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## Car drivers with an AIS2+ spine injury: Description of a sample from South Australia

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CASR REPORT SERIES

CASR182

March 2023

# Report documentation

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REPORT NO.	DATE	PAGES	ISBN	ISSN
CASR182	March 2023	17	978-1-925971-15-6	1449-2237

## TITLE

Car drivers with an AIS2+ spine injury: Description of a sample from South Australia

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## PERFORMING ORGANISATION

Centre for Automotive Safety Research  
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## FUNDING

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

## AVAILABLE FROM

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

## ABSTRACT

Car drivers from a database of road users discharged from the Royal Adelaide Hospital (RAH) between 1 July 2015 and 30 December 2017 following a road crash were analysed in this study. The hospital information was supplemented with details of the crash, obtained from the Police and the road authority. This study focused on those who had a spine injury coded at least 2 on the Abbreviated Injury Scale (AIS2+). This sample is from a single hospital, and there are several likely biases. *Results.* There were 518 car drivers with one or more AIS2+ injuries, of whom 152 had one or more AIS2+ spine injuries, mostly vertebral fractures. Of these 152, the maximum spine AIS score was 2 for 87%, 3 for 12%, and >3 for 1%. Tables and Figures are provided for characteristics of the spine-injured drivers and their accidents: gender, age group, crash location, speed limit, crash type, impact type, vehicle year, seatbelt use, Injury Severity Score, and days in hospital. *Discussion.* The biases in the dataset mean that there is no suitable comparison group. Nevertheless, data is given for three groups that provide some context: car drivers with an AIS2+ injury who did not have an AIS2+ spine injury, car drivers who did not have an AIS2+ injury, and a sample from the TARS database. (TARS refers to Traffic Accident Reporting System, that is, the accident reports that originate with the Police.) The hospitalisation characteristics show that this cohort/sample AIS2+ spine injury group is more seriously injured than other AIS2+ injured car drivers.

## KEYWORDS

Car drivers; Road accident injuries; Spinal injury; Injury severity; Vertebral fracture; Hospital length of stay

## Summary

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A database of car drivers discharged from the Royal Adelaide Hospital (RAH) between 1 July 2015 and 30 December 2017 following a road crash was used to identify those with and without a spine injury. The hospital information was supplemented with details of the crash, obtained from the Police and the road authority. This study's focus was those persons who had a spine injury coded at least 2 on the Abbreviated Injury Scale (AIS2+). This sample is from a single hospital, and there are several likely biases.

There were 518 car drivers with one or more AIS2+ injuries, of whom 152 had one or more AIS2+ spine injuries, mostly vertebral fractures. Of these 152, the maximum spine AIS score was 2 for 87%, 3 for 12%, and >3 for 1%.

Tables and Figures are provided for characteristics of the spine-injured drivers and their accidents: gender, age group, crash location, speed limit, crash type, impact type, vehicle year, seatbelt use, Injury Severity Score, and days in hospital.

The biases in the dataset mean that there is no suitable comparison group. Nevertheless, data is given for three groups that provide some context: car drivers with an AIS2+ injury who did not have an AIS2+ spine injury, car drivers who did not have an AIS2+ injury, and a sample from the TARS database. (TARS refers to Traffic Accident Reporting System, that is, the accident reports that originate with the Police.)

The hospitalisation characteristics show that in this cohort/sample AIS2+ spine injury group is more seriously injured overall than other AIS2+ injured car drivers.

We intend to prepare one or more reports on the locations in the spine of the injuries and comparisons within the AIS2+ spine group.

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# 1 Introduction

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This report is on car drivers who sustained a spinal injury with an Abbreviated Injury Scale score of 2 or more (AIS2+) in a road crash and were admitted to the Royal Adelaide Hospital. An AIS2+ spine injury includes fractures to vertebrae and spinal injury. The characteristics of the drivers, the crashes, and some aspects of the injuries, are described.

Spinal injury is a rare injury outcome from a motor vehicle crash. In an American dataset, 0.5% of restrained occupants in towaway crashes had an AIS2+ spinal injury (Bilston, Clarke, & Brown, 2011) and 0.85% of persons involved in a car crash in a German dataset had a spinal fracture (Müller et al., 2014).

A database of road users who were discharged from the Royal Adelaide Hospital (RAH) between 1 July 2015 and 30 December 2017 following a road crash was used to identify those with an AIS2+ spine injury. In it, hospital information has been supplemented with details of the crash, obtained from the Police and the road authority. The sample is from a single hospital, and several biases are likely (see Section 2). Drivers of car and car-like vehicles were sought from the database for the analysis.

Section 2 of this report is on methods and explanations. Section 3 gives the results. The first set of Tables concentrates on AIS2+ spine injuries; then there are further Tables concerned with spine-injured drivers' characteristics, which are given context by other groups of injured car drivers. The discussion (Section 4) is brief, as the purpose of this report is to describe the results.

Note that this report was substantially completed in April 2021 and does not consider developments after that date.

## 2 Methods

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For this study, a database of injured road users discharged from the Royal Adelaide Hospital (RAH) between 1 July 2015 and 30 December 2017 following a road crash was used. The database was created and maintained by one of the Authors (TL). Drivers of car and car-like vehicles in the database were included in the study. Generally, vehicle passengers were not included in the database, so their injuries could not be analysed. The hospital information was supplemented with details of the crash, obtained from the Police and the road authority. The focus of this study was those persons who had an AIS2+ spine injury.

Some details of the car drivers included in the study dataset are as follows.

- Car drivers included are those who remained in the hospital for four or more hours after being seen by a medical professional after a crash on a public road in South Australia. (Car includes sedans, hatchbacks, station wagons, utilities derived from sedans, and sports utility vehicles.)
- They were identified based on the International Classification of Diseases code (Australian Consortium for Classification Development, 2017). Information about these patients was obtained by reviewing their ambulance or medical emergency retrieval service (MedSTAR) reports, Emergency Department and hospital in-patient records.
- Using the medical and ambulance notes, injury was coded on the Abbreviated Injury Scale (AIS) according to the AIS 2005 codebook (Gennarelli & Wodzin, 2005). Not all persons have an injury which is codable. For example, 'pain' does not have an AIS code, but this may still require the care and treatment available at a hospital.
- Spine injury was defined as the AIS codes in the spine injury section of the AIS codebook. Injury to the sacrum and coccyx were excluded. Cervical, Thoracic and Lumbar injury were identified from the relevant subsection of the codebook.
- Injury region refers to other parts of the body, as in the AIS 2005 codebook.

Three other groups of drivers are considered to give some context to the AIS2+ spine group. Two of these groups are from the same database: those with an AIS2+ injury but not an AIS2+ spine injury, and those without an AIS2+ injury (that is, with an AIS 1 injury, or no codable injury). The third group was all drivers treated at or admitted to a hospital or killed due to a traffic accident in South Australia, obtained from the TARS database of crashes.

Based on road accident reports from the Police, DIT maintains the TARS database. (DIT is the South Australian Department for Infrastructure and Transport, and TARS is the Traffic Accident Reporting System.) The hospital records were supplemented with data from TARS with a manual matching process. The free text accident description, documented by Police who attended the crash, was compared with the notes in the hospital records.

Certain variables need a little explanation, as follows.

- Crash type was coded by the Police and DIT. If this information was unavailable, it was coded by the researchers using similar definitions, based on information available in the hospital records.
- The researchers coded impact type. Front impact was an impact that occurred at the front of the occupant's vehicle. Side impact was an impact to either side of the occupant's vehicle, which was coded as being on the side nearest the driver side, or on the passenger side. Vertical impact included impacts where there was a large vertical component to the loading, such as an impact with a culvert on the road, but without any other impact type. A multiple impact without rollover

was where there were several impacts from different directions, such as a rear-end and frontal impact in quick succession. Rollover: this implies there was no other crash event. Multiple with rollover was a crash involving the vehicle and some other object with a subsequent rollover.

- Arrival pathway: this refers to whether the patient arrives at the hospital by regular ambulance, by the dedicated retrieval service, be transferred from another hospital, self-present, or be otherwise unknown. Critical arrival refers to a transfer from another hospital or directly using the retrieval service. Standard arrival refers to an ambulance or any other method.
- The Injury Severity Score (ISS) is the sum of the squares of the three highest AIS scores in different body regions.
- The crash location was classified as Metro (Adelaide Metropolitan Area), Rural (within 100 km of Adelaide centre), or Rural (beyond 100 km of Adelaide centre).
- Days in hospital is approximately the number of nights spent in the hospital. Patients who spent less than 24 hours in hospital were recorded as having stayed zero days. The number of days may be the number of days in the hospital before death.

This sample is from a single hospital. There are several likely biases.

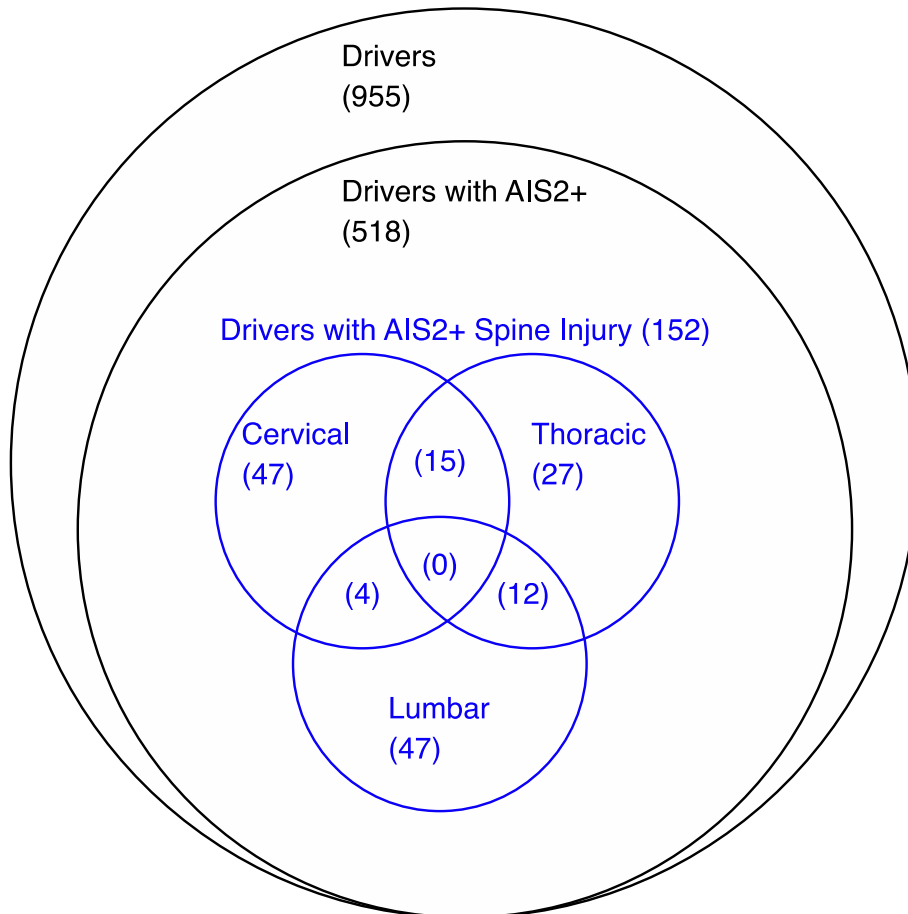
- The hospital is in the centre of the Adelaide metropolitan area. Casualties from suburban, rural, and remote areas are likely to go to a hospital closer to their crash, and consequently likely to be under-represented. Consequently, high-speed crashes are under-represented.
- The RAH is the sole referral centre for spine injury in South Australia. Most people with a significant AIS2+ spine injury will appear in the dataset.
- The RAH is a major hospital referral centre for South Australia, and anyone with significant injury is likely to come to it.

Consider a variable  $Z$  reflecting distance from the metropolitan area (distance affects the probability of AIS2+ injury, as crashes in rural and remote areas tend to be at higher speeds). Let  $X$  be a variable that we might want to tabulate (driver age or vehicle age might be examples). There is an AIS2+ spine injury sample and an AIS2+ other injury sample. The samples of  $X$  will be affected by (a) the proportions of cases in the different categories of  $Z$ , (b) the proportions in the different categories of  $X$  (given the category of  $Z$ ), (c) the effect of  $Z$  on the severity, and (d) the effect of  $Z$  on the probability that someone with an AIS2+ injury will get into the observed sample. In some respects, biases will operate similarly on the AIS2+ spine injury sample and the AIS2+ other injury sample. However, in respect of (d) it seems likely that  $Z$  has a stronger effect in the case of AIS2+ spine injury than in the case of AIS2+ other injury, as the RAH is the sole referral centre for spine injury. Consequently, the two groups are not truly comparable.

### 3 Results

Figure 3.1 shows there were 518 car drivers with one or more AIS2+ injuries, of whom 152 had one or more AIS2+ spine injuries. Figure 3.1 also identifies where on the spine the 152 drivers had their AIS2+ spine injury.

Figure 3.1  
Number of patients in the database of car drivers



The proportion having an AIS2+ spine injury is 29 per cent of all those with an AIS2+ injury: this is likely to be higher than it would be in a random sample of car drivers with an AIS2+ injury, as the RAH is the sole referral centre for spine injury.

Most of the results refer to the 152 AIS2+ spine injury cases. To begin with, though, Table 3.1 refers to the 518 car drivers and lists how many had an AIS2+ injury in each region of the body.



Table 3.1  
Number of persons with an AIS2+ injury in each body region

Location of spine injury	Number with this injury	Body region of other AIS2+ injuries, excluding spine injuries						
		Other injuries anywhere	Abdomen	Chest	External	Extremities	Face	Head & neck
Any spine injury	152	106	28	70	4	59	11	51
Cervical only	47	28	6	12	1	12	1	19
Thoracic only	27	20	4	16	1	12	4	7
Lumbar only	47	38	11	26	1	27	2	15
Cervical + Thoracic	15	9	2	5	1	3	2	7
Cervical + Lumbar	4	2	-	2	-	-	-	-
Thoracic + Lumbar	12	9	5	9	-	5	2	3
Cervical + Thoracic + Lumbar	-	-	-	-	-	-	-	-
No spine injury	366	366	40	164	15	179	20	144

Numbers of injuries to the three regions of the spine are also given in Table 3.1. Concerning AIS2+ injuries to two spinal regions, these occurred more frequently in adjacent regions (i.e. cervical and thoracic, or thoracic and lumbar). There were 15 people with AIS2+ injuries in the cervical and thoracic spine, 12 people with AIS2+ injuries in the thoracic and lumbar spine, and four people with AIS2+ injuries in the cervical and lumbar spine. No one had an AIS2+ injury in all three spinal regions.

AIS2+ spine injuries are largely vertebral fractures. Table 3.2 cross-tabulates the description of the injury with the part of the spine where it occurred and gives counts of injuries. Table 3.3 is similar, except that it gives counts of people.

Table 3.2  
The number of individually codable AIS2+ spine injuries in each spine section

Injury description	Cervical	Thoracic	Lumbar	Total injuries
Complete cord syndrome	-	1	-	1
Cord contusion	6	2	3	11
Fracture - Vertebral body	17	60	36	113
Fracture - Transverse process	14	14	52	80
Fracture - Multiple	21	5	14	40
Fracture - Spinous process	13	4	3	20
Fracture - Facet	14	4	-	18
Fracture - Pedicle	6	1	-	7
Fracture - Lamina	5	-	-	5
Fracture - Odontoid	4	-	-	4
Fracture - NFS	5	1	1	7
Dislocation	2	5	-	7
Disc injury	3	-	1	4
Brachial Plexus injury	2	-	-	2
<b>Total</b>	<b>112</b>	<b>97</b>	<b>110</b>	<b>319</b>

Table 3.3  
The number of persons with an AIS2+ spine injury in each spine section

Injury description	Cervical	Thoracic	Lumbar	Persons
Complete cord syndrome	-	-	1	1
Cord contusion	5	2	2	7
Fracture - Vertebral body	14	28	38	73
Fracture - Transverse process	11	23	9	39
Fracture - Multiple	15	9	5	27
Fracture - Spinous process	8	3	3	14
Fracture - Facet	11	-	3	14
Fracture - Pedicle	6	-	1	7
Fracture - Lamina	4	-	-	4
Fracture - Odontoid	4	-	-	4
Fracture - NFS	4	1	1	6
Dislocation	2	-	1	3
Disc injury	3	1	-	4
Brachial Plexus injury	2	-	-	2
Persons	66	54	63	152

Eight patients had a neurological deficit (complete cord syndrome, or cord contusion with or without fracture). This is 5.2% of all AIS2+ spine injured patients. Of the eight patients, one had three distinct neurological injuries and two each had two distinct neurological injuries.

Of the 152 patients, 133 (87.5%) had maximum spine AIS score of 2, 18 (11.8%) had a maximum spine AIS score of 3, and one (0.7%) had a maximum spine AIS of 5. The injuries with AIS score 3 or more are shown in Table 3.4.

Table 3.4  
Injuries with an AIS severity of 3 or greater

Injury description	Number	Spine location	Relevant AIS codes
Complete cord syndrome	1	T10	640420.5
Cord contusion	11	C2, C3, C5, C6, C7 T1, T2, L1 L4, L5	640200.3, 640204.3, 640208.3 640400.3 640604.3, 640600.3
Fracture - Vertebral body with greater than 20% loss of height	7	T5, T6, T8, T10 L1×2, L2	650434.3 650634.3
Fracture - Odontoid	4	C2×4	650228.3
Disc injury	1	C7	650205.3

Table 3.5 shows the total number of AIS2+ injuries per person for those with at least one AIS2+ spine injury.

Table 3.5  
Number of AIS2+ injuries per person from those with an AIS2+ spine injury

Number of codable injuries	Number of persons
1	69
2	38
3	25
4	11
5	4
6	2
7	2
9	1

Tables 3.1-3.5 have concentrated on AIS2+ spine injuries. The following Tables concern the characteristics of the injured people, their crashes, and the pathway of their hospital arrival.

The biases in the dataset (see section 2) mean that no group can adequately be used for comparison with the 152 car drivers in the AIS2+ spine injury group. However, data is given for three groups that provide some context: the 366 car drivers with an AIS2+ injury who did not have an AIS2+ spine injury, the 437 car drivers who did not have an AIS2+ injury, and a sample from the TARS database. In the TARS database, 9414 car drivers were either treated at a hospital (86.6%), admitted to hospital (11.7%), or killed (1.7%) between 1 July 2014 and 31 December 2017. (The definitions of injury severity, in particular of admitted to hospital, differ from those used elsewhere in this report.)

Table 3.6 shows the personal characteristics of the AIS2+ spine group, and also the three other groups. Counts are on the left side of the table, and percentages on the right side. The AIS2+ spine injury group of drivers has a slightly lower proportion of young people and a slightly higher proportion of older people than the other groups.

Table 3.6  
Personal characteristics

Grouping	Number				Column percentage			
	Hospital data source			TARS	Hospital data source			TARS
	AIS2+ spine injury	Other AIS2+ injury	Minor or no injury		AIS2+ spine injury	Other AIS2+ injury	Minor or no injury	
<b>Gender</b>								
Female	75	154	189	4,947	49	42	43	53
Male	77	212	248	4,454	51	58	57	47
<b>Age group</b>								
<16	-	-	-	11	-	-	-	0
16-19	7	31	26	916	5	9	6	10
20-29	24	79	104	2,333	16	22	24	25
30-39	24	46	72	1,604	16	13	17	17
40-49	21	58	61	1,356	14	16	14	14
50-59	20	50	56	1,129	13	14	13	12
60-69	18	31	43	865	12	9	10	9
70-79	16	33	38	617	11	9	9	7
80 or more	22	38	37	457	15	10	9	5
Unknown	-	-	-	126	-	-	-	1

Tables 3.7 and 3.8 show the crash characteristics of the AIS2+ spine group and the three other groups. Counts are on the left side of the tables, and percentages on the right side. As expected from the biases of the AIS2+ spine injury group, they come from further away and had higher speed roads than the other groups. The proportions of crash types are also somewhat different.

Table 3.7  
Crash characteristics

Grouping	Number				Column percentage			
	Hospital data source			TARS	Hospital data source			TARS
	AIS2+ spine injury	Other AIS2+ injury	Minor or no injury		AIS2+ spine injury	Other AIS2+ injury	Minor or no injury	
<b>Crash location*</b>								
Metro	52	164	313	6,913	34	45	72	73
Rural <100km	50	123	86		33	34	20	
Rural >100km	46	74	36		30	20	8	
Unknown	4	5	2		3	1	1	
<b>Speed limit</b>								
10-50	18	66	82	1,795	12	18	19	19
60-70	39	117	222	4,199	26	32	51	45
80-90	29	57	40	1,446	19	16	9	15
100-110	63	111	67	1,974	41	30	15	21
Unknown	3	15	26	-	2	4	6	-
<b>Police-coded crash type</b>								
Head on	19	49	28	502	13	13	6	5
Hit animal	1	0	2	58	1	0	1	1
Hit fixed object	58	145	104	2,122	38	40	24	23
Hit object on road	0	2	1	26	0	1	0	0
Hit parked vehicle	2	21	28	447	1	6	6	5
Hit pedestrian	-	-	-	14				0
Left road - out of control	2	3	3	87	1	1	1	1
Other	0	2	0	16	0	1	0	0
Rear end	12	26	72	2,132	8	7	17	23
Right angle	20	64	98	2,097	13	18	22	22
Right turn	12	29	49	988	8	8	11	11
Roll over	22	17	21	486	15	5	5	5
Side swipe	3	7	30	439	2	2	7	5
Unknown	1	1	1	-	1	0	0	-

\* A suitable comparison does not exist in TARS. In TARS there were 200 (2.1%) from inner Adelaide, 6713 (71.3%) from outer Adelaide, and 2501 (26.6%) from outside Adelaide.

Table 3.8  
Crash characteristics

Grouping	Number				Column percentage			
	Hospital data source			TARS	Hospital data source			TARS
	AIS2+ spine injury	Other AIS2+ injury	Minor or no injury		AIS2+ spine injury	Other AIS2+ injury	Minor or no injury	
<b>Impact type</b>								
Passenger side	6	19			4	5		
Front	55	175			36	48		
Driver side	18	49			12	13		
Multiple no rollover	11	23			7	6		
Multiple with rollover	22	37			15	10		
Rollover	19	17			13	5		
Rear	4	3			3	1		
Vertical	3	1			2	0		
Indeterminate	14	42			9	12		
<b>Vehicle year</b>								
1931-1980	2	3	2	29	1	1	1	0
1981-1990	11	14	14	286	7	4	3	3
1991-1995	14	44	47	771	9	12	11	8
1996-2000	20	90	76	1,798	13	25	17	19
2001-2005	43	82	102	2,404	28	22	23	26
2006-2010	31	60	87	2,117	20	16	20	23
2011-2015	24	53	72	1,774	16	15	17	19
2016-2020	0	3	3	160	0	1	1	2
Unavailable	7	17	34	75	5	5	8	1
<b>Seatbelt use</b>								
No	11	36	21	204	7	10	5	2
Unknown	22	34	33	1,268	15	9	8	14
Yes	119	296	383	7,942	78	81	88	84

Table 3.9 and Figures 3.2 and 3.3 refer to hospitalisation characteristics.

- The arrival pathway of the patients is shown in Table 3.9.
- The cumulative distribution of ISS is shown in Figure 3.2. Those with an AIS2+ spinal injury tended to have a higher ISS (median = 12) than those with another AIS2+ injury (median = 8), or those with a minor or no injury (median = 1).
- The cumulative distribution of the number of days spent in hospital is shown in Figure 3.3. Those with an AIS2+ spinal injury tended to have a more extended stay (median = 9 days) than those with another AIS2+ injury (median = 4 days) or those with minor injury (median = 0 days).

Table 3.9  
Arrival pathway

Pathway	Number			Column percentage		
	AIS2+ spine injury	Other AIS2+ injury	Minor or no injury	AIS2+ spine injury	Other AIS2+ injury	Minor or no injury
From another hospital or medically retrieved directly to the hospital	84	147	64	55	40	15
Standard	68	219	373	45	60	85

Figure 3.2  
Cumulative distribution of injury severity score (ISS) for each injury group

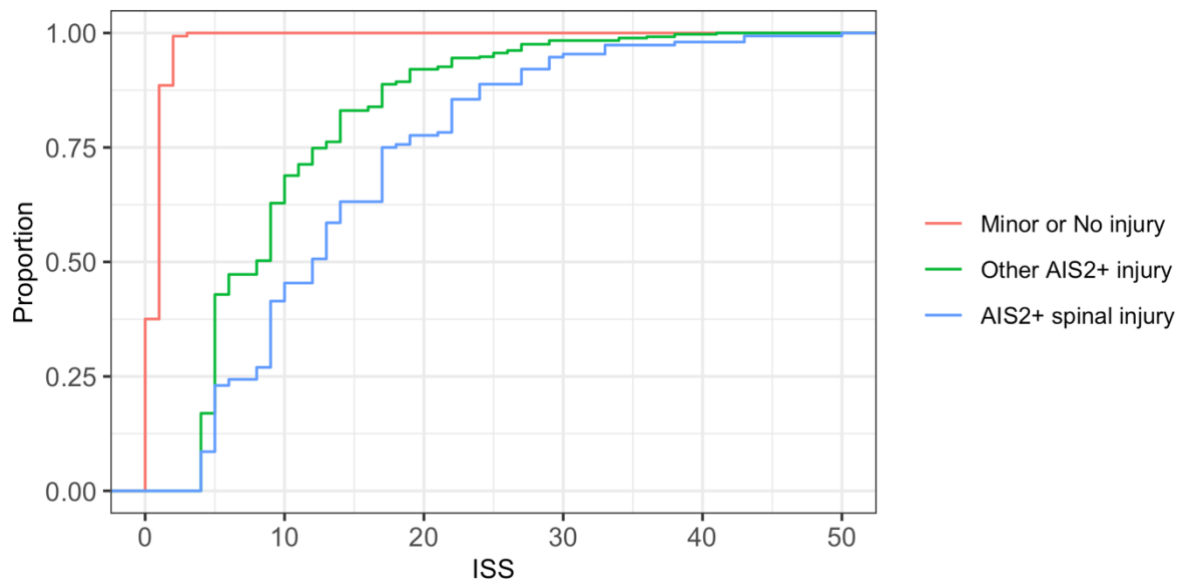
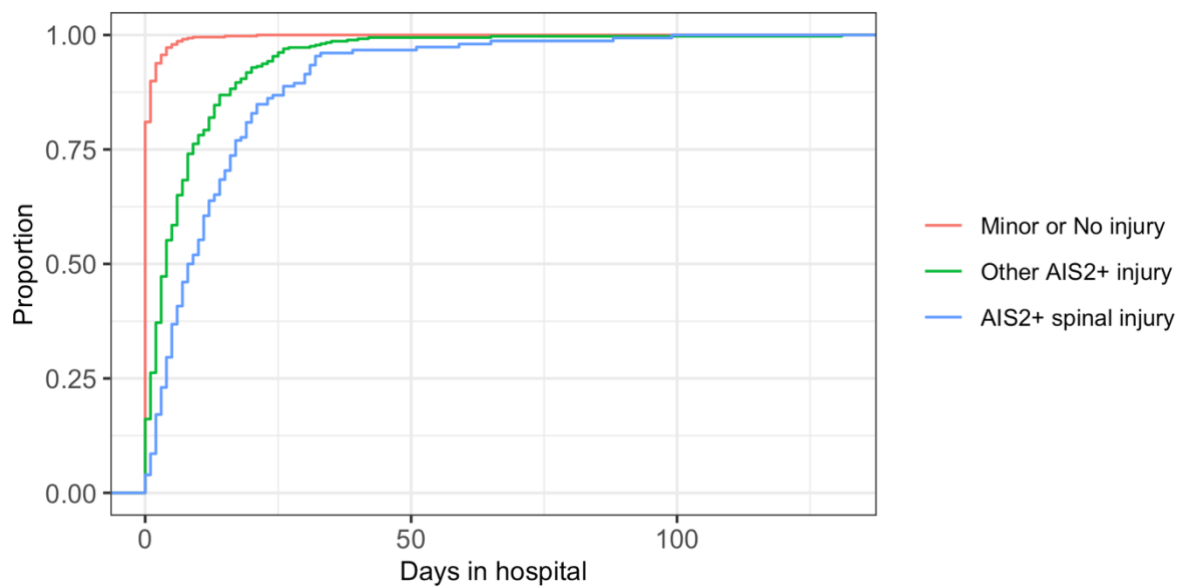


Figure 3.3  
Cumulative distribution of the number of days spent in the Royal Adelaide Hospital for each injury group



## 4 Discussion

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Characteristics of the AIS2+ spine injury group are reported in the Results section above. The group differs from what would be expected of general samples of injured car drivers in ways consistent with the biases in its collection: many of the casualties came from outside the Adelaide metro area and had been injured on high-speed roads. The characteristics of the drivers and the crashes reflect this.

Tables 3.1-3.5 give information about the injuries of car drivers who had an AIS2+ spine injury.

- Table 3.1 shows the numbers of persons having AIS2+ injuries in other regions of the body.
- Table 3.2 shows the numbers of different spine injuries in each region of the spine, and Table 3.3 is the corresponding count of persons.
- Table 3.4 gives some information about the (relatively uncommon) spine injuries having an AIS code of 3 or greater.
- Table 3.5 shows how frequent, or infrequent, are multiple AIS2+ injuries.

The Results section then gives some characteristics of the spine-injured drivers and their accidents: gender, age group, crash location, speed limit, crash type, impact type, vehicle year, seatbelt use, Injury Severity Score, and days in hospital. The biases in the dataset mean that there is no suitable comparison group. Nevertheless, data is given for three groups that provide some context: car drivers with an AIS2+ injury who did not have an AIS2+ spine injury, car drivers who did not have an AIS2+ injury, and a sample from the TARS database.

- Table 3.6. The AIS2+ spine injury group of drivers has a slightly lower proportion of young people and a slightly higher proportion of older people than the other groups.
- Tables 3.7 and 3.8. The AIS2+ spine injury group come from further away and from higher speed roads than the other groups. The proportions of crash types are somewhat different, also.
- Table 3.9, Figure 3.2, and Figure 3.3. The AIS2+ spine injury group tended to have a higher Injury Severity Score and a longer stay in hospital than those with another AIS2+ injury.

The hospitalisation characteristics show that the AIS2+ spine injury group is more seriously injured overall (at least as regards terms of ISS and length of stay in hospital) than other AIS2+ injured car drivers at the RAH.

We intend to prepare one or more further reports, on the locations in the spine of the injuries and on comparisons within the AIS2+ spine group.

## Acknowledgements

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

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.

Dr Jeffrey Dutschke is currently an Accident Analyst at Hall Technical. The majority of the technical work for this report was done while he was employed at the Centre for Automotive Safety Research.

Dr Claire Jones is Senior Research Fellow in the Centre for Orthopaedics and Trauma Research - Adelaide Medical School and the School of Mechanical Engineering, The University of Adelaide.



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