THE UNIVERSITY of ADELAIDE

CASR134 - January 2016

LN Wundersitz, SD Doecke, SJ Raftery, JE Harrison

Centre for Automotive Safety Research

Quad bikes in South Australia: an investigation of their use, crash characteristics and associated injury risks

CENTRE FOR AUTOMOTIVE SAFETY RESEARCH

THE UNIVERSITY of ADELAIDE

Quad bikes in South Australia: an investigation of their use, crash characteristics and associated injury risks

LN Wundersitz, SD Doecke, SJ Raftery, JE Harrison

CASR REPORT SERIES

CASR134

January 2016

Report documentation

REPORT NO.	DATE	PAGES	ISBN	ISSN
CASR134	January 2016	101	978 1 921645 72 3	1449-2237

TITLE

Quad bikes in South Australia: an investigation of their use, crash characteristics and associated injury risks

AUTHORS

LN Wundersitz*, SD Doecke*, SJ Raftery*, JE Harrison**

PERFORMING ORGANISATION

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

Research Centre for Injury Studies**
Flinders University
GPO Box 2100
Adelaide SA 5001
AUSTRALIA

SPONSORED BY

SafeWork SA
GPO Box 465
Adelaide SA 5001
AUSTRALIA

AVAILABLE FROM

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

ABSTRACT

Quad bikes are a leading cause of death and serious injury on Australian farms. This study provides important insights regarding quad bike use and the circumstances surrounding incidents that occur as a result of their use. It also identifies high risk uses and examines the severity and type of injury sustained by quad bike riders. This was achieved by drawing on a variety of existing data sources including ReturnToWork SA workers' compensation claims data, national hospital admissions data and the National Coronial Information System (NCIS). In addition, unique in-depth data concerning quad bike use and incidents were obtained through interviews with agricultural workers and patients admitted to hospital following a quad bike-related incident. Inspections of the quad bike and location of the incident were conducted, where possible. Together, the findings from these complementary data sources provide a detailed but complex picture of quad bike use and associated injuries in South Australia. Findings from this study are discussed within the framework of the hierarchy of controls, to assist in the development and implementation of engineering, regulatory and behavioural solutions that might reduce quad bike-related injuries in the agricultural sector.

KEYWORDS

Work health and safety, occupational health and safety, workers compensation claims, claim severity

© The University of Adelaide 2016
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.

Executive Summary

Quad bikes are a leading cause of death and serious injury on Australian farms. The aim of this project was to understand quad bike use and the complex circumstances surrounding incidents that occur as a result of their use. In particular the project identified high risk uses and why quad bikes are chosen for these applications. The severity and type of injury sustained by quad bike riders was also investigated. A wide variety of data sources were examined to capture a detailed picture of quad bike-related trauma in South Australia.

This report is comprised of four separate but complementary studies:

1. An analysis of quad bike-related workers' compensation claims in South Australia

2. Characteristics of quad bike-related fatalities in South Australia

3. Identification of quad bike injury in hospital admissions

4. In-depth analysis of quad bike use and incidents in South Australia

1. AN ANALYSIS OF QUAD BIKE-RELATED WORKERS' COMPENSATION CLAIMS IN SOUTH AUSTRALIA

This study involved the first analysis of work-related injury claims for quad bike-related injuries in South Australia. The ReturnToWork SA workers' compensation scheme claims database, provided by SafeWork SA, was examined to provide an estimate of the number of work-related injury claims associated with quad bikes, describe the circumstances surrounding each incident and understand the nature of injuries sustained.

From 2001 to 2013, 199 injuries to workers arising from a quad bike-related incident were identified within the workers' compensation data in South Australia, costing approximately $5.6 million. Note that the number of quad-related work injuries in the workers' compensation records will be an underestimate due to a high level of self employment in agriculture.

While workers' compensation data is primarily designed for administrative purposes rather than assisting injury prevention, some general information regarding worker demographics, incident details and type and nature of injury was obtained for quad-related worker claims:

- Quad bike-related injuries were most commonly reported for workers in regional and remote South Australia (82%), male workers (83%), workers aged 15-29 years (34%), and with incidents occurring late morning (10-11am; 25%).
- Worker quad-related injuries predominantly occurred within the 'Agriculture, Forestry and Fishing' industry (69%). Within the agricultural industry, dairy cattle farming and grape growing accounted for more than half (55%) of all injuries involving a quad bike.
- The most common primary mechanisms of injury for workers using a quad were striking an object on the ground (20%), mounting or dismounting the quad (12%), falling off (11%), and injuries or strains from riding (10%).
- The most common injury types were strains to the muscles, joints or tendons (33%), fractures (20%), and contusions (12%). Strains to the muscles, joints, or tendons had the highest total expenditure, while dislocations were found to have the highest median compensation expenditure.

- Upper limbs (29%), the trunk area (23%) and lower limbs (22%) were the most common body regions for injuries involving a quad. Specific body parts that were most commonly injured and attracted the highest expenditure were the back (16%) and shoulder (10%).

- Inspection of worker and employer descriptions found 20% of worker injuries involved a quad rolling over. Fractures accounted for 40% of worker injuries inflicted during rollovers, most commonly occurring in the back (60%).

- The activity undertaken at the time of the incident was not specifically coded but analysis of incident descriptions revealed 56 (28%) cases in which the worker was mustering or checking livestock when the injury occurred. Common mechanisms of quad-related injury while chasing livestock involved striking an object on the ground (34%) and striking other objects such as a bush or fence (14%). The most common types of injuries were fractures to the wrist, strains to muscles in the shoulder and back, and dislocations to the shoulder.

These findings provide the first valuable insight into worker injuries involving a quad bike in South Australia. The data used in this study included general information concerning the injury event but narrative descriptions of the event were usually brief and gave little information about the sequence of events, details about the quad bike or causal factors. In-depth studies that investigate the complex sequence of events that lead to the worker injuries and any contributing circumstances would be most valuable to further assist quad-related injury prevention.

2. CHARACTERISTICS OF QUAD BIKE-RELATED FATALITIES IN SOUTH AUSTRALIA

Quad bikes are the leading cause of deaths on Australian farms. According to data recorded by Safe Work Australia, there were 75 quad-related deaths from 2011 to 2014 in Australia, an average of 18.8 fatalities per year. In order to reduce the increasing number of quad-related deaths there is a need to understand the circumstances surrounding these incidents.

Coroner's closed case records from the National Coronial Information System (NCIS) for all Australian quad bike fatalities were examined to provide detailed information about the factors contributing to quad bike incidents and the resulting fatal injuries. The characteristics of the incident, rider, associated injuries and the quad bike for fatalities in South Australia were compared to those for the rest of Australia to determine whether certain factors were more evident in South Australia. This study is distinguished from earlier Australian studies examining fatal cases as it includes all fatalities involving an adult size quad (even those occurring on roads) and has a focus on behavioural factors including alcohol and drug use, carrying passengers, and helmet use.

A total of 161 fatalities in Australia from 2000 to 2014 resulting from the use of adult size quads were examined. Of these, eight fatalities were in South Australia. Overall, within this sample:

- Quad fatalities predominantly occurred on farms (59%), in off-road environments (75%), during daylight hours (73%) and were more likely to be recreational (63%) than work-related.

- Riders killed in quad-related incidents were more likely to be male (83%) and aged over 60 years (27%) which is likely to reflect the demographic profile for agricultural workers.

- Of those with known test results, 28% of quad fatalities tested positive for alcohol and 12% positive for drugs. Alcohol was predominantly associated with recreational incidents.

- More than half (56%) of all quad fatalities involved the quad rolling over resulting in many riders being pinned under the quad during the incident. Riders on quads that rolled over were most likely to incur injuries resulting from crush while riders on quads that did not roll over were more likely to incur injuries from contact with an object or the ground. Rollovers also occurred more frequently when carrying a load (67%) and when travelling on a slope (61%).

While many factors associated with quad fatalities in Australia were also evident in South Australia, there were a number of specific issues that were particularly salient for South Australia: children on quads, carrying passengers and loads and helmet use.

- 16% of Australian quad fatalities were children aged under 16 years. In South Australia, half of the fatalities (n=4) were children and three fatalities were older riders aged 60 years and over.

- 22% of all quad fatalities were carrying passengers. Seven of the eight quad fatal incidents in South Australia involved the carriage of passengers; three of these occurred as a direct result of passenger behaviour. All of the quad incidents in South Australia involved carrying a load, compared to 35% of all quad fatalities.

- None of the South Australian quad fatalities was wearing a helmet and five of the eight fatalities not wearing a helmet suffered a head injury. Of those with known helmet status, 14% of all quad fatalities were wearing a helmet.

3. IDENTIFICATION OF QUAD BIKE INJURY IN HOSPITAL ADMISSIONS

The study was concerned with identifying and describing injuries involving a quad bike, particularly those arising in the context of farming. Data on patients admitted to hospitals in Australia were examined. The records included are episodes in hospital that ended in the period 1 July 2002 to 30 June 2013.

Good identification of relevant cases was not achieved. This is partly due to limitations of the classification system used to specify the types of vehicles involved in injury cases, the Australian Modification of the 10th revision of the International Classification of Diseases (ICD-10-AM). That limitation is explained partly by the diversity of types of quad bikes and similar all-terrain vehicles, their uses and the terms used to refer to them.

A focus of the project was quad bikes in farming and other agricultural activities. ICD-10-AM includes categories designed to specify cases involving predominantly agricultural vehicles and machinery. However, it is probable that most cases coded to them do not involve a quad bike and it was concluded that these categories could not be used. Certain other categories include vehicles with some similarity to quad bikes (e.g. “four-wheel drive motorcycle”; “quad-cycle registrable for on-road use”). However, other types of vehicle can also be coded to the categories and coder advice was that quad bike cases would more likely be coded elsewhere.

The category to which quad bike cases are thought most likely to be coded is occupant of special all-terrain or other motor vehicle designed primarily for off-road use, injured in transport accident (ICD-10-AM V86). In data for the period reported here, a 5th character records the number of wheels (2, 3, 4 or unspecified). Records with code V86 and the 5th digit value of 2, meaning 4 wheels, are designated here as V86.n2.

Other studies have tended to include as quad bike cases all records with code V86.n2. This study examined this set of records using other data, particularly the ICD-10-AM classifications of “place of occurrence” and “activity when injured”. It was found in many V86.n2 cases that the activity was playing golf, go-carting, or other things that suggested that the vehicle was not a quad bike.

Furthermore, over half of the V86.n2 cases had unspecified activity. It was concluded that it is not safe to assume that V86.n2 cases involved a quad bike.

Based on the advice of senior clinical coders, it is thought that most quad bike cases are coded to V86.n2. However, a set including all V86.n2 is likely to overestimate quad bike cases, perhaps by a large margin. This study provides brief summary statistics on this set of cases, which includes nearly 8,000 cases in Australia over 11 years.

Two subsets of V86.n2 cases may be more likely than others to have involved a quad bike. One is the subset of V86.n2 cases for which the activity when injured was coded as driving an all-terrain vehicle (ICD-10-AM code U65.0). The other is V86.n2 cases that occurred on a farm in the course of working for income. These subsets of V86.n2 cases are thought to be fairly specific to quad bikes but not sensitive. Despite remaining uncertainty about included vehicles, this set is referred to as “quad bike cases”. The set includes 1,236 cases over 11 years who were mainly males (81%), aged 35 years and older (55%). Nearly all cases occurred off road (94%) and most resulted in fractures (58%). The body parts most often injured were head and neck (24% of cases), trunk (27%) and upper limbs (28%).

In conclusion, hospital admitted patient data were examined and were found to provide an unsatisfactory basis for quantifying admitted injury cases of quad bike users. A set of hospital admitted injury records could not be selected in which there was confidence it was both specific to quad bike cases and includes all, or nearly all, of them. A study design is described that would provide a better basis for selecting hospital admitted cases that involved a quad bike.

4. IN-DEPTH ANALYSIS OF QUAD BIKE USE AND INCIDENTS IN SOUTH AUSTRALIA

This study aimed to identify the different quad bike uses among agricultural workers, determine why quad bikes were chosen for these applications, and to investigate in-depth the complex circumstances surrounding any incidents that occurred as a result of their use. The severity and type of injuries sustained by quad bike riders was also examined.

Individual face-to-face interviews were conducted with agricultural workers from a variety of industries in South Australia who ride a quad bike for work purposes. Follow up interviews were also conducted with riders admitted to the Royal Adelaide Hospital following a quad bike incident. In addition to the interview, the quad was inspected to determine its mechanical condition and the site of the incident visited to measure the slope of the terrain and take photographs. A total of 46 interviews with agricultural workers who used a quad bike were conducted, of which six were identified from the Royal Adelaide Hospital admissions. Exactly half of the riders experienced a quad bike incident.

The findings from this study showed that quad bikes were used across a wide range of agricultural industries in South Australia. The typical terrain of the properties in which they were used varied considerably. The quad bikes are used for many different agricultural tasks including mustering, transport and spraying weeds. More than three quarters of all riders felt that quad bikes are safe but this proportion decreased for those who had an incident (68%), especially if they had attended hospital as a result of the incident (46%). The riders thought the most common cause of all quad incidents was related to inexperience or a lack of ability, yet none stated this as a cause of their own incidents. Chasing livestock or mustering was perceived to be the most risky task, and it was the most common task being undertaken when an incident occurred. Factors linked to incidents while mustering included divided attention, speed, taking the quad onto unsuitable terrain, unpredictable animal movements, and quick, sharp turning movements of the quad.

The quad bikes were found to generally be in good condition though many of the tyres of the quads were not inflated to the correct pressure. Independent rear suspension was present in 20% of quad bikes that were examined. Most riders carried loads of some form on their quad and this was a reason some stated for purchasing a quad. While many of the loads carried on the front were very light and probably of little rollover stability consequence, the loads carried on the rear tended to be quite heavy. Despite only one of the quads used by the riders being designed to carry passengers, three quarters of the riders admitted that they carry passengers on the quad, though this was not a common occurrence.

The quad rolled over in the majority of the incidents and the main source of injury was the quad striking the rider. The most severe type of rollover was when the quad rolled backwards. In this study, all backwards rollovers involved a very steep slope.

A total of 44% of riders allow children aged under 16 years to ride quad bikes either as riders or passengers and half of these children were permitted to operate the quad. It is not clear whether those interviewed appreciated the risks but there appeared to be a perception that the risks were mitigated by placing conditions or restrictions on children's use of the quads.

Recreation was over-represented as an activity being undertaken when an incident occurred, as the quad bikes were reportedly used very rarely for recreation. While this is not directly a workplace health and safety issue, the quad that is being used primarily for work tasks is then also being used for recreational purposes. The average travel speed and reported speed when the incident occurred were generally low, with three quarters occurring at speeds at or below 20 km/h.

RECOMMENDATIONS

Based on the findings from this report and other literature, the following recommendations concerning quad bikes are suggested. It is acknowledged that some of the recommendations extend beyond Safe Work SA's direct responsibilities.

- Explore options to increase the use and purchase of safer side-by-side vehicles.
- Consider ways to encourage quad riders to purchase, and manufacturers to fit, quads with independent rear suspension.
- Consider regulations that restrict children under 16 years from riding adult size quads.
- Rider training should focus on: giving guidance in eliminating hazards from the environment, emphasize the importance of choosing the safest action such as selecting the right vehicle for the right job, restrict or ban riding in risky areas or in certain conditions, and promote the wearing of personal protective equipment including helmets.
- Develop public education campaigns to promote quad safety; promote awareness of possible criminal liability if a business has not reasonably undertaken all safety obligations and draw on emotional appeals that relay the wider effects and costs of quad-related injuries on families and communities. Campaigns might also increase awareness that quad incidents can happen to anyone, even experienced riders.
- Continue to aim preventative measures at farming as this is where most quad incidents occur (recreational and work-related).
- Develop a helmet that provides maximum head protection for travel speeds compatible with quad bikes but also accommodates the needs of workers riding quads.
- Develop a standardised form to investigate all quad bike and side-by-side fatalities.
- Continue the in-depth analyses of quad-related crashes following hospital admission at the Royal Adelaide Hospital to foster a greater understanding of non-fatal quad-related incidents.

Contents

1 Introduction

A quad bike is a motorised vehicle with four wheels designed for off-road use that has a central seat designed to be straddled by the rider, handle bars for steering control, individual hand operated levers for front and rear brake control (foot for rear only) and a hand operated throttle. A side-by-side vehicle (SSV) is similar type of off-road vehicle that has more similarities to a car than a motorbike. A SSV has two or side-by-side seats, a steering wheel, a brake pedal that operates all brakes, a throttle pedal and seat belts. They are commonly fitted with a roll cage and a rear cargo tray.

The number of quad bikes available in Australia, and internationally has increased substantially over the last decade. It is estimated that within Australia, there were approximately 270,000 quad bikes in use in 2010 (Australian ATV Distributors, 2010). Rural agricultural communities have welcomed quad bikes with an estimated 80% of farm enterprises in Australia reporting using at least one quad on the property (Lower, Fragar, & Temperley, 2011). While also popular in the United States, their use has predominantly centred on recreational activities.

In recent years it has become increasingly evident that the use of quad bikes is resulting in a considerable number of deaths and injuries in Australia and New Zealand (Fragar, Pollock, & Morton, 2007; Milosavljevic et al., 2011; Morton, Fragar, & Pollock, 2009; Rechnitzer, Grzebieta, McIntosh, & Simmons, 2013) and internationally (Helmkamp, Biddle, Marsh, & Campbell, 2012; Topping & Garland, 2015; Vanlaar et al., 2015). More than 219 Australians have died from quad-related injuries since 2001 (Personal Communication, Australian Centre for Agricultural Health and Safety) and quad bikes are the leading cause of non-intentional deaths on farms (Lower & Herde, 2012).

Such quad bike trauma has a significant economic impact on Australian society. The total economic cost of quad-related fatalities in Australia from 2001 to 2010 has been estimated at $288 million or an average of $2.3 million per death (Lower, Pollock, & Herde, 2013). The most serious incidents involving quad bikes occur in agricultural settings (Fragar et al. 2007, Rechnizter et al. 2013) with quad bikes reported to cause more than twice as many on-farm deaths than any other type of farm vehicle and 13% of all on-farm deaths (2001-2004) (Morton et al. 2009).

All farming enterprises, including family farms and sole operators, come under the *Commonwealth Work Health and Safety Act (2011)* which states that they have a duty to identify and manage foreseeable risks on their enterprise. Quad bikes are defined as plant equipment on a farming enterprise and have been identified as requiring special monitoring by national and state workplace health and safety authorities (see Safe Work Australia, 2015).

The aim of this project was to understand quad bike use and the complex circumstances surrounding incidents that occur as a result of their use. In particular the project identified high risk uses and why quad bikes are chosen for these applications. The severity and type of injury sustained by quad bike riders was also investigated. A wide variety of data sources were examined to capture a detailed picture of quad-related trauma in South Australia.

This report is comprised of four separate but complementary studies:

1. An analysis of quad bike-related workers' compensation claims in South Australia

2. Characteristics of quad bike-related fatalities in South Australia

3. Identification of quad bike injury in hospital admissions

4. In-depth analysis of quad bike use and incidents in South Australia

With respect to terminology, quad bikes are also known as “All Terrain Vehicles” (ATVs) or “four wheelers”. The use of the term “All Terrain Vehicle” for a quad bike has been criticised. Coroners in Australia and New Zealand stated that the term was misleading as it implies they are suitable for use on all terrain yet they are prone to roll over in certain terrain. In this report, the vehicles will be referred to as “quad bikes” or “quads”.

Findings from this project are discussed within the framework of the hierarchy of controls, to assist in the development and implementation of engineering, regulatory and behavioural solutions that might reduce quad bike-related injuries in the agricultural sector.

2 An analysis of quad bike-related workers' compensation claims in South Australia

2.1 Introduction

Quad bikes are increasingly popular and invaluable vehicles in agriculture and other occupational settings but are now a leading cause of death and serious injuries on Australian farms (Lower & Herde, 2012). The total economic cost of quad-related fatalities in Australia from 2001 to 2010 has been estimated at $288.1 million or an average of $2.3 million per death, using a human capital approach (Lower et al., 2013).

While some research from overseas (Helmkamp, Marsh, & Aitken, 2011) and Australia (e.g. Grzebieta et al., 2015; Lower, Herde, & Fragar, 2012; Morton et al., 2009) has identified work-related fatalities involving a quad bike, less information is readily available concerning work-related injuries. For example, a study (Lower et al., 2012) examining quad bike-related deaths in Australia from 2001 to 2010 found that approximately 45% were considered work-related and the majority of these occurred on farms. Another study examined Victorian quad bike-related injuries and fatalities from a variety of data sources (Clapperton, Herde, & Lower, 2013). Interestingly, 53% of fatalities were found to be work-related compared to 18% of hospital admissions and 15% of emergency department presentations. Other studies that have used hospital admissions data to examine quad-related injuries have found that there was insufficient information to identify or examine the circumstances of work-related injuries (Worksafe Victoria, 2009; Wood, Duijff, & Christey, 2013).

Workers' compensation claims data offer an alternative means of understanding work-related injuries incurred when riding a quad bike. A study estimated that quad-related incidents on New Zealand farms caused 850 injury claims in 2000/2001 (Moore & Bentley, 2004). More recently, a study examining New Zealand Department of Labour data from 2000 to 2008 identified 355 quad-related incidents resulting in serious harm (i.e. hospitalised for 48hrs or more) as a result of work activities (Shulruf & Balemi, 2010). This total included 45 cases resulting in a fatality. Circumstances where injuries were more likely to occur were those that involved children under 10 years of age, a 4WD quad, riding on a sealed road, riding downward or backward and rolling sidewards.

Previous researchers in Australia have noted that "*Information on quad injury is not readily available from workers' compensation data as all motorcycle claims are grouped together as a subcategory under 'Mobile plant and transport'* (Fragar et al., 2007)*"*. Nevertheless, current database search mechanisms permit identification of quad-related workers' compensation cases with the use of free text fields. At the same time that this present study was undertaken, researchers in NSW examined quad bike-related worker injuries from the ReturnToWork NSW workers' compensation scheme claims database (Mitchell, Grzebieta, & Rechnitzer, 2015). They identified 232 injury cases (including three fatalities) over an eight year period from 2003 to 2011.

The aim of this study was to examine workers' compensation claims in South Australia to provide an estimate of the number of work-related injury claims associated with quad bikes, describe the circumstances surrounding the incident and understand the nature of injuries sustained.

2.2 Method

2.2.1 ReturnToWork SA workers' compensation scheme claims data

The ReturnToWork SA workers' compensation scheme claims database contains information for all work-related injury claims of workers employed in South Australia. Information recorded in the database includes details of the cause, nature, and treatment (including costs and rehabilitation time) of injuries for claimants and is based on details provided by the injured workers, employers, and medical professionals (e.g., doctors, surgeons, etc.).

This study involves the analysis of work-related injury compensations for quad bike-related injuries in South Australia. ReturnToWork SA workers' compensation claims data for all injuries sustained at work in South Australia from 1 July 2001 to 30 June 2013 were provided by SafeWork SA. During this time frame, there were 411,321 workers' compensation claims including active (compensated), pending, withdrawn (not compensated), rejected (not compensated) and incidents (recorded but no claim made).

Data in the ReturnToWork SA workers' compensation claims database do not cover all cases of occupational injuries as workers' compensation schemes do not generally provide coverage to self-employed workers. This results in an underestimate of the number of work-related injuries of workers employed in industries where self-employed workers are common such as agriculture. Note also that claims arising from a journey to or from work are excluded from workers' compensation schemes.

2.2.2 Research procedure

Work-related injuries associated with the use of a quad bike were identified from the workers' compensation claims data using the SafeWork SA tabulator and by conducting a series of free text searches in several key fields:

- Worker description of accident
- Employer description of accident
- Medical comments field
- General comments field

Search terms included:

- Quad
- Quad bike
- ATV
- 4x4
- Sbs
- Side-by-side

A total of 1,720 potential quad-related claims were identified following the initial search criteria. A review of the claim details was then undertaken to determine the likelihood that a claim was due to an injury associated with a quad or side-by-side vehicle. Only cases where the injury was positively and directly associated with some interaction with a quad bike were considered. These injuries may be caused by riding, falling off, manual handling, or be an injury caused by the quad bike itself (e.g., quad falling off of something onto worker, something on the quad caused an injury).

Of the 1,720 potential cases, 209 (12%) were found to definitely involve a quad, 25 (1%) were considered to possibly involve a quad, and the remaining 87% did not involve a quad. In the 25 cases in which a quad or side-by-side were “possibly” involved, the quad was mentioned in a descriptive field attached to a workers’ compensation claim but it was not clear whether or not the quad directly contributed to the injury in some way. As such a second, more detailed review of these cases was undertaken. The result of this process was that the 25 “possible” cases were excluded as the quad was not directly linked with the injury. For example, the worker’s description of incident might state that they had been riding a quad and dismounted to do something, and whilst undertaking that other task hurt themselves. Another example is a case where, after dismounting the quad rolled down a hill and the worker injured themselves chasing after it - it was the worker falling over while running that caused the injury, not the quad.

Consequently, the sample was restricted to cases in which a quad bike or side-by-side vehicle was, without doubt, directly related to the injury. The sample was further restricted to “active” claims (claims which have been accepted as a workplace injury and have received compensation), resulting in a final dataset of 199 incidents. This final sample of workers’ compensation claims involving quad-related injuries accounts for 0.0005% of all accepted claims. While the study is restricted to the analysis of accepted workers’ compensation claims, it nevertheless provides an indicator of trends in quad bike injuries.

2.3 Results

2.3.1 Characteristics of quad-related incidents

There were 199 workers’ compensation claims for injuries associated with the use of a quad bike identified from 2001 to 2013. There were no work-related fatal injury claims during this period. Figures 2.1 to 2.5 show the general characteristics of quad bike incidents leading to claims in terms of annual trends, month, day and hour of incident, and region in which the incident occurred. Examination of claims by year of injury (Figure 2.1) for twelve years of data shows that there has been some fluctuation in quad-related workers’ compensation claims over the period. Note that 2001 and 2013 contain only six months of claims data, aligned with the financial year. Given this limitation in the data set, the actual number of claims in 2013 is likely to be much higher than in 2012. Excluding the two years with incomplete data, there was an average of 16.2 quad-related workers compensation claims per year in South Australia from 2002 to 2012.

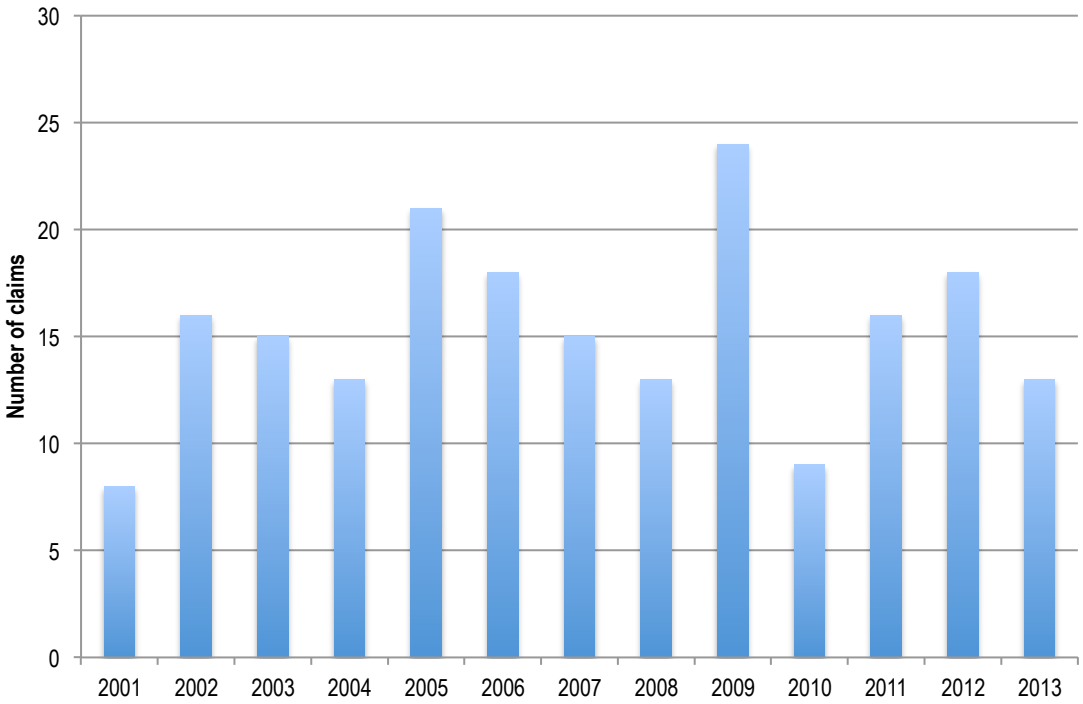


Figure 2.1
Number of claims by year of injury

Figure 2.2 appears to show a higher prevalence of quad-related claims around September and October. It is possible that quads are used for more specific seasonal work at this time during spring although no exposure data is available.

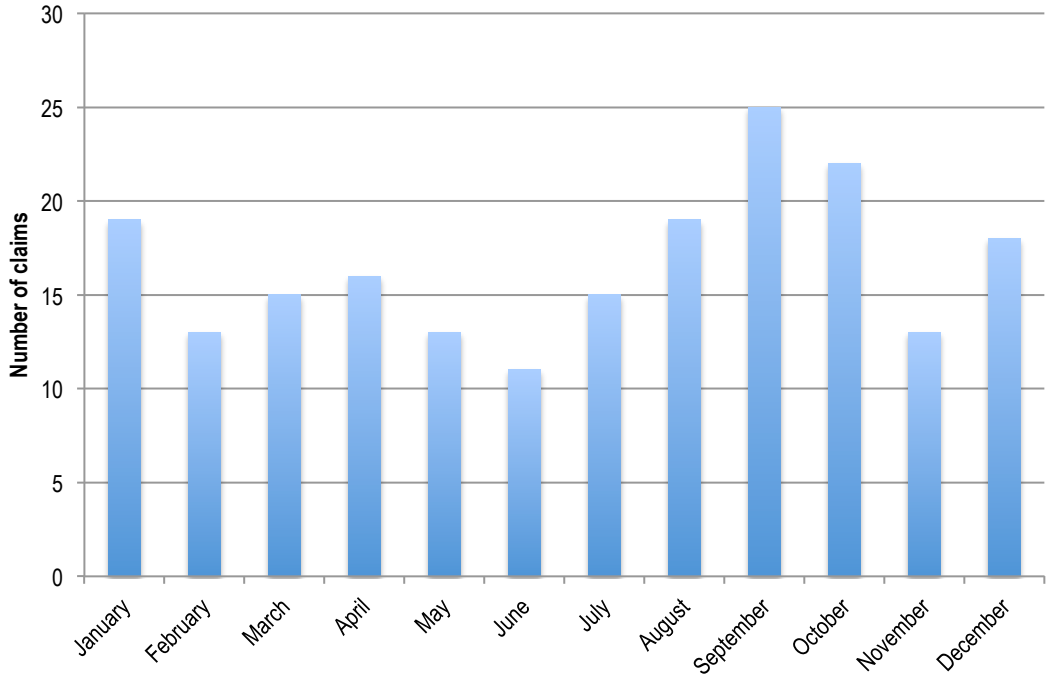


Figure 2.2
Month of injury

Day of injury, presented in Figure 2.3, clearly indicates most quad-related worker's injuries occur during the working week. This is not surprising given the data is based on work-related injuries and the majority of work is conducted on week days.

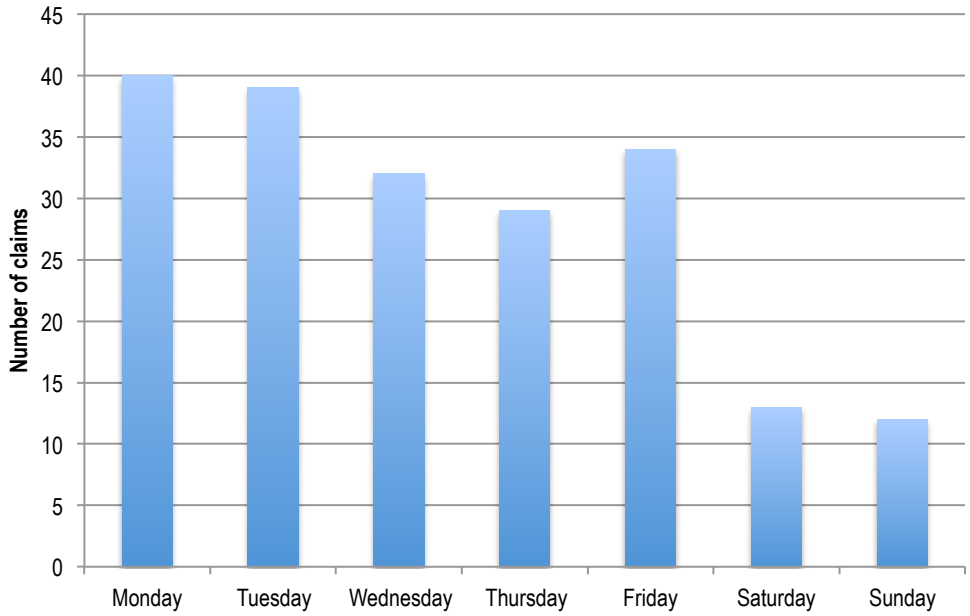


Figure 2.3
Day of injury

The time of day when the quad-related injury occurred, as seen in Figure 2.4, shows a peak in injuries in the hours before midday (10am-12pm) and, to a lesser extent, in the early afternoon (2pm-4pm). The major peak in injuries may be related to exposure, that is, when most farmers are at work.

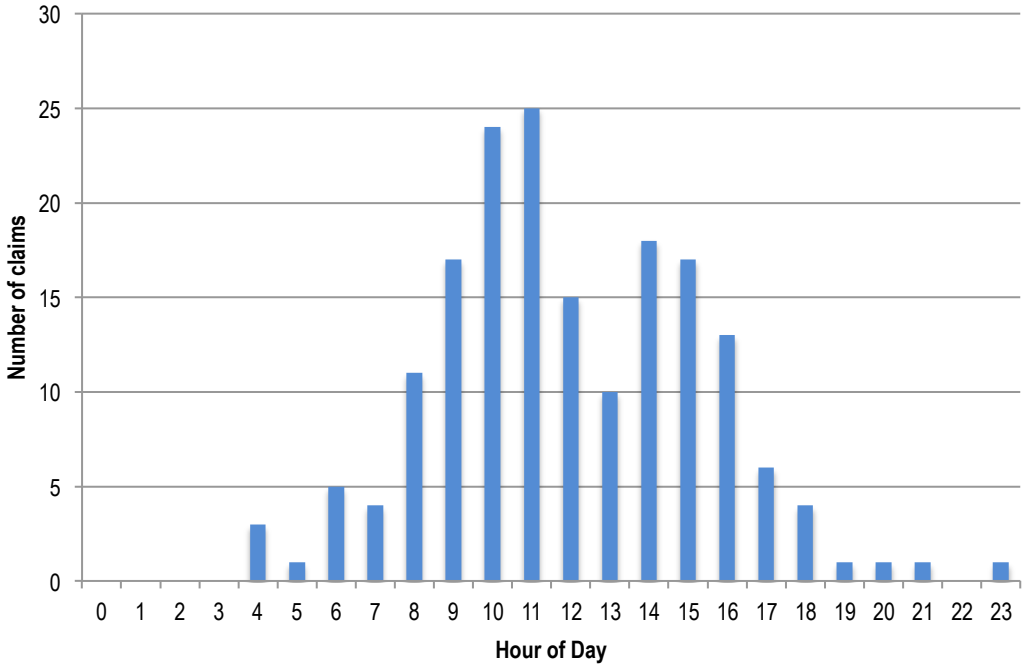


Figure 2.4
Hour of injury

Remoteness area is calculated based on ABS Australian Standard Geographical Classification (ASGC) Remoteness Area Correspondences, 2006 for Postal Area (i.e., post code). Remoteness area is based on location of business postcode, assuming that that is where the injury occurred. This may not be entirely accurate as the business postcode may refer to some other location (e.g., a field office) and not reflect where the actual injury occurred. The number of claims by remoteness is provided in Figure 2.5. The majority of quad injuries occur in regional areas (79%), which is expected based on the type of work for which they are used (typically agriculture, see Table 2.2 in Section 2.3.2). Three per cent of quad injuries occurred in remote areas.

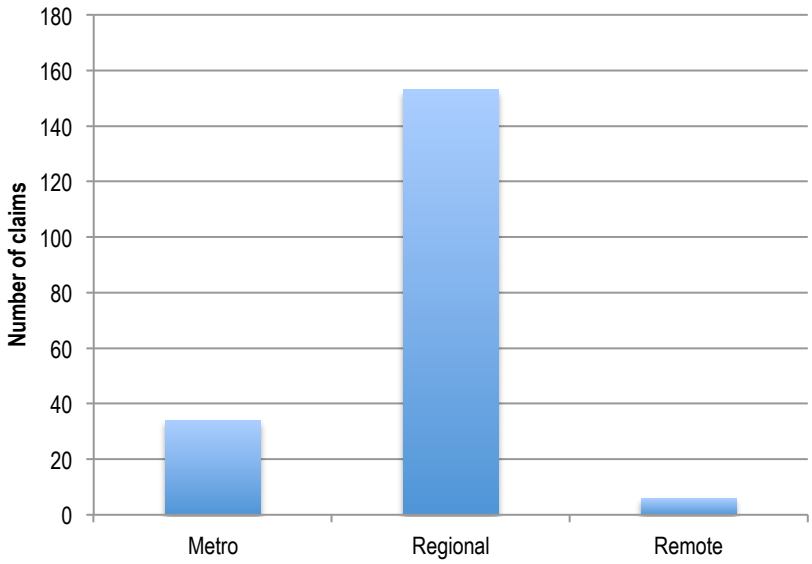


Figure 2.5
Remoteness area of injury

2.3.2 Worker characteristics

The majority of workers' compensation claims were made by males (n=166, 83%) with an age range of 14 to 68 years (M=38.8, SD=14.2), while 33 (17%) claims were for females, who ranged in age from 19 to 62 years (M=37.9, SD=13.6). Table 2.1 shows the sex and age group of injured workers and suggests that quad-related claims are made most frequently by riders aged 15-29 years (34%) followed by those aged 45-59 years (29%). The frequency of claims by sex and age group is also shown in Figure 2.6.

Table 2.1
Age group and sex of workers injured in a quad bike incident

	Female	Male	
Age group	N (%)	N (%)	Total (%)
0-15 years	0 (0.0)	1 (0.6)	1 (0.5)
16-29 years	12 (36.3)	56 (33.7)	68 (34.2)
30-44 years	9 (27.3)	45 (27.1)	54 (27.1)
45-59 years	9 (27.3)	49 (29.5)	58 (29.1)
60+ years	3 (9.1)	15 (9.0)	18 (9.0)
Total	33 (100.0)	166 (100.0)	199 (100.0)

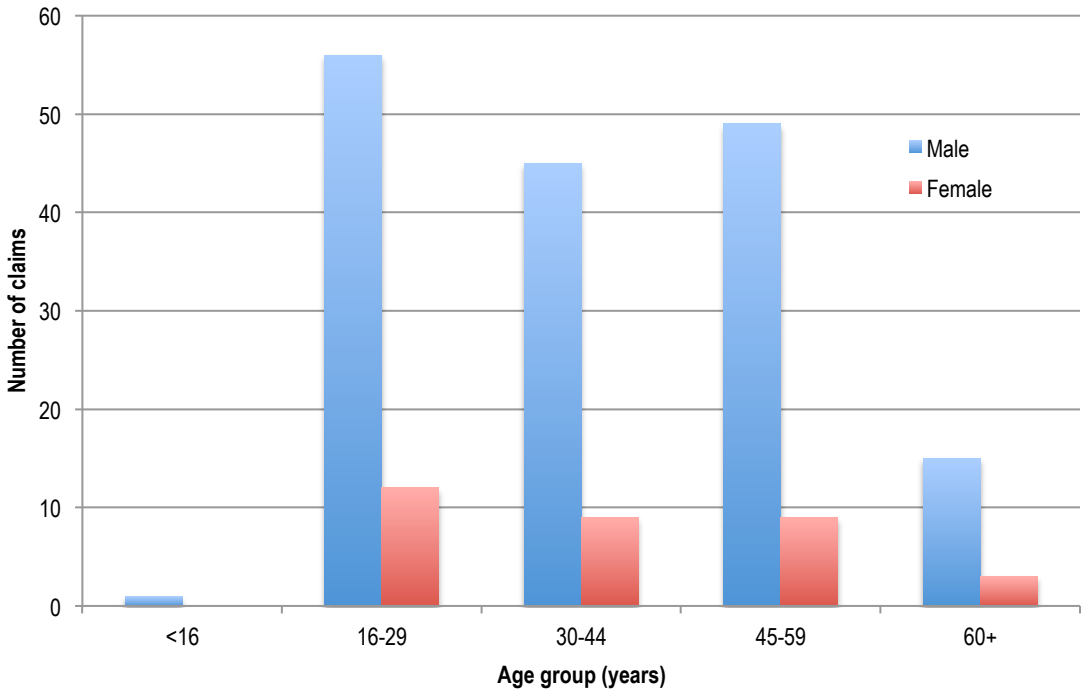


Figure 2.6
Sex and age group of quad-related injured workers

Table 2.2 shows the distribution of quad-related injury for workers across all of the industry sectors covered by the workers' compensation scheme. The majority of all claims come from workers in the "Agriculture, Forestry and Fishing" industry division. These industries are typically located in rural areas.

Table 2.2
Quad bike injury by industry

Industry division	N	%
Agriculture, Forestry and Fishing	138	69.3
Community services	15	7.5
Manufacturing	15	7.5
Public administration and Defence	7	3.5
Recreation, Personal and Other services	7	3.5
Wholesale and Retail Trade	6	3.0
Finance, Property and Business Services	4	2.0
Construction	3	1.5
Transport and Storage	2	1.0
Electricity, Gas and Water	1	0.5
Non-classifiable	1	0.5
Total	199	100.0

Table 2.3 shows the industry for workers with quad-related injuries within the "Agriculture, Forestry and Fishing" industry, providing a general indication of the type of farming linked with claims for quad-related injuries. Workers were classified according to the South Australian Workers Industrial Classification system. Dairy cattle farming (34%) and grape growing (22%) accounted for over half of all worker injuries involving a quad bike.

Table 2.3
Industry of injured workers within the "Agriculture, Forestry and Fishing" industry

Agricultural industry	N	%
Dairy cattle farming	47	34.1
Grape growing	30	21.7
Beef cattle farming	19	13.8
Sheep-beef cattle farming	10	7.3
Fruit growing	6	4.4
Services to agriculture	6	4.4
Grain-sheep and grain-beef cattle farming	5	3.6
Pig farming	5	3.6
Plant nurseries	2	1.5
Sheep farming	2	1.5
Vegetable growing	2	1.5
Agriculture	1	0.7
Aquaculture	1	0.7
Forestry and services to forestry	1	0.7
Poultry farming	1	0.7
Total	138	100.0

2.3.3 Mechanisms of quad-related injuries

A list of the primary mechanisms of injury for quad-related workers' compensation claims are presented in Table 2.4. While a number of events may have contributed to the injuries, only the main mechanism was recorded. The most common mechanism of injury for workers was striking an object on the ground (e.g., a rock, hole, wheel rut), accounting for around one in five injuries (20%). An additional 9% of injuries resulted from the rider or quad striking an object above the ground (e.g. overhanging branch, fence). Around 12% of injuries were caused when mounting or dismounting the quad, typically on an uneven surface resulting in a rolled or sprained ankle. Other common mechanisms included falling off a quad (11%) and an injury or strain from riding a quad (10%).

Table 2.4
Injury mechanism for injured workers

Mechanism of injury	N	%
Hit object on ground	39	19.6
Injured mounting/dismounting	24	12.1
Fall off	21	10.6
Injury/strain from riding	20	10.1
Struck object (quad or rider)	18	9.0
Rollover	18	9.0
Manual handling of quad	9	4.5
Pull starting quad	7	3.5
Loading bike on trailer	7	3.5
Insect sting or other	6	3.0
Loss of control	5	2.5
Struck by animal	5	2.5
Mechanical fault	4	2.0
Chemical spray in face	2	1.0
Other	13	6.5
Unknown	1	0.5
Total	199	100.0

Worker and employer descriptions of incidents in the free text fields of the workers' compensation data were examined to explore other mechanisms of injury and events that may have occurred, rather than a single primary mechanism of injury as reported in Table 2.4. For example, a rider may have struck a rock (i.e. "hit object on ground"), then rolled over. Note that these percentages are likely to be an underestimate as they are only counted when a worker or employee has mentioned them in their description of what happened. For example, injured workers were not specifically asked if the quad rolled over or if they were trapped.

Selected findings from free text include:

- The rider lost control of the quad in 22 (11%) incidents.
- The rider fell off the quad in 70 (35%) incidents.
- The quad rolled over in 39 (20%) incidents.
- The quad rider was trapped in 7 (4%) incidents.
- The quad was being used to muster or check livestock in 56 (28%) incidents.

Examples of descriptions of the quad-related incident in workers' compensation data include:

"Riding 4 wheel motorbike droving cattle, hit hole in ground, came off bike and bike landed on me. Impact on ground."

"Riding quad bike rounding up sheep when fell and dislocated left knee cap."

"Tried to start an ATV with a pull start cord that is fitted to the engine - this placed a strain on my neck and caused some pain."

"Riding 4 wheel bike through paddock. Hit bull hole - foot slipped off peg I fell forward causing bike to roll and pinning me to ground. Leg being caught between peg and brush bar whilst trapped under bike for one hour."

2.3.4 Injury characteristics

In the following section injury characteristics are expressed in terms of expenditure, that is, the amount paid for a claim. As such it provides a rough indication of severity such that more severe claims may result in higher expenditure. However, factors such as lump sum payments and calculations based on the body part injured (i.e., payments are weighted according to the body part) affect the ability to use expenditure in this manner. These limitations should be considered in the interpretation of expenditure data.

The body part injured and nature of injury are provided in Tables 2.5 and 2.6 and Figures 2.7 and 2.8 As a small number of uncharacteristically high payments can skew the average (mean), median expenditure for workers' compensation claims are used to approximate to a "typical" claim. Note also that only one body location (most serious injury) is reported for each claim even though several injuries located in different body regions may have been incurred.

Over $5.6 million was spent on quad-related work injuries in South Australia from 2001 to 2013 or approximately $469,665 per year. Upper limbs (29%), the trunk area (23%) and lower limbs (22%) were the most common body regions for injuries involving a quad bike and together accounted for $4.75 million of the total expenditure.

Injuries to the back (16%, $1.4 million) and shoulder (10%, $1.2 million) were the most common injuries and attracted the highest expenditure or payment. In contrast, injuries to the foot had the highest median expenditure ($174,450) although there were only two claims, both involving fractures. It should be noted that total expenditure may be due to a combination of severity of injuries and the number of injuries to a given body location.

There were 26 claims for head injuries of which nine involved intracranial injury, typically a concussion (see Table 2.7). Due to poor recording of helmet use in the workers' compensation claims database it is not known if these workers were wearing helmets at the time of injury.

Table 2.5
Body location of injury and related expenditure

			Expenditure ($AUD)*			
Body location	N	%	Minimum	Maximum	Total	Median
Head	26	13.1	0	94,799	245,692	854
Head/brain	11	5.5	38	94,799	143,262	3,808
Eye	5	2.5	0	56,998	57,754	199
Ear	4	2.0	38	1,227	1,379	57
Mouth	2	1.0	749	3,698	4,447	2,224
Nose	2	1.0	2,807	35,945	38,752	19,376
Face	2	1.0	45	53	98	49
Neck	3	1.5	187	89,050	89,729	492
Trunk	46	25.6	0	473900	1,604,249	3,744
Back	31	15.6	0	473,900	1,420,490	4,539
Chest, ribs, breastbone	11	5.5	58	8,133	24,856	1,057
Internal organs	3	1.5	396	118,707	125,011	5,908
Abdomen	1	0.5	10,835	10,835	10,835	10,835
Upper limbs	57	28.6	0	354,420	1,622,711	4,655
Shoulder	19	9.5	134	354,420	1,263,267	9,051
Wrist	12	6.0	0	23,971	83,381	3,510
Arm	12	6.0	45	87,517	175,629	5,485
Hand/fingers	10	5.0	0	25,147	68,300	483
Elbow	4	2.0	0	28,261	32,134	1,937
Lower limbs	45	20.1	0	258,858	1,530,036	2,700
Knee	18	9.0	45	258,858	831,146	4,532
Ankle	12	6.0	0	154,010	208,838	1,841
Leg	8	4.0	38	86,302	141,153	1,851
Hip	5	2.5	55	21,021	23,057	268
Foot	2	1.0	23,876	325,023	348,899	174,450
Multiple locations	18	9.0	45	206,565	540,285	3,505
Upper body (torso, arms, neck)	14	7.0	619	206,565	476,079	4,462
Extremities (arms and legs)	3	1.5	45	60,387	61,223	791
Head and other	1	1.0	2,983	2,983	2,983	2,983
Other	4	2.0	63	1,642	3,278	787
Other specified multiple locations	4	2.0	63	1,642	3,278	787
Total	199	100.0			5,635,980	2,898**

Note: * rounded to nearest dollar, ** median expenditure all claims

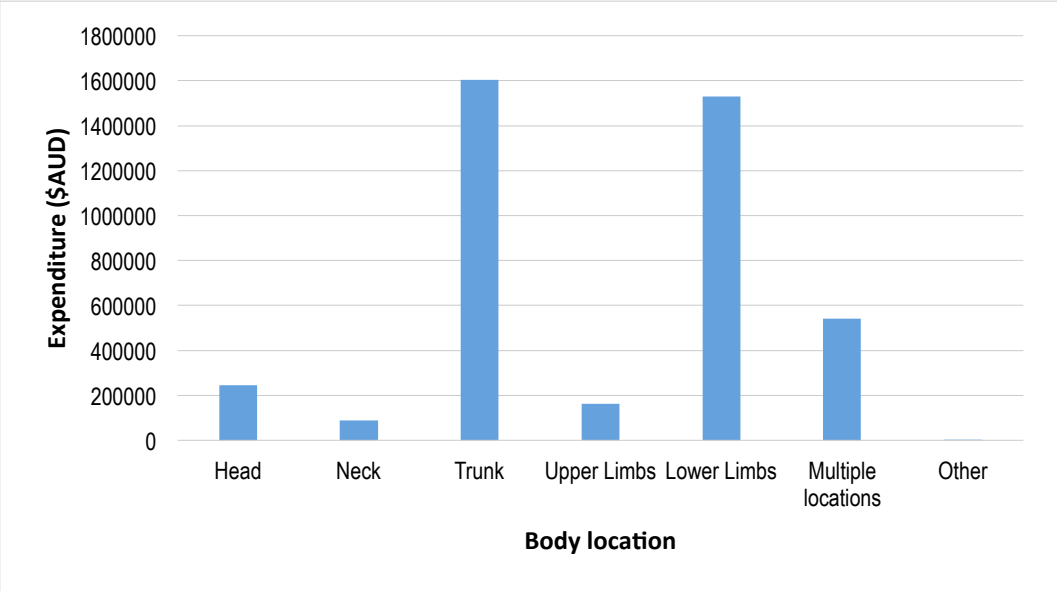


Figure 2.7
Total expenditure by body location of injury

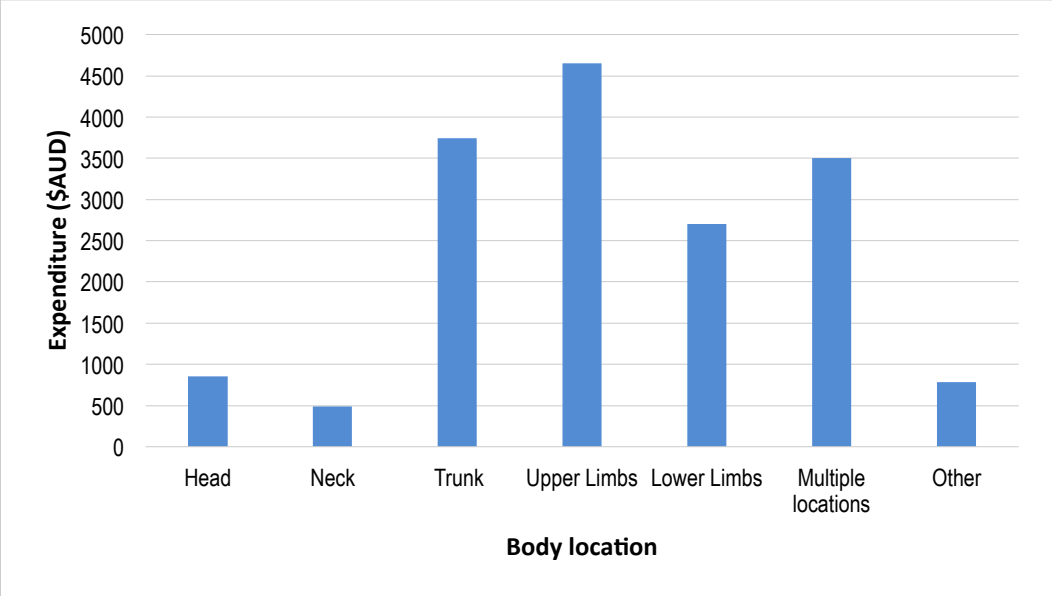


Figure 2.8
Median expenditure by body location of injury

The nature of the quad-related injury incurred by workers and related expenditure, as seen in Table 2.6, indicates that injuries to the muscles, joints or tendons (including sprains and tears) account for one third of quad-related injuries and fractures account for around one fifth. Together these two types of injury account for over half of all quad-related injuries and $3.6 million in expenditure in South Australia from 2001 to 2013 ($304,468 per year). In contrast, dislocations have the highest median expenditure per injury ($38,234). Half of these claims were for shoulder dislocations that required a long rehabilitation.

Table 2.6
Nature of injury and related expenditure

			Expenditure ($AUD)			
Nature of injury	N	%	Minimum	Maximum	Total	Median
Contusions and/or abrasions	23	11.6	0	86,302	164,945	383
Soft tissue injury, including skin issues	22	11.1	0	330,590	424,333	1,482
Intracranial injury	9	4.5	38	94,799	140,635	4,988
Muscles, joints, or tendons	65	32.7	0	473,900	2,236,708	1,351
Fractures	40	20.1	58	325,023	1,416,903	8,648
Lacerations	10	5.0	38	89,050	109,918	786
Internal injuries	3	1.5	396	10,835	17,139	5,908
Poisoning	6	3.0	0	118,707	122,371	402
Dislocations	10	5.0	1,544	354,420	936,540	38,234
Injury to eyes and ears (incl. disease and foreign body)	3	1.5	59	1,227	1,385	99
Nerves	3	1.5	4,630	10,516	22,642	7,496
Multiple injuries	1	0.5	13,646	13,646	13,646	13,646
Other	4	2.0	291	15,198	28,815	6,663
Total	199	100.0			5,635,980	2,898**

Note: * rounded to nearest dollar, ** median expenditure all claims

By examining the body location of injury and the nature of injury associated with it, a clearer picture of quad-related worker injuries begins to emerge. Table 2.7 provides a cross tabulation of body part injured and the nature of the injuries associated with those body parts.

Looking at the body location of quad injuries that are most common and account for high levels of expenditure:

- Injuries to the back had the highest expenditure and was the most common body location of injury (n=31 or 16% of all injuries). The most common injury nature for this location involve strains, etc. of the muscles, joints, or tendons (n=13 or 42% of back injuries). Soft tissue injuries ranked second (n=8, 26%), with fractures third (n=5, 16%).
- Injuries to the shoulder attracted the second highest expenditure and is also the second most common injury reported (n=19, 10%). The injury nature most commonly associated with this body area are strains, etc. of the muscles, joints, or tendons (n=7, 37%), fractures (n=6, 32%), and dislocations (n=5, 26%).
- Knee injuries attracted the third highest expenditure and knees were the third most common body part injured (n=18, 9%). The nature of injury associated with knees included strains, etc. of the muscles, joints, or tendons (n=10, 56%) and dislocations (n=3, 17%).

Table 2.7
Body location of injury by nature of injury

Body location	Nature of injury													Total
	Contusions and/or abrasions	Soft tissue injury	Intracranial injury	Muscles, joints, or tendons	Fractures	Lacerations	Internal injuries	Poisoning	Dislocations	Injury to eyes and ears	Nerves	Other	Multiple injuries	
Head/Brain	1		9			1								11
Eye	2					2				1				5
Ear						1		1		2				4
Mouth						1		1						2
Face		1						1						2
Nose					1			1						2
Neck				2		1								3
Back	2	8		13	6						1	1		31
Chest, ribs, breastbone	3			3	5									11
Internal organs							2	1						3
Abdomen							1							1
Hand/fingers				3	3	2		1				1		10
Elbow				3	1									4
Shoulder				7	6				5			1		19
Arm	3	1		3	3						1		1	12
Wrist	1	1		3	7									12
Hip/pelvis/buttocks		1		4										5
Leg	2	2		1	1	1					1			8
Knee	2	2		10					3			1		18
Ankle	1			8	1				2					12
Foot					2									2
Other	1	2		1										4
Head and other						1								1
Upper body (torso, arms and neck)	4	3		4	3									14
Extremities (arms and legs)	1	1			1									3
Total	23	22	9	65	40	10	3	6	10	3	3	4	1	199

Examining the most common nature of quad bike injuries and expenditure amounts:

- Strains of the muscles, joints, or tendons was the most common injury (n=65, 33%) and had the third highest expenditure. Back (n=13, 20%), knee (n=10, 15%), and shoulder (n=7, 11%) were the most common body locations associated with this type of injury.
- Fractures were the second most frequent injury (n=40, 20%) and had the second highest level of expenditure. Fractures were most commonly to the wrist (n=7, 18%), back (n=6, 15%), shoulder (n=6, 15%), and chest (n=5, 13%).
- The third most common injury was contusions (n=23, 12%), followed by soft tissue injuries (n=22, 11%). Respectively these injuries were ranked fifth and fourth highest in terms of expenditure. Contusions were not particularly associated with any body part, while soft tissue injuries were most often to the back (n=8, 36%).

Table 2.8 displays the most common mechanisms of injury and associated nature of injury, in summary:

- Hit object on ground (20%). Most common injury is strains to muscles, joints or tendons (33%).
- Injured mounting/dismounting (12%). Most common injury is strains to muscles, joints or tendons (63%).
- Fall off (11%). Most common injury is fractures (48%)
- Injury/strain from riding (10%). Most common injury is strains to muscles, joints, or tendons (60%).

Table 2.8
Mechanism of injury and nature of injury

Mechanism of injury	Nature of injury													
	Contusions and/or abrasions	Soft tissue injury	Intracranial injury	Muscles, joints, or tendons	Fractures	Lacerations	Internal injuries	Poisoning	Dislocations	Injury to eyes and ears	Nerves	Other	Multiple injuries	Total
Hit object on ground (rock, holes)	4	5	3	13	7	1	3		2		1			39
Injured mounting/dismounting	3	1		15	3				2					24
Fall off	3	2	3		10	1			2					21
Injury/strain from riding		2		12	1				1		1	3		20
Struck object (quad or rider)	4		1	4	3	4				1			1	18
Roll over	1	3		2	9	1			2					18
Manual handling of quad		3		6										9
Pull starting quad				5	1						1			7
Loading bike on trailer	1	2	1	1	2									7
Insect sting or other								5		1				6
Loss of control				2	2	1								5
Struck by animal	1	2			1				1					5
Mechanical fault	2	1										1		4
Chemical spray in face		1						1						2
Other	4			5	1	2				1				13
Unknown			1											1
Total	23	22	9	65	40	10	3	6	10	3	3	4	1	199

Injuries associated with rollovers

There were 39 (20%) incidents identified from the free text fields within the workers' compensation claims data in which the quad bike was reported to have rolled. Tables 2.9 to 2.10 show the mechanism of injury, body location of injury and nature of injury for the quad rollovers. Not surprisingly, the most common primary mechanism of the quad-related injury was a rollover (46%). However, other common primary mechanisms involved in the rollovers included hitting an object on the ground (23%) and falling off the quad (13%).

The most common nature of injuries for rollovers were fractures (39%), soft tissue injuries (18%), and strains to muscles, joints and tendons (15%). Fractures were associated with a variety of body parts most commonly occurring to the back (60%) and soft tissue injuries were most common in the back (29%) and upper body (29%). The upper body (18%) was the body region most commonly injured in the rollovers.

Table 2.9
Mechanism of injury for incidents where the quad bike rolled over

Mechanism	N	%
Roll over	18	46.2
Hit object on ground	9	23.1
Fall off	5	12.8
Struck by animal	2	5.1
Loading bike on trailer	2	5.1
Loss of control	1	2.6
Mechanical fault	1	2.6
Other	1	2.6
Total	39	100.0

Table 2.10
Body location of injury by nature of injury for rollovers (n=39)

	Nature of injury								
Body location of injury	Contusions, abrasions	Soft tissue injury,	Muscles, joints, tendons	Fractures	Lacerations	Internal injuries	Dislocations	Nerves	Total
Arm				2					2
Elbow			1	1					2
Shoulder			2	1			1		4
Wrist				1					1
Chest, ribs, breastbone	1			2					3
Back		2		3					5
Abdomen						1			1
Internal organs						1			1
Hip		1							1
Leg	2			1	1			1	5
Knee							1		1
Ankle	1		1						2
Foot				1					1
Upper body (torso, arms, neck)	1	2	2	2					7
Extremities (arms and legs)		1		1					2
Other		1							1
Total	5	7	6	15	1	2	2	1	39

Injuries associated with mustering livestock

A total of 56 cases were identified from the free text fields within the workers' compensation claims data where the quad was being used for mustering or checking livestock when the injury occurred. The mechanism of injury, body location of injury and nature of injury are provided in Tables 2.11 to 2.12. When workers were mustering livestock, the most common mechanism of the quad-related injury was hitting an object on the ground (34%) followed by striking an object (14%).

The most common type of quad-related injuries when mustering livestock were fractures (32%), strains to muscles, joints and tendons (25%) and dislocations (13%). Fractures most commonly occurred in the wrist (33%), strains to muscles were most common in the shoulder (21%) and back (21%) and dislocations were most common to the shoulder (57%). The body location most commonly injured when mustering was the shoulder (18%).

Table 2.11
Injury mechanism when mustering livestock

Injury mechanism	N	%
Hit object on ground	19	33.9
Struck object (quad or rider)	8	14.3
Fall off	7	12.5
Rollover	6	10.7
Struck by animal	5	8.9
Injured mounting/dismounting	3	5.4
Mechanical fault	2	3.6
Manual handling of quad	2	3.6
Loss of control	1	1.8
Insect sting or other	1	1.8
Other	2	3.6
Total	56	100.0

Table 2.12
Body location of injury by nature of injury when mustering livestock (n=56)

Body location of injury	Nature of injury										
	Contusions, abrasions	Soft tissue injury	Intracranial injury	Muscles, joints, tendons	Fractures	Lacerations	Internal injuries	Poisoning	Dislocations	Multiple injuries	Total
Head/ brain			2								2
Eye	1										1
Nose								1			1
Neck						1					1
Arm		1			2					1	4
Hand/ fingers					1	1					2
Wrist		1		2	6						9
Elbow				1							1
Shoulder				3	3				4		10
Chest, ribs, breastbone	1			1	1						3
Back		2		3	2						7
Internal organs							2				2
Knee				1					2		3
Ankle				1					1		2
Upper body (torso, arms, neck)	2			2	3						7
Other		1									1
Total	4	5	2	14	18	2	2	1	7	1	56

2.4 Discussion

This study involved the first analysis of work-related injury claims for quad bike-related injuries in South Australia. While the workers' compensation data is primarily designed for administrative purposes rather than assisting injury prevention, some general information regarding worker demographics, incident details and type and nature of injury was obtained for quad-related worker claims. From 2001 to 2013, the 199 injuries to South Australian workers arising from a quad bike-related incident identified within the ReturnToWork SA workers' compensation data, cost approximately $5.6 million. The number of quad-related work-related injuries in the workers' compensation records will be an underestimate due to a high level of self employment in agriculture. It is estimated that 55% of the total workforce within the industry division of "Agriculture, forestry and fishing" are employees (as defined by the ABS), that is, entitled to worker's compensation (Safe Work Australia, 2012). Given that agriculture is known to make up 75 to 80% of this industry division, it is likely that this analysis of workers' compensation claims identified only half, at best, of the quad-related injuries incurred by workers in South Australia. Other known under-reporting for injured workers in workers' compensation schemes are workers who are contractors, workers without dependents or young workers known not to make claims (Mitchell & Boufous, 2005). It is also possible that some cases were not identified through the search in the narrative description.

Findings from this study can be compared to those found in the study of quad-related workers' compensation claims in NSW from 2003-2011 (Grzebieta et al., 2015). Consistent with the findings from NSW data, the majority of quad bike-related injuries were for male workers (83%) and workers aged 15-29 years (34%). The demographic profile of injured workers is also consistent with other studies investigating quad-related hospital admissions and fatalities (e.g. Clapperton et al., 2013; Lower et al., 2012).

Quad incidents occurred predominantly on weekdays and during the late morning hours (10-11am; 25%). The concentration of injuries at this time may be related to exposure; times when most agricultural work is undertaken. It is also the time just before a major break when workers may become tired or lose concentration.

The majority of worker quad-related injuries occurred in regional and remote South Australia (82%). This was not surprising given that the majority of claims were from the "Agriculture, Forestry, and Fishing" industry (69%), an industry typically located in rural regions. Previous studies have identified agriculture as the most common industry for quad work-related injuries in the United States (68%, Helmkamp et al., 2011), New Zealand (61%, Moore & Bentley, 2004) and New South Wales (63%, Grzebieta et al., 2015). Within the agriculture industry, dairy cattle farming and grape growing accounted for over half (55%) of all quad-related worker injuries in South Australia. In New South Wales the most common agricultural industry for quad-related injuries were beef cattle farming followed by horse farming (Grzebieta et al., 2015). These findings possibly reflect differences in land use and terrain between jurisdictions and highlight the value of examining data specific to each jurisdiction.

While the activity undertaken at the time of the incident was not specifically coded, analysis of the worker and employer descriptions revealed 56 (28%) cases in which the worker was mustering livestock when the injury occurred. This is likely to be an underestimate of the true incidence. Few data sources have sufficient information to determine the activity undertaken at the time of the quad incident. A study examining Australian fatalities found mustering livestock was a common farming task undertaken at the time of death (Lower et al., 2012). Common mechanisms of quad-related injury while mustering livestock involved striking an object on the ground (34%) such as a hole or rock and striking other objects such as a bush or fence (14%). The most common types of injuries were fractures to the wrist, strains to muscles in the shoulder and back, and dislocations to the shoulder.

The most common primary mechanism of injury for workers using a quad was striking an object on the ground (20%), mounting or dismounting the quad (12%), falling off (11%), and injuries or strains from riding (10%). Recent studies based on Australian and New Zealand fatalities suggest that farm work-related deaths predominantly involve rollovers, particularly where the rider is pinned or trapped under the vehicle with death by asphyxia (Lower et al., 2012; McIntosh, Patton, Rechnitzer, & Grzebieta, 2015; Shulruf & Balemi, 2010). While rollovers were identified as the primary mechanism of worker injury in only 9% of cases, further inspection of worker and employer descriptions found 20% of worker injuries involved a rollover. The proportion of rollovers is consistent with the proportion (22%) identified in NSW worker injury data (Mitchell et al., 2015) and in Victorian hospital admissions (22%) and emergency department presentations (19%) from 2002/02 to 2010/11 (Clapperton et al., 2013). Fractures accounted for 40% of worker injuries inflicted during rollovers, most frequently to the back. While the most prevalent injury during a quad rollover for workers in NSW was a fracture, they most frequently occurred in the ribs (Grzebieta et al., 2015).

Workers have been found to be 4.9 times more likely than recreational riders to be pinned by the quad (McIntosh et al., 2015). Around 7% of injured workers reported being trapped or pinned under the quad, a finding similar to that found for farmers interviewed about quad bike loss-of-control events in

New Zealand (Clay, Hay-Smith, Treharne, & Milosavljevic, 2015) but generally much lower than what has been reported in studies examining fatalities (49%, McIntosh et al., 2015). While being pinned under the quad has been associated with higher injury severity, particularly increasing the likelihood of being killed (Shulruf & Balemi, 2010), the proportion of riders pinned in this study is still likely to be an underestimate as it was not a recorded data field but information attained through worker incident descriptions.

The most common worker injury types involving a quad bike were strains to the muscles, joints or tendons (33%) and fractures (20%), with strains to the muscles, joints or tendons having the highest total expenditure for claims. These findings were consistent with the two most common quad-related injury types found for NSW workers (44%, 22% respectively) (Mitchell et al., 2015) and Victorian emergency department presentations (25%, 25% respectively) (Clapperton et al., 2013). Fractures accounted for half of all Victorian hospital admissions related to quad incidents.

Consistent with data for NSW injured workers using a quad (Grzebieta et al., 2015), the body regions most frequently injured were upper limbs (29%), trunk (23%) and lower limbs (22%) and the body parts most commonly injured were the back (15%) and shoulder (10%). Injuries to the back had the highest total expenditure. These findings are also consistent with the location of injuries for quad riders admitted to hospital and presenting at an emergency department in Victoria (Clapperton et al., 2013).

The findings from this study provided the first useful insight into worker injuries involving a quad bike in South Australia. While the data included some useful, general information concerning the injury event, narrative descriptions of the event were usually very brief and gave little information about the sequence of events, details about the quad bike or causal factors. In-depth studies that investigate the complex sequence of events that lead to the worker injuries and any contributing circumstances would be most valuable to aid quad-related injury prevention

3 Characteristics of quad bike-related fatalities in South Australia

3.1 Introduction

The safety of quad bikes has received considerable international concern during the past decade following a growing number of quad injuries and fatalities (Denning, Jennissen, Harland, Ellis, & Buresh, 2013; Persson, 2013; Topping & Garland, 2015; Vanlaar et al., 2015; Wood et al., 2013). Quad bikes are important to many agricultural industries in Australia, but the number of injuries associated with quad bike use has risen as they have become more popular. Quad bikes are the leading cause of non-intentional deaths on Australian farms (Lower & Herde, 2012). According to data recorded by Safe Work Australia (QuadWatch), there were 75 quad-related deaths from 2011 to 2014 in Australia, an average of 18.8 fatalities per year. In order to reduce the increasing number of quad-related deaths we need to understand the circumstances surrounding these tragic incidents.

International research has investigated the causes of fatalities involving quad bikes however, many of these studies are from the United States where a greater proportion of quads are used on-road and for recreational purposes than in Australia (National Center for Statistics and Analysis, 2015; Denning & Jennissen, 2015; Hall, Bixler, Helmkamp, Kraner, & Kaplan, 2009; Helmkamp, Aitken, Graham, & Campbell, 2012; Shulruf & Balemi, 2010; Williams, Oesch, McCartt, Teoh, & Sims, 2014). There are several notable studies that have examined quad-related fatalities within Australia in recent times. Lower, Herde and Fragar (2012) examined 127 quad bike-related deaths in Australia from 2001 to 2010 recorded in the National Farm Injury Data Centre (NFIDC) Register of Quad Bike Deaths. Information was sourced from the National Coronial Information System (NCIS) and alerts via a media monitoring program. It was found that approximately 45% were considered work-related and the majority of these occurred on farms and were the result of a rollover. Another study by Clapperton, Herde, and Lower (2013) examined 19 Victorian quad-related fatalities identified in the NFIDC Register using NSIC data, amongst other data sources.

Very recently, as part of a larger *Quad Bike Performance Project* in NSW, Grzebieta et al. (2015) analysed Australian quad-related deaths from 2000-2012. From a dataset of 141 closed cases identified in NCIS, a subset of 109 cases involving a quad bike or side-by-side vehicle was examined. Quad crashes on roads with other vehicles and quad passenger fatalities were excluded. A significant strength of the study was that original Coroner's files were viewed or obtained from each jurisdiction to provide a full brief of evidence. The characteristics of work-related (farm) quad fatalities were compared to recreational quad fatalities and it was found that work-related incidents typically involved the quad rolling over and pinning the rider, resulting in crush injuries and asphyxia. In contrast, recreational quad fatalities were less likely to be rollovers but tended to involve the rider being ejected from the quad and striking an object at high speed or interacting with the moving quad, leading to head injuries.

None of the aforementioned studies specifically investigated quad-related fatalities in South Australia. In this study, Coroner's closed case records from the National Coronial Information System (NCIS) for quad bike fatalities in South Australia were examined to provide detailed information about the factors contributing to quad bike incidents and the resulting fatal injuries in South Australia. While the emphasis was on quad bikes in South Australia, national case records for fatalities were examined for comparative purposes to determine whether any characteristics of the South Australian environment contributed to a greater relative proportion of quad fatalities than is evident in other jurisdictions.

Given the recent publication of the findings from the *Quad Bike Performance Project,* the current study does not focus on the distinction between work-related and recreational quad fatalities but focuses on the incidence of a number of behavioural factors that might contribute to quad-related trauma including

alcohol and drug use, carrying passengers, and helmet use. In contrast to the NSW study, all fatalities on adult sized quad bikes and side-by-side vehicles were examined, including passenger fatalities and those occurring on roads, as these are ways in which quad bikes are used (i.e. farmers may need to cross roads to get to other parts of their property). It is anticipated that a number of quad injuries and deaths are associated with the leisure operation of quads purchased for use on farms.

3.2 Method

3.2.1 The National Coronial Information System (NCIS)

The National Coronial Information System (NCIS) is a data storage, retrieval, analysis, interpretation and dissemination system for coronial information reported in Australia and New Zealand. It is an initiative of the Australasian Coroner's Society and managed by the Victorian Department of Justice on behalf of a Board of Management. NCIS contains data about deaths reported to an Australian Coroner from July 2000 for all states and territories with the exception of Queensland data which is reported from January 2001.

For each NCIS case record, a host of data fields are available including demographics, temporal factors relating to the incident, mechanisms of injury, medical cause of the death, and work relatedness including occupation and industry. Full text reports for each case may also include the police report narrative of circumstances, forensic autopsy report, forensic toxicology report and the Coroner's findings related to the cause of death, including any recommendations made. However not all documents are available for each case and the level of detail in each document can vary considerably between cases and jurisdictions.

For the South Australian cases, it was discovered that the forensic autopsy and toxicology reports were not included in NCIS and the police narratives were very brief. Consequently there was not enough detailed information in the NCIS case records to accurately determine the circumstances surrounding quad bike deaths in South Australia. To overcome this issue, CASR submitted a written request to the South Australian Coroner's Court requesting access to the original case files for quad bike fatalities in South Australia.

3.2.2 NCIS search strategy

Ethical approval was obtained to access NCIS data from the Victorian Department of Justice Human Research Ethics Committee (JHREC) Ref No: CF/14/13668 (NCIS Project No: M0304) and the Western Australian Coronial Ethics Committee (WACEC) Ref No: EC05-14. Access to all closed fatal quad-related cases reported in NCIS from 2000 to 2014 (as of March 2015) occurring in Australia was permitted.

Two search strategies were initially undertaken to identify quad-related cases within NCIS. Firstly, in the object section of the "Mechanisms of injury" page, each of the three individual searches were undertaken using the following fields and changing the "Mechanism of injury" between "Primary", "Secondary 1" and "Secondary 2":

- Category 1: Mobile Machinery or Special Purpose Vehicle
- Category 2: Other Mobile Machinery or Special Purpose Vehicle
- Description: Special All-Terrain Vehicle/Off-Road Vehicle, Quad Bike

The second search strategy involved using a combination of the following search terms within all NCIS case text fields: “Quad bike”, “Quad” and “ATV”.

The case lists returned from these strategies were collated then compared to a list of closed fatal quad files identified by the *Quad Bike Performance Project* (QBPP) research team. Any additional cases in the list provided by QBPP were included.

Finally, all cases were individually checked to confirm that the fatality involved the operation of a quad bike, and that it was a full size adult quad (child or youth model quads usually have an engine size under 100cc). Note that cases involving children were included if they were riding, or were a passenger on, a full size quad. This checking process was usually undertaken by examining the Coroner’s finding or the Police narrative. In rare cases where neither of these were available or gave insufficient information, if the “Mode of transport” was listed as “Special All-Terrain or Off-Road Vehicle: Quad Bike, ATV” the case was included.

From the 167 Australian cases identified during the search (excluding South Australia), nine cases were excluded because they did not involve a quad or side-by-side vehicle (e.g. dune buggy, mower) and five cases were excluded because the quad was a child or youth model. Twelve cases from South Australia were identified with three cases excluded because they did not involve a quad or side-by-side vehicle (i.e. dune buggy, three wheel motorcycle, 4WD) and one case was omitted because a quad was not being used at the time of the incident. The final sample consisted of 161 quad cases of which eight occurred in South Australia.

3.2.3 Research procedure

National closed Coroner’s reports for quad-related fatalities occurring from 2000 to 2014 involving a rider or passenger were investigated with the aim of understanding the circumstances surrounding the quad bike fatalities. Two road safety experts with many years of crash investigation experience independently reviewed and analysed each case. For each case, NCIS coded variables were extracted including demographics, temporal factors relating to the incident, mechanisms of injury, medical cause of death and work relatedness including occupation and industry. In addition researchers coded a number of new variables based on the data contained in the full text reports including type of incident, on/off road and on/off farm status, type of terrain, type of quad, quad make and model, quad engine size, load and attachment details, rollover protection device, trapped under quad, alcohol use, drug use, helmet use, and if carrying any passengers. It is acknowledged that not all information was reported for each of the cases. Where the information was not available or unclear, the variable was labelled as unknown.

3.3 Results

In order to understand the characteristics of quad-related fatalities in South Australia, the characteristics of the incident, rider, associated injuries and the quad bike were compared to those for the rest of Australia to determine whether certain factors were more evident in South Australia. The overall number of quad fatalities in South Australia was very small, therefore statistical analyses of any differences were not meaningful.

A total of 161 closed fatal cases occurring in Australia and involving an adult size quad bike from 2000 to 2014 were analysed. The distribution of the final sample for number of quad cases by jurisdiction is presented in Table 3.1. Half of the total number of quad-related fatalities included in this study occurred in Queensland and New South Wales and 5% occurred within South Australia. Figure 3.1 shows the distribution of fatalities for completed or ‘closed’ cases by year. Note that Queensland cases were not recorded in 2000. Fatalities in recent years (i.e. 2012-2014) are likely to be an

underestimate as the study only included closed Coroner's case reports, that is, cases that were no longer under investigation. Cases can be 'open' for up to several years after the fatal incident. The eight South Australian cases occurred between 2002 and 2012.

Table 3.1
Distribution of quad cases by Australian jurisdiction

Australian jurisdiction	Number	%
Queensland	41	25.5
New South Wales	41	25.5
Victoria	26	16.2
Western Australia	24	14.9
Tasmania	13	8.1
South Australia	8	5.0
Northern Territory	7	4.4
Australian Capital Territory	1	0.6
Total	161	100.0

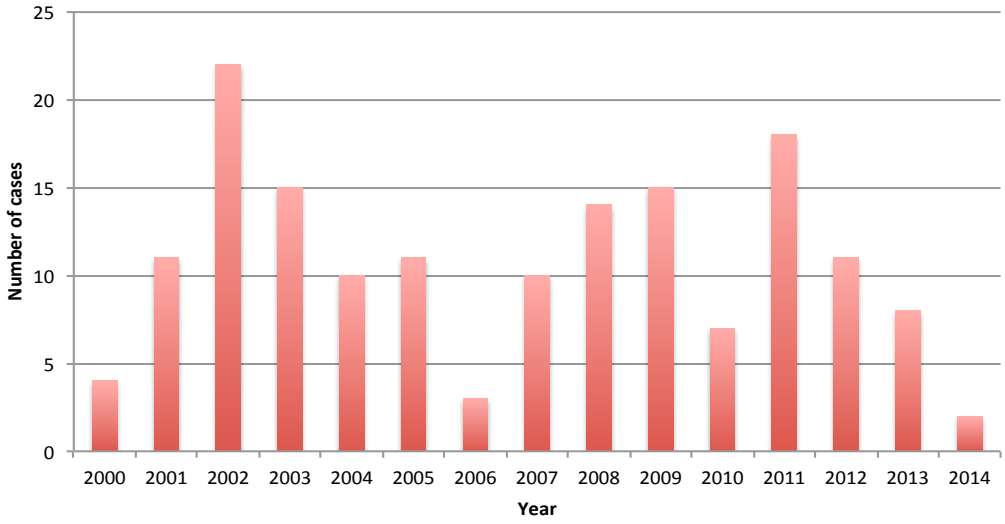


Figure 3.1
Distribution of all quad fatalities by year, 2000-2014

3.3.1 Incident characteristics

The characteristics of the quad incident or crash are presented in Table 3.2. Overall, 37% of quad crashes were classified as occurring during a work-related activity, as defined by NCIS[1]. However, 59% of the crashes occurred on farms, showing that farms are the main location for quad crashes for both recreational and work-related crashes. While only one South Australian case was classified as work-related, five of the cases occurred on farms. Two of these cases involved children aged under 16

1 NCIS defined the concept of 'work related' as including activities that contribute to a business or undertaking. Any case where it is determined that exposure of the deceased to their own or another person's work environment or activities contributed to the death. This broader definition of work-relatedness includes cases for which the deceased (or relevant persons) would not be eligible for workers' compensation.

years. This suggests that in South Australia, similar to the rest of Australia, the quads were primarily farm quads but were used for recreational purposes at the time of the incident.

The majority (75%) of fatal quad incidents Australia wide occurred in off-road environments. This was also the case in South Australia (63%) where four of the off-road quad incidents occurred in farm paddocks and one incident occurred at a beach. The type of terrain was coded from the reports but in almost 30% of all cases it was not specified whether the incident occurred on flat ground or a slope. Of those where information was known, half of all quad incidents were on a slope compared to 63% of those occurring in South Australia.

The type of incident refers to the primary initiator of the incident and was coded based on any narrative associated with the case. Note that in some cases the quad may have rolled after the primary impact or loss of control but is not coded as a rollover for this variable. The most common type of fatal quad incident was a rollover (28%), closely followed by hitting an object (26%) and loss of control (24%). For South Australia, three quad incidents predominantly involved a rollover, three were due to a loss of control, one involved hitting an object (i.e. rock) and one was a collision with a vehicle.

In relation to temporal factors at the time of the incident, almost three quarters of all quad incidents occurred during daylight hours. The same trend was evident in South Australia. Further analyses indicated that a greater proportion of work-related quad incidents were during the day (82%) compared to recreational crashes (67%). Figure 3.2 shows the distribution of all quad incidents by month. The month with the greatest proportion of quad incidents was March (14%) and the least July (5%). With respect to season, autumn had the greatest proportion of quad incidents with one third of all cases. Fatalities in South Australia were evenly spread between the seasons.

Table 3.2
Incident characteristics involved in quad-related fatalities, 2000-2014

	SA		Rest of Australia		Total	
Incident characteristics	N=8	%	N=153	%	N=161	%
Work-relatedness						
Work-related	1	12.5	59	38.6	60	37.3
Recreational	7	87.5	94	61.4	101	62.7
Farm						
On farm	5	62.5	90	58.8	95	59.0
Off farm	3	37.5	63	41.2	66	41.0
Road						
On road	3	37.5	37	24.2	40	24.8
Off road	5	62.5	116	75.8	121	75.2
Terrain						
Flat	3	37.5	54	35.3	57	35.4
Slope	5	62.5	52	34.0	57	35.4
Unknown	-	-	47	30.7	47	29.2
Type of incident						
Rollover	3	37.5	42	27.5	45	28.0
Hit object	1	12.5	40	26.1	41	25.5
Loss of control	3	37.5	35	22.9	38	23.6
Collision with vehicle	1	12.5	13	8.5	14	8.7
Fall off	-	-	6	3.9	6	3.7
Other	-	-	4	2.6	4	2.5
Unknown	-	-	13	8.5	13	8.1
Time of day						
Day	6	75.0	111	72.5	117	72.7
Night	2	25.0	24	15.7	26	16.2
Unknown	-	-	18	11.8	18	11.2

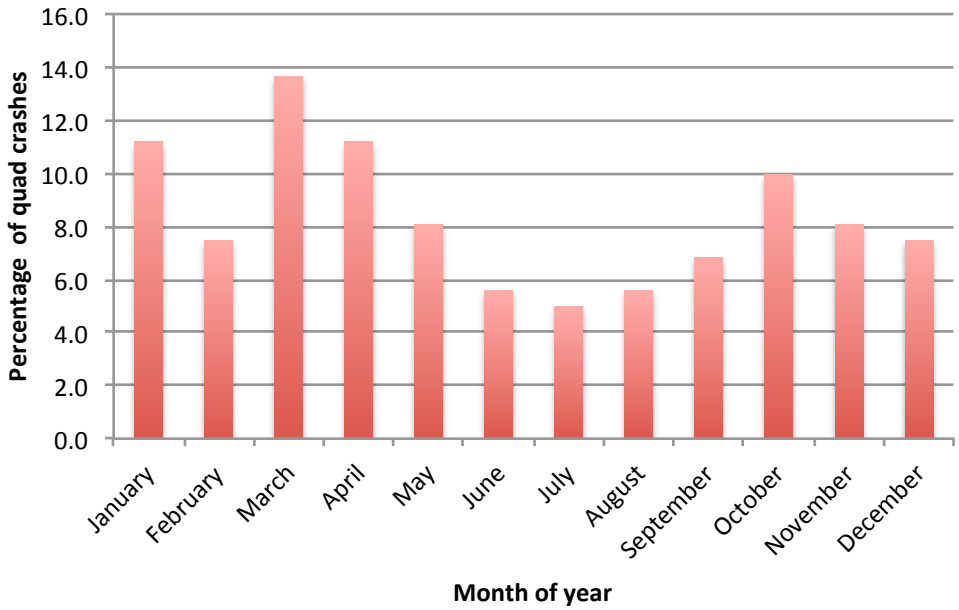


Figure 3.2
Distribution of all quad fatalities by month of year, 2000-2014

3.3.2 Rider characteristics

Table 3.3 shows the characteristics of those killed in the quad incidents. The vast majority (83%) of all quad fatalities were males although this proportion was lower in South Australia (63%). The mean age of all quad fatalities was 42 years (median 39 years). Around 60% of all fatally injured riders were aged 30 years and over with the greatest proportion (27%) aged 60 years and over. Although only adult sized quads were included in the sample, 16% of fatalities were children aged under 16 years. In South Australia, half of the fatalities (n=4) were children (<16 years) and three fatalities were older riders aged 60 years and over. Of the 26 children fatally injured in this sample, 13 were riding an adult sized quad, two were driving a side-by-side and the remaining 11 were passengers (10 quad, 1 side-by-side).

Of all the quad-related fatalities, 88% were riders and 9% were passengers at the time of the incident. Of interest, 18% of all female quad-related fatalities were passengers compared to 8% of all male quad-related fatalities who were passengers. In South Australia, half of the fatalities on quad bikes were passengers and two were female.

Quad bikes are not designed to carry passengers while side-by-sides usually have seating for at least one passenger. When considering only incidents involving a quad (excluding side-by-sides), in 22% (n=32/143) of incidents the quad was carrying one or more passengers. Of the seven incidents involving a quad in South Australia, six involved the carriage of passengers and of these incidents, three occurred as a direct result of passenger behaviour (the passenger inadvertently knocked the rider or quad controls).

Alcohol and drug use was obtained from the forensic toxicology reports. A blood alcohol concentration (BAC) reading was not reported in 30 cases and a drug screen was not reported for 34 cases. Of those for whom alcohol status was known, 28% (n=36) of all riders tested positive for alcohol, of which 31 were riders and five were passengers. The distribution of BAC readings for quad-related fatalities is presented in Figure 3.3. One third of all positive BAC readings were at a high level over 0.150g/100mL. A higher proportion of quad fatalities who were involved in a recreational incident recorded a positive BAC (39%) than those involved in a work-related incident (5%). Six of the incidents involving alcohol occurred on a farm. One rider from South Australia recorded a positive alcohol reading. This crash occurred at night time on a farm and was not work-related.

Forensic drug testing covers a wide range of licit and illicit drugs with some slight variations between jurisdictions. Riders were coded as positive for drug use if they recorded a positive blood drug test for the following drugs for which there is evidence that they impair driving performance: cannabis, MDMA and methamphetamine. Of those with a known drug test result (excluding unknown), 12% (n=15) tested positive for these drugs of which 14 were riders and one was a passenger. Cannabis was the most common drug detected with 12 riders testing positive (7 cannabis only, 5 in combination with other drugs). Interestingly, of those for whom drug status was known there was little difference in the proportion testing positive for drugs for riders involved in a work-related incident (10%) and those involved in a recreational incident (13%). Four (27%) of the quad fatalities testing positive for drugs were injured on a farm. None of the quad fatalities from South Australia recorded a positive drug test.

Of all the quad fatalities in Australia, only 22 (14%) were known to be wearing a helmet at the time of the incident. In 63 cases, it could not be established from the available information whether a helmet was worn or not. None of the fatalities occurring within South Australia was wearing a helmet.

Table 3.3
Rider characteristics involved in quad-related fatalities, 2000-2014

	SA		Rest of Australia		Total	
Rider characteristics	N=8	%	N=153	%	N=161	%
Sex						
Male	5	62.5	128	83.7	133	82.6
Female	3	37.5	25	16.3	28	17.4
Age						
<16 years	4	50.0	22	14.4	26	16.1
16-29 years	1	12.5	37	24.2	38	23.6
30-44 years	-	-	23	15.0	23	14.3
45-59 years	-	-	31	20.3	31	19.3
60+ years	3	37.5	40	26.1	43	26.7
User type						
Rider	4	50.0	138	90.2	142	88.2
Passenger/pillion	4	50.0	11	7.2	15	9.3
Other	-	-	3	2.0	3	1.9
Unknown	-	-	1	0.7	1	0.6
Carrying passenger						
Yes	7	87.5	27	17.5	34	21.1
No	1	12.5	115	74.7	116	72.0
Unknown	-	-	11	7.1	11	6.8
Alcohol use						
0 BAC	7	87.5	88	57.5	95	59.0
Positive BAC	1	12.5	35	22.9	36	22.4
Unknown	-	-	30	19.6	30	11.5
Drug use						
Yes	-	-	15	9.8	15	9.3
No	8	100.0	104	68.0	112	69.6
Unknown	-	-	34	22.2	34	21.1
Helmet use						
Worn	-	-	22	14.4	22	13.7
Not worn	8	100.0	68	44.4	76	47.2
Unknown	-	-	63	41.2	63	39.1

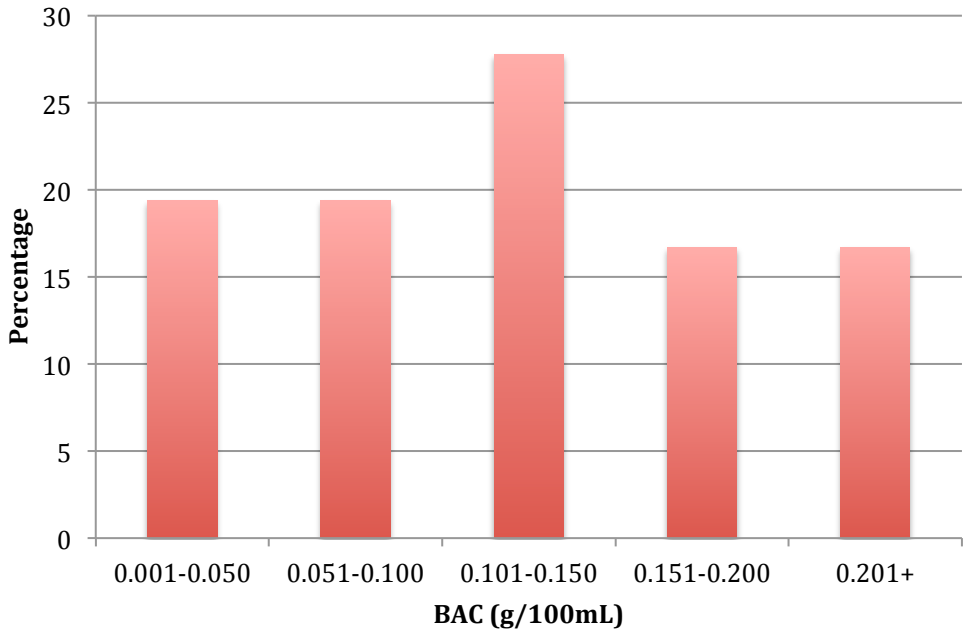


Figure 3.3
Distribution of positive BAC readings for quad-related fatalities, 2000-2014

The characteristics and nature of injuries associated with quad-related fatalities are presented in Table 3.4. Around 43% of all deceased riders were known to be trapped under the quad bike such that they were pinned between part of the vehicle and the ground. In many cases the rider was found trapped under the quad many hours after the incident. A greater proportion of all work-related riders (55%) were pinned by the quad than all recreational riders (36%) which is likely to reflect the nature of the activity. Farm work often involves working in isolation while recreational riding tends to be a more social activity that involves riding with others. In 13 cases, it could not be ascertained from case reports if the person was trapped. In South Australia, half of the quad riders (n=4) were trapped under the vehicle following the incident. In three cases, the rider was freed immediately after the incident but had already suffered fatal injuries. In one case, the rider was alone and was found approximately two hours after the incident.

The mechanism of injury refers to the way in which the injury resulting in death was sustained, that is, how the deceased was injured. While a number of events may have contributed to the injuries, in this case one mechanism was coded (by NCIS) to represent the start of the injury event. The most common mechanism of injury for quad fatalities was contact with an object (43%), followed by crushing (26%). The most common injury source for quad fatalities, defined by NCIS as the object/substance producing the injuries causing death, was the ground (22%), followed by the quad (19%). A similar trend for the mechanism of injury was evident for the South Australian quad incidents. Five riders received injuries resulting from contact with the ground (n=2), road, vehicle and a rock.

Head injuries were recorded as the cause of death, as deemed by the Coroner in each jurisdiction, in 38% of all quad fatalities in Australia. Of those with a head injury, 79% were riding for recreational purposes at the time of the incident. Of the 76 quad riders who were not wearing a helmet, 42 (55%) suffered a fatal head injury. Five of the South Australian riders received a head injury; none of them were wearing a helmet.

Table 3.4
Injury characteristics involved in quad-related fatalities, 2000-2014

	SA		Rest of Australia		Total	
Injury characteristics	N=8	%	N=153	%	N=161	%
Trapped/pinned						
Yes	4	50.0	65	42.5	69	42.9
No	4	50.0	75	49.0	79	49.1
Unknown	-	-	13	8.5	13	8.1
Mechanism of injury						
Contact with object	5	62.5	64	41.8	69	42.9
Crushing	2	25.0	40	26.1	42	26.1
Transport event	1	12.5	8	5.2	9	5.6
Mechanical threat to breathing	-	-	6	3.9	6	3.7
Poisoning or exposure to chemical	-	-	6	3.9	6	3.7
Fall	-	-	1	0.7	1	0.6
Unknown	-	-	28	18.3	28	17.4
Injury source						
Ground	3	37.5	33	21.6	36	22.4
Quad	1	12.5	30	19.6	31	19.3
Tree	-	-	18	11.8	18	11.2
Fence, gate	-	-	8	5.2	8	5.0
Roadway	1	12.5	6	3.9	7	4.4
Embankment	-	-	3	2.0	3	1.9
Beach	-	-	3	2.0	3	1.9
Branch	-	-	3	2.0	3	1.9
Rock/stone	1	12.5	1	0.7	2	1.2
Other	1	12.5	15	9.8	16	9.9
Unknown	1	12.5	33	21.6	34	24.2
Head Injury						
Yes	5	62.5	56	36.6	61	37.9
No	3	37.5	97	63.4	100	62.1

3.3.3 Quad bike characteristics

The characteristics of the quad bikes involved in the fatalities are shown in Table 3.5 Within the sample, the majority (85%) of vehicles involved were standard quad bikes (n=137), six were recreational or sports quad bikes, seven were side-by-sides or mules and in eleven cases the type of quad was unknown. In South Australia, one side-by-side and one sports quad were involved in quad fatalities. The engine capacity of the quads involved in all fatalities varied but a large proportion (57%) were not reported. Yamaha (n=32) and Honda (n=25) were the most common manufacturers. Five of the South Australian fatalities were riding Yamaha quads.

From a review of case reports, in only five incidents it was reported that a quad was towing a trailer or attachment. With respect to load, 35% (n=57) of quads were identified as carrying a load at the time of the incident including 34 carrying passengers, 13 with fitted spray tanks and the remainder carrying various pieces of equipment/tools. In 69 cases there was insufficient detail to determine whether the quad was carrying a load. All of the quad incidents occurring in South Australia involved carrying a load; six were carrying passengers, one carrying a passenger and a spray tank and one carrying equipment.

Researchers identified 90 (56%) incidents in which the quad bike rolled, although in 17 incidents there was insufficient information. Consequently, for those in which information was available, 63% of quad incidents involved a rollover. Around 61% of the quads that rolled over pinned the rider under the quad

during the incident. Of the rollovers, 67% (n=38) were carrying a load and 61% (n=45) occurred while travelling on a slope. Six of the quad incidents in South Australia involved a rollover; all of these were carrying a load and five transpired while travelling on a slope.

Despite the high incidence of rollovers, only six vehicles were known to have a rollover protection system and these were all side-by-side vehicles, one of which was in South Australia. In many cases (79%), there was insufficient information to determine whether a system was fitted as there were no vehicle photographs.

Table 3.5
Quad bike characteristics involved in quad-related fatalities, 2000-2014

	SA		Rest of Australia		Total	
Quad characteristics	N=8	%	N=153	%	N=161	%
Quad type						
Quad	6	75.0	131	85.6	137	85.1
Recreational quad	1	12.5	5	3.3	6	3.7
Side-by-side/Mule	1	12.5	6	3.9	7	4.3
Unknown	-	-	11	7.2	11	6.8
Quad engine size						
< 250cc	3	37.5	11	7.2	14	8.7
251-350cc	3	37.5	20	13.1	23	14.3
351-450cc	-	-	14	9.2	14	8.7
451cc +	1	12.5	17	11.1	18	11.2
Unknown	1	12.5	91	59.5	92	57.1
Rollover						
Yes	6	75.0	84	54.9	90	55.9
No	2	25.0	52	34.0	54	33.5
Unknown	-	-	17	11.1	17	10.6
Rollover protection						
Yes	1	12.5	5	3.3	6	3.7
No	7	87.5	21	13.7	28	17.4
Unknown	-	-	127	83.0	127	78.9
Quad towing						
Yes	-	-	5	3.3	5	3.1
No	8	100.0	105	68.6	113	70.2
Unknown	-	-	43	28.1	43	26.7
Quad load						
Yes	8	100.0	49	32.0	57	35.4
No	-	-	35	22.9	35	21.7
Unknown	-	-	69	45.1	69	42.9

Table 3.6 shows the mechanism of injury for all quad fatalities by rollover status. Riders with a quad that rolled over were most likely to incur injuries resulting from crush (36%) while riders on quads that did not rollover were more likely to incur injuries from contact with an object or the ground (59%).

Table 3.6
Mechanism of injury for quad fatalities by rollover status, 2000-2014

	Rollover		No rollover	
Mechanism of injury	N=90	%	N=54	%
Crushing	32	35.6	5	9.3
Contact with object	28	31.1	32	59.3
Other	14	15.6	7	13.0
Unknown	16	17.8	10	18.5

3.4 Discussion

This study provides detailed information about the factors contributing to fatalities resulting from the use of adult-size quads in South Australia compared with those for Australia. While the study examined the circumstances surrounding the incident, the characteristics of the rider, patterns of injury and factors associated with the quad, there was a specific focus on the incidence of behavioural factors contributing to quad-related trauma. General findings concerning all quad fatalities in Australia from 2000 to 2014 are discussed followed by comments related to risk factors that are particularly pertinent to quad fatalities in South Australia. Note that the small number of quad fatalities precludes any statistical analyses of trends.

A total of 161 quad fatalities occurring from 2000 to 2014, were identified from closed Coroner's case reports in NCIS. The majority of fatalities occurred in Queensland and New South Wales with eight fatalities recorded in South Australia. Of those killed in a quad incident, 88% were riders and 9% were passengers**.** Overall, there were 137 (85%) standard quads, six recreational/sports quads, seven side-by-sides or mules and 11 quads for which the exact type was unknown.

Across Australia, 37% of quad-related fatalities were classified as occurring during a work-related activity however, 59% of the incidents occurred on farms. Consistent with previous studies, these findings show that farm settings are the most common place for quad fatalities regardless of whether they are work-related or recreational incidents and should remain a central focus for any preventative approaches or safety measures (e.g. Lower et al., 2012). The high incidence of deaths on farms is also likely to reflect the popularity of quad bikes within agriculture in Australia. The majority (75%) of fatal incidents occurred off-road which is consistent with other Australian studies but in contrast to the United States where the majority of quad incidents occur on roads (Denning, Harland, Ellis, & Jennissen, 2013; Williams et al., 2014). Approximately half of the fatalities occurred on a slope.

With respect to temporal factors, quad fatalities within Australia occurred predominantly during daylight hours (73%) and were most common during the Autumn months (33%).

Consistent with previous research from Australia (e.g. Clapperton et al., 2013) and overseas (e.g. Helmkamp, Aitken, et al., 2012; Vanlaar et al., 2015), riders who were killed in quad incidents were more likely to be male. This finding is likely to reflect the dominance of males in the agricultural sector. The greatest proportion (27%) of fatally injured riders were aged 60 years and over. This may, to some degree, reflect the aging population of farmers but also the increased frailty of older riders. As their physical capabilities decline, such as balance, older riders might be choosing to use quads rather than two wheel motorcycles or other vehicles for farming tasks because they are easier to ride and do not require the movement of getting in and out of a vehicle.

Quad bikes are not designed to carry passengers but in 22% (n=32) of fatal incidents a quad (excluding side-by-sides) was carrying one or more passengers. In 13 (41%, 8 male, 5 female) of these incidents, the person killed was a passenger. In general, females fatalities tended to be more likely to be passengers than male fatalities.

Few studies have documented the level of alcohol intoxication and drug use among quad riders in Australia. Of those for whom alcohol status was known, 28% (n=36) of quad fatalities tested positive for alcohol. One study of riders hospitalised following a quad incident in northern Queensland reported 19% of casualties were intoxicated by alcohol at the time of the incident (O'Connor, Hanks, & Steinhardt, 2009). The level of alcohol use found in this study is similar to that reported for fatally injured drivers in Australia: 29% in 2008 recorded an illegal BAC (Watson, 2012). Alcohol was predominantly associated with recreational quad incidents (39%) rather than those that were work-related (5%) and six (17%) of those with a positive BAC occurred on a farm. With respect to drugs, of

those with a known drug test result, 12% (n=15) tested positive for at least one drug (THC, MDMA, methamphetamine) with cannabis the most common drug detected. This proportion is slightly less than that found in a study of South Australian fatal road crashes where 19% of drivers/riders killed were positive for drugs that had the capacity to affect their driving (Baldock & Lindsay, 2015). In contrast to alcohol, there was little difference in the proportion testing positive for drugs for riders involved in a work-related incident (10%) compared to those involved in a recreational incident (13%). Four (27%) of the quad fatalities testing positive for drugs were injured on a farm. These findings suggest that quad use while impaired by drugs was not entirely constrained to recreational and off farm settings.

Only 22 (14%) of quad fatalities were known to be wearing a helmet at the time of the incident. However, in 63 cases it could not be established from the available information whether a helmet was worn or not. While low rates of helmet use by injured quad riders is documented within the literature in Australia (Grzebieta et al., 2015; O'Connor et al., 2009), they are usually estimates based on limited data. In many cases, as with the present study, helmet use is not often recorded because it is not routinely collected or coded information. Improvements in data collection will assist in estimating the true prevalence of quad helmet use. Of the 76 quad riders who were not wearing a helmet, 42 (55%) suffered a fatal head injury. Those who received a fatal head injury were more likely to riding for recreational purposes (79%) at the time of the incident. These findings are suggestive that helmet use would be most beneficial in recreational settings, but still of value for work-related activities.

Loads can make a quad bike unstable by raising the centre of gravity, particularly moving loads such as liquid (i.e. sprays), and increase the likelihood of rollovers (Australian Centre for Agricultural Health and Safety, 2011). A total of 57 (35%) quads were identified as carrying a load at the time of the incident of which 34 were carrying passengers and 13 with fitted spray tanks. However, in many cases (n=69, 43%) there was insufficient detail to determine whether the quad was carrying a load.

More than half (56%) of all quad fatalities involved the quad rolling over. Around 61% of the quads that rolled over pinned the rider under the quad during the incident. A New Zealand study found that being pinned under the quad increased the likelihood of being killed by 10.3 times (Shulruf & Balemi, 2010). This finding is not surprising given that a quad can weigh around 250kg. Indeed, riders on quads that rolled over were most likely to incur injuries resulting from crush (36%) while riders on quads that did not roll over were more likely to incur injuries from contact with an object or the ground (59%) consistent with previous research (Hall et al., 2009; Lower et al., 2012; McIntosh et al., 2015). Of the rollovers, 67% (n=38) were carrying a load and 61% (n=45) occurred while travelling on a slope.

Despite the high prevalence of rollovers, only six vehicles were known to have a rollover protection system (ROPS) and these were all side-by-side vehicles. Note that most standard quad bikes do not have ROPS fitted as standard equipment. A ROPS may be a roll bar or cage, or even a strong cabin, and should include restraint(s) to retain the rider within the area protected by the ROPS. Other products have also been developed that aim to prevent the quad from crushing the rider in the case of a rollover. These are referred to as crush protection devices. A Crush Protection Device (CPD), which is a two bar or circular structure attached to the rear of the vehicle, aims to provide a protective space in the event of a roll over, (but without a seat belt). The utility of either device has been the subject of considerable debate and disagreement.

South Australia

While many factors associated with quads fatalities in Australia were also evident in South Australia, there are a number of specific issues that were particularly salient for South Australia and warrant further discussion: children on quads, carrying passengers and loads and helmet use. Note that there was a very small number of quad fatalities in South Australia so findings should be viewed as observations rather than established trends.

While the greatest proportion of Australian quad fatalities were older riders aged over 60 years, 16% (n=26) of fatalities were children aged under 16 years. In South Australia, half of the fatalities (n=4) were children and three fatalities were older riders aged 60 years and over. This finding is consistent with a New Zealand study that found riders aged 66 years and over and children aged 11 to 15 years were at the greatest risk for fatalities (Shulruf & Balemi, 2010). Of the 26 children fatally injured in Australia, 15 were riding an adult sized quad or side-by-side and the remaining 11 were passengers. Within South Australia, three were riding an adult size quad or side-by-side and one was a passenger. The three children controlling a quad/side-by-side all had child passengers at the time of the incident. The high proportion of children receiving quad-related fatal injuries in this study, and particularly in South Australia is a major concern. Quad manufacturers and several reputed organisations (Royal Australasian College of Surgeons, 2013; Yanchar, 2012) recommend children under the age of 16 years should not be riding quads as research indicates that children do not have the physical strength, size or cognitive ability to operate a quad safely (Mattei et al., 2011; Pearce & Miles, 2015). Indeed the proportion of children with fatal quad-related injuries in this study is likely to be an underestimate as only riders of adult sized quads were included.

Quad manufacturers state that quads are not designed to carry passengers as the rider needs to be able to move for optimal control of the vehicle (Safe Work Australia, 2012). Of the eight quad incidents in South Australia, seven involved the carriage of passengers and of these incidents, three occurred as a direct result of passenger behaviour. In each of these cases a passenger inadvertently knocked the rider or the quad operator controls which resulted in a loss of control of the quad. Furthermore, passengers and loads can increase the instability of the quad and increase the likelihood of a rollover. All of the quad incidents in South Australia involved carrying a load; six were carrying passengers, one carrying a passenger and a spray tank and one carrying equipment. Of all the rollovers in South Australia (n=6), all were carrying a load and five transpired while travelling on a slope.

Helmet use or non-use could be established for all of the South Australian quad fatalities from the information in the original Coroner's reports. None of the South Australian quad fatalities was wearing a helmet. Five of the eight fatalities not wearing a helmet suffered a head injury. From all of the information available, it was estimated by a health care professional that four of the riders were likely to have survived their injuries if wearing a helmet.

Limitations

Using data from NCIS allows a comprehensive capture of quad-related fatalities. However it is limited by the level of detailed information available for each case and cases were found to vary widely. More detailed information was available for South Australian quad fatalities as original Coroner's reports were obtained. Comprehensive police investigations, photographs and mechanical inspections of the quad were included in the original South Australian reports. While not within the scope of this study, obtaining original Coroner's reports from all jurisdictions would allow a more comprehensive analysis.

The analysis of fatality data for quad (and motorcycle) incidents would be greatly aided by the routine recording of helmet use by police and the subsequent coding in NCIS. This would afford more accurate estimates of helmet use and assist in guiding injury prevention strategies. The standard reporting and coding of other variables such as carrying passengers and loads/attachments would also assist in understanding quad-related trauma.

3.5 Conclusions

This study examined factors contributing to 161 fatalities in Australia from 2000 to 2014 resulting from the use of adult size quads with a specific focus on quad fatalities occurring in South Australia. Overall, within this sample quad fatalities predominantly occurred on farms, in off-road environments, during daylight hours and were more likely to be recreational. Riders killed in quad-related incidents were more likely to be male and aged over 60 years which is likely to reflect the demographic profile for agricultural workers. Of those with known test results, 28% of quad fatalities tested positive for alcohol and 12% positive for drugs. More than half of all quad fatalities involved the quad rolling over resulting in many riders being pinned under the quad during the incident. Riders on quads that rolled over were most likely to incur injuries resulting from crush while riders on quads that did not roll over were more likely to incur injuries from contact with an object or the ground. Rollovers also occurred more frequently when carrying a load and when travelling on a slope.

The findings from a small number of cases in South Australia suggest quad-related trauma might be reduced in South Australia by restricting the carriage of passengers on quads not designed to carry passengers and not allowing children under the age of 16 years to ride an adult size quad. In addition increased helmet use could reduce the number of head injuries. These recommendations are also relevant to quad use throughout Australia and have the potential to prevent many quad-related injuries and save lives.

4 Identification of quad bike injury in hospital admissions

4.1 Introduction

This study was concerned with identifying and describing the injuries of patients admitted to hospitals in Australia following an incident with a quad bike. A specific focus of this study was on quad bikes in farming and other agricultural activities. The Australian Modification of the 10th revision of the International Classification of Diseases (ICD-10-AM) includes categories designed to specify cases involving predominantly agricultural vehicles and machinery.

Other reports examining hospital admissions following an incident involving a quad bike have tended to include as quad bike cases all records with ICD-10-AM code V86.n2 in Victoria (Clapperton et al. 2013) and in New South Wales (Mitchell et al. 2015). This study will attempt to identify and describe demographic and injury characteristics associated with quad bike use among all patients admitted to hospitals in Australia.

4.2 Method

The National Hospital Morbidity Database (NHMD) was interrogated (AIHW, 2014). Preliminary investigation focused on criteria for identifying cases where injury involved a quad bike, which is described in the next section. Other aspects of the method are described here.

The NHMD data inspected are for admitted patient episodes that ended from 1 July 2002 to 30 June 2013. Certain extensions to the Australian Modification of the International Classification of Diseases ICD-10-AM that were introduced in 2002 make that a suitable starting date. Data for 2012-13 were the latest on hand when analysis for this project commenced (NCCH, 2010; WHO, 1992).

Injury cases were specified in the way that is used for most injury reports by the AIHW National Injury Surveillance Unit (AIHW: Pointer, 2015). Admissions were considered to be due to injury if the principal diagnosis code was in the ICD-10-AM range S00 – T75 or T79. This includes all conditions in the injury chapter of ICD-10 except complications of medical and surgical care and sequelae (i.e. late effects). Inward transfers from other acute hospitals were omitted to reduce multiple counting of cases that involve more than one episode of care, resulting in more than one record in the NHMD.

A statistical description of the selected subset of records was produced using Stata SE/13 software (Statacorp, 2013).

4.3 Results

4.3.1 Criterion for quad bike involvement

“Quad bike” has somewhat variable meaning and is not a term that appears in ICD-10-AM (NCCH 2010). Hence, it is not self-evident how cases involving the machines that are in mind for this study are coded in hospital data, nor how best to select one or more relevant subsets of records.

“All-terrain vehicle” is sometimes taken to be a synonym for quad bike (Mitchell et al., 2015), though use of the term is discouraged by some (see Grzebieta et al., 2015). Quad bike has been defined by the American National Standards Institute (ANSI) as a vehicle that travels on low-pressure tires, with a seat that is straddled by the operator, along with handlebars for steering control.

Five categories or sets of categories in recent editions of the ICD-10-AM might, at face value, potentially have been used to code cases involving a quad bike. These are shown in Table 4.1, below.

Table 4.1 ICD-10-AM codes that might be applied to cases involving a quad bike

ICD-10-AM code	Category title	Stated inclusions & exclusions
V2n	Motorcycle rider injured in transport accident	Includes: moped motor scooter motorcycle with sidecar motorised bicycle Excludes: three-wheeled motor vehicle
V2n.n2*	Motorcycle designed primarily for off-road use	Includes: Ag-bike, Dirt-bike or Trail-bike registrable for on-road use Excludes: drag racing bike (V86.-0) special all-terrain or other off-road motorcycle (2-, 3- or 4-wheeled) not registrable for on-road use (V86.-)
V4n	Car occupant injured in transport accident	
V4n.n1**	…all-terrain four-wheel drive	Includes: 4WD NOS All-terrain or 4WD designed primarily for off-road use; All-terrain or other off-road motor vehicle registrable for on-road use such as: Honda CR-V, Mitsubishi Pajero, Nissan Patrol, Subaru Forester, Toyota Landcruiser / Prado / RAV4. Excludes: sedan-shaped 4WD not primarily designed for off-road use (.0) special all-terrain or other off-road motor vehicle not registrable for on-road use (V86.-2)
V4n.n2***	…four-wheeled motorcycles	Includes: Four-wheel drive motorcycle Quad-cycle registrable for on-road use Excludes: four-wheel drive motorcycle; quad-cycle not normally registrable for on-road use (V86.-2)
V84	Occupant of special vehicle mainly used in agriculture injured in transport accident	Excludes: Vehicle in stationary use or maintenance (W30.-)
V86.n****	Occupant of special all-terrain or other motor vehicle designed primarily for off-road use, injured in transport accident.	Excludes: special all-terrain or other off-road motor vehicle registrable for on-road use (V20-V49) vehicle in stationary use or maintenance (W31.-)

* *The subset of motorcyclist cases where the 5th character = 2, 'motorcycle designed primarily for off-road use*
** *The subset of car occupant cases where the 5th character = 1, 'all-terrain four-wheel drive'*
*** *The subset of car occupant cases where the 5th character = 2, 'four-wheeled motorcycles'.*
**** *The 4th character allows coding of number of wheels: 0 = 2; 1 = 3; 2 = 4; 9 = unspecified number.*

Still other ICD-10-AM categories could, conceivably, be relevant. A focus of this project is the use of quad bikes in farming. Notably, in this context, is that the devices under consideration could possibly be regarded as "special vehicle[s] mainly used in agriculture", coded to V84.

Some distinctions made in these categories, and potentially relevant here, are subtle and likely to be difficult for clinical coders to make reliably in practice. Notably, a clause such as "designed primarily for off-road use" requires judgement of a characteristic that may not, strictly, be knowable and may often not be known to those reporting information to clinicians, recording information in hospital

records or coding that information. The clause “registrable for on-road use”, and the complementary negative clause, also refer to a complex characteristic, as eligibility for registration depends on specific characteristics of machines and jurisdiction. Moreover, special limited registration is available in some jurisdictions, and it is not indicated in ICD-10-AM how that should be handled.

Furthermore, ICD-10-AM does not appear to provide a good basis for distinguishing quad bikes from broadly similar vehicles, which are designed for off-road use and have four wheels, but do not fit the ANSI definition mentioned above. As defined there, a quad bike has handlebars and is straddled by the operator. Some similar vehicles are operated by a steering wheel and have seats similar to those in a car. These include devices with one seat, two seats (generally placed side-by-side) and more than 2 seats (generally in two rows).

Senior expert clinical coders were consulted about how quad bike cases are likely to have been coded. They agreed that the necessary distinctions and categories make the task complex and susceptible to uncertainty and variation. They advised that the categories most likely to have been used for ‘quad bikes’ are in V86.n (Special all-terrain or other motor vehicle designed primarily for off-road use), particularly those that refer to vehicles with 4 wheels. The ICD-10-AM code specification for these vehicles is summarised here as V86.n2, where ‘n’ means any 4th character value allowed by ICD- 10-AM. Categories V4n.n2 (4-wheel motorcycle) might possibly also have been used. Many fewer cases were coded to V4n.n2 and most of these were recorded as occurring in traffic (i.e. on-road).

Cases with V86.n2 were included in recent Australia studies of hospital admitted quad bike injury cases (Clapperton et al., 2013, Mitchell et al., 2015). Cases with V4n.n2 were also included in one of these projects (Clapperton et al., 2013). In this project, attention was restricted to V86.n2, noting that the exclusion terms for V4n.n2 can be expected to limit its use for quad bikes (Table 4.1)[1].

Of 9,923 hospital-admitted injury cases in Australia in the 11 years to 30 June 2013 that include code V86 (Special all-terrain or other motor vehicle designed primarily for off-road use), over 80% were recorded as having 4 wheels (Table 4.2).

Table 4.2
Admitted injury cases with external cause *Occupant of special all-terrain or other motor vehicle designed primarily for off-road use*, by number of wheels, Australia, 2002–03 to 2012–13

Wheels	Number	%
2	1,245	12.6
3	116	1.2
4	7,969	80.3
Unspecified	593	6.0
Total	9,923	100.0

Source: AIHW National Hospital Morbidity Database.

The scope of this project does not extend to two-wheeled all-terrain vehicles. Only 1% of the V86 cases were recorded as having 3 wheels. Some all-terrain vehicles otherwise similar to quad bikes have three wheels, but they are now uncommon. Whether the 116 cases involved quad bike-like 3-wheeled vehicles or other tricycles is not known. This small group was omitted in the interests of maximising focus on (4-wheeled) quad bikes. It is likely that many of the vehicles with an unspecified

1 Cases meeting the inclusion criteria for Tables 7 to 18 but with mention of a “*four-wheeled motorcycle*” (ICD-10-AM codes commencing with V4 and with 2 as the fifth character) instead of a “*special all-terrain or other motor vehicle designed primarily for off-road use*” numbered 42 during the study period.

number of wheels had four. However, this is a supposition and since the unspecified type made up a small proportion of all cases coded to ICD-10-AM code V86 it was decided to omit them. Accordingly, attention was limited to cases with external code V86 in which the fifth character of the code-string was '2', meaning "Four-wheeled special all-terrain or other off-road motor vehicle" (V86.n2).

4.3.2 A set of cases likely to include most injury cases involving a quad bike

Further opportunity to identify quad bike cases flows from the availability and use of 'place of occurrence' and 'activity when injured' codes, which form part of the external causes chapter in ICD-10-AM (NCCH, 2010).

While the inclusion criteria for V86.n2 allow quad bike injury cases to be assigned this code, they are not specific to quad bikes. This becomes clear when injury cases with V86.n2 are subdivided by activity when injured (Table 4.3).

Table 4.3
Admitted injury cases with external cause *Occupant of four-wheeled special all-terrain or other motor vehicle*, by type of activity when injured, Australia, 2002–03 to 2012–13

Type of activity	Number	%
Motorsports:		
Riding ATV	577	7.2
Motorcycling	188	2.4
Motor car racing	50	0.6
Go-carting	370	4.6
Other specified	54	0.7
Unspecified	6	0.1
Other sport or leisure activity*	712	8.9
Working for income	728	9.1
Other specified activity	912	11.4
Unspecified activity	4,372	54.9
Total	7,969	100.0

Source: AIHW National Hospital Morbidity Database.
*Other sport or leisure activity includes 108 with code U60.5, Golf.

Some of the specified categories appear to refer to types of conveyance that are in-scope for ICD-10-AM codes V86.n2 but out of scope for this project (e.g. go-carts; golf-buggies). Others are more ambiguous, possibly reflecting uncertain or varying interpretation of inclusion criteria (e.g. motorcycle and motor-car racing). It was concluded that we should not treat cases with motorsport categories other than "Riding ATV" as being in-scope.

The other 'Activity' when injured category that was found to be helpful when selecting a subset of V86.n2 cases that were likely to have involved a quad bike was V73.0, 'while working for income' (n=728). There was no strong reason to think that all of the involved conveyances in this group were quad bikes. However, when examined in terms of place of occurrence, it was noted that 594 (82%) of the "working for income" cases were recorded as having occurred on a farm. It was considered that the conveyances in this subset (i.e. V86.n2 vehicle, on a farm, in the course of work for income) were particularly likely to be quad bikes.

The next three tables (Tables 4.4 - 4.6) include V86.n2 cases but omit those with certain specific activities that are unlikely to have involved use of a quad bike, namely participation in motor-sports (code U65) except the cases described as occurring while driving an ATV (code U65.0), and cases recorded as occurring while playing golf (code U60.5). Omission of other motor-sport cases reduced included cases by n=668 and omission of the golfing cases reduced the count by another n=108. The

remaining V86.n2 cases, over 90% of the total, are thought to include most quad bike cases, but cannot be assumed to include only quad bike cases. This is because more than half of the cases have unspecified activity, and these probably include at least some cases that did not involve a quad bike.

Table 4.4
Injured Occupant of special all-terrain or other motor vehicle designed primarily for off-road use (V86) with 4 wheels, by age and sex, Australia, 2002–03 to 2012–13

	Males		Females		Persons	
Age group	Number	%	Number	%	Number	%
0-4	120	2.2	76	4.2	196	2.7
5-9	344	6.4	204	11.3	548	7.6
10-14	577	10.7	296	16.4	873	12.1
15-24	1,186	22.0	440	24.4	1,626	22.6
25-34	894	16.6	233	12.9	1,127	15.7
35-54	1,480	27.5	316	17.5	1,796	25.0
55-64	435	8.1	131	7.3	566	7.9
65-74	225	4.2	60	3.3	285	4.0
75+	128	2.4	49	2.7	177	2.5
Total	5,389	100.0	1,805	100.0	7,194	100.0

Source: AIHW National Hospital Morbidity Database.
Excludes cases with activity codes U65.1 to U65.9 and U60.5

Three-quarters of the cases were males and in nearly two-thirds of cases the person was aged 15 to 54 years (Table 4.4). 22% of cases were children aged under 15 years. Place of occurrence was not specified for almost half of the cases (Table 4.5). Where it was specified it was most often a farm (23.7% of all cases; 45.6% of cases with a specified place). Many of the other specified places were open areas, particularly beaches (over 10% of specified places).

Table 4.5
Injured Occupant of special all-terrain or other motor vehicle designed primarily for off-road use (V86) with 4 wheels, by type of place, Australia, 2002–03 to 2012–13

Type of place	Number	%
Home	406	5.6
Racetrack/racecourse	56	0.8
Street/highway	505	7.0
Farm	1,704	23.7
Beach	385	5.4
Forest	144	2.0
Desert	20	0.3
Other specified	513	7.1
Unspecified	3,461	48.1
Total	7,194	100.0

Source: AIHW National Hospital Morbidity Database.
Excludes cases with activity codes U65.1 to U65.9 and U60.5

Since cases with specific activities thought not to involve use of a quad bike have been excluded, the proportion of remaining cases for which a specific activity code was not supplied is over 80%, even higher than the already high proportion of all V86.n2 cases (Table 4.6). Of the remainder, most are cases coded to motorsport – riding and ATV and working for income in primary industries. It seems likely that most hospitalised cases due to injury involving a quad bike are in this set (i.e. it probably has good sensitivity). However, the evidence shown above that V86.n2 cases include some in which the vehicle is unlikely to have been a quad bike and a large number in which the activity is not known

(Table 4.3). Thus, we do not have a good basis for assuming that all of the cases included in the set shown in Tables 4.4 to 4.6 involved a quad bike (i.e. it has doubtful specificity).

Table 4.6
Injured *Occupant of special all-terrain or other motor vehicle designed primarily for off-road use* (V86) with 4 wheels, by type of activity, Australia, 2002–03 to 2012–13

Type of activity	Number	%
Specific activity not assigned	5,802	80.7
Riding an ATV (motorsport)	577	8.0
Working for income: agriculture, forestry, or fishing	600	8.3
Working for income: other-specified	45	0.6
Working for income: unspecified	63	0.9
Engaged in other type of work	107	1.5
Total	7,194	100.0

Source: AIHW National Hospital Morbidity Database.
Excludes cases with activity codes U65.1 to U65.9 and U60.5

4.3.3 A set of cases likely to be nearly specific to quad bike injury cases

The available data provide a basis for selecting a set of cases that is likely to be more specific to quad bike cases than the set shown in Tables 4.4 to 4.6. However the data do not provide a good basis for selecting a set which is both sensitive (i.e. includes all or nearly all of the quad bike cases) and specific (i.e. all of the cases included involved a quad bike).

A benefit of identifying a specific set is that statistical description of it is more likely to be relevant to quad bike cases than a statistical description of a non-specific. The main disadvantage is that the size of the set cannot be assumed to provide a good guide to the total number of hospitalised injuries due to events that involved a quad bike.

After careful assessment of ICD-10-AM categories and available data on injury cases admitted to hospitals in Australia, it was concluded that two subsets of the V86.n2 cases were the most likely to be largely restricted to quad bikes. These are cases with V86.n2 in which:

- The activity when injured was 'riding an ATV', or
- The activity when injured was working for income and the place of occurrence was a farm.

That set, which numbers 1,236 cases during the eleven years 2002–03 to 2012–13, was selected and is described statistically in the next section. For brevity, the group is referred to as quad bike cases, though it is acknowledged that it may not be entirely specific to this type of case. It should be noted that the number of quad bike cases may well be considerably larger than this. However, the available information did not allow selection of a larger set for analysis without increasing the likelihood of including cases that did not involve a quad bike.

In principle, a method could be used to estimate the number of quad bike cases that are present among cases that lacked specific information on external cause, place and/or activity. Doing so on the basis of the information at hand would be, in essence, a guess. A special study could be done in which a sample of cases in a wider set is identified (e.g. all cases in a period that have codes V86.n2; perhaps also some of the other codes discussed above) and the hospital records of these cases are examined to assess which actually involved a quad bike. Such a study might be able to produce an algorithm that could be applied (with some caveats) to estimate numbers of injury cases involving a quad bike (see also Discussion, below).

The injured person

Nearly 81% of cases in the relatively specific set were males, a higher proportion than for all V86.n2 cases (Table 4.7). The age distribution of cases in the specific set is similar to that for other V86.n2 cases, though a little older: 55% of cases in the specific set were at ages 35 and older, whereas 39% of other V86.n2 cases were in this age range. Fewer cases were aged under 15 years in the specific set (13%) compared to V86.n2 cases (22%).

Table 4.7
Admitted quad bike cases by age and sex, Australia, 2002–03 to 2012–13

	Males		Females		Persons	
Age group	Number	%	Number	%	Number	%
0-4	9	0.9	5	2.1	14	1.1
5-9	36	3.6	18	7.6	54	4.4
10-14	58	5.8	34	14.3	92	7.4
15-24	203	20.3	62	26.1	265	21.4
25-34	146	14.6	39	16.4	185	15.0
35-54	316	31.7	42	17.7	358	29.0
55-64	129	12.9	25	10.5	154	12.5
65-74	66	6.6	8	3.4	74	6.0
75+	35	3.5	5	2.1	40	3.2
Total	998	100.0	238	100.0	1,236	100.0

Source: AIHW National Hospital Morbidity Database.

The injurious event

In over 87% of cases in the set, the injured person was identified as having been driving the vehicle (Table 4.8). In an even higher proportion of cases the event was recorded as having occurred in a 'non-traffic' setting (Table 4.9). For present purposes, 'non-traffic' can be regarded as synonymous with 'off road'. About three-quarters of cases in the set were coded to a type of place of occurrence (Table 4.10); 58% of all of the cases, and a higher proportion of cases with specified place, were recorded as having occurred on a farm. Other open areas, particularly beaches, were also prominent.

Table 4.8
Admitted quad bike injury cases by user role, Australia, 2002–03 to 2012–13

User role	Number	%
Driver	1,079	87.3
Passenger	53	4.3
Person on outside	18	1.5
Boarding or alighting	8	0.7
Unspecified occupant	78	6.3
Total	1,236	100.0

Source: AIHW National Hospital Morbidity Database.

Table 4.9
Admitted quad bike injury cases by whether in traffic, Australia, 2002–03 to 2012–13

Traffic status	Number	%
Traffic	62	5.0
Non-traffic	1,166	94.3
Board/alight	8	0.7
Total	1,236	100.0

Source: AIHW National Hospital Morbidity Database.

Table 4.10
Admitted quad bike injury cases by type of place, Australia, 2002–03 to 2012–13

Type of place	Number	%
Home	28	2.3
Racetrack/racecourse	26	2.1
Street/highway	18	1.5
Farm	716	57.9
Beach	59	4.8
Forest	26	2.1
Desert	12	1.0
Other specified	49	4.0
Unspecified	302	24.4
Total	1,236	100.0

Source: AIHW National Hospital Morbidity Database.

Activity codes form part of the selection criteria for cases in this set, so a specific activity code is available for all 1,236 (Table 4.11). Similar proportions of the included cases are of the two main: Riding an ATV (47%) and Working for income in primary industries (45%).

This pattern is quite different from that for the full set of cases with external cause code V86, more than half of which had unspecified activity (Table 4.3), 7% had Riding an ATV and 9% had Working for income.

Table 4.11
Admitted quad bike injury cases by type of activity, Australia, 2002–03 to 2012–13

Type of activity	Number	%
Riding an ATV (motorsport)	577	46.7
Working for income: agriculture, forestry, or fishing	560	45.3
Working for income: other-specified	14	1.1
Working for income: unspecified	20	1.6
Engaged in other type of work	65	5.3
Total	1,236	100.0

Source: AIHW National Hospital Morbidity Database.

The injury sustained

In over 70% of the cases, the main injury (the one specified in the Principal Diagnosis code) referred to an injury in one of three body regions: *Head and neck, Trunk, and Shoulder and upper limb* (Table 4.12), each of which accounted for more than 20% of the cases.

Table 4.12
Admitted quad bike injury cases by body region injured, Australia, 2002–03 to 2012–13

Body part injured	Number	%
Head and neck	298	24.1
Trunk (thorax, abdomen, lower back, lumbar spine, pelvis).	335	27.1
Shoulder and upper limb (except wrist and hand)	275	22.3
Wrist and hand	64	5.2
Hip and lower limb (except ankle and foot)	217	17.6
Ankle and foot	29	2.4
Other, multiple and incompletely specified body region	15	1.2
Injuries not described in terms of body region	3	0.2
Total	1,236	100.0

Source: AIHW National Hospital Morbidity Database.

Some injuries of particular concern in the context of quad bike crashes are crush injuries of the chest and spinal cord injuries. In this set of 1,236 cases, the Principle Diagnosis was fracture of multiple ribs in 69 cases (S22.4), flail chest in 7 cases (S22.5) and injury of the spinal cord in 16 cases (S14, S24 or S34), 8 of which were at neck level.

The injury conditions referred to in Principal Diagnosis codes can also be summarised in terms of type or 'nature' of injury (Table 4.13). More than half of the injuries were fractures.

Table 4.13
Admitted quad bike injury cases by nature of injury, Australia, 2002–03 to 2012–13

Nature of injury	Number	%
Fracture	640	51.8
Dislocation	49	4.0
Soft-tissue injury	56	4.5
Open wound	101	8.2
Intracranial injury	100	8.1
Internal organ or vessel of trunk	69	5.6
Burn	6	0.5
Superficial injury	76	6.2
Other specified	55	4.5
Unspecified	84	6.8
Total	1,236	100.0

Source: AIHW National Hospital Morbidity Database.

The disposition of the cases in the set at the end of these inpatient episodes is shown in Table 4.14. This provides some insight into the severity profile of the cases. Three cases ended with the death of the person while in hospital. Nearly 21% of the cases were transferred to another acute care hospital at the end of the current episode. While the data source did not allow identification of the specific hospital to which transfer was made, the typical circumstance prompting transfer is when more specialised care is required than can be provided at the current hospital. The high proportion of transfers is likely to reflect two features of these cases. First, many cases will have occurred at places far from a major hospital. The individuals may have been admitted first to a relatively nearby hospital before being transferred to a hospital with higher-level trauma care capabilities. Second, this set may include a relatively high proportion of cases that are serious.

Table 4.14
Admitted quad bike injury cases by mode of separation, Australia, 2002–03 to 2012–13

Mode of separation	Number	%
Transfer to other acute-care hospital	257	20.8
Transfer to other health facility or nursing home	3	0.2
Statistical discharge (type change)	20	1.6
Discharge at own risk	12	1.0
Died	3	0.2
Other – to usual residence	941	76.1
Total	1,236	100.0

Source: AIHW National Hospital Morbidity Database.

Another characteristic of cases in the reported set that provides an indication of their severity is duration of stay in hospital. Mean length of stay, in days, is shown in Table 4.15, by age at injury. Case numbers are also shown. For the 1,236 cases overall, mean length of stay was 3.38 days (SD 6.43), ranging from 1 to 110 days. Mean length of stay was shortest for the youngest age group and longer for older groups, ranging from less than three days for children to nearly 5 days for those aged 75 and older. This pattern – longer length of stay at older ages – is commonly found for hospitalised injury cases.

Table 4.15
Admitted quad bike cases and mean length of stay, by age, Australia, 2002–03 to 2012–13

	Persons	
Age group	Number	Mean length of stay (days)
0-4	14	2.1
5-9	54	2.4
10-14	92	2.9
15-24	265	2.9
25-34	185	3.1
35-54	358	3.6
55-64	154	3.9
65-74	74	4.3
75+	40	4.8
Total	1,236	3.4

Source: AIHW National Hospital Morbidity Database.

Another way in which the severity of injury cases can be summarised makes use of the ICD-based Injury Severity Score (ICISS) method, as used in many reports produced by the AIHW National Injury Surveillance Unit. In this method, injury diagnosis codes are assigned weights, calculated as the proportion of all cases in a large test set with that diagnosis where the person survived to discharge. Table 4.16 shows the proportion of the cases in the study set for which a summary value, calculated as the product of the ICISS value for each injury diagnosis in a case record, was below (i.e. more life-threatening) than a commonly used threshold (0.941). Overall, almost 31% of cases in the set were selected as relatively life-threatening according to this criterion. The proportion was lower for young children and highest for the cases where the person was middle-aged or older.

Table 4.16
Admitted quad bike cases and proportion with high threat to life injuries, by age, Australia, 2002–03 to 2012–13

	Persons	
Age group	Number	High Threat to Life (%)
0-4	14	7.1
5-9	54	18.5
10-14	92	27.2
15-24	265	26.1
25-34	185	26.0
35-54	358	35.2
55-64	154	38.3
65-74	74	39.2
75+	40	37.5
Total	1,236	30.9

Source: AIHW National Hospital Morbidity Database.

Admitted cases are normally assigned an urgency status. Of the 1,236 cases in the set reported here, urgency status had been assigned for 1,223, of which 1,122 (91%) were assigned urgency status *emergency*.

Variation over time

The annual numbers of cases in the selected set tended to rise over the 11 year period ending in mid-2013 (Table 4.17).

Table 4.17
Admitted quad bike cases by year of separation and sex, Australia, 2002–03 to 2012–13

Year	Males	Females	Persons
2002-03	82	13	95
2003-04	59	16	75
2004-05	56	9	65
2005-06	60	10	70
2006-07	76	25	101
2007-08	97	24	121
2008-09	127	26	153
2009-10	111	24	135
2010-11	102	31	133
2011-12	119	29	148
2012-13	109	31	140
Total	998	238	1,236

Source: AIHW National Hospital Morbidity Database.

Administrative characteristics

As might be expected, Workers' Compensation was prominent as the sources of funding hospital care for cases that occurred while working for income (Table 4.18). Far from all of the work-related cases were funded by Workers' Compensation. That is also to be expected, as, particularly in farming, many workers do not come within the scope of workers' compensation schemes. The great majority of cases that occurred while riding an ATV were funded by the general mechanism that funds public patients (referred to as Australian Health Care Agreements in the table).

Table 4.18
Admitted quad bike cases by activity and funding source, Australia, 2002–03 to 2012–13

			Principal source of funding*			
Activity group	Australian Health Care Agreements	Private health insurance	Workers' compensation	Motor vehicle third party insurance	Other and unspecified	Total
Riding an ATV (motorsport)	444	74	6	28	25	577
Working for income: agriculture, forestry, or fishing	274	120	135	14	17	560
Working for income: other-specified	4	3	7	0	0	14
Working for income: unspecified	4	5	9	1	1	20
Engaged in other type of work	42	18	1	4	0	65
Total	768	220	158	47	43	1,236

Source: AIHW National Hospital Morbidity Database.

** Coding and naming of some categories changed in the last year of included data. See http://meteor.aihw.gov.au for details.*

Of the 1,236 cases in the set reported here, 1,162 (94%) had been admitted to a public hospital.

4.3.4 Summary of data table inclusion criteria

Restrictions applied throughout:

- episodes recorded in the NHMD that ended in the period 1 July 2002 to 30 June 2013;
- the principal diagnosis code was in the ICD-10-AM range S00 – T75 or T79; and
- source of referral was not an inward transfer.

Table-specific criteria, applied in addition to the general restrictions	Applies to tables
1. V86, Occupant of special all-terrain or other motor vehicle designed primarily for off-road use In any external cause code field	4.2
2. Records with code V86 and the 5th digit value of 2 (meaning 4 wheels), (designated here as V86.n2)	4.3
3. As for Criterion 2 but omitting cases with activity codes U65.1 to U65.9 and U60.5.	4.4 to 4.6
4. As for Criterion 3, but further restricted to records coded as: a. Activity when injured was 'riding an ATV' (U65.0), or b. Activity when injured was working for income (U73.0) and the place of occurrence was a farm (Y92.7)	4.7 to 4.18

4.4 Discussion

The surprising finding of this investigation was that available coded data on hospital-admitted cases of injury provided a poorer basis for identifying instances involving a quad bike than was anticipated.

We anticipated that adequate, though probably not perfect, identification of a relevant set of records could be achieved solely or largely by focusing on the external cause of injury category with the rubric Occupant of special all-terrain or other motor vehicle designed primarily for off-road use (V86). In doing that, we were informed by previous work (Clapperton et al., 2013; Mitchell et al., 2015).

However, inspection of other variables in the set of records with external cause codes in the V86 block revealed many instances which it was implausible to regard as involving a quad bike. Prominent examples are the cases in which activity at the time of injury was playing golf (we think that it is most likely that the vehicle in these cases was a golf buggy), or to categories in activity block “Motorsport”, namely “go-carting”, “car racing” or certain other things. One activity category in the motor-sport was thought likely to be fairly specific to quad bikes: “Riding an ATV”, but only 7% of V86 cases are coded to that activity.

Cases with these characteristics that strongly imply involvement of a machine other than a quad bike can be omitted. More problematic, however, is that activity is not specified in more than half of the V86 cases. The findings noted here imply that it is not safe to assume that V86 cases with unspecified activity involved quad bikes.

Codes for place of occurrence were of some further assistance. It was concluded that V86 cases that occurred on a farm were likely to have involved a quad bike, particularly those in which the injured person was reported to have been working for income at the time. We selected from among all V86 cases these two subsets that were thought more likely than others to have involved a quad bike, and described them statistically.

This situation might be improved by conducting a special study in which the hospital records of a sample of cases that might have involved injury due to a quad bike (certainly including V86.n2 cases; probably also including the other types of cases referred to in Table 4.1, above) would be inspected to determine which cases did involve a quad bike, and to identify characteristics of the records of those cases. More specifically, the main aims would be to determine (1) the proportion of cases of this type in which a quad bike was involved; (2) the proportion of records in which available information was sufficient to allow this to be determined; and (3) the ICD-10-AM external cause codes (including place and activity) that had been assigned to these types of case. This study would provide information on how best to estimate admitted quad bike cases from the available records. It would also provide a basis for deciding whether there is much variability in how quad bike cases are coded, and on whether the hospital records on which coders rely provide sufficient information to permit adequate coding. These findings would provide the basis for deciding the actions that might be warranted. Depending on findings, types of action might include advocating:

(1) provision of an external-cause category (or categories) in ICD-10-AM specific to quad bikes and available for use in quad bike cases generally (e.g. not restricted to cases where use is for sport or leisure).
(2) the addition of a definition of quad bikes to ICD-10-AM, with accompanying guidance on how to code cases involving a quad bike.
(3) briefing hospital personnel who record case information on the value of doing so in a way that makes clear when a quad bike has been involved.

4.5 Conclusions

Identifying quad bike cases in Australian admitted patient data is far from easy, partly due to terms and concepts, but mostly due to classification issues.

Injury cases involving a quad bike as an external cause might be coded in any of several ways. The ICD-10-AM category block into which it is considered probable that most such cases are put is V86, Occupant of special all-terrain or other motor vehicle designed primarily for off-road use.

Attention can be restricted to four-wheeled vehicles of that type by further restricting the selected cases to those with codes of the type V86.n2. Doing so excludes conveyances with two, three or an unknown number of wheels. However, over 80% of the cases are coded as having four wheels.

It is not safe to assume that the cases selected in this way all involved a quad bike. Codes on activity at the time of injury indicate that some involved vehicles such as go-carts and golf buggies.

No certain and reliable basis is available to select all and only quad bike cases from the set coded to V86.n2. However, it was concluded that a set could be selected that is likely to predominantly have involved quad bikes. These are the cases with V86.n2 in which:

- The activity when injured was “riding an ATV”, or
- The activity when injured was working for income and the place of occurrence was a farm.

That most specific set, which numbers 1,236 cases during the eleven years 2002–03 to 2012–13, was selected and described statistically.

Sensitivity is problematic. It is clear that some cases with codes V86.n2 did not involve a quad bike. Examples are those where Activity=golf, go-karting, and some of the activities included in 'other spec' activities. More problematically, large proportions of V86.n2 cases are not specified as to place or activity. Many of these might be relevant to the study, but there is no straightforward and reliable way to identify them.

Demographic and injury characteristics of cases in the specific set are largely similar to patterns described in earlier work. Cases are mainly adult males, fractures are the most common type of injury and head, trunk and upper limbs are commonly injured.

A special study would be required to confirm the sensitivity and specificity of the criteria described here for identifying quad bike cases and to obtain information required to improve the estimation of quad bike cases in hospital-admitted injury data.

5 In-depth analysis of quad bike use and incidents in South Australia

5.1 Introduction

The number of quad bikes available in Australia, and internationally has increased substantially over the last decade. It is estimated that within Australia, there were approximately 270,000 quad bikes in use in 2010 (Australian ATV Distributors, 2010). Quads are commonly used in the agricultural industry within Australia due to their adaptability, ability to operate in a range of conditions without leaving a 'footprint' and low operating costs (Australian Centre for Agricultural Health and Safety, 2011). A survey conducted by the Rural Industries Research and Development Corporation found that 80% of farm enterprises in Australia (agricultural operations valued over $40,000) reported using at least one quad on the property (Lower et al., 2011). However, few studies provide details about the precise range of tasks quad bikes are used for in agriculture and the range of terrains in which quads are used on Australia farms.

Given the increase in quad bike popularity, and also an increase in the number of injuries associated with their use, there is a need to understand how quad bike consumers make purchase decisions, how and why quads are used and examine the availability and suitability of alternative vehicles for these uses and any barriers that might prevent their use. One of the few studies to explore some of these issues conducted focus groups and interviews with farmers, retailers, repairers, healthcare professionals and regulators (McBain-Rigg, Franklin, McDonald, & Knight, 2014). The study found attitudes towards the purchase and use of quad bikes in north western Queensland varied and may be influenced by retailers. These issues also need to be explored in the South Australian context.

In order to reduce quad-related trauma in agriculture, there is a need to understand the circumstances surrounding the incidents that lead to quad-related injuries. In recent years, a number of studies have examined routinely collected administrative data concerning quad crashes and associated injuries (e.g. Clapperton et al., 2013; Wood et al., 2013). A recent review of six different administrative data collections examining fatal and non-fatal quad-related injuries, predominantly within NSW, found that while information regarding demographic characteristics for individual riders were readily available, information concerning the model of quad and any attachments, the purpose for which quad was being used and circumstances of the crash (including terrain) was not ideal (Mitchell et al., 2015). The authors stressed that there was a need for an in-depth investigation of quad bike crashes in Australia to obtain detailed information concerning the circumstances of such events. Indeed, no in-depth studies in Australia have incorporated an examination of the crash site, inspection of the quad bike, interviewed participants about the crash circumstances and collected information concerning the type and nature of injuries.

One noteworthy study investigated the human factors related to quad crashes and associated injuries in north Queensland by interviewing quad bike riders who were admitted to four regional hospitals from March 2004 to June 2007 and examining medical records (O'Connor et al., 2009). Of the 42 quad-related casualties, 18 participated in the interviews that collected information about previous driving experience and offences, helmet use, alcohol use and a short narrative of the events leading to the crash. While providing important information, the study did not examine the crashes and injuries in the context of the quad used or the type of environment in which they occurred.

This study aimed to identify the different quad bike uses among agricultural workers, particularly high risk uses and why quad bikes are chosen for these applications, and also investigate in-depth the complex circumstances surrounding any incidents that occurred as a result of their use within the context of their specific environment. The severity and type of injury sustained by quad bike riders was also examined.

5.2 Method

5.2.1 Interviews with agricultural workers

Individual face-to-face interviews were conducted with agricultural workers from a variety of industries in South Australia who ride a quad bike for work purposes. The purpose of the interviews was to obtain detailed information about quad bike use and the causes and contributing factors associated with any incidents that may have occurred. The interviews were conducted between September 2014 and July 2015.

A variety of methods were employed to attract voluntary participation in the study including a media release and television, radio and newspaper interviews with media specifically targeting rural issues. In addition Primary Producers SA and the leaders of each commodity group under this umbrella organisation were contacted to encourage their members to participate through the circulation of project flyers and information sheets. Members from the Advisory Board of the Agriculture Bureau in South Australia also actively promoted participation in the project.

The interview was conducted at either the participant's place of work where they used the quad or their home. The interview was completed in approximately 40-60 minutes and was audio recorded. Two experienced researchers (interviewer, mechanical engineer) attended each interview. Where possible, the mechanical engineer inspected and photographed the quad to determine its mechanical condition. If the participant reported a quad-related incident and the location of the incident was accessible, interviewers visited the site and took photographs and basic measurements of key features including the slope of the terrain.

The interview was conducted in a questionnaire format using a mixture of open and closed questions. All participants were asked questions regarding personal/demographic details, type of agriculture and terrain, riding history, quad specifications, quad maintenance, quad purchase and use, carrying of passengers, carrying and towing of loads, use of personal protective equipment (e.g. helmet use), quad use by children and perceptions of quad safety and the causes of quad incidents.

Participants were also asked about any personal involvement in a quad incident, defined as: "*A riding experience where the rider lost control of the quad being used at the time and was involuntarily ejected or tipped off the vehicle as an operator or passenger. The rider may have been either injured or uninjured during the event and the quad may have been either damaged or undamaged*". For those who were involved in an incident, a series of open and closed questions were asked concerning the incident including site/terrain and temporal information, type of incident, activity, use of personal protective equipment, estimated travel speed, load details, carrying of passengers, details of rollover (if applicable), causes of the incident, perceptions of the incident, familiarity with the quad and site, distractions or obstructions, injury severity, type of injury, source of injury and details about the quad if different from the current quad.

5.2.2 Interviews with Royal Adelaide Hospital admissions

Quad bike-related injuries can be identified through the monitoring of hospital admissions. The Royal Adelaide Hospital is a 650 bed tertiary referral hospital located in the centre of Adelaide. The hospital is one of two designated adult major trauma services in South Australia with the services provided by the hospital catering for around 1800 “trauma call” cases per year which is over two thirds of the total state workload (Royal Adelaide Hospital, 2015). As one of the major tertiary care providers in South Australia, the Royal Adelaide Hospital provides some specialist services that are not provided in other centres including spinal and orthopaedic care services, a burns unit and a brain injury and rehabilitation services. Due to the extended services of the Royal Adelaide Hospital, it is expected that the severity of injury seen amongst the patients who present for care may not necessarily reflect a representative sample for all those injured as a result of quad bike incident involvement.

All patients who are admitted to the Royal Adelaide Hospital undergo International Classification of Disease coding utilising version ten, Australian Modification (ICD-10AM). Within the ICD10-AM are specific codes related to external cause of injury, some of which relate to vehicle crashes. From these codes the ICD10-AM specialised coders within the hospital are able to identify those individuals who are admitted as a result of a vehicle crash.

Patients admitted through the Royal Adelaide Hospital Trauma Services from 1 July 2014 to 30 June 2015 following a quad bike incident were identified using this procedure. A designated researcher with a health care background examined all patient records for vehicle crashes and identified those that involved a quad bike. While time consuming, this method maximised sensitivity to ensure most quad bike-related crashes were identified, rather than using specific but somewhat ambiguous ICD10-AM codes aimed at identifying quad bike crashes. Medical records were examined including ambulance officer notes, and all patient injuries and subsequent treatment documented. Medical data included admission vital signs, type of injuries, clinical intervention, length of stay, and admission outcome. Details surrounding the circumstances of the incident such as helmet use, alcohol involvement and estimated speed of vehicle were also often recorded within the notes.

The medical records related to the riders involved in quad-related crashes during the data collection period were sourced at the Royal Adelaide Hospital following approval from the Royal Adelaide Hospital Research Ethics Committee and the University of Adelaide Compliance and Ethics Unit prior to commencement of the study. The project was also endorsed by the Director of Trauma Services at the Royal Adelaide Hospital. Access to confidential information from these records was facilitated by Section 64D, Form 7 status within the *South Australian Health Care Act 2008* that has been declared and granted by the South Australian Health Minister to the Centre for Automotive Safety Research. This declaration has been in place since 1987 and was re-declared in February 2011.

Personal contact with the patient was made as soon as possible after discharge and they were invited to participate in an interview about the quad incident. Participants recruited following admission to the RAH followed the same interview procedure as the agricultural workers, with an interviewer conducting the same questionnaire. Where accessible, a mechanical engineer also inspected the quad bike involved in the incident and visited the site where the incident occurred.

5.2.3 Sample

A total of 40 interviews with agricultural workers who used a quad bike were conducted. Participants were from a wide range of rural regions in South Australia (see Table 5.1) representing many agricultural industries including dairy, cattle, sheep, cropping, vineyards, and horticulture. Within a 12 month period, seven cases were identified in which a person was hospitalised at the RAH due to an incident involving a quad bike. Six riders were interviewed and one declined.

Note that this sample should not be considered a random sample. Riders were asked to volunteer for the study and so there are likely to be self selection biases. For example, it is likely that some participants volunteered because they wanted to show that quad bikes were safe while others may have participated as they had been injured and wanted to share their experience. Nevertheless, the data from this sample are still useful for examining patterns in quad bike use.

Table 5.1
Riders region of residence in South Australia

Region	Agricultural workers n=40	Hospital admissions n=6
Adelaide	-	1
Adelaide Hills	6	1
Barossa Valley	1	-
Eyre Peninsula	5	1
Fleurieu Peninsula	7	1
Mid North	5	1
Riverland	5	-
South East	6	1
Yorke Peninsula	5	-

5.3 Results

The demographic details of the quad riders interviewed and the characteristics of their properties are presented in Table 5.2. The riders interviewed were predominantly male (94%), with the majority (70%) aged 45 years and over and an average age of 51 years. The age and sex profile of the quad riders is presented in Figure 5.1. They were more likely to be the manager or owner of the property than an employee. Note that 41 riders worked on farms, three worked on hobby farms and two hospital admission cases did not work on farms (although they were involved in an incident on a property). Many riders worked on properties that had more than one type of agriculture and so the percentages do not add up to 100%. The most common type of agriculture in which riders worked was grain followed by sheep and in 18 cases it was a combination of both. The main agricultural commodities produced in South Australia are wheat and grapes (Australian Bureau of Statistics, 2011). The terrain on properties was varied with almost equal proportions from flat, rolling flat and hilly land. Around 46% of riders worked on properties that had more than one quad. Within some of these properties, one quad was used for a specific purpose such as spraying (spray tank left on quad) and the other for general farm duties.

Table 5.2
Characteristics of quad riders and their properties

Demographics	Total	
	N=46	%
Sex		
Male	43	93.5
Female	3	6.5
Age group		
16-29 years	6	13.0
30-44 years	8	17.4
45-59 years	16	34.8
60+ years	16	34.8
Employment status		
Manager / owner	36	78.3
Employee	10	21.7
Type of agriculture		
Grain	27	58.7
Sheep	20	43.5
Beef	9	19.6
Vineyard	9	19.6
Horticulture	8	17.4
Mixed livestock	6	13.0
Dairy	6	13.0
Pig	1	2.2
Other	2	4.3
Typical terrain		
Flat	14	30.4
Rolling flat	14	30.4
Hilly	13	28.3
Combination	5	10.9
Number of quads on property		
1	25	54.3
2	16	34.8
3+	5	10.9

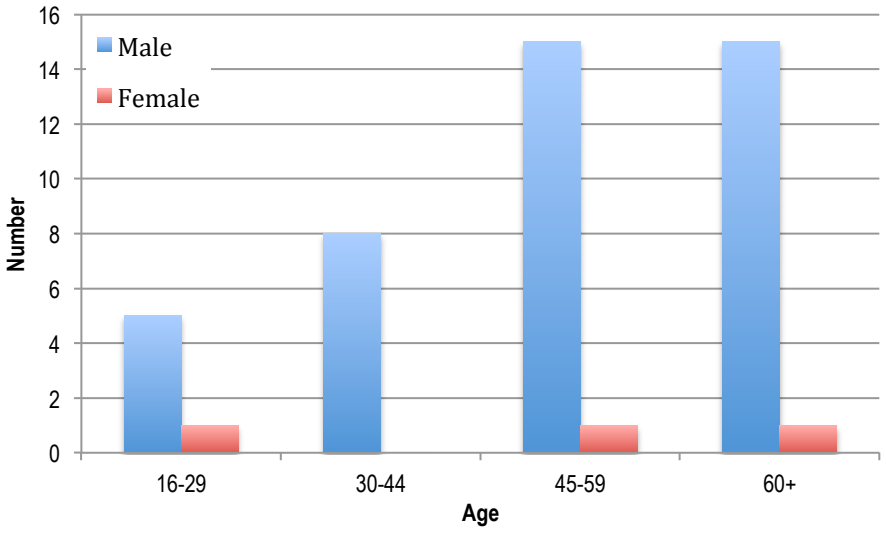


Figure 5.1
Age and sex distribution of quad bike riders

Table 5.3 shows the riding history of the quad riders interviewed. The majority of riders were very experienced with 67% reporting riding quads for more than ten years. A majority of 38 (83%) of the quad riders also had experience riding motorcycles, with 31 riders reporting that they rode motorcycles before riding quads. The majority of riders (74%) self taught themselves how to ride a quad and some (22%) learned with the assistance of a family member or friend. Only one participant learned to ride a quad through a training course. The agency/dealership selling the quad came to the farm to provide training but the rider commented "*Not that useful as they were not good at teaching*". Another rider learned from a DVD that was provided with the quad when it was purchased "*Showed how to ride on the terrain, no kids on board, protective clothing, all that sort of stuff*." An additional rider who learned to ride via a family member commented that he received quad training during an WHS course but it was theoretical and not practical.

Table 5.3
Riding history of quad riders

Riding history		
Quad riding experience	N=46	%
0 - 5 years	7	15.2
6 - 10 years	8	17.4
More than 10 years	31	67.4
Ride a motorcycle		
Yes	38	82.6
No	8	17.4
How learned to ride quad		
Self taught	34	73.9
Family member/friend	10	21.7
Training course	1	2.2
Training DVD	1	2.2

5.3.1 Quad bikes

Table 5.4 shows the manufacturer, engine size, condition and age of the main quad bike that was used by the participant. Yamaha (30%) and Honda (28%) were the most common makes, followed by Kawasaki (20%). One of the quads was a Chinese made brand, Kazuma. Two of the quads were designed for recreational purposes. One side-by-side made by John Deer is included in this list. The majority (72%) of the quads had engines below 400cc, most commonly 300cc or less. Only 12 had engines larger than 400cc, and only three had engines larger than 500cc. The riders were asked to comment on the condition of the quad. Most of the riders stated the quad was in good condition (70%). Only one rider stated that the quad was in poor condition. The quads tended to be newer, yet a third were more than 15 years old and six were more than 20 years old. The mean age of the quads was 10 years. Note that the age of seven quads could not be determined.

Table 5.4
Make , engine size, condition and age of quads ridden by interviewees

Make of quad bike	N=46	%
Yamaha	14	30.4
Honda	13	28.3
Kawasaki	9	19.6
BRP	3	6.5
Polaris	3	6.5
Suzuki	2	4.3
John Deer*	1	2.2
Kazuma	1	2.2
Quad engine size	**N=46**	**%**
00-300cc	20	46.5
301-400cc	11	25.6
401-500cc	9	20.9
501-600cc	3	7.0
Self reported quad condition	**N=46**	**%**
Good	32	69.6
Reasonable	13	28.3
Poor	1	2.2
Age of quad bike (years)	**N=39**	**%**
0-4	11	28.2
5-9	10	25.6
10-14	5	12.8
15-19	7	17.9
>20	6	15.4

*Side-by-side

Only one quad had rollover protection fitted, a quad bar. The following is his response to the question "What are the reasons you have rollover protection":

"There is a steep part on the property in one spot. It's a safety thing. It's also a place to put a flashing light up when moving sheep over the road but it is high and (the light) often hits branches. I am happy with it. However it does restrict access to the tow bar and we can't tow the auger. I don't really want to extend the tow bar."

The riders of the quads that did not have rollover protection were asked why they did not have rollover protection. The responses are summarised in Table 5.5. The most common reason was that it simply was not fitted when the quad was purchased. This was closely followed by that response that it was not needed and that it gets in the way. A number also felt that they were not safe (20%). Two of the riders were discouraged by the dealer from fitting rollover protection when they purchased the quad. Six of the riders had never even considered rollover protection, and five thought they were not available. Some riders indicated that they simply had not got around to fitting rollover protection. The one rider that did not have rollover protection due to a previous negative experience stated that he had ridden a quad with rollover protection that rattled around a lot and he therefore found it to be annoying.

The riders were also asked if they had ever been injured by rollover protection. None of the riders had been injured but this was, at least partially, due to the lack of exposure to rollover protection.

Table 5.5
Reasons do not have rollover protection

Reasons do not have rollover protection	N=44	%
Not fitted when purchased	13	29.5
Not needed	12	27.3
Gets in the way	12	27.3
Not safe	9	20.5
Never considered	6	13.6
Difficulty with overhanging branches	5	11.4
Didn't think were available	5	11.4
Haven't got around to it	3	6.8
Dealer discouragement	2	4.5
Not recommended	1	2.3
Adds weight	1	2.3
No reason	1	2.3
Previous negative experience	1	2.3

Table 5.6 shows the types of loads carried on the quads by their position on the quad. Equipment was the most common load carried on the front of the quads, though 20% did not carry any load on the front. Spraying equipment and/or liquids (37%) and animals (37%) were the most common loads carried on the rear of the quad. The animals carried were commonly dogs, but some also carried sheep and calves. Less than 10% did not carry any load on the rear.

Table 5.6
Types of loads carried on quad

Type of load carried	Front		Rear	
	n=41	%	n=41	%
Equipment	27	58.7	14	30.4
Spray / liquids	5	10.9	17	37.0
Bags (fertilizer / feed)	5	10.9	5	10.9
Animals	4	8.7	17	37.0
Other	5	10.9	8	17.4
None	9	19.6	4	8.7

The distribution of the weight of the heaviest front load is shown in Figure 5.2. The majority of the loads on the front were 10 kg or less, though there were a couple of riders that carried loads of more than 50 kg on the front.

Figure 5.2
Weight of the heaviest front load carried by quad riders

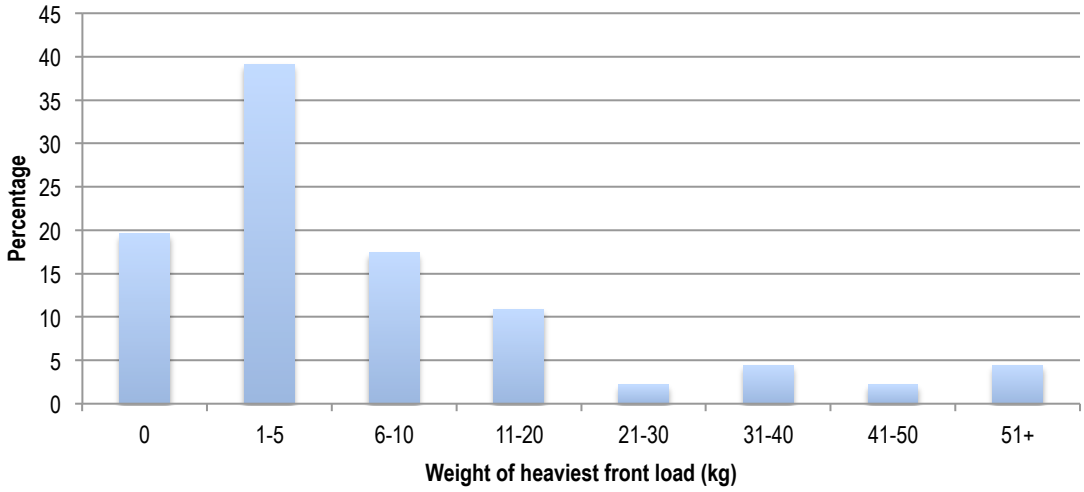
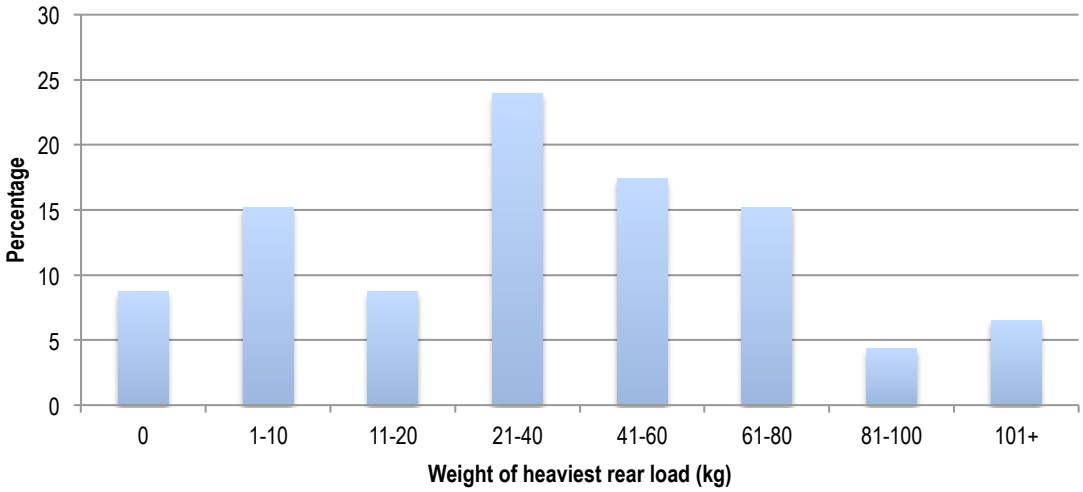


Figure 5.3 shows the distribution of the weight of the heaviest rear load. Note that Figure 5.3 uses a different scale than Figure 5.2. The most common weight of the heaviest load was in the range 21 to 40 kg, though more than a quarter carried loads that exceeded 60 kg and about 6% carried loads of above 100 kg.

Figure 5.3
Weight of the heaviest rear load carried by quad riders



5.3.2 Quad use

Of those who purchased or knew where the quad was purchased (n=41), 21 riders stated the quad was purchased at a bike only dealership, nine quads were purchased at a general vehicle dealership, eight quads by private sale and two quads by other means.

The reasons the riders gave for purchasing a quad are shown in Table 5.7. Half of the riders said they were good for the purpose(s) they wanted to use them for, either generally (33%) or more specifically for mustering (19%). Note that the interviewer did not prompt the rider to respond to this question in reference to another type of vehicle, though it seems that many riders were responding in reference to the previous vehicle in which they conducted the same tasks. For example, seven riders stated that

they purchased a quad because they perceived it to be safer than a motorcycle. In addition eight riders cited a reason for purchase was because a quad could carry equipment or a dog, something a motorcycle is not well equipped for.

Besides being generally good for the purpose, the reasons for purchasing a quad varied considerably. Some rider's stated monetary reasons such as price (14%), running costs (9%) or increased efficiency (5%) as reasons for purchasing a quad. Others stated reasons related to the handling of the quad including its capability on wet, muddy ground (12%) and its manoeuvrability (9%). Others again stated reasons related to the ease of use such as ease of getting off and on (7%), that it is comfortable (9%), it is convenient (7%) or that generally it is just easy to use (9%). Some of the 'other' reasons included: it allows for scrub access, it has quick acceleration, the stability, the ability to fit children on it, and that it allows good vision all around while riding it.

Table 5.7
Reasons for rider purchase of quad

Reasons for quad purchase	n=43	%
Good for purpose - general	14	32.6
Good for mustering	8	18.6
Carry gear /dog	8	18.6
Safer than motorbike	7	16.3
Price	6	14.0
Wet / muddy ground capability	5	11.6
Comfort	4	9.3
Manoeuvrable / turning circle	4	9.3
Cheap to run	4	9.3
Ease of use	4	9.3
Convenient	3	7.0
Ease of getting off / on	3	7.0
Towing	2	4.7
Increased efficiency	2	4.7
Fits between rows	2	4.7
Other	11	25.9

Table 5.8 shows the various work tasks for which the quad was used. Note that riders could list more than one response. Almost three quarters of riders used their quad for mustering stock. More than half of the riders used their quad for transport, spraying, inspecting their property, checking livestock and checking crops. Transporting equipment, checking irrigation and fencing were also common tasks undertaken on the quad. For many of the tasks, the clear majority said that they could use another vehicle for the task. However, many preferred the quad to other vehicles. Some of examples of their reasons for using the quad over the other vehicles were:

"More manoeuvrable, easier access, cheaper to run, like to ride it, easier to see, can go places ute can't go." (Mustering stock)

"The tractor and ute could be used but inefficient and costly. Motorbike can fall over on soft ground, riskier and not practical. Ok for going around but can't carry stuff." (Transport)

"I use a ute depending on what the job is. Out in the paddocks I use the quad because it's not accessible in the ute. It's a lot quicker to get around and spray with the quad." (Spraying)

Table 5.8
Work tasks on quad

Work tasks	N=46	%	% could use another vehicle
Mustering stock	34	73.9	74.3
Transport	32	69.6	75.0
Spraying	30	65.2	59.3
Inspecting property	29	63.0	73.1
Checking livestock	27	58.7	78.3
Checking crop	25	54.3	76.2
Transporting equipment	23	50.0	64.7
Checking irrigation	22	47.8	61.9
Fencing	20	43.5	66.7
Feeding stock	11	23.9	75.0
Predator elimination	8	17.4	37.5
Bird scaring	7	15.2	14.3
Planting / trimming	6	13.0	33.3
Other	14	30.4	55.6

Mustering was not only the most common task, but it was also most commonly identified by the rider as the most risky task or situation in which the quad was used (Table 5.9). Steep inclines were also commonly identified as the most risky task or situation (30%). Creek crossings, most likely closely related to steep inclines, were specifically identified by 12% of riders as the most risky task/situation. Going fast was also identified as a common risky task/situation. Four of the 43 riders felt that they did not undertake any tasks or put themselves in situations that were risky.

Table 5.9
Most risky task or situation when using the quad

Most risky tasks/situation	N=43	%
Mustering	19	44.2
Steep incline	13	30.2
Going fast	8	18.6
Creek crossings	5	11.6
Riding through scrub	4	9.3
None	4	9.3
Carrying load	4	9.3
Crossing intersections	3	7.0
Hidden rocks / hole	3	7.0
Irrigation / spraying	3	7.0
Towing	2	4.7
Loading the quad	1	2.3
Carrying passengers	1	2.3
Loose surface	1	2.3
Hedging	1	2.3

The riders were also asked how frequently they travelled on terrain they considered risky. The results are shown in Table 5.10. Just over 40% travelled on risky terrain at least sometimes, while 28% stated they travelled on risky terrain rarely. Around 26% of riders did not consider there was any risky terrain on the property or risky tasks.

Table 5.10
Frequency of travel on risk terrain by quad rider

Frequency of travel on risky terrain	N=46	%
Always	6	13.0
Usually	8	17.4
Sometimes	5	10.9
Rarely	13	28.3
None on property	12	26.1
Unknown	2	4.3

Table 5.11 shows the typical terrain travelled on for work purposes by riders. Flat and rolling flat make up 70% of the typical terrain. Only 24% of the riders considered the typical terrain they ride on for work to be hilly.

Table 5.11
Typical terrain travelled on for work by riders

Typical terrain travelled on for work	N=46	%
Hilly	11	23.9
Combination	3	6.5
Rolling flat	16	34.8
Flat	16	34.8

The number of people that ride the quad varied from a sole rider (24%) to one quad that was ridden by 15 different people (Table 5.12). Half were ridden by one or two people, but 15% were ridden by five or more people.

Table 5.12
Number of people that ride the quad

Number of people that ride the quad	N=46	%
1	11	23.9
2	12	26.1
3	8	17.4
4	6	13.0
5+	7	15.2

The riders estimated average travel speeds on the quads is shown in Table 5.13. The majority reported an average travel speed of 30 km/h or less (80%) and 40% travelled at an average of 20 km/h or less. Only 9% of riders estimated their average travel speed to be above 40 km/h.

Table 5.13
Average travel speeds on quad

Average speed (km/h)	N=46	%
0-10	10	21.7
11 to 20	9	19.6
21 to 30	18	39.1
31 to 40	5	10.9
41+	4	8.6

Recreational use

Quads were used primarily for work activities with riders estimating the quads were used for an average of 7.3 hours a week for work activities and an average of 0.8 hours per week for recreational activities. When asked how frequently the quad was used for recreational activities, 46% (n=21) said they never used it for recreational purposes and a further 39% (n=18) said they used it rarely for recreation. Some of the recreational activities undertaken by riders included taking children for a ride, going to the beach or camping, hunting, and looking at something:

"Going down the beach to go fishing".

"I sometimes take the grand kids for a ride".

Side-by-sides

All riders interviewed were aware of side-by-side vehicles. Of the riders (n=33) who were asked if they had considered purchasing a quad, 55% reported they had considered it and two riders already had one. Several riders mentioned they might purchase one when they got rid of their current quad. Many (n=14) riders felt the cost of a side-by-side was a barrier, for example:

"I considered purchasing one in the past but it cost $14,000 while a quad was $6000. It's a financial reason why I haven't got one".

In comparison to quads, some riders had concerns about the manoeuvrability and bigger size of the side-by-sides but acknowledged that there were also advantages such as being able to carry bigger loads:

"You would be able to do the work but it would probably be a bit more difficult with a side-by-side. It would still be better than a ute. They don't turn as sharp as a quad bike does, but they have the advantage of being able to carry more in terms of weight."

"Yes, I like that they have a tray behind. I can use it for fencing or put an injured calf on the tray. I'm in the process of getting one. Price is an issue though so we use what we have for now."

Children

Twenty (44%) of the riders said they let children use the quad bike and half of these riders reported that they allowed the children to ride as passengers only. The children who were permitted to operate the quad (n=10) ranged from 4 to 15 years. In five cases riders said the children operated the quad for helping around the farm including checking sprinklers, general farm activities, getting sheep in and helping getting a quad back home. Three riders specified that their children operated the quads for recreational purposes only. Nine of the ten riders who let children ride as passengers only stated that the rides were for recreational purposes or joy rides only.

Some riders had specific rules that the children had to adhere to when riding and controlling the quad such as parental supervision, restrictions around where and when they could ride and limitations regarding gear selection. For example:

"The kids must tell us where they are going and only ride around the house. They are not allowed to ride in the paddock unless someone is with them."

"Not when wet or at night. If we are not around, they are not allowed to ride."

"The kids usually sit in front of me. They might want to ride through a gate and I will sit behind them. They are only allowed to use the quad in first or second gear and on flat ground only where it is safe. They are only allowed to ride if I am home."

Those who did not let children ride the quad (n=26) gave a variety of reasons including concerns about safety, children are too young and do not know/have any children. Some examples:

"Quad is too big for them. I don't have time to train them and I won't let them ride if not trained."

"I'm of the opinion that they're not capable of riding."

"Insurance - its not worth it now with the injury/death statistics. We hear and read about deaths of young children."

Passengers

Almost three quarters (74,% n=34) of riders admitted that they carry passengers on the quad. When asked in what situations they might carry passengers 12 riders stated that they only carry children as passengers. Other situations in which passengers were carried predominantly included as a means of transport to retrieve other vehicles (e.g. tractor) (n=11) but also to travel short distances, giving someone a lift on the property, checking sheep and when working with others (e.g. vines, trellis work). A number of riders also mentioned that carrying passengers was not a regular activity.

"Only about once a year. When seeding we need transport to bring the tractor in from the paddock."

"Myself and my partner check sheep and go to the feed lot. It tends to happen when the ute is at another property."

"Only carry kids, not adults. Kids might drop me off at a vehicle."

Helmet use and protective gear

Table 5.14 shows that only 11% of riders said they "always" wore a helmet when riding a quad, citing safety reasons. Those that wore helmets less frequently tended to wear helmets when undertaking specific tasks or under specific conditions that they perceived were risky (i.e. mustering/cattle work, travelling at faster speeds, difficult terrain). Riders also mentioned wearing helmets when travelling on roads as they were concerned about detection by police.

The majority of riders (52%) said they "never" wear a helmet. Reasons for not wearing a helmet included discomfort (e.g. hot head in summer, heavy in rough terrain), inconvenience (e.g. interferes with tasks), no sun protection, restricts hearing and vision, not travelling very fast, and not required to wear it on private property.

"It's a pain - helmets restrict vision, my head gets hot and I can't hear properly. I am only going slow and not on the road, there are no other cars. I hurt my back not my head in a crash."

"I never wear a helmet on a quad but always wear one on a motorbike - a motorbike travels at faster speeds, is more dangerous. It is easier to ride without a helmet on as it gets in the way, I can't communicate on the radio, I can't work the dogs and I can't hear".

"I haven't got one that fits. Lack of comfort. I am travelling slowly. It's too hard to take on and off while doing tasks like checking sprinklers."

Table 5.14
Frequency of helmet use on quads

Frequency of helmet use	N=46	%
Always	5	10.9
Usually	3	6.5
Sometimes	10	21.7
Rarely	4	8.7
Never	24	52.2

Thirteen riders (28%) did not have a helmet to use when riding a quad. Of those who did have a helmet, 17 had a full face helmet, 14 had an open face helmet, one owned a bicycle helmet and one used a skateboard helmet.

Riders were asked if there were any safety procedures, training or PPE required when riding the quad for work purposes. Twenty one (46%) riders mentioned helmets were available or recommended for riders but only two of these riders explicitly mentioned that it was policy that they must wear helmets. Thirteen of those who had a helmet available when conducting work activities stated that they did not wear them (unprompted). Speed limitations when travelling on the quad were imposed by four riders who were employers (40km/h, 20km/h x 2, 15km/h is specific area). Several riders mentioned wearing work boots and gloves. Only two riders mentioned any form of training for quad users with one employer offering limited quad training for those with no experience and another employer mentioned quad safety was covered in their OH&S induction procedures.

Active riding is when the rider shifts or balances their body weight to enhance the performance of the quad. There were 43% of riders that “always” or “usually” participated in active riding when on the quad and 24% said they “rarely” or “never” actively rode the quad (Table 5.15).

Table 5.15
Frequency of active riding on quads

Frequency of helmet use	N=46	%
Always	14	30.4
Usually	6	13.0
Sometimes	15	32.6
Rarely	5	10.9
Never	6	13.0

Perceptions: Are quads safe?

The riders were asked an open question, “Do you think quads are safe?”. Table 5.16 shows the clear majority said that they thought quads are safe, but they are less likely to think they are safe if they have had an incident, especially if it resulted in hospital attendance. Most of the riders who thought quads were safe clarified their answer in some way, for example:

“Yes, it's the idiots using them. It's how you use it. People use it for things it is not designed for.”

“If they're ridden properly, yes. If they're not messed around with, if people are sensible, not going too fast, choosing the right place to go up a creek. You need to use sensible judgement.”

“Yes, It all comes back to how you ride it. Ride it stupid you increase the chances of hurting yourself. If you know what you're doing and are sensible they're safe as houses.”

A number of riders did not feel they could give a yes or no answer (11%), but some riders did feel they were unsafe (11%). For example:

"No. It's how they are built, high centre of gravity. The problem is how do you replace them. It's how you ride them. Training probably doesn't help as people get licences when they probably shouldn't."

"No, Only safe if you know what you're doing. They're just too easy to ride, people think they know how to ride a quad bike so they hurt themselves because anyone can ride a quad. Anyone can jump on and ride, that's why it's dangerous. They don't understand the power or how easy it can flip if they don't know what they're doing, especially over hills and slopes. On a motorbike you need to be able to balance and change gear. On a quad bike you can go as fast as you want straight away."

Table 5.16
Rider opinion on the safety of quads

	All riders		Riders who had an incident		Hospital attended	
Rider opinion "are quads safe"	N=45	%	N=22	%	11	%
Yes	35	77.8	15	68.2	5	45.5
No	5	11.1	4	18.2	4	36.4
Unsure	5	11.1	3	13.6	2	18.2

The riders were asked an open question on what they thought was the cause of most quad incidents. The answers have been summarised in Table 5.17. Note that the rider's answer could include more than one factor. The three most common answers were all related to rider behaviours. The most frequent answer was that most quad incidents are caused by inexperience and/or a lack of ability (60%). This was followed by recklessness/riding too hard/stupidity (38%), and speed (27%). The terrain also featured relatively high on the list with 22% attributing most incidents to steep terrain and 14% to uneven terrain. Vehicle factors were not stated often, the stability of the quad being the most common vehicle factor at only 11%.

Table 5.17
Riders perceptions of causes of quad incidents

Riders opinion of causes of most quad incidents	N=37	%
Inexperience/ lack of ability	22	59.5
Recklessness / riding too hard / stupidity	14	37.8
Speed	10	27.0
Steep terrain	8	21.6
Inattention/ concentration	6	16.2
Uneven terrain	5	13.5
Carelessness	4	10.8
Stability of quad	4	10.8
Unseen objects	3	8.1
Misuse	3	8.1
Vehicle fault / lack of maintenance	3	8.1
Rider error	2	5.4
Alcohol	2	5.4
Recreation	2	5.4
False sense of security	2	5.4
Kids	2	5.4
Too powerful	1	2.7
Lack of training	1	2.7
Turning too quickly	1	2.7

5.3.3 Quad incidents

Participants were asked if they had ever had an "incident" or a "near miss" on a quad bike. A quad incident was defined as: "*A riding experience where the rider lost control of the quad being used at the time and was involuntarily ejected or tipped off the vehicle as an operator or passenger. The rider may have been either injured or uninjured during the event and the quad may have been either damaged or undamaged*." A near miss was defined as: "*A riding experience where the rider lost control of the quad being used at the time but did not fall off the quad and was not injured as an operator or passenger."*

Table 5.18 shows that 23 (50%) riders reported ever having an incident on a quad bike, of which six were identified through hospital admission at the RAH. Nine riders (20%) reported involvement in more than one incident.

Table 5.18
Number of quad incidents and near misses

	Incidents		Near miss	
Number	N=46	%	N=46	%
0	23	50.0	21	45.7
1	14	30.4	12	26.1
2	6	13.0	3	6.5
3+	3	6.5	6	13.0
Unknown	-	-	4	8.7

A total of 21 riders recalled having a near miss on the quad. Some examples of near misses include:

"I had the spot spray on back and I ran into a fox hole. I was only going slow but missed with front corner but hit with the back corner. All the weight was right out the back. Also I was sitting pretty back at that stage. Suddenly I felt like I was on a two-wheel motor bike and that didn't feel very comfortable."

"I was travelling at 40km/h down into a tight left corner when I thought the wire gate was open. I swept into the corner but the gate was lying on the ground. I locked up the quad but slid into it, picked up when I got closer and went onto 2 wheels. Through experience I lent into it, I was not concerned. The two wheels went 100ml off the ground."

"The quad had a trailer with spray unit on the back. I left the gate open - sheep can smell an open gate - I was spot spraying and I looked back and the sheep were heading towards the gate so I flew back to head them off and was going too fast and when I was slowing up to cut 'em off she got a bit of a fishtail then and that was a bit of a scare. That was because of the weight of the trailer behind me."

Agricultural workers were asked to provide further detailed information about the *most recent* incident and riders admitted to the RAH were asked to refer to the incident that resulted in their admission. A brief summary of selected descriptors and what happened in each incident is compiled in Appendix A. More detailed information regarding these 23 incidents are provided in the following tables.

A number of temporal factors for quad incidents described by riders are presented in Table 5.19. Quad incidents predominantly occurred in open paddocks (61%) with ground covered in grass (61%). Incidents almost equally occurred on terrain that was flat and had a slope. Incidents also occurred more frequently during weekdays rather than weekends and all incidents occurred during daylight hours.

Table 5.19
Temporal factors for quad incident

Temporal factors	N=23	%
Location of incident		
Open paddock	14	60.9
Private track	3	13.0
Public road	2	8.7
Other	4	17.4
Terrain		
Flat	12	52.2
Slope	11	47.8
Surface		
Short grass	8	34.8
Tall grass	6	26.1
Soft dirt / sand	2	8.7
Hard dirt / clay	4	17.4
Gravel	1	4.3
Rocky	1	4.3
Unknown	1	4.3
Day of the week		
Weekday	13	56.5
Weekend	6	26.1
Unknown	4	17.4

Table 5.20 shows that the most common type of incident was characterised as a rollover (48%) followed by an incident where an object or animal was struck (26%). Note that incidents not defined as a rollover may have also involved the quad rolling but it was not the main factor initiating the incident. The majority (78%, n=18) of incidents occurred while undertaking work related activities and the most common work activity was chasing or mustering livestock. Eleven (61%) of those undertaking work activities at the time of the incident were working alone.

Table 5.20
Type of quad incident

Incident characteristics	N=23	%
Incident type		
Rollover	11	47.8
Struck object	6	26.1
Fall off	2	8.7
Loss of control	2	8.7
Other	2	8.7
Activity undertaken		
Chasing/mustering stock	10	43.5
Recreational	5	21.7
Checking irrigation	2	8.7
Transport	2	8.7
Spraying	1	4.3
Fencing	1	4.3
Checking crop	1	4.3
Other	1	4.3
Working alone		
Yes	11	47.8
No	7	30.4
Not working	5	21.7

Characteristics associated with the quad and how it was being controlled are shown in Table 5.21. In the majority of cases (74%, n=17), the quad was estimated to be travelling 20km/h or less at the time of the incident suggesting these are not excessively high speed incidents. Of the six incidents that the rider estimated the travel speed to be over 30km/h, two occurred while undertaking recreational activities.

In three cases the quad had a load at the time of the incident and in one case the load (full 100L spray tank) directly contributed to the incident.

The majority (70%) of participants were not actively riding the quad at the time of the incident. In nine incidents the rider was turning when the incident occurred and in four of these cases the turning manoeuvre contributed to the incident resulting in three rollovers and a rider ejected. An object was struck in almost half of the incidents (n=11). In three incidents the object was obscured by tall grass and in two incidents the rider admitted they were distracted (i.e. pursuit of animal, another vehicle) and did not detect the object.

In 14 (61%) incidents the rider reported the quad rolled over. Details concerning the characteristics of the rollover are presented in Table 5.22.

Table 5.21
Characteristics of quad incident

Characteristics	N=23	%
Travel speed		
0 to 10	11	47.8
11 to 20	6	26.1
21 to 30	-	-
31 to 40	4	17.4
41+	2	8.7
Quad loaded		
Load	3	13.0
No load	20	87.0
Active riding		
Yes	7	30.4
No	16	69.6
Manoeuvre		
Straight	12	52.2
Slight turn	4	17.4
Tight turn	5	21.7
Stationary	2	8.7
Object struck		
None	12	52.2
Embankment	3	13.0
Animal	2	8.7
Gate/fence	2	8.7
Bush/stick	2	8.7
Rock	2	8.7
Quad rollover		
Yes	14	60.9
No	9	39.1

Of the 14 incidents in which the quad rolled, in nine cases the quad rolled sideways (six left side leading, three right side leading) and in five incidents the quad rolled longitudinally (four backward, one forward). For these rollovers, the most common tripping mechanism was the slope of the ground

(50%). The slopes that could be measured for the backwards rollovers were 29 and 38 degrees (Figure 5.4), and the ones that could not be accessed were reported to be steep. The slope for side rollovers varied from less than 1 degree in two cases, 6 degrees in another and a further two above 10 degrees (10.5 and 15). Of the nine side rollovers, four considered they were on a steep slope, three on a moderate slope and two were on the flat. Of interest was a side rollover that occurred in an area that appeared to be flat, but due to unevenness in the surface a side slope of 10 degrees was present (Figure 5.5).

Only one tripping mechanism was recorded per incident, but in a number of case where the slope was considered the tripping mechanism, the rider was going over an undulation of some type such as a hidden rock, stump or even a small bush and this may have also contributed to the vehicle rolling over. Examples of these are shown in Figure 5.6.

Three riders were trapped by the quad. Two riders managed to self extract themselves very quickly but one rider was trapped for approximately two hours until he regained consciousness and self extracted. All three riders had a leg trapped under the quad.

Table 5.22
Characteristics of quad rollover

Characteristic	N=14	%
Quad rollover		
Left side	6	42.9
Right side	3	21.4
Backward	4	28.6
Forward	1	7.1
Tripping mechanism		
Slope	7	50.0
Animal	2	14.3
Tight turn	2	14.3
Rock	1	7.1
Embankment	1	7.1
Surface change	1	7.1

Figure 5.4
The steep slopes involved in backwards rollovers

Figure 5.5
The landscape where a slow speed side rollover occurred (left) and low down photo highlighting the uneven surface (right)

Figure 5.6
Examples of an obscured obstacle (left) and the size of an obscured rock that was struck in a paddock (right)

Behavioural factors associated with the quad incident can be seen in Table 5.23. The average age of the riders at the time of the incident was 41 years old. The rider's level of quad riding experience at the time of the incident ranged from none to 26 years with an average of 13.3 years of experience. For two riders the incident occurred on the first day they had used the quad. Neither of them were conducting work-related activities.

Only five riders (22%) were wearing a helmet at the time of the incident. Of the five who were wearing a helmet, three had a full face helmet and two had an open face helmet. Of the 18 riders not wearing a helmet, four received injuries to the head region and two of these reported a loss of consciousness. Eleven riders stated they were wearing protective gear (other than a helmet) at the time of the incident such as boots, gloves, long trousers or sunglasses.

One rider was carrying a passenger (child) at the time of the incident and the behaviour of the passenger directly contributed to the incident.

Just over half of the participants (52%) did not perceive the site of the incident to be dangerous. In addition, the majority of the riders (83%) stated they were very familiar with the site and very familiar with the quad (78%).

Table 5.23
Behavioural factors for quad incident

Behavioural factors	N=23	%
Age at incident (years)		
<16	1	4.3
16-29	4	17.4
30-44	6	26.1
45-59	7	30.4
60+	4	17.4
Unknown	1	4.3
Quad riding experience		
0 to 5 years	5	21.7
6 to 10 years	6	26.1
More than 10 years	12	52.2
Helmet use		
Helmet	5	21.7
No helmet	18	78.3
Carrying passengers		
Yes	1	4.3
No	22	95.7
Perceived danger of site		
Not dangerous	12	52.2
Slightly dangerous	5	21.7
Moderately dangerous	4	17.4
Highly dangerous	2	8.7
Familiarity with site		
Very familiar	19	82.6
Slightly familiar	2	8.7
Not familiar	2	8.7
Familiarity with quad		
Very familiar	20	78.0
Slightly familiar	-	-
Not familiar	3	13.0

Alcohol consumption and fatigue prior to the incident are explored in Table 5.24. One rider admitted that he was under the influence of alcohol at the time of the incident. He had consumed eight alcoholic drinks in the afternoon prior to the incident. As a measure of fatigue, riders were asked how long they were working prior to the incident. Four of the 18 (22%) riders who were undertaking work-related activities reported working eight hours or longer before the incident including two who had been working for 11 hours.

Table 5.24
Alcohol and fatigue prior to quad incident

Factors	N=23	%
Alcohol use		
Yes	1	4.3
No	22	95.7
Hours working prior	N=18	
<4 hours	6	33.3
4 - 7.9 hours	8	44.5
8 hours or more	4	22.2

Four riders reported being in a hurry to complete a work-related activity that involving checking or chasing livestock at the time of the incident (see Table 5.25). While three riders felt they were under pressure due to specific circumstances (i.e. almost dark, visitor, working elsewhere), one rider stated that the task required rushing as the livestock were always trying to get away. Seven riders admitted they were distracted at the time of the incident; four occurred while checking or chasing livestock (two cattle, two sheep) with the riders concentrating on looking at the livestock rather than the path of the quad. Note than one of these riders also said they were in a hurry. When asked if there were any obstructions to their vision, three riders mentioned long grass obstructed their view of hidden hazards that they struck and one found sun glare from a setting sun impaired his vision.

Table 5.25
Distractions/obstructions for quad incident

Distractions/obstructions	N=23	%
In a rush/hurry	4	17.4
Trying to get job done quickly	3	
Nature of task	1	
Distracted	7	30.4
Livestock	4	
Fixing irrigation	1	
Another vehicle	1	
Looking at rocks, tree	1	
Obstructions to vision	4	17.4
Long grass	3	
Sun glare	1	

Details about any injuries incurred as a result of the quad incident are shown in Table 5.26. Injury severity varied with seven riders who did not incur any physical injuries as a result of the incident while 11 riders attended hospital. Note that six of the riders admitted to hospital were identified and contacted as a result of being admitted to the RAH. The main source of injury for riders was striking the quad (35%), followed by hitting the ground (22%). In many incidents riders obtained injuries from both. A shoulder injury was the most common and ranged from stiff and sore shoulders to a broken scapula. The frequency of spinal injuries is concerning given how severe these injuries can be: two involved fractured vertebrae (in one case five vertebrae) and one involved displacement of vertebrae. The two that involved vertebrae fractures also involved long periods of rehabilitation, loss of quality of life and in one case mental health issues. Head injuries were not common in the sample. The one head injury was a small haematoma and the rider was not wearing a helmet.

Table 5.26
Injury characteristics for quad incident

Injury characteristics	N=23	%
Injury severity		
No injury	7	30.4
Self managed	4	17.4
Doctor	1	4.3
Hospital treatment	2	8.7
Hospital admission	9	39.1
Main source of injury		
Quad	8	34.8
Ground	5	21.7
Object struck	2	8.7
Other	1	4.3
No injuries	7	30.4
Location of injury		
Shoulder	4	17.4
Spine	3	13.0
Extremities	3	13.0
Knee	2	8.7
Ribs	2	8.7
Head	1	4.3
Hip	1	4.3
Eye	1	4.3
Neck	1	4.3

In Table 5.27 the location of injury is disaggregated by rollover type. This reveals that two of the three spinal injuries were suffered during a backwards roll. It should also be noted that these were the severe spinal injuries that involved vertebrae fractures, long hospitalisation and extensive rehabilitation. Only one backwards rollover resulted in no injuries. In contrast six of the nine side rollovers resulted in no injuries. The injuries that did result from side rollovers included knee, hip and extremity injuries.

Table 5.27
Location of injury by rollover type

	Rollover type		
Location of injury	Backward (n=4)	Forward (n=1)	Side (n=9)
Shoulder	1	1	-
Spine	2	-	-
Extremities	-	1	2
Knee	-	-	1
Ribs	1	-	-
Hip	-	-	1
None	1	-	6

A comparison of helmet wearing, speed, age and rollover by hospital attendance (treated and admitted) is shown in Table 5.28. There was very little difference in helmet wearing between those who attended hospital and those who did not. Those that attended hospital were more likely to be travelling at speeds above 20 km/h and their median speed was proportionally much higher, yet still relatively slow. Riders aged 60 years and over involved in an incident were more likely to attend hospital than younger riders. When considering all rollovers, a rollover does not appear to make it

more likely that the rider will attend a hospital. However, backwards rollovers were highly likely to result in hospital attendance. Having only one forward rollover makes it difficult to comment on the severity of this form of rollover.

Table 5.28
A comparison of selected variables by hospital attendance

	Hospital not attended		Hospital attended	
	n = 12	%	n =11	%
Helmet wearing				
Not worn	9	75	9	81.8
Worn	3	25	2	18.2
Speed (km/h)				
0-20	10	83.3	7	63.6
21-40	0	0.0	3	27.3
41+	2	16.7	1	9.1
Median speed	5		13	
Age				
0-29	4	33.3	2	16.7
30-44	3	25.0	3	25.0
45-59	4	33.3	3	25.0
60+	1	8.3	3	25.0
Median age	32		54	
Rollover				
Yes	7	58.3	7	63.6
No	5	41.7	4	36.4
Backwards	1	8.3	3	27.3
Forwards	0	0.0	1	9.1
Sideways	6	50.0	3	27.3

The riders were asked what they thought caused their incident. The results are summarised in Table 5.29. There was a wide range of responses. Steep terrain, speed and recklessness/riding too hard/stupidity featured at the top of the list closely followed by unseen objects and inattention. Interestingly, inexperience/lack of ability, the most frequent response to what riders perceived was the cause of most incidents, was not mentioned as a causal factor in their own incidents.

Table 5.29
Riders opinions of causes of their quad incident

Riders opinion of causes of their quad incident	N=23	%
Steep terrain	4	17.4
Speed	4	17.4
Recklessness / riding too hard / stupidity	4	17.4
Unseen objects	3	13.0
Inattention	3	13.0
Uneven terrain	2	8.7
Rider error	2	8.7
Sharp steering and acceleration	1	4.3
Unexpected terrain	1	4.3
Overconfidence	1	4.3
Distraction	1	4.3
Poor lighting	1	4.3
Temper / aggressive riding	1	4.3
Load	1	4.3
Alcohol	1	4.3
Vehicle fault	1	4.3
Inquisitive young boy	1	4.3

The riders were also asked what they thought could have prevented the incident. This produced a wide range of answers specific to the situation that could not be easily summarised. Three of the 23 thought nothing could have prevented their incident. Below are some examples of responses:

"Going a different way. We've levelled off some areas there now to go mustering so we don't have to go up the steep areas as much. We use dogs a lot more now. Just changed management"

"Possibly going slower may have prevented the incident. I know where most holes are but not all of them."

The riders involved in an incident were asked how rollover protection or using a different vehicle may have changed the outcome of the crash, as seen in Table 5.30. Of the 14 riders involved in a rollover, half thought rollover protection would have had no impact on the outcome, three thought it would have had made it worse and one thought it would have improved the outcome. In contrast, more than half thought using a different vehicle would have improved the outcome and only one thought it would have been detrimental. Many said they simply did not know what effect a different vehicle would have had on the outcome.

Table 5.30
Perceived changes to outcome of incident with rollover protection or using a different vehicle type

	Rollover protection		Use different vehicle	
Perceived outcome	N=14	%	N=21	%
Improved outcome	1	7.1	11	52.4
No impact	7	50.0	4	19.0
Detrimental	3	21.4	1	4.8
Don't know	3	21.4	5	23.8

5.3.4 Quad inspection

A basic inspection was performed on the main quad bike used by the rider, or the quad they were riding when they had an incident. The quad was available for inspection in 41 of the 46 cases. The purpose of the inspection was to identify basic faults, obtain objective information about the specifications of the quad, and examine any modifications or accessories fitted.

The inspection for faults was conducted without removing any parts of the quad or riding the quad and included:

- Tyre pressures
- Tyre tread depths
- Brake operation, including the parking brake
- Headlight operation
- Shock absorbers
- Steering
- Throttle operation

The specification information that was collected from the quad included:

- VIN (if available)
- Year of Manufacture (if available)
- Engine size
- Odometer / hour meter reading
- Track (front and rear)
- Wheelbase
- Towing capacity
- Rollover protection type (if any)
- Maximum speed listed on the speedometer (if analogue)
- Front load limit
- Rear load limit
- Type of rear suspension

Many photographs were also taken of each quad to create a visual record. The photographs included different angles of the quad, close ups of all warning stickers and any damage to the quad. Photographs were also taken of equipment that was fitted to, or towed by, the quad.

Faults identified in the inspections

The tyre pressures were measured using a low-pressure tyre gauge with a range of 0-15 psi and graduations of 0.2 psi. Six tyres were found to be flat (0-0.5 psi), with three of these being on the one quad. One tyre was also found to be severely overinflated, exceeding the 15 psi range of the gauge despite having a recommended pressure of 3.6 psi.

Figure 5.7 shows the percentage difference between the measured pressure and the recommended pressure. Recommended tyre pressures ranged from 2.8 to 6psi. In some instances minimum and maximum tyre pressure was given rather than a recommended pressure. In these cases the

recommended was taken as the mean of these two values. Only 23% of the tyres were inflated to within ±20% of the recommended pressure. The tyres were more likely to be overinflated by more than 20% (57% of tyres) than underinflated by more than 20% (20% of tyres) and 21% were inflated to more than twice the recommended pressure.

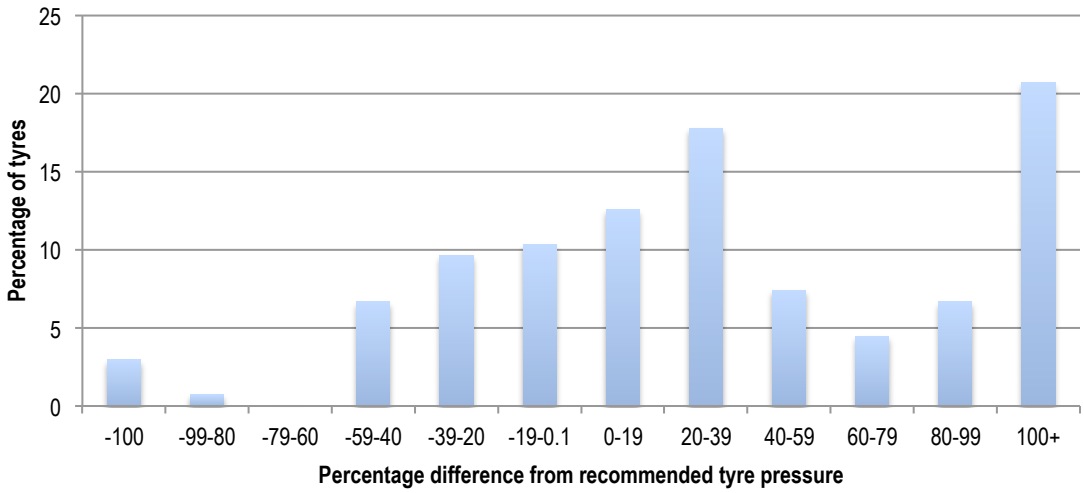


Figure 5.7
Percentage difference in measured tyre pressures from recommended tyre pressures on the inspected quads

Seven quad bikes did not have the recommended tyre pressures listed on the quad bike and are therefore not included in the table. These were quads that were quite old. Where the sticker that listed the recommended tyre pressure had been rendered unreadable, the recommended tyre pressures from a quad of the same model from within the sample were used. An example of such a sticker is shown in Figure 5.8.

Figure 5.8
A unreadable recommended tyre pressure sticker: position on quad- circled (left) and close up view (right)

Anecdotally the tendency towards over inflation may be due to riders wanted to guard against slow leaks and the need to inflate them too regularly, though in some instances it may be due to a lack of awareness of the correct pressure.

Figure 5.9 shows the distribution of tyre tread depths. Almost half of all tyres had more than 8mm of tread depth, but 10% were effectively bald (0-2mm tread depth) and a further 11% had very little tread remaining (2-4mm tread depth). Low tread depth will lead to decreased traction. If tyres are worn unevenly front to rear this could lead to a loss of control.

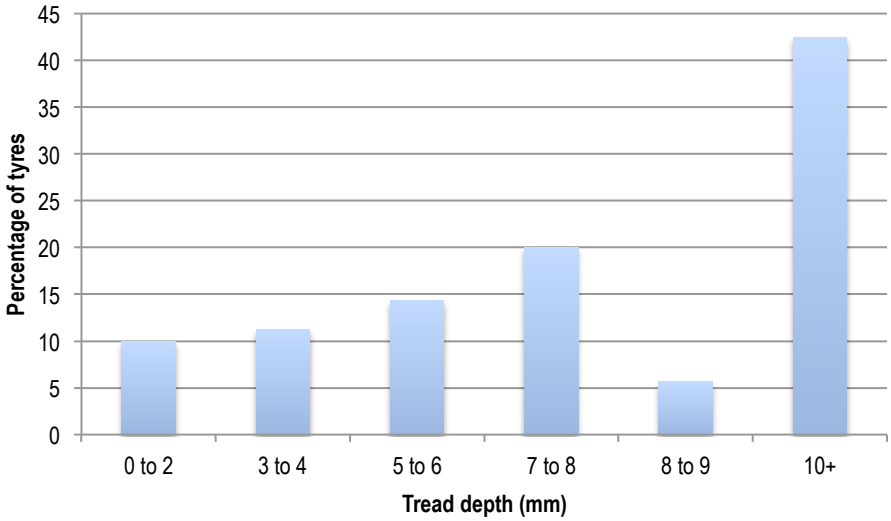


Figure 5.9
Tyre tread depth on the inspected quads

The brake operation of the inspected quad bikes is shown in Table 5.31. It should be noted that the wheels were not removed to inspect the brake pads. Only one of the regular brakes was not working at all, though four of the parking brake mechanisms were not working. The rear brake was more likely to be worn or maladjusted, with almost a third of all rear brakes in this condition.

The majority of the braking force in any vehicle comes from the front brakes as load transfers to the front under braking; therefore this could be considered the more important brake to have functioning correctly. For quads being used in 4WD mode the front and rear braking effectively becomes linked, meaning the operation of the brake on one axle will also brake the other axle. A parking brake that is not working can be worked around by either leaving the quad in gear or ensuring it is parked on a flat surface.

Table 5.31
Brake operation on the inspected quads

	Front		Rear		Parking	
Brake operation	n=41	%	n=41	%	n=41	%
Good	35	85.4	28	68.3	29	70.7
Worn / maladjusted	5	12.2	13	31.7	4	9.8
Not working	1	2.4	0	0.0	4	9.8

All the quads were found to have headlights that were working and smooth throttle operation. Three quads were found to have shock absorbers that were leaking and six were found to have steering free play, but this was always a relatively minor amount of free play.

Quad specification from inspection

The odometer readings from the quad bikes inspected are summarised in Table 5.32. Nearly a third of the quad bikes either did not have odometer, had an odometer that only went to 999 km, or had an odometer that had stopped working. The kilometres travelled by the quads ranged from 1,326 to 55,661, though only two had exceeded 40,000 km. Nine of the 41 had less than 5,000 km.

Table 5.32
Odometer readings on the inspected quads

Odometer reading (km)	Number	%
<5000	9	22.0
5,000 to 9,999	7	17.1
10,000 to 19,999	4	9.8
20,000 to 39,999	7	17.1
40,000+	2	4.9
Unknown	12	29.3
Total	41	100.0

Figure 5.10 shows the distribution of the track widths of the quads inspected. The track width was measured from the centre of the tyre. The tracks widths ranged from 0.54 to 1.12 metres. Both the front and rear track widths were most commonly in the 0.8 to 0.899 metre range, representing 56% of front tracks and 68% of rear tracks. Very few of the quad bike track widths exceeded one metre. By comparison the one side-by-side that was included in the sample had a track of 1.28 metres at the front and 1.22 metres at the back.

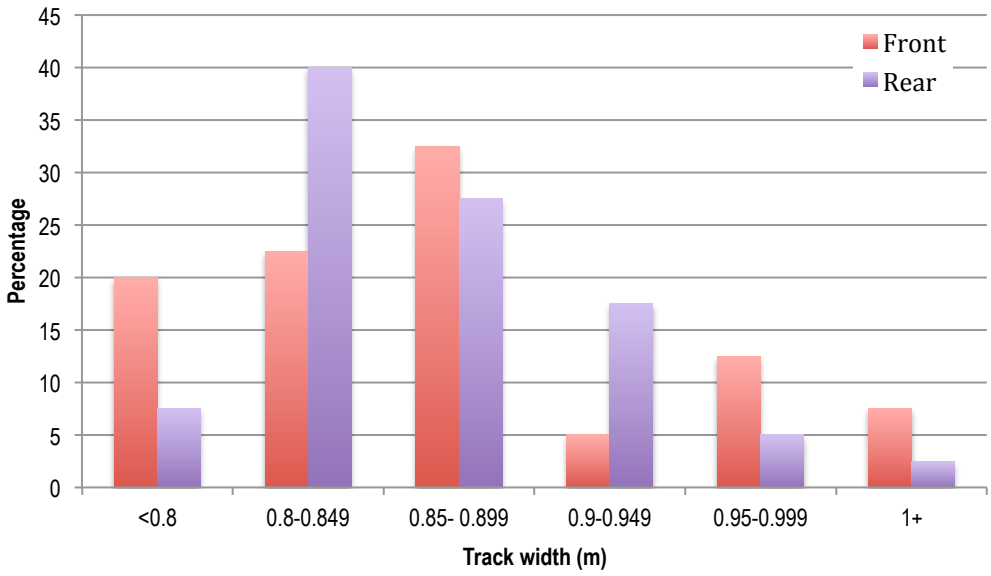


Figure 5.10
The track width of the quad bikes inspected

Stickers that state the maximum load for the cargo racks are placed on or near the cargo rack they refer to (Figure 5.11), but the inspections revealed that these often wear off. Table 5.33 shows that 42% of quads inspected did not have a readable front max cargo sticker present, and 49% did not have a rear max cargo sticker present.

Figure 5.11
A recommended rack load sticker that has worn off: position on quad- circled (left) and close up view (right)

Table 5.33
The presence of a readable max cargo rack load sticker on the inspected quads

Readable max cargo rack load sticker present	Front		Rear	
	n=41	%	n=41	%
Yes	24	58.5	21	51.2
No	17	41.5	20	48.8

Table 5.34 shows the type of rear suspension on the quads inspected. The clear majority had a solid axle type rear suspension: only 20% were equipped with independent rear suspension. Independent rear suspension allows the quad to better handle terrain and obstacles that are uneven from side to side. This may be particularly important when the quad strikes a small obstacle, such as a rock, with just one side.

Table 5.34
The type of rear suspension on the inspected quads

Type of rear suspension	Number	%
Solid axle	33	80.5
Independent	8	19.5
Total	41	100.0

5.4 Discussion

The findings showed that quad bikes are used across a wide range of agricultural industries in South Australia. The typical terrain of the properties in which they are used also varies considerably. The quads are used for many different agricultural tasks such as mustering stock, spraying, checking irrigation, and trimming foliage. Quads appear to have great utility for the tasks undertaken in these work places, with each rider interviewed using the quad for an average of six different tasks. This was also highlighted in the rider's reasons for purchase, which was most commonly that is was good for the tasks they wanted to use it for. This presents a difficulty for regulators. A product that has little utility and presents a real hazard can be easily banned, such as a children's toy or novelty item. However, when something has great utility the burden placed on the community by not allowing the sale of that item needs to be weighed against the hazard it presents. For example, motor vehicles

present a real hazard but they have not been banned because of their great utility. Rather than banning them, standards and design rules have been applied to ensure a certain level of safety.

In the hierarchy of hazard controls, if a hazard can not be eliminated the next option to be considered is substitution. In the case of quad bikes this could mean substituting the quad bike for a safer alternative. Of course, for a substitution to be suitable for a consumer it would need to be equivalent in terms of utility and costs. The most likely vehicle that could be an effective substitution for quad bikes are side-by-sides (e.g. Yamaha Rhino, John Deer Gator). A recent report found side-by-sides to be more stable than quad bikes and concluded they were safer (Grzebieta, Rechnitzer, Simmons, & McIntosh, 2015). There were two riders who had already purchased side-by-sides for their business. The largest barrier to side-by-sides being an effective substitution, from the rider's point of view, was their cost compared to a quad bike. This may be partly due to a lack of used side-by-sides in the market, with their relatively recent introduction and smaller sales numbers thus far. Some concerns were also expressed regarding their suitability for the task due to less manoeuvrability. This could be offset by increased utility in other areas such as greater load carrying capability and the ability to carry a passenger. Some caution should be exercised when considering side-by-sides as a completely safe alternative. While the greater stability, roll cage and seatbelts will undoubtedly improve safety, drivers not wearing seatbelts may undo some of the safety benefit. Indeed the conclusion by Grzebieta *et al.* (2015) was predicated on the driver being restrained (and wearing a helmet). Unfortunately the non-wearing of seatbelts, when a seatbelt is available, is common practice in vehicles used for agriculture (Blackman, Cheffins, Veitch, & O'Connor, 2009).

More than three quarters of all riders felt that quad bikes were safe but this proportion decreased for those who had an incident (68%), especially if they had attended hospital as a result of the incident (46%). A recent study from New Zealand found that perceptions of personal risk were higher when farmers experienced a quad bike incident that was severe enough to threaten their wellbeing (Clay, Hay-Smith, Treharne, & Milosavljevic, 2015). Another study of farmers showed that the level of impact resulting from an injury event determined the length of heightened personal awareness of risk but incidents not resulting in harm were found to reinforce current behaviour even if it was risky (Lovelock, 2012).

It is interesting to note that the most common perceived cause of quad incidents was related to inexperience or a lack of ability, yet this was not a common cause of the incidents reported in this study. None of the riders attributed lack of experience as a cause of their incident; generally the riders were experienced at the time of the crash with an average of 12.6 years of quad riding experience. These findings are broadly suggestive of a perception that quad bike incidents are something that happen to other people. This perception is further demonstrated in many of the comments that were made in relation to the question of "are quads safe?" Many answered that, "yes, they are safe, provided you ride them properly and don't do stupid things on them".

One area where rider perception appears to match reality is the task of mustering or chasing livestock. It was perceived by riders to be the most risky task and it was the most common task being undertaken when an incident occurred. There are many reasons why mustering with a quad bike might be risky. Firstly the rider's attention is divided between the tasks of tracking the animals they are mustering and scanning the ground ahead for hazards. This can lead to not seeing an object in the path of the quad such as a rock, or unevenness in the terrain. This was a factor in five of the ten incidents where the rider was mustering. The second issue with mustering is that there are occasions where the rider is going at high speed and may be rushing to cut off livestock. While a lot of mustering is done at very slow speed a rider may have to react quickly to an animal that is straying. This speed often combines with the aforementioned divided attention to create a risky situation. This was observed in three of the ten mustering incidents recorded. Another factor that can make mustering

risky is that the rider may take the quad over terrain that is not suitable for the quad, such as a steep slope, in pursuit of a straying animal. This was a factor in two of the ten mustering cases. A further factor is that animals can be unpredictable and the rider can actually strike an animal if it responds unpredictably. In particular, this can be an issue with animals that are blind or deaf. In two mustering incidents a rider struck an animal and this caused the quad to roll over. Finally, mustering can involve the risky manoeuvre of turning the quad quickly and sharply to head off an animal. There were two mustering incidents in our sample where this was a factor. While the ability of a quad to turn sharply is seen as a positive attribute by the riders, it can also lead to a side rollover. More than one of these factors might be present in a single incident. All of these factors illustrate why mustering is a very risky task to undertake on a quad bike.

Recreation was over represented as an activity being undertaken when an incident occurred, as the quad bikes were reportedly used very rarely for recreation. While this is not directly a workplace health and safety issue, the quad that is being used primarily for work tasks is then also being used for recreational purposes. Consequently anything that is done to increase the safety of the quad will also have a benefit for these types of incidents.

The average travel speed and reported speed when the incident occurred were generally low, with three quarters occurring at speeds at or below 20 km/h. Four riders thought that speed was a factor in their incident. Other researchers have also found that quad bike riders riding for agricultural work purposes have low average speeds (Milosavljevic *et al.* 2015), and were travelling at low speeds when involved in an incident (Grzebieta et al., 2015).

Most riders carried loads of some form on their quad and this was a reason why some chose to purchase a quad. As the loads are carried above the centre of gravity any load will decrease the stability of the quad bike. Grzebieta, Rechnitzer and Simmons (2015b) found that loading a quad bike to its maximum rated load reduced the static lateral rollover angle by close to 10%, but having the maximum rear load only could reduce the backwards rollover angle by 16%. The static backwards rollover angles found by Grzebieta *et al*. (2015b), 37.9° to 43.6° unloaded and 31.8° to 38.4° with maximum rear load, closely matched those observed in this sample, 38.1° unloaded and 28.6° with heavy rear load. While many of the loads carried on the front were very light and probably of little rollover stability consequence, the loads carried on the rear tended to be quite heavy.

In addition to being places of work, farms are unique in that they are also homes, often with children. It is of great concern that a large number of riders allowed children to ride quad bikes either as riders or passengers. Many had certain rules that must be followed by children when riding the quad bike, but this may simply give the illusion of lowering the risk without actually controlling it. Children may act impulsively or simply circumvent the rules. One rider acknowledged that while he only allowed his children to ride the quad in first gear he was aware that they would often disobey this rule as soon as they were out of his sight.

Despite only one of the quads used by the riders being designed to carry passengers, three quarters of the riders admitted that they carry passengers on the quad. Many of the riders said that this was not a common occurrence or was associated with specific tasks such as providing transport. Grzebieta, *et al.* (2015b) found that the addition of one rider could reduce the static side rollover angle by over 30%. The addition of a passenger may have a similar reduction on rollover stability compared to just having a rider, especially if the passenger is an adult. The increased chance of rollover is compounded by the increased exposure (two people rather than one) and it may also be harder to jump clear when there are two people on the quad bike.

The quad rolled over in the majority of the incidents and the main source of injury was the quad striking the rider. This highlights that increased stability and restraining the rider within a roll cage if the

vehicle does roll over, such as on a side-by-side, could have a large effect on reducing injury. In terms of injury, the most severe type of rollover occurred when the quad rolled backwards. Two of these riders were able to jump clear of the quad but two did not and sustained severe injuries. Sideways rollovers tended to be less severe than longitudinal rollovers. This may be as a result of the low speeds typically involved, meaning that the quads only completed one quarter turn. The number of quarter turns was not a specific question that was asked. While some riders mentioned the number of quarter turns in the open question concerning "what happened" during the incident, many were unclear about the number of turns. In this study, all backwards rollovers involved a very steep slope therefore, the risk of backwards rollovers may be reduced by having an angle based warning. Not carrying loads on the rear when navigating steep slopes would also assist in minimising this risk (R Grzebieta et al., 2015b).

The quad bikes were found to generally be in good condition though many of the tyres of the quads were not inflated to the correct pressure. Over inflation of the tyre causes the tyre to become stiffer, and not conform to the uneven road surface as well. This will decrease traction but could increase resistance to lateral rollover when turning. The stiffer tyre could increase the chance of rollover if such a tyre struck a rock or sharp undulations in the terrain. Under inflation and the resulting reduction in tyre stiffness could cause a decrease in resistance to lateral rollover when turning, especially if the outside front tyre is under inflated. Under inflation may cause a decreased chance of rollover if the tyre struck a rock or sharp undulations in the terrain, providing that the tyre is not so under inflated that the tyre is deformed to the rim in such an impact. Under inflation may also cause a reduction in traction, especially as the tyre becomes severely under inflated.

Independent rear suspension was present in 1 in 5 (20%) quad bikes that were examined. Quads with independent rear suspension have been found to disturb the quad and rider less when travelling over a small obstacle, similar in size to the rocks struck in our sample, with just one side of the quad (Grzebieta, Rechnitzer, & Simmons, 2015a). It is therefore worthwhile to consider ways to encourage more riders to purchase, and manufacturers to fit, quads with independent rear suspension.

6 Conclusions

This study provides important insights regarding quad bike use and the circumstances surrounding incidents that occur as a result of their use. The study also identifies high risk uses and examines the severity and type of injury sustained by quad bike riders. This was achieved by drawing on a variety of existing data sources including ReturnToWork SA workers' compensation claims data, national hospital admissions data and the National Coronial Information System. In addition, in-depth data concerning quad use and incidents were obtained through interviews with agricultural workers and patients admitted to hospital following a quad-related incident. Together, the findings from these complementary data sources provide a detailed but complex picture of quad bike use and associated injuries in South Australia.

Inquests into the deaths arising from quad bike accidents have been conducted in Victoria (2003-2007), New Zealand (2013) and very recently in Queensland and New South Wales (2015). The findings from these inquests have been published, including well-considered recommendations to prevent further quad-related deaths in Australia. It is not within the scope of this study to list all possible recommendations that might improve quad safety. The following discussion will relate to specific issues that were highlighted within this study with reference to the hierarchy of controls.

The hierarchy of controls (Safe Work Australia, 2009) is a framework for assessing risk and implementing management controls as reasonably practical. The hierarchy of controls assists in the management of identified hazards or risk through six levels of possible intervention; elimination of the hazard, substitution of the hazard, isolation of the hazard, engineering controls, administrative controls and the use of personal protective equipment. In this representation, elimination of the hazard (e.g. elimination of quad bikes) is the safest and most effective intervention while the use of personal protective equipment (e.g. helmet use) is the least safe or least effective intervention.

Usage of quads

The findings from this research show that quad bikes are used across a wide range of agricultural industries in South Australia and are utilised to undertake a wide variety of tasks. Fatality and interview data suggest that in many cases a quad is purchased for work activities on the farm but it is also occasionally used for recreational purposes. Therefore, any controls used to increase the safety of the quad on the farm might also benefit recreational use.

This study found that one of the most common yet riskiest tasks undertaken by quad riders in an agricultural setting is mustering livestock. Mustering livestock is an essential task within numerous agricultural industries. Many of the agricultural workers interviewed mentioned they purchased a quad specifically because it was good for mustering livestock and 74% of the riders used the quad for mustering. Mustering was also identified by riders as the most risky task when using a quad and was the most common activity being undertaken when an incident occurred. The quad incidents described by the agricultural workers revealed that mustering was a high risk activity for a number of reasons: it may involve the rider turning the quad quickly and sharply or travelling at higher speeds to head off livestock, riders may travel in difficult terrain such as steep slopes in pursuit of straying animals, livestock may react unpredictably, and it divides the riders attention between tracking the livestock and scanning the ground ahead. Indeed, at least 28% of injured workers from the workers' compensation claim data were mustering stock when they were injured and the most common injury mechanism was striking an object on the ground. The most common types of injuries associated with these incidents were fractures, particularly to the wrist; strains to muscles and joints, most commonly in the shoulder and back; and dislocations of the shoulder.

The hierarchy of controls suggests the safest intervention to manage a hazard is to eliminate it. However, it is evident that quad bikes have some utility and the burden placed on the community by limiting or not allowing their use needs to be weighed against the hazard it presents. It is clear that the riders interviewed in this study were unwilling to eliminate the quad. However, there were some limited insights into the potential elimination of hazards that would assist with their safe use (i.e. do not use quads in difficult/risky terrain, flattening steep areas, speed limitations).

According to the hierarchy of controls, if a hazard can not be eliminated the next most practicable option is substitution for a safer alternative. The most likely effective substitution for quad bikes are side-by-sides although utilities, tractors or motorcycles might also be an alternative. Recent vehicle testing has found side-by-sides to be more stable and safer than quad bikes (Grzebieta *et al.*, 2015). While many had considered purchasing a side-by-side, the largest perceived barrier to being an effective substitution was their cost compared to a quad bike. Some concerns were also expressed regarding their manoeuvrability with respect to specific tasks. This could be offset by increased utility in other areas such as greater load carrying capability and the ability to carry a passenger.

Most riders carried loads on their quad and this was a reason why some chose to purchase a quad. As loads are carried above the centre of gravity, any load will decrease the stability of the quad and increase the likelihood of rollovers. In this study, it was found that in 35% of fatal crashes a quad bike was carrying a load and in more than half of these cases it was a passenger. Indeed, 74% of riders interviewed reported that they carried passengers indicating that it was not a common occurrence but sometimes needed for specific or seasonal tasks.

Given the inherent risks involved with mustering livestock, or any other risky tasks, and the need to carry loads, farmers should consider whether a side-by-side might be a safer alternative. Further research might explore options to increase the use and purchase of safer side-by-side vehicles. For example, a scheme in which farmers are able to trial the use of a side-by-side on their property to establish suitability.

Quads and rollovers

The hierarchy of controls suggests that engineering controls are the next safest option after elimination and substitution. In this case, engineering controls bring us to the quad bike itself. While engineering controls for plant or equipment often take the form of barriers that physically separate the user from the hazard, in vehicle design they often fit into two categories; controls that prevent the hazardous situation from occurring, and controls that protect the user if the hazardous situation occurs.

For quad bikes, the main hazard requiring engineering controls is the quad rolling over. Rollover is the most common cause of quad fatalities in Australia of which 56% fatalities were recorded as rolling over in this study. McIntosh *et al.* (2015) found rollovers to be particularly prevalent amongst work fatalities. Almost half of the incidents for agricultural workers interviewed involved rollover, and at least 20% of the worker injuries examined in the workers compensation claims data involved rollovers (likely to be an underestimate).

The rollover resistance of a vehicle is dependant on the track width (of wheelbase for forward or backwards rolls), the position of the centre of mass and the suspension characteristics (including the tyres). The easiest path to increasing the rollover resistance of a quad would be to increase the track width and make changes to the suspension. It was these very parameters that were adjusted in a prototype quad that was tested for rollover stability as part of the Quad Bike Performance Project (Grzebieta *et al.* 2015b). This prototype quad bike was found to have 50% higher resistance to lateral rollover than the average standard quad bike.

Another potential engineering control to help prevent quad rollover is a rollover warning alarm. Warning devices for quad rollover have been developed (U.S. Patent No. 8,902,055, 2014) but the authors are not aware of any that are currently fitted to quad bikes. Carman *et al. (2010)* state that it is unknown if such a device would reduce the risk of quad rollovers due to the unpredictable nature of many such events. It should be noted that the patented rollover warning device referenced above is quite advanced in that it includes measurement of longitudinal acceleration, lateral acceleration, vertical acceleration, a roll rate, and yaw rate. It combines measurements from at least two of these measurements to issue rollover warnings. The difficulty with any warning device is the timeliness of the warning: issuing a warning when the quad is already on the steep slope may be too late in some cases. The issue of a steep slope leading to rollover was highlighted in the incidents documented from the interviews and corresponding site inspections in this study.

Another engineering control that may help to reduce the risk of a quad rolling over is independent rear suspension. Quads with independent rear suspension have been found to disturb the quad and rider less when travelling over a small obstacle, similar in size to the rocks struck in our sample, with just one side of the quad (Grzebieta, Rechnitzer and Simmons, 2015a). It is therefore worthwhile to consider ways to encourage more riders to purchase, and manufacturers to fit, quads with independent rear suspension. The most effective option would be to make it mandatory for new quad bikes to be fitted with independent rear suspension.

The second type of engineering controls are those that are aimed at preventing injury should a hazardous situation occur, in this case a quad rolling over. Devices typically known as crush protection devices (CPDs) have been invented for this purpose. CPDs have been a great source of controversy. Some researchers have concluded that they would have negative to neutral effects (Zellner, Kebschull, & Van Auken, 2014) while others have suggested that there would be a net benefit for slow speed crashes and have recommended they be installed on all quad bikes (Grzebieta, Rechnitzer, Simmons, et al., 2015). The current research is not able to add much evidence to this debate due to the rarity of quad bikes fitted with CPDs. Only one of the 46 quad bikes examined as part of the interviews was fitted with a CPD. All riders were asked if they had been injured by rollover protection. That none had been injured may be purely due to a lack of exposure. It should be noted that a new semi deformable CPD may overcome some of the possible negative consequences that have been suggested for CPDs. The new CPD design can deform around the rider and should not transmit a concentrated load to the rider during a rollover.

A further device to protect the occupant in case of a rollover would be a full roll cage or roll over protection system (ROPS) including seatbelts or other restraints. While side-by-side vehicles come standard with ROPS they have not usually been available for quads. However, some manufacturers have recently designed quad bikes with full ROPS including a three point harness to restrain the rider. There is not the same debate around the safety of ROPS that there is around CPDs. The only real concern with ROPS is that, to be effective, the rider must be effectively restrained. Unfortunately the non-wearing of seatbelts, when a seatbelt is available, is common practice in vehicles used for agriculture (Blackman *et al.*, 2009). This tendency could be reduced with a further engineering control, seatbelt interlocks, that will not allow the vehicle to function without the seatbelt fastened.

Administrative controls: Rider training and regulation

Engineering controls clearly have the potential to reduce quad-related trauma. In addition to engineering measures, administrative controls such as training and regulations might have a complimentary role. Of the riders who were interviewed in this study, very few had received any formal training as to how to operate a quad bike with only two riders who were employers, offering any

training in a work context. The majority of riders were self taught and many had been riding motorcycles before riding a quad.

Quad rider training programs are widely used in the United States but their effectiveness has never been formally established (Williams et al., 2014). The reliance on training as a risk reduction strategy has been questioned in WHS and road safety (Woolley, Bailey, & Raftery, 2014). A meta-analysis of twenty-two studies investigating the effectiveness of safety training for workers concluded that, due to the low demonstrated effectiveness of training in preventing worker illness and injury, training should not be used as the sole intervention for worker safety (Robson et al., 2012). Training programs involving motor vehicle or motorcycle use have not been shown to reduce crashes (Christie, 2001; Kardamanidisk, Martiniuk, Ivers, Stevenson, & Thistlethwaite, 2010). It is possible that training, particularly advanced skills training, could increase the confidence and risk taking of quad riders as is the case in road safety (Mayhew & Simpson, 2002). Training or induction courses might be more beneficial if they focus on eliminating hazards from the environment and emphasize the importance of choosing the safest action such as giving guidance in determining the right vehicle for the right job, restricting or banning riding in risky areas or in certain conditions and wearing personal protective equipment including helmets.

In this study, it was evident during interviews that mandating legislation will not be popular to users of quad bikes in the agricultural community. Increased regulation might have an effect on sense of autonomy felt by users to make decisions relative to their needs and circumstances (Franklin, McBain-Rigg, & Knight, 2015). However, it sets a standard and provides an incentive to change behaviour. A study from the United States showed that regulations requiring training for quad riders had little impact in terms of mitigating quad-related deaths, but regulations requiring helmet use had some impact on the rate of quad deaths (Helmkamp et al, 2012). However, for any policy or law to be effective, it must be enforced. Enforcement in the Australian rural context will be difficult given the vast distances to cover and issues surrounding access to private property.

In the United States, Williams et al, (2014) observed “the absence of laws, weaknesses in those that exist, and enforcement challenges hamper law-based approaches to protecting ATV riders.” Nevertheless, there has been some positive reductions in paediatric injuries in Massachusettes, following the introduction of a law banning children aged under 14 years from using adult size quad bikes in 2010 (Locke, 2015). Indeed there appears to be a case for age-based restrictions for riding adult size quads in Australia. Consistent with international research documenting quad-related paediatric injuries and deaths (Anson, Segedin, & Jones, 2009; Mazotas et al., 2014; Pearce & Miles, 2015; Shults, West, Rudd, & Helmkamp, 2013; Wood et al., 2013), this study found that 16% of Australian fatalities involving an adult sized quad were children aged under 16 years; within South Australia, half of the fatalities were children. Of the riders who were interviewed, 44% let children ride the quad and half of these children were permitted to operate the quad. Adults who allow children to have access to a quad need to be aware of the risks in which they are placing those children and the potential consequences. It is not clear whether those interviewed appreciated the risks, but there appears to be a perception that the risks are mitigated by placing conditions or restrictions on children’s use of the quads (e.g. only when adult supervision, only use first gear).

McBain et al. (2014) explored northern Queensland farmers’ attitudes towards quad bikes in great detail through focus groups and identified a “culture of acceptable risk”. The observed culture involved the acceptance of risks, such as the use of quads, as part of everyday life within the agricultural industry. The challenge now is to create a culture of safety around quad bikes and this will take time. To create a safety culture, regulation may be needed to influence behaviour, as was the case for seat belts in motor vehicles, but it is likely that enforcement will be problematic. There is also a strong case for public education campaigns to promote quad safety. Such campaigns might promote awareness of possible criminal liability if a business (including family farms) has not reasonably undertaken all safety

obligations, including risk management controls, when operating plant equipment such as quad bikes. This might be most effectively conveyed by drawing on an emotional appeal that relays the wider effects and costs of quad-related injuries on families and the community using real stories.

Among the interviewed riders there was a common perception that quad incidents were due to rider inexperience, recklessness and excessive speed. In reality, few of the rider incidents reported were due to inexperience. In fact, the majority of riders who had an incident were very experienced quad riders (with over 10 years experience). Public education campaigns might also be useful in promoting awareness that quad incidents can happen to anyone, even experienced riders. Given these perceptions, future research might also examine the specific causes of a sample of quad bike incidents, in the context of whether the incident involved risky or extreme behaviour, such as recklessness or speed, or was the result of a simple mistake such as striking an obscured rock. Understanding the relative contribution of each in quad incident causation has important implications for the improvement of quad safety as incidents involving simple mistakes or errors can be addressed through system wide improvements to quad bike safety, specifically through management of quad bike design.

Public education campaigns by themself are unlikely to result in significant behaviour change, but the combination of regulation and education might assist in promoting a culture of quad safety. While administrative controls can have a role in improving quad safety, it is the engineering controls and those higher in the hierarchy of controls that will be most effective.

Personal protective equipment

Wearing personal protective equipment is the last level of the hierarchy of controls and generally the least effective for managing hazards and decreasing the risk of injury. Helmet use is the most important personal protective equipment for quad riders. Consistent with other research, this study found a low rate of helmet use among quad-related fatalities (14%) and among interviewed riders who were injured in an incident (22%). Note that information concerning helmet use was not available in the workers' compensation data and there was a significant proportion of fatalities (19%) where helmet use was unknown. Of the 76 fatalities who were not wearing a helmet, 42 (55%) suffered a fatal head injury. Those who received a fatal head injury were more likely to be riding for recreational purposes (79%) at the time of the incident. Other research examining Australian fatalities concluded there was a need for higher helmet wearing rates for recreational riders, but higher helmet wearing rates might only slightly alter the incidence of fatal farm work crashes (McIntosh et al., 2015). In the worker's compensation data, 13% of workers received injuries in the head region and within the sample of incidents described by agricultural workers there were also only a small number of injuries in the head region. Consequently, helmets will be of value in preventing some quad-related trauma but other measures are also needed to prevent injuries to the body regions receiving the most injuries (i.e. upper limbs, trunk, lower limbs) in work-related incidents.

To promote the use of helmets among the agricultural industry, there is a need for the development of a helmet that accommodates the needs of workers riding quads (i.e. lightweight, allows airflow, does not restrict vision or hearing) yet offers maximum head protection for travel speeds compatible with quad bikes.

Future data needs and research

The analysis of fatality data for quad incidents would be greatly improved with a standardised investigation form for all quad bike and side-by-side related fatalities in Australia and New Zealand. The standard reporting of variables such as make and model of quad bike, engine capacity, rollover protection, pinning under vehicle, helmet use, carrying passengers, carrying or towing loads and/or

attachments would greatly assist in understanding quad-related trauma and guide injury prevention strategies. A similar recommendation has been made by the Queensland Coroner.

Of all the data sources examined within this study, the in-depth analyses of quad-related crashes following hospital admission at the Royal Adelaide Hospital provided the best methodology to effectively capture the most detailed information about the circumstances surrounding quad-related incidents and resulting injuries. Using this methodology, a complete picture of the event was established by interviewing the rider involved, inspecting the quad bike, viewing the location of the incident and reviewing medical records. Moreover, although a labour intensive method was used to identify quad incidents, this method ensured that the majority of quad cases were captured. However, within one year of data collection only seven quad-related injury cases were identified. More invaluable cases might be identified if Royal Adelaide Hospital admissions were monitored over two to three years. Alternatively, more hospitals, particularly those in rural areas, might be monitored to increase the likelihood of obtaining a greater number of cases.

Extending the monitoring of hospital admission records might also assist in investigating the ICD-10-AM external cause codes (including place and activity) that had been assigned to these types of cases. Identifying quad bike cases in Australian admitted hospital patient data is difficult, partly due to terms and concepts, but mostly due to classification issues. A specific study would be required to confirm the sensitivity and specificity of the criteria described in this study for identifying quad bike cases and to obtain information required to improve the estimation of quad bike cases in hospital-admitted injury data.

6.1 Recommendations

Based on the findings from this report and other literature, the following recommendations concerning quad bikes are suggested. It is acknowledged that some of the recommendations extend beyond Safe Work SA's direct responsibilities.

- Explore options to increase the use and purchase of safer side-by-side vehicles.
- Consider ways to encourage quad riders to purchase, and manufacturers to fit, quads with independent rear suspension.
- Consider regulations that restrict children under 16 years from riding adult size quads.
- Rider training should focus on: giving guidance in eliminating hazards from the environment, emphasize the importance of choosing the safest action such as selecting the right vehicle for the right job, restrict or ban riding in risky areas or in certain conditions, and promote the wearing of personal protective equipment including helmets.
- Develop public education campaigns to promote quad safety; promote awareness of possible criminal liability if a business has not reasonably undertaken all safety obligations and draw on emotional appeals that relay the wider effects and costs of quad-related injuries on families and communities. Campaigns might also increase awareness that quad incidents can happen to anyone, even experienced riders.
- Continue to aim preventative measures at farming as this is where most quad incidents occur (recreational and work-related).
- Develop a helmet that provides maximum head protection for travel speeds compatible with quad bikes but also accommodates the needs of workers riding quads.
- Develop a standardised form to investigate all quad bike and side-by-side fatalities.
- Continue the in-depth analyses of quad-related crashes following hospital admission at the Royal Adelaide Hospital to foster a greater understanding of non-fatal quad-related incidents.

Acknowledgements

This study was funded by the SafeWork SA through a Project Grant to the Centre for Automotive Safety Research. The SafeWork SA Project Manager was Brian Adams.

The Centre for Automotive Safety Research is supported by both the South Australian Department of Planning, Transport and Infrastructure and the South Australian Motor Accident Commission.

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.

Chapter 2 of this report is based on data made available by the Department of Justice in Victoria through the National Coronial Information System (NCIS) database.

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

Chapter 4 of this report is based on data made available by the Australian Institute of Health and Welfare. The authors are responsible for the use made of the data in this report.

Special thanks to the following individuals and organisations who assisted with this project:

Members of the advisory panel:

Raphael Grzebieta, Transport and Road Safety, University of New South Wales

Tony Lower, Australian Centre for Agricultural Health and Safety, The University of Sydney

Robert Anderson, Hall Technical

Brian Adams, SafeWork SA

James Harrison, Research Centre for Injury Studies, Flinders University

Simon Berry and Nick Brokenshire, primary producers.

The Agriculture Bureau of South Australia and Primary Producers SA (and commodity groups) for helping to source participants.

Tori Lindsay, Jamie Mackenzie and James Thompson for assisting with data collection and data management.

Marleen Sommariva, Jaime Royals and Trevor Bailey for document review and information management.

All of the quad bike users who kindly gave up their time and participated in the study.

References

Anson, K., Segedin, E., & Jones, P. (2009). ATV (quad bike) injuries in New Zealand children: their extent and severity. *New Zealand Medical Journal*, 122(1302), 11-28.

Australian ATV Distributors, *Australian ATV Distributors position paper*. 2010, Australian ATV Distributors: Brisbane.

Australian Bureau of Statistics (2011). *1345.4 - SA Stats*, June 2011. Retrieved from http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/1345.4Main%20Features1Jun%202011?opendocument&tabname=Summary&prodno=1345.4&issue=Jun%202011&num=&view=

Australian Centre for Agricultural Health and Safety. (2011). *Safety of quad bikes and side-by-side vehicles on Australian farms: a practical management guide*. Moree: Australian Centre for Agricultural Health and Safety, University of Sydney.

Australian Institute of Health and Welfare (AIHW). (2015). *Trends in hospitalised injury, Australia: 1999–00 to 2012–13*. Injury research and statistics series no. 95. Cat. no. INJCAT 171. Canberra: Australian Institute of Health and Welfare.

Australian Institute of Health and Welfare (AIHW). (2014). *Australian hospital statistics 2012–13*. Health services series no. 43. Cat. no. HSE 117. Canberra: Australian Institute of Health and Welfare.

Baldock, M. R., & Lindsay, V. L. (2015). Examination of the role of the combination of alcohol and cannabis in South Australian road crashes. *Traffic Injury Prevention, 16*(5), 443-449. doi: 10.1080/15389588.2014.969804

Blackman, R., Cheffins, T., Veitch, C., & O'Connor, T. (2009). At work or play: A comparison of private property vehicle crashes with those occurring on public roads in north Queensland. *Australian Journal of Rural Health, 17*(4), 189-194.

Carman, A. B., Gillespie, S., Jones, K., Mackay, J., Wallis, G., & Milosavljevic, S. (2010). All terrain vehicle loss of control events in agriculture: Contribution of pitch, roll and velocity. *Ergonomics, 53*(1), 18-29.

Christie, R. (2011). *The Effectiveness of Driver Training/Education as a Road Safety Measure*. Melbourne: Royal Automobile Club of Victoria.

Clapperton, A. J., Herde, E. L., & Lower, T. (2013). Quad bike related injury in Victoria, Australia. *Medical Journal of Australia, 199*(6), 418-422. doi: 10.5694/mja12.11456 [pii]

Clay, L., Hay-Smith, E., Treharne, G., & Milosavljevic, S. (2015). Unrealistic optimism, fatalism, and risk-taking in New Zealand farmers' descriptions of quad-bike incidents: a directed qualitative content analysis. *Journal of Agromedicine, 20*(1), 11-20. doi: 10.1080/1059924X.2014.976727

Clay, L., Hay-Smith, J., Treharne, G., & Milosavljevic, S. (2015). "There are risks to be taken and some just push it too far": how farmers perceive quad-bike incident risk. *Australian and New Zealand Journal of Public Health*. doi: 10.1111/1753-6405.12454

Denning, G., Harland, K., Ellis, D., & Jennissen, C. (2013). More fatal all-terrain vehicle crashes occur on the roadway than off: increased risk-taking characterises roadway fatalities. *Injury Prevention*, 19(4), 250-256. doi: 10.1136/injuryprev-2012-040548injuryprev-2012-040548 [pii]

Denning, G., & Jennissen, C. (2015). All-Terrain Vehicle Fatalities on Paved Roads, Unpaved Roads, and Off-Road: Evidence for Informed Roadway Safety Warnings and Legislation. *Traffic Injury Prevention*, ePub. doi: 10.1080/15389588.2015.1057280

Denning, G., Jennissen, C., Harland, K., Ellis, D., & Buresh, C. (2013). All-terrain vehicles (ATVs) on the road: a serious traffic safety and public health concern. *Traffic Injury Prevention, 14*(1), 78-85. doi: 10.1080/15389588.2012.675110

Fragar, L., Pollock, K., & Morton, C. (2007). *ATV injury on Australian farms: The facts - 2007*. Moree: Australian Centre for Agricultural Health and Safety.

Franklin, R. C., McBain-Rigg, K. E., & Knight, S. M. (2015). Factors to be considered in developing occupational regulations for quad bikes in Australia. *Journal of Agromedicine, 20*(3), 370-380. doi: 10.1080/1059924X.2015.1047108

Grzebieta, R., Rechnitzer, G., McIntosh, A., Mitchell, R., Patton, D., & Simmons, K. (2015). *Investigation and analysis of quad bike and side by side vehicle (SSV) fatalities and injuries*. (Vol. Supplemental report). Sydney: Transport and Road Safety, University of New South Wales.

Grzebieta, R., Rechnitzer, G., & Simmons, K. (2015a). *Quad bike performance project: dynamic handling test results.* Sydney: Transport and Road Safety, University of New South Wales.

Grzebieta, R., Rechnitzer, G., & Simmons, K. (2015b). *Quad bike performance project: static stability test results*. Sydney: Transport and Road Safety, University of New South Wales.

Grzebieta, R., Rechnitzer, G., Simmons, K., & McIntosh, A. (2015). *Quad bike performance project test results, conclusions, and recommendations*. Sydney: Transport and Road Safety, University of New South Wales.

Hall, A. J., Bixler, D., Helmkamp, J. C., Kraner, J. C., & Kaplan, J. A. (2009). Fatal all-terrain vehicle crashes: injury types and alcohol use. *American Journal of Preventative Medicine*, 36(4), 311-316. doi: 10.1016/j.amepre.2008.11.019S0749-3797(09)00023-3 [pii]

Helmkamp, J. C., Aitken, M. E., Graham, J., & Campbell, C. R. (2012). State-specific ATV-related fatality rates: an update in the new millennium. *Public Health Reports, 127*(4), 364-374.

Helmkamp, J. C., Biddle, E., Marsh, S. M., & Campbell, C. R. (2012). The economic burden of all-terrain vehicle related adult deaths in the U.S. workplace, 2003-2006. *Journal of Agricultural Safety and Health, 18*(3), 233-243.

Helmkamp, J. C., Marsh, S. M., & Aitken, M. E. (2011). Occupational all-terrain vehicle deaths among workers 18 years and older in the United States, 1992-2007. *Journal of Agricultural Safety and Health, 17*(2), 147-155.

Holbert, T. J., Holden, D. J., Nelson, D. C., Nelson, M. A., & Wyler, J. M. (2014). U.S. Patent No. 8,902,055. Washington, DC: U.S. Patent and Trademark Office.

Kardamanidisk, K., Martiniuk, A., Ivers, R. Q., Stevenson, M. R., & Thistlethwaite, K. (2010). Motorcycle rider training for the prevention of road crashes (review). *Cochrane Database of Systematic Reviews*. Oxfordshire, England: The Cochrane Collaboration (Issue 10, Article no. CD005240).

Locke, S. (2015). *US visitors outline how Massachusetts banned children from quad bikes and cut deaths*. Retrieved from http://www.abc.net.au/news/2015-11-26/massachusetts-cuts-quad-bike-deaths/6976010

Lovelock, K. (2012). The injured and diseased farmer: occupational health, embodiment and technologies of harm and care. *Sociology Health and Illness, 34*(4), 576-590. doi: 10.1111/j.1467-9566.2011.01394.x

Lower, T., Fragar, L., & Temperley, J. (2011). *Health and Safety on Australian farms*. Canberra: Rural Industries Research and Development Corporation.

Lower, T., & Herde, E. (2012). Non-intentional farm injury fatalities in Australia, 2003-2006. *NSW Public Health Bulletin*, 23(1-2), 21-26. doi: 10.1071/NB11002NB11002 [pii]

Lower, T., Herde, E., & Fragar, L. (2012). Quad bike deaths in Australia 2001 to 2010. *Australian and New Zealand Journal of Health, Safety and Environment, 28*(1), 1-15.

Lower, T., Pollock, K., & Herde, E. (2013). Australian quad bike fatalities: what is the economic cost? *Australian and New Zealand Journal of Public Health, 37*(2), 173-178. doi: 10.1111/1753-6405.12036

Mattei, T. A., Bond, B. J., Hafner, J. W., Jr., Morris, M. J., Travis, J., Hannah, G., . . . Lin, J. J. (2011). Definition and measurement of rider-intrinsic physical attributes influencing all-terrain vehicle safety. *Neurosurgical Focus, 31*(5), E6. doi: 10.3171/2011.9.FOCUS11176

Mayhew, D. R., & Simpson, H. M. (2002). The safety value of driver education and training. *Injury Prevention, 8*(Suppl II), ii3-ii8.

Mazotas, I., Toal, M., Borrup, K., Saleheen, H., Hester, A. L., Copeland, D., . . . Campbell, B. T. (2014). *A prospective, multi-institutional study of pediatric all-terrain vehicle crashes*. Journal of Trauma and Acute Care Surgery, 77(1), 103-108; discussion 107-108. doi: 10.1097/TA.0000000000000026601586154-201407000-00017 [pii]

McBain-Rigg, K. E., Franklin, R. C., McDonald, G. C., & Knight, S. M. (2014). Why quad bike safety is a wicked problem: an exploratory study of attitudes, perceptions, and occupational use of quad bikes in northern Queensland, Australia. *Journal of Agricultural Safety and Health, 20*(1), 33-50.

McIntosh, A., Patton, D., Rechnitzer, G., & Grzebieta, R. H. (2015). Injury mechanisms in fatal Australian quad bike incidents. *Traffic Injury Prevention*. doi: 10.1080/15389588.2015.1091073

Milosavljevic, S., McBride, D. I., Bagheri, N., Vasiljev, R. M., Carman, A. B., Rehn, B., & Moore, D. (2011). Factors associated with quad bike loss of control events in agriculture. *International Journal of Industrial Ergonomics, 41*, 317-321.

Mitchell, R., & Boufous, S. (2005). Self-reported work-related injury and illness in NSW. *Australian and New Zealand Journal of Occupational Health and Safety, 21*(3), 229-236.

Mitchell, R., Grzebieta, R., & Rechnitzer, G. (2015). Capture and surveillance of quad-bike (ATV)-related injuries in administrative data collections. *International Journal of Injury Control and Safety Promotion*, 1-9. doi: 10.1080/17457300.2014.992353

Moore, D., & Bentley, T. (2004). All-terrain vehicle-related Accident Compensation Corporation claims in New Zealand 2000/01: a descriptive analysis. *Journal of Occupational Health and Safety - Ausr NZ, 20*(4), 335-343.

Morton, C., Fragar, L., & Pollock, K. (2009). *Vehicle injury associated with Australian agriculture - the facts 2008*. Moree: Australian Centre for Agricultural Health and Safety.

National Centre for Classification in Health (NCCH) (2010). *International classification of diseases and related health problems, tenth revision*, Australian modification (ICD-10-AM). 7th edn. Sydney: NCCH.

National Center for Statistics and Analysis. (2015). *Fatalities in traffic crashes involving all-terrain vehicles* (Research note). Washington, DC: National Highway Traffic Safety Administration.

O'Connor, T., Hanks, H., & Steinhardt, D. (2009). All-terrain vehicle crashes and associated injuries in north Queensland: findings from the Rural and Remote Road Safety Study. *Australian Journal of Rural Health*, 17(5), 251-256. doi: 10.1111/j.1440-1584.2009.01086.xAJR1086 [pii]

Pearce, R., & Miles, F. (2015). 7-year retrospective review of quad bike injuries admitted to Starship Children's Hospital. *New Zealand Medical Journal, 128*(1414), 44-50.

Persson, J. (2013). *Better Safety on quad bikes*. Borlange, Sweden: Swedish Transport Administration.

Rechnitzer, G., Grzebieta, R., McIntosh, A., & Simmons, K. (2013). *Reducing all-terrain vehicle injuries (ATVs) and deaths - a way ahead.* Paper presented at the The 23rd International Technical Conference on the Enhanced Safety of Vehicles (ESV), Seoul, Republic of Korea, 27-30 May, 2013.

Robson, L. S., Stephenson, C. M., Schulte, P. A., Amick, B. C. III, Irvin, E. L., Eggerth, D. E., Chans, S., Bielecky, A. R. ...Grubb, P. L. (2012). A systematic review of the effectiveness of occupational health and safety training. *Scandinavian Journal of Work Environment and Health, 38(3),* 193-208.

Royal Adelaide Hospital, (2015, 16 June 2015). *Royal Adelaide Hospital Trauma Service*. Retrieved 18 November, 2015, from https://www.rah.sa.gov.au/trauma/index.php

Royal Australasian College of Surgeons. (2013). Position paper Royal Australasian College of Surgeons: Trauma prevention. Retrieved from http://www.surgeons.org/media/348313/2013-07-31_pos_fes-fel-047_trauma_prevention.pdf

Safe Work Australia. (2009). *How to manage work health and safety risks: Code of Practice.* Canberra: Safe Work Australia

Safe Work Australia. (2012). *Design and engineering controls for improving quad bike safety: key findings from the discussion paper and forum*. Retrieved from http://www.safeworkaustralia.gov.au/sites/swa/news/pages/tn191212

Safe Work Australia. (2015). *Quadwatch*. Retrieved 13 August, 2015, from http://www.safeworkaustralia.gov.au/sites/swa/whs-information/agriculture/quad-watch/pages/quad-watch

Shulruf, B., & Balemi, A. (2010). Risk and preventive factors for fatalities in All-terrain Vehicle Accidents in New Zealand. *Accident Analysis and Prevention, 42*(2), 612-618. doi: 10.1016/j.aap.2009.10.007S0001-4575(09)00271-1 [pii]

Shults, R. A., West, B. A., Rudd, R. A., & Helmkamp, J. C. (2013). *All-terrain vehicle-related nonfatal injuries among young riders in the United States*, 2001-2010. Pediatrics, 132(2), 282-289. doi: 10.1542/peds.2013-0751peds.2013-0751 [pii]

StataCorp. 2013. *Stata Statistical Software: Release 13*. College Station, TX: StataCorp LP.

Topping, J., & Garland, S. (2015). 2013 Annual report of ATV-related deaths and injuries. Bethesda: US Consumer Product Safety Commission.

Vanlaar, W., McAteer, H., Brown, S., Crain, J., McFaull, S., & Hing, M. M. (2015). Injuries related to off-road vehicles in Canada. *Accident Analysis and Prevention*, 75, 264-271. doi: 10.1016/j.aap.2014.12.006S0001-4575(14)00385-6 [pii]

Victoria, W. (2009). Literature review - Quad bike related injuries and deaths. Retrieved from http://www.healthnetworks.health.wa.gov.au/docs/injury_quad_bike.pdf

Watson, B. (2012). Impaired driving countermeasures: an Australian perspective. Retrieved from http://eprints.qut.edu.au/55107/1/BW's_presentation_to_the_NTSB_Impaired_Driving_Forum_-_Final.pdf

Williams, A. F., Oesch, S. L., McCartt, A. T., Teoh, E. R., & Sims, L. B. (2014). On-road all-terrain vehicle (ATV) fatalities in the United States. *Journal of Safety Research*, 50, 117-123. doi: 10.1016/j.jsr.2014.05.001S0022-4375(14)00059-0 [pii]

Wood, A., Duijff, J. W., & Christey, G. R. (2013). Quad bike injuries in Waikato, New Zealand: an institutional review from 2007-2011. *ANZ Journal of Surgery, 83*(4), 206-210. doi: 10.1111/ans.12106

Woolley, J. E., Bailey, T. J., & Raftery, S. J. (2014). *What can work health and safety learn from road safety?* Adelaide: Centre for Automotive Safety Research, University of Adelaide.

World Health Organization (WHO) 1992. *The International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10)*. Geneva: WHO.

Yanchar, N. L. (2012). *Position statement, Canadian Paediatric Society: Preventing injuries from all-terrain vehicles.* Retrieved from http://www.cps.ca/documents/position/preventing-injury-from-atvs

Zellner, J. W., Kebschull, S. A., & Van Auken, R. M. (2014). *Updated injury risk/benefit analysis of quadbar crush protection device (CPD) for all-terrain vehicles (ATVs)*. Torrance: Dynamic Research Inc.

Appendix A: Summary of quad bike incidents

Rider	Farm type /terrain	Quad riding experience	Activity	Make and engine size	Estimated speed	Rollover	Type of incident	Injury severity	Description
M10	Beef/Grain Rolling flat	None	Recreation	Yamaha 350	5 km/h	Left side	Rollover	No injury	Owner using quad for recreational purposes with grandchildren. Got off quad. Grandson still on quad, turned the handle bars sharply to the left and accelerated. Quad tipped over onto its left side, rider thrown clear. Tore ligaments in knee.
M56	Beef /Horticulture Hilly	8 years	Chasing stock	Polaris 550	15 km/h	Left side	Rollover	Hospital admission	Riding on steep cross slope (15 degrees) following bull, wheel hit rock, rider leant to the right but the quad rolled onto its left side. Rider was knocked unconscious, left leg and right hand trapped. Managed to push the quad off.
M55	Sheep/Grain Hilly	20 years	Chasing stock	Kawasaki 300	45 km/h	None	Other	No injury	Saw a steep little creek/gutter quite deep and wide ahead, thought approaching at bad angle and didn't have time to stop so jumped off.
M59	Sheep/Grain Rolling flat	26 years	Checking crop	Kawasaki 300	15 km/h	None	Struck object	Self managed	Checking crops, driving past a wire gate, hit a pole sticking out hidden in grass / crop. It caught the front wheel and the back has spun around and rider fell off. Minor shoulder injury.
M65	Beef/Grain Hilly	15 years	Chasing stock	Honda 400	15 km/h	Left side	Struck Animal	No injury	Moving cattle, one went off a bit, went up to turn it. Unexpectedly the animal did not turn. Quad clipped its leg with front wheel tipping the bike on its side.
M62	Vineyards/ Grain Rolling flat	5 years	Fencing	John Deer	13 km/h	None	Struck object	Hospital admission	Driver of Side-by-side, driving between vines and road when distracted by the another vehicle and drove into a fence, with top wire hitting driver straight in the neck inflicting deep wound
M63	Mixed livestock Rolling flat	18 years	Chasing stock	Kawasaki 300	2.5 km/h	None	Other	Hospital admission	Riding through scrub looking for missing cow, a stick flicked over the front of the bike and penetrated the riders eye.
M30	Mixed livestock/Grain Flat	11 years	Chasing stock	BRP 500	2 km/h	Backward	Rollover	Self managed	Rode up the drain bank (38 degree slope) and the front lifted and the quad flipped backwards. Minor shoulder injury.

Rider	Farm type /terrain	Quad riding experience	Activity	Make and engine size	Estimated speed	Rollover	Type of incident	Injury severity	Description
M26	Mixed livestock Flat	10 years	Recreation	Yamaha 400	5 km/h	Left side	Rollover	No injury	Riding around a big hole in the ground, being “a bit stupid”, going up side, self estimated as 45 degrees, turned to go down and bike rolled on to its side.
M59	Mixed livestock Flat	10 years	Chasing stock	Yamaha 350	0.5 km/h	Right side	Rollover	No injury	Rider watching a calf that he had just gotten through a gate, was just turning and stopping and there was a small drop off near the gate (10 degrees lateral slope) and the bike tipped on its side.
M37	Dairy/Beef /Grain Flat	25 years	Chasing stock	Suzuki 400	35 km/h	Forward	Struck object	Hospital admission	Chasing cows when a cow backed out of the group. Front of quad struck cow and quad rolled forwards throwing rider onto ground. Rider struck by quad fracturing riders scapula.
M56	Not agriculture Hilly	13 years	Other (specify)	Honda 300	km/h	Backward	Rollover	Hospital admission	Trying to flatten blackberry bushes to make a walking path. Going up steep slope, quad rolled over backwards with bike striking rider during the roll. Spine facture and broken ribs
M54	Sheep /Grain Rolling flat	15 years	Chasing stock	Yamaha 250	50 km/h	None	Fall off	Hospital admission	Mustering sheep, was in a hurry, went too fast and hit a rock half buried in the grass. The rider was thrown off and landed on the ground. Multiple rib fractures, minor shoulder injury.
M24	Sheep Grain/ Pig Hilly	10 years	Chasing stock	Kawasaki 300	5 km/h	Left side	Rollover	Self managed	Chasing sheep down a steep slope. Tried to turn a bit on the side of the hill, hit a little tussock bush and tipped over.
M37	Vineyards/ Horticulture Steep hilly	10 years	Spraying	Yamaha 350	1 km/h	Backward	Rollover	Hospital treatment	Going up steep hill (29 degrees) with full 100L spray tank on back, bike rolled over backwards one full roll, rider remained on bike during roll. Multiple spinal factures.
M34	Sheep/Grain Hilly	18 years	Chasing stock	Yamaha 350	15 km/h	None	Fall off	No injury	Turning quad sharply and accelerating to try to cut off some sheep, quad dug into sandy soil and threw rider off.
M7	Sheep/Grain Flat	1 years	Recreation	Honda 300	5 km/h	Right side	Rollover	Self managed	Deliberately sliding on wet grass, hit a patch of gravel and the tyres gripped as rider made a full lock turn. Quad rolled and the handle bar hit rider’s hip, bruising it.

Rider	Farm type /terrain	Quad riding experience	Activity	Make and engine size	Estimated speed	Rollover	Type of incident	Injury severity	Description
M30	Beef/Grain Hilly	23 years	Recreation	Honda 300	40 km/h	None	Struck object	Doctor	Intoxicated rider “having fun” forgot he was approaching a small gully and rode through it at speed. Rider hit chest on handlebars and hit knees on front rack damaging a knee ligament.
M18	Mixed livestock /Grain/Sheep Flat	8 years	Other (specify)	Yamaha 450	10 km/h	Left side	Rollover	Hospital admission	Exiting shed and turning when throttle jammed on and the quad rolled landing on rider’s leg, trapping him but he managed to push it off. Minor leg injury.
F18	Sheep/Grain Combination	None	Other (specify)	Yamaha	33 km/h	None	Fall off	Hospital admission	In transit riding on public unsealed road, lost control and was thrown from quad. Spinal injury (rotatory subluxation)
M35	Beef/Other Rolling flat	None	Recreation	Polaris 500	35 km/h	Backward	Fall off	Hospital treatment	Riding on motorcross track, tried to ride up steep slope and quad cut out and rolled backwards striking rider on as it rolled.
M69	Horticulture/ Vineyards Combination	21 years	Other (specify)	Kawasaki 220	7 km/h	Right side	Loss of control	Hospital admission	Rode quad up a steep bank but didn't have enough momentum and the motor stalled, used front brakes but quad slid back and veered to the left side, hit an embankment and rolled over the top of the rider, striking his ear inflicting a laceration.
M50	Vineyards /Horticulture Flat	23 years	Other (specify)	Yamaha 250	5 km/h	None	Fall off	No injury	Quad stationary but in gear, son also sitting on quad pushed the accelerator. The quad went forward, spun, fell, and flipped backwards.

For further enquiries

Centre for Automotive Safety Research
The University of Adelaide
SA 5005 Australia

Telephone: +61 8 8313 5997
Facsimile: +61 8 8232 4995
Email: casr@adelaide.edu.au

casr.adelaide.edu.au

DISCLAIMER: The information in this publication is current as at the date of printing and is subject to change. You can find updated information on our website at **adelaide.edu.au**

CRICOS 00123M © The University of Adelaide. Published January 2016

SOUTH AUSTRALIA