

Overall, 19% of regional/remote fatal crashes were attributed to driver inattention. In comparison, a recent study examining the prevalence of inattention and driver distraction in a sample of fatal and injury crashes in South Australia from 2014 to 2018, using CASR's in-depth crash investigation data, reported 31% of crashes involved driver inattention (Wundersitz, 2019). However, the study found inattention crashes were more prevalent in metropolitan areas, occurred more frequently at intersections and on roads with a speed limit of 60 km/h or lower, which likely explains the smaller proportion found in this current study which only examined regional/remote crashes. Distraction, a subtype of inattention (defined as the driver's attention being diverted away from activities critical for safe driving toward a competing activity) was identified as a contributing factor in 14.4% of regional/remote fatal crashes, a similar proportion to that found for the study examining fatal and injury crashes (13.8%, Wundersitz, 2019).

Fatigue is known to be a source of driver impairment despite problems in defining the construct and objectively measuring and quantifying the incidence among crash-involved drivers (Palamara, 2016). Estimates for the involvement of fatigue in crashes within Australian jurisdictions vary from 9% to 17% and are most likely influenced by how fatigue is measured in each jurisdiction (Wundersitz et al, 2019). In the absence of a measure of fatigue, some jurisdictions, including South Australia, use a proxy measure or criteria to determine fatigue crashes. Consistent with the upper end of this range, fatigue was found to be a contributing factor in 16.2% of regional/remote crashes, and this is likely to be an underestimate as it only included crashes in which there was evidence that fatigue was a contributing factor. There are suggestions in the research literature that fatigue is more prevalent in rural areas. For example, in Western Australia, fatal and serious injury crashes from 2009 to 2013 occurring in regional areas were 1.86 times more likely than crashes in metropolitan areas to be fatigue-related, as deemed by police (Palamara, 2016).

Also noteworthy, is that single vehicle crashes and, to a lesser extent, head on crashes, are a significant issue in regional/remote areas, regardless of the reason for lane/road departure. Loss of control (typically single vehicle crashes) and fail to keep left (typically head on crashes) were identified as contributing factors in 17.1% and 13.5% of crashes respectively although, as discussed in section 3.5, this is an underestimate of the true number. For fatalities (see section 3.3.1), the most common crash type was single vehicle (49%) (equivalent to run-off road) followed by head on (21%). The prevalence is slightly lower than that reported for regional/remote areas in Australia (53% and 26%, respectively; Wundersitz et al., 2019). Nevertheless, the incidence is much higher than in major cities (28% single vehicle, 11% head on) indicating that this is a significant issue to address on regional/remote roads.

Mental health

Mental health issues were over-represented in the sample of culpable road users, with 30.8% of culpable drivers having at least one indicator to suggest that at the time of the crash they were experiencing a mental health condition, or undergoing difficulties in their emotional functioning. Notably this is higher than the 18.3% prevalence of mental illness in the general South Australian population documented from 2014 to 2015 for individuals aged between 16 and 85 years (ABS,

2018b). By contrast, only 4.9% of non-culpable road users involved in fatal crashes had a suspected mental health condition. Moreover, in this crash sample, mental health indicators were comorbid (or co-occurring) with drug or alcohol use, such that 45.5% of culpable road users with mental health indicators were also found to be positive for an illicit drug and or had an illegal BAC. For fatally injured vehicle occupants, in 28.3% there was an indication that they were experiencing a mental health condition. It is acknowledged that the current findings are possibly an underrepresentation of the true prevalence of mental health conditions in this sample, given that background information regarding mental health for fatally injured individuals was often not investigated nor reported on, unless there was an indication of suicide. None of these cases, however, were related to suicide. While the current investigation was unable to confidently attribute mental health conditions as a causal factor in fatal road crashes (and a conservative estimate has therefore been made), it was estimated that in 9% of the fatal crashes mental health conditions were a contributing factor.

4.2 Potential interventions for regional/remote crashes

While risky driving behaviours are clearly large contributors to fatal crashes in regional/remote areas, the findings from this study have indicated that it is road and vehicle-based interventions that have the greatest potential to prevent or mitigate these crashes and injuries (94.6%, 93.7%, respectively). This is a significant finding that should underpin road safety strategies aimed at eliminating harm on regional/remote roads in South Australia and nationally. This finding is also consistent with research examining interventions for injury crashes in South Australia through in-depth crash investigation (Doecke, Thompson & Stokes, 2020).

Interestingly, in all crashes at least one intervention could have prevented the crash or mitigated the injuries. While this finding is positive, it does not mean that the nominated interventions are all cost effective or easy to implement, as these factors were not considered in the process. Overall, the interventions with the most potential for preventing or mitigating fatal regional/remote crashes and related injuries were: road infrastructure- (i.e. side and centre barriers, ATLM) and vehicle technology-based measures (i.e. LKA, ESC, AEB) for crash types in which the vehicle departs the lane or the road; interventions aimed at ensuring restraint use compliance; speed limit reductions; and enforcement to deter drug and drink driving.

A list of all countermeasures and their potential effectiveness in preventing/mitigating crashes was presented in section 3.7. The interventions are organised and discussed here according to the Safe System pillars (rather than by contributing factors), as many interventions are effective for addressing multiple crash types or risky behaviours. While organised under separate pillars, it is acknowledged that each pillar represents part of a holistic system and should not be viewed in isolation. Importantly, all parts of the system work together, and together they can multiply their effect in reducing harm on regional/remote roads. Furthermore, there are a number of organisations and agencies that can make a significant impact by implementing and managing these countermeasures and therefore creating a safer system which will improve road safety in South Australia.

4.2.1 Road

Road-based countermeasures could have prevented or mitigated 94.6% of regional/remote fatal crashes. The most prevalent crash types were single vehicles departing their lane (71%), either crossing the centre line, or running off the left side of the road resulting in either head-on collisions or, more commonly, loss of control leading to rollovers or collisions with roadside hazards. Crashes involving road departures may be due to a number of factors including driver fatigue, distraction or impairment (alcohol, drugs). The top five road-related countermeasures are all potentially effective for preventing these types of crashes (see Table 4.1). Importantly, flexible roadside barriers, known to be

more beneficial in preventing run off road crashes than the traditional clear zone approach (Woolley, Stokes, Turner & Jurewicz, 2018), could have potentially prevented or mitigated the outcomes of 42% of all regional/remote crashes. The significant potential benefits of centre barriers for preventing road departures to the right and head-on collisions were also demonstrated by the findings. While not as effective as barriers, audible tactile centre and edge lines also offer a relatively cost effective means to alert drivers when they deviate from their lane, and sealed shoulders can mitigate or prevent run off road crashes. An evaluation of the Rural run-off-road crash program in Western Australia, including shoulder sealing/widening and the application of audible tactile edge lines, found that the program (covering 984km of rural roads) contributed to a 35.5% reduction in run-off-road crashes with a benefit cost ratio of 2:1 at treatment sites (Chow, Meuleners & Wong, 2016).

Table 4.1
Road-based interventions for fatal crashes in regional/remote South Australia, 2014-2015

Intervention	Responsibility	Number (N=111)	% of crashes
Side barrier	Road authority	47	42.3
Centre barrier	Road authority	40	36.0
Audio tactile centre lines	Road authority	19	17.1
Sealed shoulders	Road authority	18	16.2
Audio tactile edge line	Road authority	14	12.6
Seal road	Road authority	9	8.1
Active warning sign	Road authority	6	5.4
Roundabout	Road authority	6	5.4
Grade separated junction	Road authority	5	4.5
Improved sight distance	Road authority	5	4.5
Road maintenance	Road authority	5	4.5
Vertical deflection	Road authority	5	4.5
Warning signs	Road authority	4	3.6
Give way sign	Road authority	3	2.7
Improved geometry of junction	Road authority	3	2.7
Motorcycle protection on barrier	Road authority	3	2.7
Separated road	Road authority	3	2.7
Stop sign	Road authority	3	2.7
Street lighting	Road authority	3	2.7
Traffic lights	Road authority	3	2.7
Improved road marking	Road authority	2	1.8
Overtaking lane	Road authority	2	1.8
Prevent right turn	Road authority	2	1.8
Acceleration lane	Road authority	1	0.9
Bicycle lane	Road authority	1	0.9
Centre line	Road authority	1	0.9
Controlled right turn (signalised intersection)	Road authority	1	0.9
Improved channelisation	Road authority	1	0.9
Pedestrian fencing	Road authority	1	0.9
Pedestrian signals	Road authority	1	0.9
Rest area	Road authority	1	0.9
Right turn lane	Road authority	1	0.9
Roadside fencing	Road authority	1	0.9
Solid centre line (overtaking prohibited)	Road authority	1	0.9
Wide centre median	Road authority	1	0.9

Despite the clear benefits associated with road infrastructure-based countermeasures, these treatments require significant investment and the regional/remote road network is extensive, with low traffic volumes and low quality roads. A network safety plan should be used to allocate treatments and resources on high risk corridors to create a safe road system (Aumann et al., 2020).

4.2.2 Vehicle

The current study indicated that vehicle-related interventions could have prevented or mitigated 93.7% of regional/remote crashes. In addition, 31% of vehicles in which a fatality occurred were aged over 15 years old. Newer, safer vehicles provide a higher level of occupant protection to reduce injury severity in crashes and are also more likely to feature advanced safety technologies that can mitigate crash types that commonly occur on regional/remote roads. However, promoting safer vehicles in regional/remote areas has some challenges including higher levels of social disadvantage (ABS, 2018c) and the preference for 'fit for purpose' vehicles such as utilities which have lower levels of occupant protection (compared to passenger vehicles) (Budd & Newstead, 2019). Innovative policies and incentives are needed to accelerate the uptake of safer new and used vehicles with proven safety technologies into the driving fleet. For example, the Western Australian Road Safety Commission is conducting a feasibility study on how best to use expired government fleet vehicles to improve the safety of vehicles in regional/remote areas (Wundersitz et al., 2019).

As seen in Table 4.2, lane keep assist (LKA) was the leading vehicle technology estimated to prevent or mitigate 38% of fatal crashes on regional/remote roads with lane departure warning (LDW) preventing or mitigating 20% of crashes. These technologies have the greatest potential to prevent single vehicle (run off road) and head on crash types, including those that may be attributable to driver distraction and impairment (fatigue, alcohol, drugs). LDW alerts drivers that they are departing the driving lane without having indicated their intention to do so, while LKA goes a step further by automatically taking corrective action to steer the vehicle back into the lane if the driver has not taken action. The successful operation of both systems is dependent on the accurate detection of road lane markings which may not always be present on regional/remote roads and are absent on unsealed roads. Recent research in Western Australia exploring the suitability of lane markings on remote roads for lane departure warning systems found they were, for the most part, sufficient on the roads tested, although there were some issues with 'pseudo lines' (black painted lines over previous lane markings) (Elsegood, Mackenzie, Dutschke & Mongiardini, 2019).

Electronic stability control (ESC) has the potential to prevent or mitigate almost a third of regional/remote crashes (up to 44% in remote areas), particularly crash types in which the vehicle deviates from its intended path through loss of control (i.e. single vehicle). ESC detects when a vehicle is losing traction or stability and applies automatic braking to individual wheels of the vehicle to assist it in returning to the intended direction of travel. In 2011, an Australian Design Rule requiring all new passenger vehicles to fit ESC was introduced. However, given that the average age of a vehicle in the South Australian is 11.3 years (ABS, 2015), it will be some time before ESC is prevalent in the vehicle fleet and the full impact of its beneficial effects will be recognised.

Seat belt interlocks, designed to prevent the vehicle from starting unless the seat belt is fastened, could have reduced the injury severity in 25% of regional/remote fatal crashes. Researchers advocate that they can be a very effective means to increase seat belt use but some research from the United States suggests that they are not well accepted by drivers (Sivak, et al., 2007). Seat belt interlocks are not currently available in passenger vehicles (although the technology exists) but are offered in other contexts such as the workplace with forklift operation (RTC, 2020). A study from the United States on

seat belt interlocks that prevent the vehicle being put into gear unless the seat belt is worn found that the interlock significantly increased the likelihood of using a seat belt in part-time seat belt users by 21%, increasing the overall rate of seat belt use by 16% (Kidd, Singer, Huey & Kerfoot, 2018).

Autonomous emergency braking (AEB) utilises forward facing sensors to measure the distance and speed of objects in front of a vehicle. It can determine the risk of an imminent collision before automatically reducing vehicle speed and applying brakes to avoid or reduce the severity of the impact. In the regional/remote area context, high speed AEB systems can utilise long range radar to detect vehicles/objects up to 200 metres ahead. AEB has the potential to mitigate frontal (pedestrian, cyclist) and rear end crashes (striking vehicle) with the research literature indicating potential crash reductions of 27% to 50% for these crash types (e.g. Fildes et al., 2015; Haus, Sherony & Gabler, 2019) but potentially less for other crash types such as head on, right turn and right angle (7-17%) (Anderson et al., 2012; 2013). In this study AEB was estimated to prevent or mitigate 22% of the fatal crashes in regional/remote areas (note that there is no evidence, of which we are aware, that current AEB systems can detect objects such as trees).

Intelligent speed adaption (ISA) uses systems that can either recognise and interpret speed limit signs or rely on spatial databases of speed zones. Advisory ISA can sound a warning when the speed limit is exceeded while limiting ISA intervenes with the vehicle so that it cannot be driven at a speed higher than the speed limit. Questions have been raised with respect to the use of ISA in regional/remote areas where the appropriate speed may be influenced by road and weather conditions rather than the posted speed (Wundersitz et al., 2019). Regardless of this possible limitation, this study indicated ISA (limiting mode) could potentially prevent or mitigate 11% of speed-related fatal crashes in regional/remote areas.

An alcohol interlock is a device that can be retrofitted to a vehicle and prevents the engine from starting until the driver has provided a breath test result below a set threshold. Devices are usually fitted to vehicles of drivers who have been caught drink driving, often as a re-licensing requirement. Participation in such alcohol interlock schemes has been effective in reducing recidivism, at least while the interlock is installed in the vehicle (e.g. Bailey, Lindsay & Royals, 2013; Elder et al., 2011). Vehicle manufacturers could either include alcohol interlocks in all new vehicles or provide sockets/plugs in all new vehicles for the easy and less costly installation of alcohol interlocks. Such a measure could potentially prevent 18% of regional/remote alcohol related fatal crashes.

A recent review of drowsiness detection measures for commercial vehicles, such as the monitoring of eye movements or other driver performance affected by driver fatigue (i.e. steering wheel variability, lateral lane variability), reported that there were no independent scientific evaluations of manufacturer developed systems for detecting drowsiness (Sparrow, LaJambe & Van Dongen, 2019). Nevertheless, effective (and validated) drowsiness detection systems could potentially prevent or mitigate 16% of regional/remote crashes.

The importance of vehicle occupant protection is evident in the finding that greater structural integrity of the occupant compartment with respect to rollovers and frontal impacts could have mitigated the injury severity of 15% and 12% of crashes, respectively. Preventing deformation of the occupant compartment not only protects the occupant from injuries sustained when striking the interior of the vehicle or being crushed, but also ensures that the effectiveness of other passive safety features (e.g. airbags, seat belts) are not compromised.

The time taken for emergency services to be notified of a crash can be a significant issue in remote areas, often due to the crash not being discovered (Ponte, Ryan & Anderson, 2016). In five crashes automatic crash notification technology in vehicles, which can potentially reduce delays in discovery of the crash and notification, may have prevented the fatal injury outcome of the crash.

Table 4.2
Vehicle-based interventions for fatal crashes in regional/remote South Australia, 2014-2015

Intervention	Responsibility	Number (N=111)	% of crashes
Lane keep assist	Vehicle manufacturers	42	37.8
Electronic stability control	Vehicle manufacturers	35	31.5
Seatbelt interlock	Vehicle manufacturers	28	25.2
Autonomous emergency braking	Vehicle manufacturers	24	21.6
Lane departure warning	Vehicle manufacturers	22	19.8
Alcohol interlock in all vehicles	Vehicle manufacturers	20	18.0
Collision warning	Vehicle manufacturers	19	17.1
Drowsiness detection/warning	Vehicle manufacturers	18	16.2
Rollover structural integrity	Vehicle manufacturers	17	15.3
Frontal impact intrusion protection	Vehicle manufacturers	13	11.7
Intelligent speed adaptation - limiting	Vehicle manufacturers	12	10.8
Side airbag	Vehicle manufacturers	11	9.9
Curtain airbag	Vehicle manufacturers	10	9.0
Side intrusion protection	Vehicle manufacturers	7	6.3
Top speed limiter	Vehicle manufacturers	7	6.3
Automatic crash notification	Vehicle manufacturers	5	4.5
Driver airbag	Vehicle manufacturers	5	4.5
Curve speed warning	Vehicle manufacturers	4	3.6
More tread depth on tyres	Driver	4	3.6
Anti-locking brake system	Vehicle manufacturers	3	2.7
Vehicle maintenance	Driver	3	2.7
Correctly maintained brake system	Driver	2	1.8
Passenger airbag	Vehicle manufacturers	2	1.8
Reversing camera/sensors	Vehicle manufacturers	2	1.8
Adaptive cruise control	Vehicle manufacturers	1	0.9
Animal detection device	Vehicle manufacturers	1	0.9
Appropriate tow bar	Driver	1	0.9
Automatic headlights	Vehicle manufacturers	1	0.9
Blindspot warning	Vehicle manufacturers	1	0.9
Brighter lights	Vehicle manufacturers	1	0.9
Cargo barrier	Vehicle manufacturers	1	0.9
Intelligent speed adaptation - advisory	Vehicle manufacturers	1	0.9
Knee airbag	Vehicle manufacturers	1	0.9
Lower centre of gravity	Vehicle manufacturers	1	0.9
Pedestrian protection	Vehicle manufacturers	1	0.9
Puncture resistant / run flat tyres	Vehicle manufacturers	1	0.9
Removing bull bar	Vehicle manufacturers	1	0.9
Traction control	Vehicle manufacturers	1	0.9

4.2.3 Road user

While road user based interventions could have prevented or mitigated fewer regional/remote crashes than road or vehicle based interventions (65.8%), they still have a significant role to play in achieving a Safe System. Of significance, responsibility for road user based interventions lies with a number of different agencies and individuals, illustrating why a holistic and collaborative approach is needed.

The top three road user based interventions, listed in Table 4.3, were all related to enforcement. Enforcement of seat belt non-use could have reduced the injury severity of 25% of crashes, while apprehension for drug driving and drink driving could have prevented or mitigated 19-21% of crashes. Enforcement of illegal behaviours in regional and remote areas is seriously hindered by the extent of the road network, limited resources and competing duties. As there is often less enforcement in regional/remote areas, road users commonly perceive that there is a lower risk of detection by police. In the absence of technologies in vehicles that can prevent these behaviours (i.e. alcohol interlock, seat belt interlock), effective enforcement strategies for regional and remote areas need to be deployed to increase the perceived risk of detection. Enforcement can be more effective when combined with accompanying public education campaigns (e.g. Elliott, 1993), particularly campaigns that directly address and involve communities in regional/remote areas. Together these activities can work towards creating a cultural change in risky driving behaviours (Davey & Freeman, 2011).

Table 4.3
Road user-based interventions for fatal crashes in regional/remote South Australia, 2014-2015

Intervention	Responsibility	Number (N=111)	% of crashes
Apprehension for seatbelt offence	Police	28	25.2
Apprehension for drug driving offence	Police	23	20.7
Apprehension for drink driving offence	Police	21	18.9
Alternative transport options	Road authority /driver	12	10.8
Mental health treatment	Health	10	9.0
Drug use treatment program	Health	10	9.0
Trip planning	Driver	8	7.2
Driver training/re-training	Road authority	6	5.4
Better medical control of/advice regarding medication	Health	5	4.5
Apprehension for young driver restriction offence	Police	4	3.6
Enforcement using ANR technology	Police	4	3.6
Alcohol interlock for all prior drink driving offenders	Road authority	3	2.7
Suspension of licence for being medically unfit to drive	Road authority	3	2.7
Alcohol use treatment program	Health	2	1.8
Brighter clothing worn	Pedestrian	2	1.8
Mobile phone blocking technology	Vehicle manufacturers	2	1.8
Route planning	Driver	2	1.8
Use of appropriate child restraint	Police	2	1.8
Addition of drug to drug driver testing	Police	1	0.9
Carry medication at all times	Health	1	0.9
Education - safe overtaking large vehicles	Road authority	1	0.9
Fatigue management training	Employer	1	0.9
Inflatable jacket for motorcyclists	Driver	1	0.9
Peer passengers - no exemptions	Road authority	1	0.9
Wearing of better protective clothing	Driver	1	0.9
Wearing of full face helmet	Driver	1	0.9

Alternative transport services can provide safe travel links between communities and larger service centres. Not only can they offer an alternative to impaired or unlicensed driving, but also enable access to health, employment, education and social opportunities, particularly among remote communities. One example is the Remote Bus Program in the Northern Territory which provides support for operational and capital costs for a commercially operated service to remote Aboriginal

communities (MRCagney, 2017). Such alternative safe transport options could be trialled in South Australia.

The health sector has a role to play in road safety interventions through mental health and drug treatments. Conservatively, it was estimated that in 9% of the fatal crashes analysed that mental health conditions were a contributing factor to the crash. Importantly, in these cases, it is plausible to assume that prior mental health intervention may have prevented the fatal crash. In addition, 9% of crashes may have been prevented with prior drug treatment programs, and in some cases mental health issues were comorbid with drug or alcohol use (i.e. 46% of culpable road users). It is of concern, however, that in regional/remote South Australia there are fewer specialist mental health and substance use services, and access to treatment can be difficult, or fraught with stigmatisation, particularly in smaller communities where individuals seeking treatment may be concerned about their anonymity. Research shows that, as remoteness in residency increases, access to mental health support services and substance use treatment decreases (although the rates of access to such services in all geographic locations are reportedly rising; AIHW, 2019b). Arguably, with the rise in mental health difficulties (ABS, 2018b), coupled with preliminary research demonstrating the negative impact of emotional states (such as anxiety and depression) on crash risk and driving behaviour (Cunningham & Regan, 2016), preventative therapeutic interventions could play an important step towards preventing road trauma.

4.2.4 Speed

Speed is an important issue in regional/remote areas as higher speeds result in higher severity injuries. The findings indicated that speed-related interventions could have prevented or mitigated 36.9% of regional/remote fatal crashes. Speed limit reductions are one of the key interventions for preventing or mitigating crashes and in reducing the severity of injuries in regional/remote areas (23%) (see Table 4.4). Speed limits are often high in regional/remote areas and do not reflect the risks associated with travelling on roads with variable conditions (e.g. unsealed surface) or with a lack of protective infrastructure (i.e. unprotected trees close to the edge of road). Of the 11 crashes in which a driver was travelling too fast for the conditions, eight were on unsealed roads with a default speed limit of 100km/h and no protective roadside infrastructure.

In the absence of adequate infrastructure to address risk (often not feasible due to the large road network and low traffic volumes), speed management is needed (Wundersitz et al, 2019). Speed compliance can be obtained through enforcement, which was estimated to prevent or mitigate 12% of regional/remote crashes. Speed enforcement can be challenging in regional, and particularly remote areas, due to the expansive road network and lack of resources. However, automated speed enforcement such as point-to-point speed camera and mobile camera deployment can be effective in regional/remote areas (Soole et al., 2013; Newstead et al., 2014).

Table 4.4
Speed-based interventions for fatal crashes in regional/remote South Australia, 2014-2015

Intervention	Responsibility	Number (N=111)	% of crashes
Speed limit reduction	Road authority	26	23.4
Apprehension for speed offence	Police	13	11.7
Curve speed advisory sign	Road authority	5	4.5

4.3 Conclusions

The findings from this study show that, while road user behaviour is a large contributor to fatal crashes in regional/remote areas, it is vehicle and road-based countermeasures that provide the greatest potential to prevent these crashes and mitigate the related injuries. Investment in safe roadside infrastructure, particularly to protect the road user in road departure crashes, and the promotion of policies and incentives to accelerate the uptake of newer vehicles with safe vehicle technologies, such as lane keeping technology, electronic stability control and autonomous emergency braking, have the most potential in the challenging regional/remote environment. These interventions should also be accompanied with the most effective enforcement strategies to deter unsafe driver behaviours and increase the perceived risk of detection; speed management, such as lower speed limits to match the quality of the road and infrastructure; and measures to ensure restraint use compliance. Importantly, interventions should not be viewed in isolation, but used together to provide a safe road transport system for all road users. Given that fatal crashes generally involve more extreme or risky behaviours than injury crashes (Wundersitz, Baldock & Raftery, 2014), further research could explore which interventions are most effective for injury crashes in regional/remote areas.

Acknowledgements

This study was funded by the South Australian Department for Infrastructure and Transport through a project grant to the Centre for Automotive Safety Research. The Department project manager was Marg Howard.

The authors would like to acknowledge the cooperation of the South Australian State Coroner's Court in providing access to the Coroner's investigation files.

Special thanks to Matthew Baldock for reviewing the report and Giulio Ponte for technical advice.

The Centre for Automotive Safety Research is supported by the South Australian Department for Infrastructure and Transport.

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

References

Allan, J., Clifford, A., Ball, P., Alston, M., & Meister, P. (2012). 'You're less complete if you haven't got a can in your hand': Alcohol consumption and related harmful effects in rural Australia: the role and influence of cultural capital. *Alcohol and Alcoholism,* 47(5):624-9.

Anderson, R., Doecke, S., Mackenzie, J., Ponte, G. (2013). *Potential benefits of autonomous emergency braking based on in-depth crash reconstruction and simulation*, In: 23rd International Technical Conference on the Enhanced Safety of Vehicles (ESV). Seoul, Korea.

Anderson, R., Doecke, S., Mackenzie, J., Ponte, G., Paine, D., Paine, M. (2012). *Potential benefits of forward collision avoidance technology (No. CASR106).* Centre for Automotive Safety Research, Adelaide, Australia.

Aumann, P., Bekavac, M., Steinmetz, L., Tziotis, M., Ahmed, F., Fanning, R., & Bobberman, D. (2020). *Road cross-section design for road stereotypes (including network safety plans) and a safe system*. (AP-R618-20). Sydney, NSW: Austroads.

Australian Bureau of Statistics. (2018a). *Australian Statistical Geography Standard (ASGS): Volume 5 - Remoteness structure, July 2016.* (No.1270.0.55.005). Retrieved June 4 2020, from https://www.abs.gov.au/ausstats/abs@.nsf/mf/1270.0.55.005.

Australian Bureau of Statistics. (2018b). *Mental Health.* Retrieved September 21, 2020 from https://www.abs.gov.au/statistics/health/health-conditions-and-risks/mental-health/latest-release

Australian Bureau of Statistics. (2018c). *Census of population and housing: Reflecting Australia – Stories from the census, 2016* (2071.0) Retrieved October 20, 2020 from https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/2071.0~2016~Main%20Features~Socio-Economic%20Advantage%20and%20Disadvantage~123

Australian Bureau of Statistics. (2015). *Motor Vehicle Census, Australia, cat. no. 9309.0*. Canberra: ABS.

Australian Criminal Intelligence Commission (2020). *National wastewater drug monitoring program – Report 10*. Canberra: Australian Criminal Intelligence Commission.

Australian Institute of Health and Welfare. (2019a). *Alcohol and other drug use in regional and remote Australia: consumption, harms and access to treatment, 2016–17*. Cat. no. HSE 212. Canberra: AIHW.

Australian Institute of Health and Welfare. (2019b). *Mental Health Services - In brief 2019.* Cat. no. HSE 228. Canberra: AIHW. Retrieved September 21, 2020 from https://www.aihw.gov.au/getmedia/f7395726-55e6-4e0a-9c1c-01f3ab67c193/aihw-hse-228-in-brief.pdf.aspx?inline=true

Austroads. (2009). *Non-wearing of adult seat belts in Australia: Where to next?* (AP-R346-09). Sydney, NSW: Austroads.

Bailey, T., Lindsay, V., & Royals, J. (2013). *Alcohol ignition interlock schemes: best practice review* (No. CASR119). Adelaide, SA: Centre for Automotive Safety Research.

Baldock, M. R. J., & Kumar, M. (Unpublished). *Profiling fatal crashes on Safe System dimensions.* Adelaide, SA: Centre for Automotive Safety Research.

Baldock, M. R. J., & Lindsay, V. L. (2020). Illicit drugs are now more common than alcohol among South Australian crash-involved drivers and riders. *Traffic Injury Prevention, 21*(1), 1-6.

Budd, L., & Newstead, S. (2019). *Potential road safety benefits of making safe vehicle choices in Australia*, Clayton, Victoria: Monash University Accident Research Centre.

Chow, K., Meuleners, L. & Wong, A. (2016). *An evaluation of the effectiveness and cost-effectiveness of a rural run-off-road crash program in Western Australia*. Perth, WA: Curtin-Monash Accident Research Centre.

Cunningham, M. & Regan, M. (2016). The impact of emotion, life stress and mental health issues on driving performance and safety. *Road & Transport Research, 25*, 40-50.

Davey, J. D., & Freeman, J. E. (2011). Improving road safety through deterrence-based initiatives: A review of research. *Sultan Qaboos University Medical Journal, 11*(1), 29.

Department for Infrastructure and Transport. (2019). *Rural road crashes in South Australia*. Retrieved March 12, 2020 from https://dpti.sa.gov.au/__data/assets/pdf_file/0003/247341/Rural_Road_Crash_Fact_Sheet.pdf

Doecke, S. D., Thompson, J. P., & Stokes, C. S. (2020). How do we prevent and mitigate crashes? Evidence from Australian at-scene in-depth crash investigations. *Journal of Road Safety, 31*(2), 35-43.

Elder, R., Voas, R., Beirness, D., Shults, R., Sleet, D., Nichols, J., & Compton, R., (2011). Effectiveness of ignition interlocks for preventing alcohol-impaired driving and alcohol-related crashes: A community guide systematic review. *American Journal of Preventive Medicine 40*, 362–376.

Elliott, B. (1993). *Road safety mass media campaigns: A meta-analysis* (No. CR 118). Canberra: Federal Office of Road Safety.

Elsegood, M. E., Mackenzie, J. R. R., Dutschke, J. K., & Mongiardini, M. (2019). *Automated Vehicles and the Readiness of Western Australian roads (Phase 2): Suitability of WA roads for Lane Departure Warning systems* (RR 19-07). Bentley WA: Curtin-Monash Accident Research Centre (C-MARC).

Fildes, B., Keall, M., Bos, N., Lie, A., Page, Y., Pastor, C., Pennisi, L., Rizzi, M., Thomas, P., Tingvall, C. (2015). Effectiveness of low speed autonomous emergency braking in real-world rear-end crashes. *Accident Analysis & Prevention 81*, 24–29.

Haus, S.H., Sherony, R. & Gabler, H.C. (2019). Estimated benefit of automated emergency braking systems for vehicle–pedestrian crashes in the United States. *Traffic Injury Prevention 20*, S171–S176.

Kidd, D. Singer, J., Huey, R. & Kerfoot, L. (2018). The effect of a gearshift interlock on seat belt use by drivers who do not always use a belt and its acceptance among those who do. *Journal of Safety Research, 65*, 39-51.

Kloeden, C., Ponte, G., & McLean, A. (2001). *Travelling speed and the risk of crash involvement on rural roads*. Adelaide, SA: Australian Transport Safety Bureau.

Mackie H.W., Gulliver, P., Scott, R.A., Hirsch, L., Ameratunga, S. & de Pont, J. (2017). *Serious injury crashes: How do they differ from fatal crashes? What is the nature of injuries resulting from them?* Auckland, New Zealand: Mackie Research, the University of Auckland, and TERENZ prepared for the AA Research Council.

MRCagney. (2017). *NT Remote bus program service evaluation. Final report.* Northern Territory, Australia: MRCagney Pty Ltd.

Newstead, S., Diamantopoulou, K., Lawrence, B., Clark, B., & Palamara, P. (2014). *An evaluation of automated traffic enforcement operations in Western Australia, 1995-2013* (Report 12-025RSC). Perth, WA: Curtin-Monash Accident Research Centre.

Palamara, P. (2016). *The application of a proxy measure to estimate the incidence of driver fatigue in Western Australian motor vehicle crashes* (RR 16-003). Perth, WA: Curtin-Monash Accident Research Centre.

Ponte, G., Ryan, G., & Anderson, R. (2016). An estimate of the effectiveness of an in-vehicle automatic collision notification system in reducing road crash fatalities in South Australia. *Traffic Injury Prevention, 17(*3), 258-263.

RTC. (2020) *Smarter, safer seatbelt interlocks.* Retrieved September 24, 2020 from http://www.wsae.com.au/wp-content/uploads/2015/09/34-Smartrack-Sequantial-Seatbelt-Interlock_SBMH0409071_WSAE.pdf

Sivak, M., Luoma, J., Flannagan, M. J., Bingham, C. R., Eby, D. W., & Shope, J. T. (2007). Traffic safety in the U.S.: Re-examining major opportunities. *Journal of Safety Research, 38*(3):337-355.

Soole, D., Watson, B., & Fleiter, J. (2013). Effects of average speed enforcement on speed compliance and crashes: A review of the literature. *Accident Analysis and Prevention, 54*, 46-56.

Sparrow, A., LaJambe, C. & Van Dongen, H. (2019). Drowsiness measures for commercial motor vehicle operations. *Accident Analysis & Prevention 126*, 146–159.

Woolley, J. E., Stokes, C. S., Turner, B., & Jurewicz, C. (2018). *Towards Safe System Infrastructure: A Compendium of Current Knowledge* (AP-R560-18). Sydney: Austroads.

Wundersitz, L. N. (2019). Driver distraction and inattention in fatal and injury crashes: Findings from in-depth road crash data. *Traffic Injury Prevention, 20*(7), 696-701.

Wundersitz, L. N., Baldock, M. R. J., & Raftery, S. J. (2014). The relative contribution of system failures and extreme behaviour in South Australian crashes. *Accident Analysis & Prevention, 73,* 163-169.

Wundersitz, L. N., Palamara, P., Brameld, K., Raftery, S. J., Govorko, M., & Thompson, J. P. (2019). *National View on Regional and Remote Road Safety* (AP-R603-19). Sydney: Austroads.

Appendix A – Contributing factors

The list of possible factors that could be selected as having contributed to a crash was as follows:

Road user related factors

Alcohol
Attention unspecified
Avoid other errant vehicle
Competing demands for attention
Deliberate unsafe act
Disobey traffic signal
Distraction
Drugs
Fail to check for traffic
Fail to give way
Fail to keep left (reason unknown)
Fatigue
Following too close
Impulsive decision
Inattention
Incorrect positioning
Inexperience
Inexperience with vehicle
Medical condition
Misjudgement
Misuse/overuse of medication
Peer effects
Pedestrian conspicuity
Recognition failure
Restraint use
Speed exceeds limit
Speed too high for conditions
Suicide
Unfamiliarity with vehicle
Unfamiliarity with road
Unlicensed/disqualified driver
Unsafe overtaking
Vision
Young driver

Road related factors

Animal on road
Delineation
Horizontal alignment
Obstacle on road
Road layout
Road marking
Roadside drop off
Road surface
Roadworks
Signage
Signal control
Unsealed road
Unsealed shoulder
Unexpected road or traffic conditions
Vertical alignment
Visibility
Weather conditions
Wet road

Vehicle related factors

Airbag failure
Brakes
Conspicuity
Cabin intrusion
Dirty windows
Dynamic stability
Fail to use headlights
Broken headlight
Loss of control (reason unknown)
Modified vehicle
Overloaded
Old vehicle
Seatbelt failure
Steering
Tinted windows
Tyre low tread depth
Tyre blowout

Additional factors

Delayed medical response
Other

Appendix B – Interventions

The list of possible interventions that could be selected that would prevent the crash and/or the resulting injuries was as follows:

Road user interventions
Addition of drug to drug driver testing
Alcohol interlock for all prior drink driving offenders
Alcohol interlock in all vehicles
Alcohol use treatment program
Alternative transport options
Apprehension for drink driving offence
Apprehension for drug driving offence
Apprehension for seatbelt offence
Apprehension for young driver restriction offence
Better medical control of/advice regarding medication
Brighter clothing worn
Carry medication at all times
Driver training/re-training
Drug use treatment program
Education - safe overtaking large vehicles
Enforcement using ANR technology
Fatigue management training
Geographical restriction on licence
Inflatable jacket for motorcyclists
Medical treatment
Mental health treatment
Mobile phone blocking technology
Peer passengers - no exemptions
Route planning
Suspension of licence for being medically unfit to drive
Trip planning
Use of appropriate child restraint
Wearing of better protective clothing
Wearing of full face helmet
Wearing of helmet

Speed interventions
Apprehension for speed offence
Speed limit reduction
Curve speed advisory sign

Vehicle interventions
ABS
Active head rest
Adaptive cruise control
Adding a bull bar
Autonomous emergency braking
Animal detection device
Anti-theft device
Appropriate tow bar
Automatic crash notification
Automatic headlights
Blindspot warning
Booster seat
Brighter lights
Cargo barrier
Collision warning
Combined braking system
Forward facing child restraint
Frontal impact intrusion protection
Intelligent speed adaption - advisory
Intelligent speed adaption - limiting
Knee airbag
Lane departure warning
Lane keep assist
Lower centre of gravity
More tread depth on tyres
More visible colour
Passenger airbag
Pedestrian protection
Puncture resistant/run flat tyres
Rear facing child restraint
Removing bull bar
Reversing cameras/sensors

Correct tyre pressures
Correctly maintained brake system
Curtain airbag
Curve speed warning
Daytime running lights
Driver airbag
Drowsiness detection/warning
Emergency braking assist
Electronic stability control
Rollover structural integrity
Seatbelt interlock
Seatbelt load limiters
Seatbelt pretensioners
Side airbag
Side intrusion protection
Top speed limiter
Traction control
Vehicle maintenance
Window tinting removal

Road interventions

Acceleration lane
Active warning sign
Audio tactile centre lines
Audio tactile edge line
Bicycle lane
Centre barrier
Centre line
Chevrons
Controlled right turn (signalised intersection)
Curve re-profiling
Edge of road line
Give way sign
Grade separated junction
Guide post
Improved barrier end treatment
Improved channelisation
Improved geometry of junction
Improved road marking
Improved sight distance
Improved superelevation
Improved surface friction
Left turn lane
Motorcycle protection on barrier
Narrow centre median (1 metre)
Overtaking lane
Pedestrian signals
Prevent right turn
Raised median
Rest area
Retro reflective signs
Right turn lane
Road maintenance
Roundabout
Seal road
Sealed shoulders
Separated road
Side barrier
Solid centre line (overtaking prohibited)
Stop sign
Street lighting
Traffic lights
Vertical deflection
Warning signs
Wide centre median (5 metres or wider)

Appendix C – Contributing factors in regional/remote fatal crashes

Table C
Factors contributing to fatal crashes in regional/remote South Australia, 2014-2015

Contributing factor	Number (N=111)	% of crashes
Restraint use	27	24.3
Drugs	25	22.5
Alcohol	22	19.8
Loss of control (reason unknown)	19	17.1
Fatigue	18	16.2
Distraction	16	14.4
Fail to keep left (reason unknown)	15	13.5
Speed exceeds limit	15	13.5
Cabin intrusion	12	10.8
Speed too high for conditions	11	9.9
Fail to give way	9	8.1
Inexperience	6	5.4
Medical condition	6	5.4
Unlicensed/disqualified driver	6	5.4
Visibility	6	5.4
Fail to check for traffic	5	4.5
Road surface	5	4.5
Unsealed road	5	4.5
Overcrowded vehicle	4	3.6
Inexperience with vehicle	4	3.6
Old vehicle	4	3.6
Unsafe overtaking	4	3.6
Unsealed shoulder	4	3.6
Avoid other errant vehicle	3	2.7
Competing demands for attention	3	2.7
Pedestrian conspicuity	3	2.7
Roadside drop off	3	2.7
Wet road	3	2.7
Animal on road	2	1.8
Attention unspecified	2	1.8
Brakes	2	1.8
Obstacle on road	2	1.8
Overloaded	2	1.8
Seatbelt failure	2	1.8
Signage	2	1.8
Tyre blowout	2	1.8
Tyre low tread depth	2	1.8
Unexpected road or traffic conditions	2	1.8
Unfamiliarity with road	2	1.8
Weather conditions	2	1.8
Young driver	2	1.8
Airbag failure	1	0.9
Broken headlight	1	0.9

Conspicuity (motorcycle)	1	0.9
Delayed medical response	1	0.9
Fail to use headlights	1	0.9
Misjudgement	1	0.9
Misuse/overuse of medication	1	0.9
Other	1	0.9
Peer effects	1	0.9
Recognition failure	1	0.9
Road layout	1	0.9
Road marking	1	0.9
Unfamiliarity with vehicle	1	0.9

Appendix D – Interventions for regional/remote fatal crashes

Table D1
Interventions for fatal crashes in regional/remote South Australia, 2014-2015

Safe System	Intervention	Responsibility	Number (N=111)	% of crashes
Road	Side barrier	Road authority	47	42.3
Vehicle	Lane keep assist	Vehicle manufacturers	42	37.8
Road	Centre barrier	Road authority	40	36.0
Vehicle	Electronic stability control	Vehicle manufacturers	35	31.5
Vehicle	Seatbelt interlock	Vehicle manufacturers	28	25.2
Road user	Apprehension for seatbelt offence	Police	28	25.2
Speed	Speed limit reduction	Road authority	26	23.4
Vehicle	Autonomous emergency braking	Vehicle manufacturers	24	21.6
Road user	Apprehension for drug driving offence	Police	23	20.7
Vehicle	Lane departure warning	Vehicle manufacturers	22	19.8
Vehicle	Alcohol interlock in all vehicles	Vehicle manufacturers	20	18.0
Road user	Apprehension for drink driving offence	Police	21	18.9
Road	Audio tactile centre lines	Road authority	19	17.1
Vehicle	Collision warning	Vehicle manufacturers	19	17.1
Vehicle	Drowsiness detection / warning	Vehicle manufacturers	18	16.2
Road	Sealed shoulders	Road authority	18	16.2
Vehicle	Rollover structural integrity	Vehicle manufacturers	17	15.3
Road	Audio tactile edge line	Road authority	14	12.6
Vehicle	Frontal impact intrusion protection	Vehicle manufacturers	13	11.7
Speed	Apprehension for speed offence	Police	13	11.7
Road user	Alternative transport options	Road authority /Driver	12	10.8
Vehicle	Intelligent speed adaption - limiting	Vehicle manufacturers	12	10.8
Vehicle	Side airbag	Vehicle manufacturers	11	9.9
Vehicle	Curtain airbag	Vehicle manufacturers	10	9.0
Road user	Drug use treatment program	Health	10	9.0
Road user	Mental health treatment	Health	10	9.0
Road	Seal road	Road authority	9	8.1
Road user	Trip planning	Driver	8	7.2
Vehicle	Side intrusion protection	Vehicle manufacturers	7	6.3
Vehicle	Top speed limiter	Vehicle manufacturers	7	6.3
Road user	Driver training/re-training	Road authority	6	5.4
Road	Active warning sign	Road authority	6	5.4
Road	Roundabout	Road authority	6	5.4
Vehicle	Automatic crash notification	Vehicle manufacturers	5	4.5
Road user	Better medical control of/advice regarding medication	Health	5	4.5
Speed	Curve speed advisory sign	Road authority	5	4.5
Vehicle	Driver airbag	Vehicle manufacturers	5	4.5
Road	Grade separated junction	Road authority	5	4.5
Road	Improved sight distance	Road authority	5	4.5
Road	Road maintenance	Road authority	5	4.5
Road	Vertical deflection	Road authority	5	4.5
Road user	Apprehension for young driver restriction offence	Police	4	3.6
Vehicle	Curve speed warning	Vehicle manufacturers	4	3.6

Road user	Enforcement using ANR technology	Police	4	3.6
Vehicle	More tread depth on tyres	Driver	4	3.6
Road	Warning signs	Road authority	4	3.6
Vehicle	ABS	Vehicle manufacturers	3	2.7
Road user	Alcohol interlock for all prior drink driving offenders	Road authority	3	2.7
Road	Give way sign	Road authority	3	2.7
Road	Improved geometry of junction	Road authority	3	2.7
Road	Motorcycle protection on barrier	Road authority	3	2.7
Road	Separated road	Road authority	3	2.7
Road	Stop sign	Road authority	3	2.7
Road	Street lighting	Road authority	3	2.7
Road user	Suspension of licence for being medically unfit to drive	Road authority	3	2.7
Road	Traffic lights	Road authority	3	2.7
Vehicle	Vehicle maintenance	Driver	3	2.7
Road user	Alcohol use treatment program	Health	2	1.8
Road user	Brighter clothing worn	Pedestrian	2	1.8
Vehicle	Correctly maintained brake system	Driver	2	1.8
Road	Improved road marking	Road authority	2	1.8
Road user	Mobile phone blocking technology	Vehicle manufacturers	2	1.8
Road	Overtaking lane	Road authority	2	1.8
Vehicle	Passenger airbag	Vehicle manufacturers	2	1.8
Road	Prevent right turn	Road authority	2	1.8
Vehicle	Reversing camera/sensors	Vehicle manufacturers	2	1.8
Road user	Route planning	Driver	2	1.8
Road user	Use of appropriate child restraint	Police	2	1.8
Road	Acceleration lane	Road authority	1	0.9
Vehicle	Adaptive cruise control	Vehicle manufacturers	1	0.9
Road user	Addition of drug to drug driver testing	Police	1	0.9
Vehicle	Animal detection device	Vehicle manufacturers	1	0.9
Vehicle	Appropriate tow bar	Driver	1	0.9
Vehicle	Automatic headlights	Vehicle manufacturers	1	0.9
Road	Bicycle lane	Road authority	1	0.9
Vehicle	Blindspot warning	Vehicle manufacturers	1	0.9
Vehicle	Brighter lights	Vehicle manufacturers	1	0.9
Vehicle	Cargo barrier	Vehicle manufacturers	1	0.9
Road user	Carry medication at all times	Health	1	0.9
Road	Centre line	Road authority	1	0.9
Road	Controlled right turn (signalised intersection)	Road authority	1	0.9
Road user	Education - safe overtaking large vehicles	Road authority	1	0.9
Road user	Fatigue management training	Employer	1	0.9
Road	Improved channelisation	Road authority	1	0.9
Road user	Inflatable jacket for motorcyclists	Driver	1	0.9
Vehicle	Intelligent speed adaption - advisory	Vehicle manufacturers	1	0.9
Vehicle	Knee airbag	Vehicle manufacturers	1	0.9
Vehicle	Lower centre of gravity	Vehicle manufacturers	1	0.9
Road	Pedestrian fencing	Road authority	1	0.9
Vehicle	Pedestrian protection	Vehicle manufacturers	1	0.9
Road	Pedestrian signals	Road authority	1	0.9
Road user	Peer passengers - no exemptions	Road authority	1	0.9

Vehicle	Puncture resistant / run flat tyres	Vehicle manufacturers	1	0.9
Vehicle	Removing bull bar	Vehicle manufacturers	1	0.9
Road	Rest area	Road authority	1	0.9
Road	Right turn lane	Road authority	1	0.9
Road	Roadside fencing	Road authority	1	0.9
Road	Solid centre line (overtaking prohibited)	Road authority	1	0.9
Vehicle	Traction control	Vehicle manufacturers	1	0.9
Road user	Wearing of better protective clothing	Driver	1	0.9
Road user	Wearing of full face helmet	Driver	1	0.9
Road	Wide centre median (5m+)	Road authority	1	0.9

Table D2
Interventions for fatal crashes in regional South Australia, 2014-2015

Safe System	Intervention	Responsibility	Number (n=88)	% of crashes
Road	Side barrier	Road authority	38	43.2
Vehicle	Lane keep assist	Vehicle manufacturers	36	40.9
Road	Centre barrier	Road authority	36	40.9
Vehicle	Electronic stability control	Vehicle manufacturers	25	28.4
Vehicle	Autonomous emergency braking	Vehicle manufacturers	22	25.0
Speed	Speed limit reduction	Road authority	20	22.7
Road user	Apprehension for drug driving offence	Police	19	21.6
Road user	Apprehension for seatbelt offence	Police	18	20.5
Vehicle	Lane departure warning	Vehicle manufacturers	18	20.5
Vehicle	Seatbelt interlock	Vehicle manufacturers	18	20.5
Road user	Apprehension for drink driving offence	Police	18	20.5
Vehicle	Collision warning	Vehicle manufacturers	17	19.3
Vehicle	Alcohol interlock in all vehicles	Vehicle manufacturers	17	19.3
Road	Audio tactile centre lines	Road authority	15	17.0
Vehicle	Drowsiness detection/warning	Vehicle manufacturers	14	15.9
Road	Sealed shoulders	Road authority	13	14.8
Vehicle	Intelligent speed adaption - limiting	Vehicle manufacturers	12	13.6
Vehicle	Frontal impact intrusion protection	Vehicle manufacturers	12	13.6
Road	Audio tactile edge line	Road authority	12	13.6
Speed	Apprehension for speed offence	Police	12	13.6
Vehicle	Rollover structural integrity	Vehicle manufacturers	11	12.5
Vehicle	Side airbag	Vehicle manufacturers	11	12.5
Road user	Alternative transport options	Driver	10	11.4
Road user	Mental health treatment	Health	9	10.2
Vehicle	Curtain airbag	Vehicle manufacturers	9	10.2
Road user	Drug use treatment program	Health	8	9.1
Vehicle	Side intrusion protection	Vehicle manufacturers	6	6.8
Road	Roundabout	Road authority	6	6.8
Road user	Trip planning	Driver	6	6.8
Vehicle	Top speed limiter	Vehicle manufacturers	6	6.8
Road	Active warning sign	Road authority	6	6.8
Road user	Driver training/re-training	Road authority	5	5.7
Road	Improved sight distance	Road authority	5	5.7
Road	Vertical deflection	Road authority	5	5.7

Road	Grade separated junction	Road authority	5	5.7
Vehicle	Curve speed warning	Vehicle manufacturers	4	4.5
Road user	Apprehension for young driver restriction offence	Police	4	4.5
Road user	Better medical control of/advice regarding medication	Health	4	4.5
Vehicle	ABS	Vehicle manufacturers	3	3.4
Road	Give way sign	Road authority	3	3.4
Road	Improved geometry of junction	Road authority	3	3.4
Vehicle	Driver airbag	Vehicle manufacturers	3	3.4
Road	Traffic lights	Road authority	3	3.4
Road	Motorcycle protection on barrier	Road authority	3	3.4
Road	Seal road	Road authority	3	3.4
Vehicle	More tread depth on tyres	Driver	3	3.4
Road user	Alcohol interlock for all prior drink driving offenders	Road authority	3	3.4
Road user	Suspension of licence for being medically unfit to drive	Health	3	3.4
Road	Stop sign	Road authority	3	3.4
Road	Separated road	Road authority	3	3.4
Road	Prevent right turn	Road authority	2	2.3
Road user	Alcohol use treatment program	Road authority	2	2.3
Road	Overtaking lane	Road authority	2	2.3
Road user	Enforcement using ANR technology	Police	2	2.3
Road user	Route planning	Driver	2	2.3
Vehicle	Mobile phone blocking technology	Vehicle manufacturers	2	2.3
Road	Road maintenance	Road authority	2	2.3
Road	Warning signs	Road authority	2	2.3
Speed	Curve speed advisory sign	Road authority	2	2.3
Road	Street lighting	Road authority	2	2.3
Road	Improved road marking	Road authority	2	2.3
Road	Wide centre median (5m+)	Road authority	1	1.1
Vehicle	Animal detection device	Vehicle manufacturers	1	1.1
Vehicle	Passenger airbag	Vehicle manufacturers	1	1.1
Vehicle	Removing bull bar	Vehicle manufacturers	1	1.1
Road	Roadside fencing	Road authority	1	1.1
Vehicle	Correctly maintained brake system	Driver	1	1.1
Vehicle	Appropriate tow bar	Driver	1	1.1
Road	Controlled right turn (signalised intersection)	Road authority	1	1.1
Road user	Fatigue management training	Employer	1	1.1
Vehicle	Intelligent speed adaption - advisory	Vehicle manufacturers	1	1.1
Road user	Education - safe overtaking large vehicles	Road authority	1	1.1
Road	Centre line	Road authority	1	1.1
Road user	Addition of drug to drug driver testing	Police	1	1.1
Road	Solid centre line (overtaking prohibited)	Road authority	1	1.1
Vehicle	Reversing camera/sensors	Vehicle manufacturers	1	1.1
Road user	Carry medication at all times	Driver	1	1.1
Vehicle	Pedestrian protection	Vehicle manufacturers	1	1.1
Vehicle	Cargo barrier	Vehicle manufacturers	1	1.1
Road user	Wearing of full face helmet	Driver	1	1.1
Vehicle	Brighter lights	Vehicle manufacturers	1	1.1
Vehicle	Vehicle maintenance	Driver	1	1.1
Road user	Brighter clothing worn	Pedestrian	1	1.1

Road user	Use of appropriate child restraint	Police	1	1.1
Road	Bicycle lane	Road authority	1	1.1
Road user	Wearing of better protective clothing	Driver	1	1.1
Road user	Peer passengers - no exemptions	Road authority	1	1.1
Vehicle	Lower centre of gravity	Vehicle manufacturers	1	1.1
Vehicle	Automatic headlights	Vehicle manufacturers	1	1.1
Vehicle	Adaptive cruise control	Vehicle manufacturers	1	1.1
Vehicle	Automatic crash notification	Vehicle manufacturers	1	1.1
Road	Acceleration lane	Road authority	1	1.1
Road	Pedestrian signals	Road authority	1	1.1
Vehicle	Knee airbag	Vehicle manufacturers	1	1.1
Road	Improved channelisation	Road authority	1	1.1

Table D3
Interventions for fatal crashes in remote South Australia, 2014-2015

Safe System	Intervention	Responsibility	Number (n=23)	% of crashes
Vehicle	Seatbelt interlock	Vehicle manufacturers	10	43.5
Road user	Apprehension for seatbelt offence	Police	10	43.5
Vehicle	Electronic stability control	Vehicle manufacturers	10	43.5
Road	Side barrier	Road authority	9	39.1
Vehicle	Lane keep assist	Vehicle manufacturers	6	26.1
Speed	Speed limit reduction	Road authority	6	26.1
Road	Seal road	Road authority	6	26.1
Vehicle	Rollover structural integrity	Vehicle manufacturers	6	26.1
Road	Sealed shoulders	Road authority	5	21.7
Vehicle	Automatic crash notification	Vehicle manufacturers	4	17.4
Road	Audio tactile centre lines	Road authority	4	17.4
Vehicle	Drowsiness detection / warning	Vehicle manufacturers	4	17.4
Road user	Apprehension for drug driving offence	Police	4	17.4
Road	Centre barrier	Road authority	4	17.4
Vehicle	Lane departure warning	Vehicle manufacturers	4	17.4
Road user	Apprehension for drink driving offence	Police	3	13.0
Vehicle	Alcohol interlock in all vehicles	Vehicle manufacturers	3	13.0
Road	Road maintenance	Road authority	3	13.0
Speed	Curve speed advisory sign	Road authority	3	13.0
Road user	Drug use treatment program	Health	2	8.7
Vehicle	Vehicle maintenance	Driver	2	8.7
Road	Audio tactile edge line	Road authority	2	8.7
Road user	Alternative transport options	Driver	2	8.7
Road user	Trip planning	Driver	2	8.7
Road user	Enforcement using ANR technology	Police	2	8.7
Vehicle	Autonomous emergency braking	Vehicle manufacturers	2	8.7
Road	Warning signs	Road authority	2	8.7
Vehicle	Collision warning	Vehicle manufacturers	2	8.7
Vehicle	Driver airbag	Vehicle manufacturers	2	8.7
Vehicle	Blindspot warning	Vehicle manufacturers	1	4.3
Road user	Inflatable jacket for motorcyclists	Driver	1	4.3
Road	Rest area	Road authority	1	4.3

Road user	Use of appropriate child restraint	Police	1	4.3
Vehicle	Side intrusion protection	Vehicle manufacturers	1	4.3
Vehicle	Traction control	Vehicle manufacturers	1	4.3
Vehicle	Puncture resistant / run flat tyres	Vehicle manufacturers	1	4.3
Road	Right turn lane	Road authority	1	4.3
Road	Pedestrian fencing	Road authority	1	4.3
Road user	Better medical control of/advice regarding medication	Health	1	4.3
Vehicle	Passenger airbag	Vehicle manufacturers	1	4.3
Road	Street lighting	Road authority	1	4.3
Vehicle	Curtain airbag	Vehicle manufacturers	1	4.3
Road user	Apprehension for speed offence	Police	1	4.3
Vehicle	Correctly maintained brake system	Driver	1	4.3
Vehicle	Top speed limiter	Vehicle manufacturers	1	4.3
Vehicle	More tread depth on tyres	Driver	1	4.3
Vehicle	Frontal impact intrusion protection	Vehicle manufacturers	1	4.3
Road user	Mental health treatment	Health	1	4.3
Vehicle	Reversing camera/sensors	Vehicle manufacturers	1	4.3
Road user	Brighter clothing worn	Pedestrian	1	4.3
Road user	Driver training/re-training	Road authority	1	4.3