Characteristics of High Injury Severity Crashes on 80 – 110 km/h Rural Roads in South Australia

Mackenzie, J. R. R.
Centre for Automotive Safety Research, University of Adelaide, SOUTH AUSTRALIA, 5005
email: jamie@casr.adelaide.edu.au

ABSTRACT

This paper aims to present an overview of the characteristics of high injury severity rural road crashes in South Australia by examining the relationship between high severity injuries and other crash variables. A data set of approximately five thousand crashes was generated by taking all casualty crashes (excluding pedestrian and non-motorised vehicles) on South Australian rural roads, outside of Adelaide, with a speed limit of 80 km/h or more from the years 2002 to 2006. The results provide an overview of the proportion of high injury severity outcomes associated with various crash, road, vehicle and driver characteristics and are summarised in tables. A logistic regression analysis indicated that a higher speed limit, hours of darkness or low light and a dry road predicted high injury severity for single vehicle crashes involving cars and car derivatives.

Keywords

Rural road, High injury severity, Crash characteristics

INTRODUCTION

This paper presents an overview of the characteristics of high injury severity rural road crashes in South Australia by examining the relationship between high severity injuries and other crash variables.

Previous studies of rural crashes in South Australia have focussed mainly on the relationship that the number of casualty crashes has with other crash variables [1,2]. Only brief references are made as to what may affect the injury severity of a crash.

For this paper a rural road was defined as any road outside the greater Adelaide metropolitan area. This was further refined to exclude roads in rural towns and cities by excluding any roads with a speed limit of less than 80 km/h. There was no distinction made between rural and remote roads.

The paper is arranged in the following manner. The method section describes the data set and how it was generated. The results section examines the relationship between the proportion of high severity injuries and several other crash, road, vehicle and driver variables. Tables under the subheadings of crash, road, vehicle and driver characteristics provide information about the number of crashes and the proportion of high injury severity crashes attributed to the categories of each variable. A logistic regression analysis was performed to determine which characteristics predict a high injury severity outcome for single vehicle crashes involving cars and car derivatives. Finally, the discussion section summarises the findings of the paper.

METHOD

The data used for this study were obtained from the Traffic Accident Reporting System (TARS). Data are entered into the TARS database by the South Australian Department for Transport, Energy and Infrastructure (DTEI). Each crash record consists of a set of variables based upon the police report of the crash. Unfortunately some variables are unreliable due to missing data and could not be used, including blood alcohol concentration (BAC) of the driver and seatbelt usage by casualties.

Crash records from 2002 to 2006 were extracted from the TARS database (final data from 2007 were not available at the time of the study). The five year time frame was selected to ensure enough data were available to reveal a significant result, while still representing current conditions. After removing non casualty crashes, as well as crashes involving pedestrians and non-motorised vehicles (including parked vehicles), 28,180 records remained.

Only rural roads outside of rural towns/cities were of interest for this study. Crashes occurring in the metropolitan area and crashes occurring in speed zones below 80 km/h were removed but are shown in Table 2 of the results section under 'Excluded Data' for comparison. The final 'rural road' data set contained 5,014 records.

The injury severity of each crash was determined by the highest category of injury sustained by an occupant/rider of any vehicle involved in the crash. There were four categories of injury severity, shown in Table 1. For this study, crashes were also classed as either 'high' or 'low' severity. Differences in the numbers of low and high severity crashes were tested for statistical significance using the Chi-square statistic.

Table 1 - Categories of Injury Severity

Category	Severity	Description
Doctor	Low	Treated by local doctor
Treated	Low	Treated at hospital
Admission	High	Admitted to hospital
Fatal	High	Died either during or as a result of crash (within 30 days)

RESULTS

Overview

The breakdown of the 'rural road' data set selected according to the method section, by year and severity category, is shown in Table 2. The proportion of the total number of crashes accounted for by each of the severity categories is also shown. Of the 5,014 crashes on rural roads, 6% were fatal and 37% required an admission to hospital. In comparison, only 1% of the excluded metropolitan and rural town crashes were fatal and only 11% required an admission to hospital.

Table 2 - Number of 'rural road' crashes per year by severity category, 2002 - 2006

Severity	Year							Excluded	
	2002	2003	2004	2005	2006	Total	%	Data	%
Doctor	107	99	90	89	74	459	9%	8979	39%
Treated	508	507	467	435	450	2367	47%	11343	49%
Admitted	400	434	352	351	337	1874	37%	2629	11%
Fatal	77	68	59	64	46	314	6%	215	1%
Total	1092	1108	968	939	907	5014	100%	23166	100%

In this table and all subsequent tables, percentages have been rounded to the nearest whole number and may not sum to exactly 100%

Crash Characteristics

Table 3 shows that single vehicle crashes accounted for almost 75% of all crashes in the sample. Of these single vehicle crashes, 'hit fixed object' was the most frequent category of crash, followed by 'roll over'. Both of these crash types showed a similar proportion of high injury severity outcomes.

'Right angle' crashes were the most frequent type of multiple vehicle crash, followed by 'head on' crashes. 'Head on' crashes showed the highest proportion of high severity injuries at 55%, while 'rear end' showed the lowest at 27%.

Since the injury severity of any individual crash in part depends upon the occupants involved in the crash, it should be noted that a larger number of occupants may result in an increased chance of a high injury severity outcome. This effect was ignored given the generally low number of vehicle occupants. It should however be considered when comparing single vehicle crashes with multiple vehicle crashes (which would in general involve more occupants).

Table 3 – Proportion of casualty crashes that were high injury severity by type of crash, 2002 - 2006

Crash Type	High Injury Severity	Number of Casualty Crashes	
MULTIPLE VEHICLE	**42%**	**1237**	**(25%)**
Head On	55%	335	(7%)
Rear End	27%	274	(5%)
Side Swipe	43%	169	(3%)
Right Angle	42%	393	(8%)
Right Turn	32%	66	(1%)
SINGLE VEHICLE	**44%**	**3741**	**(75%)**
Hit Fixed Object	44%	2050	(41%)
Hit Object/Animal on Road	28%	178	(4%)
Roll Over	47%	1287	(26%)
Left Road Out of Control	42%	226	(5%)
OTHER THAN ABOVE	**50%**	**36**	**(1%)**
Total	44%	5014	(100%)

Table 4 shows that the number of crashes during hours of daylight for each day of the week remained relatively constant through the weekdays but increased slightly on Friday and over the weekend. The proportion of high injury severity crashes also increased on Friday, Saturday and Sunday with the differences between days of week during daylight being statistically significant ($p < 0.05$).

Table 5 shows that the number of crashes during hours of darkness or low light for each day of the week increased on Friday and Saturday but the proportions of high injury severity crashes remained constant across the entire week. The differences between days of the week during hours of darkness or low light were not statistically significant however ($p < 0.05$). Crashes which occurred at or before 5 am were attributed to the previous day of the week. This was done in order to group together crashes of a similar nature; eg drink driving and fatigue. There was no variable to record artificial street lighting.

Two thirds of the crashes occurred during hours of daylight and 41% of them resulted in a high severity injury. During hours of darkness or low light, 49% of crashes resulted in a high severity injury. The increase in the proportion of high injury severity crashes during hours of darkness or low light was observed across all days of the week.

Table 4 - Proportion of casualty crashes that were high injury severity by day of week during hours of daylight, 2002-2006

Day	High Injury Severity	Number of Casualty Crashes	
Monday	36%	456	(14%)
Tuesday	40%	427	(13%)
Wednesday	38%	464	(14%)
Thursday	39%	413	(12%)
Friday	44%	507	(15%)
Saturday	42%	531	(16%)
Sunday	45%	545	(16%)
Total	41%	3343	(100%)

Table 5 – Proportion of casualty crashes that were high injury severity by day of week during hours of darkness or low light, 2002 - 2006 (pre 5 am crashes attributed to previous day)

Day	High Injury Severity	Number of Casualty Crashes	
Monday	47%	159	(10%)
Tuesday	45%	188	(11%)
Wednesday	50%	179	(11%)
Thursday	53%	211	(13%)
Friday	50%	368	(22%)
Saturday	49%	367	(22%)
Sunday	52%	199	(12%)
Total	49%	1671	(100%)

Road Characteristics

In South Australia, the default speed limit outside metropolitan areas is 100 km/h unless signed otherwise. Table 6 shows that the majority of crashes occurred on roads with speed limits of 100 km/h or 110 km/h. Crashes on roads with a higher speed limit displayed a higher proportion of high severity injuries and the differences between speed zones were statistically significant ($p < 0.05$).

Table 6 – Proportion of casualty crashes that were high injury severity by speed zone, 2002 - 2006

Speed Zone	High Injury Severity	Number of Casualty Crashes	
80 - 90 km/h	34%	843	(17%)
100 km/h	44%	2037	(41%)
110 km/h	47%	2134	(43%)
Total	44%	5014	(100%)

Table 7 and Table 8 show that 80% of crashes occurred on sealed roads and 15% occurred on wet roads. The proportion of high injury severity crashes was only slightly higher on sealed roads when compared with unsealed roads but the difference between surface types was not statistically significant ($p < 0.05$). The proportion of high injury severity crashes on wet roads was much lower than on dry roads and the difference between road wetness was statistically significant ($p < 0.05$).

Table 7 - Proportion of casualty crashes that were high injury severity by road surface type, 2002 - 2006

Surface	High Injury Severity	Number of Casualty Crashes	
Sealed	44%	4010	(80%)
Unsealed	42%	1004	(20%)
Total	44%	5014	(100%)

Table 8 - Proportion of casualty crashes that were high injury severity by road wetness, 2002 - 2006

Wetness	High Injury Severity	Number of Casualty Crashes	
Wet	35%	737	(15%)
Dry	45%	4277	(85%)
Total	44%	5014	(100%)

Table 9 shows that approximately 60% of crashes occurred on straight sections of road, with the remaining 40% occurring on curved sections. The direction of the curve was not recorded. The view around the curve was recorded as either open or obscured, however this is a subjective variable and likely to be unreliable. Roads which were curved with an open view displayed the greatest proportion of high injury severity crashes, while curves with an obscured view displayed the lowest, however the differences between road alignment were not statistically significant ($p < 0.05$). The proportion of high injury severity crashes for both curve types combined was 40%.

Table 9 - Proportion of casualty crashes that were high injury severity by road alignment, 2002 - 2006

Road Alignment	High Injury Severity	Number of Casualty Crashes	
Straight	44%	2982	(59%)
Curved - View Obscured	39%	820	(16%)
Curved - View Open	46%	1181	(24%)
Unknown	52%	31	(1%)
Total	44%	5014	(100%)

Table 10 shows that the vast majority of crashes occurred on a mid-block section of road. The 'other' category of road feature refers to railway crossings, on/off ramps, etc. Crashes which occurred at an intersection displayed a lower proportion of high injury severity crashes compared to crashes occurring on a mid-block section of road and the differences between road features were statistically significant ($p < 0.05$).

Table 10 - Proportion of casualty crashes that were high injury severity by road feature, 2002 - 2006

Road Feature	High Injury Severity	Number of Casualty Crashes	
Intersection	39%	760	(15%)
Mid-block	45%	4194	(84%)
Other	42%	60	(1%)
Total	44%	5014	(100%)

Vehicle Characteristics

Table 11 shows that over 80% of vehicles involved in crashes were passenger cars or car derivatives including panel vans, utilities, station wagons as well as 4WDs. Trucks and motorcycles both accounted for 8% of the total respectively. Trucks and motorcycles were both involved in a high proportion of high injury severity crashes when compared with cars and car derivatives with the differences between vehicle types being statistically significant ($p < 0.05$).

Table 11 - Proportion of casualty crashes that were high injury severity by type of vehicle involved, 2002 - 2006

Vehicle Type	High Injury Severity	Number of Vehicles	
Car and Derivatives	41%	5262	(82%)
Truck	52%	486	(8%)
Motorcycle	57%	502	(8%)
Other	36%	103	(2%)
Unknown	43%	86	(1%)
Total	43%	6439	(100%)

Table 12 shows that more than half of the vehicles in which an occupant was injured were over 10 years old including a small proportion over 20 years old. The proportion of casualties with high severity injuries was greater when the vehicle, in which they were an occupant, was older. The differences between vehicle ages were statistically significant ($p < 0.05$).

Table 12 - Proportion of casualty crashes that were high injury severity by age of vehicle in which an occupant was injured (car and derivatives), 2002 - 2006

Vehicle Age	High Injury Severity	Number of Vehicles with Injured Occupant	
5 years or less	39%	906	(20%)
6 - 10 years	42%	1040	(23%)
11 - 15 years	43%	947	(21%)
16 - 20 years	45%	807	(18%)
Over 20 years	48%	688	(15%)
Unknown	56%	219	(5%)
Total	43%	4607	(100%)

Driver Characteristics

As parked vehicles had been removed from the sample, there was a driver for each of the 6,439 vehicles. The majority of drivers held a full licence while only a small number of drivers held a provisional licence, a learner's permit or no licence at all. Those drivers with either a learner's permit or no licence were involved in a higher proportion of high injury severity crashes with the differences between licence types being statistically significant ($p < 0.05$).

Table 13 - Proportion of casualty crashes that were high injury severity by licence type of driver, 2002 - 2006

Licence Type	High Injury Severity	Number of Drivers	
Learners	54%	107	(2%)
Provisional	38%	575	(9%)
Full	43%	4416	(69%)
None	55%	108	(2%)
Unknown	45%	1233	(19%)
Total	43%	6439	(100%)

Table 14 shows that the majority of drivers were aged 20 to 40 years. The proportion of high injury severity crashes tended to increase slightly as age increased with the differences between driver ages being statistically significant ($p < 0.05$).

Table 14 - Proportion of casualty crashes that were high injury severity by age of driver involved, 2002 - 2006

Age	High Injury Severity	Number of Drivers	
<16	50%	18	(0%)
16-19	37%	887	(14%)
20-29	42%	1521	(24%)
30-39	45%	1285	(20%)
40-49	46%	1058	(16%)
50-59	45%	776	(12%)
60-69	47%	378	(6%)
70-79	49%	249	(4%)
>79	52%	89	(1%)
Unknown	31%	178	(3%)
Total	43%	6439	(100%)

Table 15 shows that two thirds of the drivers were male. Male drivers were involved in a much greater number of crashes and a greater proportion of high injury severity crashes compared with female drivers. The differences between driver sex was statistically significant ($p < 0.05$)

Table 15 - Proportion of casualty crashes that were high injury severity by sex of driver involved, 2002 - 2006

Sex	High Injury Severity	Number of Drivers	
Male	47%	4225	(66%)
Female	37%	2143	(33%)
Unknown	32%	71	(1%)
Total	43%	6439	(100%)

LOGISTIC REGRESSION

A logistic regression analysis was carried out on single vehicle crashes involving passenger cars and derivatives with the dependent variable being the probability of a crash being high injury severity (Table 16). Each of the variables analysed in the results section was included as a predictor variable. After excluding unknown data points, 2,719 cases were included in the analysis.

Some explanation of why the data were restricted to single vehicle crashes involving cars and derivatives is necessary. It was not suitable to mix both single and multiple vehicle crashes due to the different number of vehicles and drivers involved in each group. Single and multiple vehicle crashes also display different crash characteristics. Cars, trucks and motorcycles needed to be separated as they too display different crash characteristics. Cars and derivatives were chosen as they were the largest of the vehicle type categories.

Three variables showed a significant result. The odds ratio of a casualty crash being of high severity was higher on roads with a speed limit of 100 km/h or 110 km/h compared to roads with a speed limit of 80 km/h or 90 km/h. The odds ratio of a casualty crash being of high severity was lower during hours of daylight compared to hours of darkness or low light. Lastly, the odds ratio of a casualty crash being of high severity was higher on dry roads compared to wet roads.

Table 16 - Logistic regression analysis of single vehicle crashes involving cars and car derivatives predicting probability of high injury severity crash (N = 2,719), 2002 - 2006

Variable (n)	B	Odds Ratio	95% CI
Roll Over			
No (917)	-		
Yes (1802)	-0.155	0.856	0.727 - 1.009
Day of the Week			
Sunday - Thursday (1760)	-		
Friday - Saturday (954)	0.117	1.124	0.956 - 1.322
Speed Limit			
80km/h, 90km/h (364)	-		
100km/h, 110km/h (2355)	0.479*	1.614	1.270 - 2.051
Lighting			
Dark (983)	-		
Light (1736)	-0.373*	0.688	0.584 - 0.811
Driver Sex			
Male (1641)	-		
Female (1078)	-0.011	0.989	0.845 - 1.158
Driver Age			
21 - 59 (1842)	-		
20 or younger (578)	-0.075	0.928	0.756 - 1.126
60 or older (299)	0.143	1.154	0.900 - 1.481
Vehicle Age	0.005	1.005	0.993 - 1.018
Road Wetness			
Wet (415)	-		
Dry (2304)	0.547*	1.727	1.383 - 2.158
Road Alignment			
Straight (1492)	-		
Curve (1227)	-0.039	0.962	0.824 - 1.123
Road Feature			
Mid-block (2556)	-		
Intersection (163)	-0.218	0.804	0.576 - 1.122
Constant	-0.837*	0.433	

* Significant ($p < 0.001$)

DISCUSSION

As expected, in South Australia there is an overrepresentation of crashes which result in fatal or serious injuries on rural roads with speed limits of 80 km/h or greater compared with other types of road. By examining the relationship between high injury severity and other crash variables, some of the characteristics of high injury severity crashes on rural roads have been shown. The purpose of this paper was to simply present the results without elucidation. The following section however, highlights and gives some suggestions for interpreting the results which may be of interest.

For single vehicle crashes, the two main crash types of 'roll over' and 'hit fixed object' showed little difference in the proportion of high injury severity outcomes. This may be an indication that high speed, single vehicle crashes on rural roads have a tendency to result in high severity injuries regardless of the collision mechanism.

For multiple vehicle crashes, the two main crash types were 'head on' and 'right angle'. The events leading up to a head on type crash are often similar to those leading up to a single vehicle, hit fixed object type crash. A driver may lose control of their vehicle but collide with an oncoming vehicle instead of a roadside object. The combined speed of both vehicles is the likely reason for the high prevalence of high injury severity injuries as a result of such a crash. Right angle crashes may be the result of poor driver judgement in choosing gaps at intersections, especially when entering traffic travelling at high speeds.

Crashes which occurred during hours of darkness showed an increased proportion of high injury severity outcomes across all days of the week. Crashes which occurred on Friday and Saturday during darkness displayed a greater number of crashes per day (compared with the other days). The reasons for these effects are not immediately clear; however it has been suggested in a similar study of rural road crashes in Victoria that crashes which occur during darkness may correspond with alcohol use and fatigue [3].

Crashes which occur in higher speed zones show a larger proportion of high injury severity outcomes. What is particularly noteworthy is that despite a default rural speed limit of 100 km/h, the majority of crashes occurred on roads with a speed limit of 110 km/h, which had the largest proportion of high injury severity outcomes. This result is consistent with a previous study on South Australian rural roads of 80 km/h and above, which found that higher travelling speed are associated with higher casualty crash risk [4].

The difference in the proportion of high injury severity crashes on wet and dry roads was substantial, with a higher proportion of dry road crashes being serious. It has been suggested that this difference may be explained by an increase in the number of low injury severity, skidding crashes on wet roads [5], rather than a decrease in the risk of having a serious crash on a wet road.

Crashes which occurred on curved sections of road did not appear to show any difference in the proportion of high severity injuries compared with crashes which occurred on straight sections of road. However, given that the amount of curved sections of road is considerably smaller than the amount of straight sections of road, the number of crashes on curves is alarming. The likelihood of a crash occurring on a curved section of road appears to me much greater than on a straight section of road.

Crashes which occurred at intersections were found to have a lower proportion of high injury severity outcomes compared with those which occurred on a mid-block section of road. This is consistent with a similar study of rural road crashes in Victoria which found that crashes at intersections are less severe than crashes not at intersections [3].

There was a large difference in the proportion of high injury severity crashes for different categories of vehicle. Both motorcycles and trucks displayed an increased proportion of high injury severity crashes. For motorcycles, this effect may arise from the limited protection given to motorcycle riders during a crash. For trucks, this effect is likely due to their large mass which can result in severe injuries for the occupants of any vehicle with which they collide.

An increase in vehicle age was associated with an increase in the proportion of high severity injuries to the occupants. This effect was also noted in [6] and while no clear explanation was given, it has been shown through the analysis of real-world crashes that newer vehicles incorporating modern safety features better protect occupants during a crash [7]. The highest proportion of high injury severity crashes was found for vehicles of unknown age. This result was unusual as variables which are recorded as 'unknown' usually indicate a low injury severity crash. High injury severity crashes are, in general, followed up more diligently. No explanation for this result was discovered.

The proportion of high injury severity crashes associated with different driver age ranges did not reveal anything conclusive. There was a small tendency for older drivers to be involved in a greater proportion of high injury severity crashes but establishing the effect was hampered by small sample sizes for some age groups. The expected result of a large proportion of high injury severity crashes for young drivers was noticeably absent. The reasons for this were not clear.

Male drivers were involved in a greater proportion of crashes and also showed a higher proportion of high injury severity outcomes.

A logistic regression analysis indicated that a higher speed limit, the hours of darkness and a dry road were associated with a single vehicle, casualty crash, involving cars and car derivatives, being of high injury severity. These three predictors are likely to be the critical characteristics that differentiate single vehicle, high injury severity crashes from single vehicle low injury severity crashes.

Cross tabulations of the variables ‘vehicle age’, ‘driver sex’ and ‘road feature’ showed them to be good predictors of greater proportions of high severity injuries but they were not found to be statistically significant in the logistic regression.

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