Quad bike-related injury in Victoria, Australia

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Quad bikes are four-wheeled vehicles that have erroneously been described as all-terrain vehicles.[1] They are common work vehicles on Australian farms, and are also increasingly being used recreationally. It is estimated that there are about 220 000 quad bikes in operation in Australia. With annual sales over the past few years exceeding 20 000 bikes,[2] the burden of injury from the use of these vehicles is expected to increase.

Data from Canada and the United States show an increasing incidence of injuries associated with quad bikes.[3-8] These data have been derived largely from hospital admissions and trauma centre and emergency department (ED) presentations. Although the duration, methods and age cohorts of these studies vary, they all indicate increases in the number of cases of quad bike-related injury over time, in some instances by up to 325%.[4] The most comprehensive of these assessments was based on hospitalisations in 37 states in the US, where an increase of 90% was identified over the 5 years from 2000 through 2004.[3] Outside of the US, there are also reports that confirm the burden of injury associated with quad bikes.[9,10]

Despite these data, there are few studies that comprehensively examine the overall impact of quad bike-related injury, which includes deaths, hospital admissions and ED presentations. A Canadian study is one of the few that does, but it was restricted to patients 18 years and older, and included only cases where a death occurred or the injury severity score was greater than 12. The findings of this study suggest that the incidence of severe trauma increased annually from 1998 to 2008, and that the increase in mortality is out of proportion to the increase in the number of registered quad bikes.[5]

Australian coronial data indicate that the use of quad bikes was the second leading cause of unintentional deaths from injury on farms in 2003–2006.[11] Furthermore, recent data sourced from the media illustrate that quad bikes were the leading cause of on-farm trauma deaths (causing 28 deaths) in 2011 and 2012.[12,13] Victoria has almost a quarter of Australia's farms and recorded the third-highest number of quad bike-related fatalities from 2001 to 2010.[14]

While there is robust evidence on fatal incidents, less is known about the morbidity imposed by quad bikes. One Australian study that assessed trauma in northern Queensland identified that 6.1% of all vehicle incidents in which there was a fatality or a hospital admission of more than 24 hours involved quad bikes.[15] While providing important information, this study does not consider the full spectrum of injuries resulting from quad bike use, which limits consideration of potential interventions.

In this study, we aimed to enumerate cases of fatal and hospital-treated injury associated with quad bike use over the 9 years to the end of June 2011 by using coronial records and data on admissions and ED presentations in Victoria.

Methods

Through collaboration between the Victorian Injury Surveillance Unit (VISU) and the National Farm Injury Data Centre (NFIDC), we examined quad bike injury in Victoria for the financial years 2002–03 to 2010–11 using the National Coronial Information System (NCIS), Victorian Admitted Episodes Dataset (VAED) and Victorian Emergency Minimum Dataset (VEMD). The NFIDC maintains a national register of all quad bike-related deaths in Australia since 2001, based on NCIS records. The NCIS is an internet-based data storage and retrieval system for Australian coronial cases, and contains information about all deaths reported to an Australian coroner since July 2000 (January 2001 for Queensland).[16] Quad bike-related cases added to the NFIDC register are analysed through exploration of NCIS police documents, autopsy and coroners' findings reports. The NFIDC register is coded using the Farm Injury Optimal Dataset — a coding guide developed to help researchers accurately describe injury in the agricultural sector.[17]

The VISU — the repository for de-identified injury surveillance data in Victoria — extracted data from the VAED and the VEMD. The VAED

Abstract

Objective: To enumerate and describe fatal and hospital-treated injury associated with quad bike use in Victoria.

Design: Retrospective descriptive analysis of coronial records and hospital-treated injury data (2002–03 to 2010–11).

Main outcome measures: Number of quad bike-related fatalities, hospital admissions, emergency department (ED) presentations, and results of a trend and severity analysis (International Classification of Disease-based Injury Severity Score; ICISS).

Results: There were 19 fatalities, 766 hospital admissions and 816 ED presentations. The peak age group for fatalities and admissions was 15–29 years (26.3% and 27.9%, respectively), with children 0–14 years being the most common group presenting to EDs (32.2%). Males were strongly overrepresented (84.2% of fatalities, 73.8% of admissions and 71.2% of ED presentations). Intracranial injury (26.3%), fractures (15.8%) and traumatic asphyxiation (15.8%) were the most common injuries among fatal cases. Fractures accounted for half all admissions. Twenty-eight per cent of admissions were classified as "serious" (ICISS, $\leqslant 0.941$) and, over the 9-year study period, the frequency of admissions increased significantly by an estimated 41.4% (95% CI, 9.6%–78.9%). This was significant for males (53.2%; 95% CI, 11.5%–104.4%) and people aged 15–29 years (163.1%; 95% CI, 75.2%–253.7%).

Conclusion: Quad bikes are imposing a significant injury burden in Victoria. Fatalities are frequent, while the number of admissions, often serious, increased over the study period. Children were involved across all levels of severity. A range of prevention approaches, such as mandatory fitting of crush protection devices to protect riders in the event of a roll over, are required.

includes all admissions to public and private hospitals in Victoria, and cases are coded to the *International statistical classification of diseases and related health problems, 10th revision, Australian Modification* (ICD-10-AM).[18] Cases with external cause code V86 (if the 5th character indicated the vehicle was four-wheeled) or V40–V49 (if the 5th character indicated the vehicle was a four-wheeled motorcycle) were selected. Deaths in hospital were excluded, as these are also recorded in the NCIS, and transfers within and between hospitals were excluded to avoid duplication of cases. Admissions were assigned an ICD-based injury severity score (ICISS), which involves estimating the probability of death using the injury diagnosis codes recorded in a person's hospital record.[19] An injury is defined as "serious" (ie, a high threat to life) if the ICISS is less than 0.941.

The VEMD contains demographic, administrative and clinical data detailing presentations from 38 Victorian public hospitals with 24-hour EDs. Cases were extracted by text searching within the "description of injury event" variable. Cases in which patients were admitted to hospital were excluded to avoid duplication with VAED data. However, for analyses of mechanism of injury, location and activity, the admitted VEMD cases were examined as the level of detail was greater than that provided in the VAED.

Statistical analyses

Chi-square analyses were completed to compare the severity of admissions for injuries involving quad bikes with admissions for other injuries. A log-linear regression model of the data assuming a Poisson distribution of cases was used to analyse trends in admissions. The form of the model used was

$$\ln(y_i) = \alpha + \beta x_i$$

where y_i is the injury count for year (with i assumed to be a Poisson random variable), x_i is the year (2002–03 … 2010–11) and α and β are the intercept and slope parameters of the model. Each of the demographic and age-specific count series were modelled separately. The statistics relating to the trend curves, slope and intercept and the P value were calculated using the regression model in SAS version 9.2 (SAS Institute Inc). A trend was considered to be statistically significant if the P value of the slope of the regression model was less than 0.05. The overall change was estimated over 9 full years.

Ethics approval

Ethics approval was obtained from the Justice Human Research Ethics Committee for NCIS data and the Human Research Ethics Committee at the Victorian Department of Health for VAED and VEMD data.

Results

There were 19 fatalities, 766 hospital admissions and 816 ED presentations for quad bike-related injury in Victoria in 2002–03 to 2010–11.

Box 1 shows that the age group with the highest proportions of fatalities and admissions was the 15–29-years group; whereas the age group with the highest proportion of ED presentations was the 0–14-year-old group. Males were over-represented at all three levels of severity, accounting for 84.2% of fatalities, 73.8% of admissions and 71.2% of ED presentations.

Fatalities were most commonly associated with intracranial injury, fractures and traumatic asphyxia (Box 2). Fractures accounted for half of all admissions for injury and a quarter of ED presentations (Box 2).

1 Quad bike-related injury by age and sex in Victoria for the financial years 2002–03 to 2010–11

Patient details	Fatalities (n = 19)	Hospital admissions (n = 766)	Emergency department presentations (n = 816)
Age			
0–14 years	3 (15.8%)	158 (20.6%)	263 (32.2%)
15–29 years	5 (26.3%)	214 (27.9%)	221 (27.1%)
30–44 years	2 (10.5%)	184 (24.0%)	190 (23.3%)
45–59 years	3 (15.8%)	123 (16.1%)	99 (12.1%)
60–74 years	3 (15.8%)	59 (7.7%)	34 (4.2%)
≥ 75 years	3 (15.8%)	28 (3.7%)	9 (1.1%)
Sex			
Male	16 (84.2%)	565 (73.8%)	581 (71.2%)
Female	3 (15.8%)	201 (26.2%)	235 (28.8%)

2 Quad bike-related injury by part of body injured and nature of injury in Victoria for the financial years 2002–03 to 2010–11

Injury details	Fatalities (n = 19)	Hospital admissions (n = 766)	Emergency department presentations (n = 816)
Part of body injured*			
Head/face/neck	8 (42.1%)	193 (25.2%)	138 (16.9%)
Trunk	8 (42.1%)	177 (23.1%)	90 (11.0%)
Upper extremity	0	236 (30.8%)	303 (37.1%)
Lower extremity	0	140 (18.3%)	186 (22.8%)
Multiple body regions	2 (10.5%)	0	86 (10.5%)
Unspecified body region	1 (5.3%)	20 (2.6%)	13 (1.6%)
Nature of injury*			
Superficial injury	0	54 (7.0%)	134 (16.4%)
Open wound	0	72 (9.4%)	95 (11.6%)
Fracture	3 (15.8%)	379 (49.5%)	201 (24.6%)
Dislocation, sprain and strain	0	35 (4.6%)	202 (24.8%)
Injury to muscle and tendon	0	13 (1.7%)	54 (6.6%)
Intracranial injury	5 (26.3%)	56 (7.3%)	19 (2.3%)
Crushing injury	2 (10.5%)	6 (0.8%)	17 (2.1%)
Injury to internal organs	2 (10.5%)	35 (4.6%)	—†
Traumatic asphyxiation	3 (15.8%)	0	—†
Multiple injuries	2 (10.5%)	0	0
Other and unspecified injury	2 (10.5%)	116 (15.1%)	92 (11.3%)

* Part of body injured and nature of injury are based on the principal diagnosis or primary cause of death. † Small numbers of patients treated in emergency departments have been suppressed to ensure patient confidentiality. ◆

injured motorcycle riders ($\chi^2 = 11.8$; $N = 25\,305$, $P = 0.001$).

Box 4 shows that the frequency of hospital admissions for quad bike injury increased significantly from 80 in 2002–03 to 100 in 2010–11, an estimated per annum increase of 3.9% (95% CI, 1.0%–6.7%) and an overall increase of 41.4% (95% CI, 9.6%–78.9%). The increase was significant for males and for people aged 15–29 years.

Discussion

Several studies have examined quad bike injury, but this is the first Australian study quantifying injuries from three different data sources. Our study highlights the significant number of injuries that occur in the farming sector — most fatal cases and more than a third of hospital admissions and ED presentations were the result of injuries that occurred on farms.

The strengths of our study include the complete capture of fatality data through the NCIS and of hospital admissions in the VAED, as well as the comprehensive nature of the ED presentations data — Victoria is the only Australian state with a data collection that covers all public hospitals with 24-hour emergency department services.

Although the datasets are comprehensive, there is still potential for underreporting of cases of quad bike injury. The analysis of fatalities is limited by the level of detailed information available on the NCIS at the time of data retrieval and, while the VAED coding is completed by specialist coders, there were 100 potentially relevant admissions not specifying the number of wheels which could not be included

3 Quad bike-related injury by mechanism, activity and location in Victoria for the financial years 2002–03 to 2010–11

Incident details	Fatalities ($n = 19$)	Hospital admissions* ($n = 378$)	Emergency department presentations ($n = 816$)
Mechanism			
Roll over	6 (31.6%)	84 (22.2%)	155 (19.0%)
Collision — other vehicle	3 (15.8%)	7 (1.9%)	11 (1.3%)
Collision — pedestrian/animal	0	5 (1.3%)	—†
Collision — fixed/stationary object	8 (42.1%)	36 (9.5%)	74 (9.1%)
Loss of control	1 (5.3%)	12 (3.2%)	—†
Fall (not further specified)	0	156 (41.3%)	413 (50.6%)
Other specified	0	21 (5.6%)	79 (9.7%)
Unspecified	1 (5.3%)	57 (15.1%)	73 (8.9%)
Activity			
Work	10 (52.6%)	69 (18.3%)	118 (14.5%)
Leisure/sports	7 (36.8%)	211 (55.8%)	535 (65.6%)
Other specified	0	41 (10.8%)	57 (7.0%)
Unspecified	2 (10.5%)	57 (15.1%)	106 (13.0%)
Location			
Road	4 (21.1%)	45 (11.9%)	50 (6.1%)
Farm	13 (68.4%)	147 (38.9%)	280 (34.3%)
Other off-road	2 (10.5%)	97 (25.7%)	302 (37.0%)
Other specified	0	50 (13.2%)	83 (10.2%)
Unspecified	0	39 (10.3%)	101 (12.4%)

* Admissions from the Victorian Emergency Minimum Dataset ($n = 378$) were used because the level of detail was greater than that provided in the Victorian Admitted Episodes Dataset. † Small numbers of patients treated in emergency departments have been suppressed to ensure patient confidentiality. ◆

Box 3 shows that the most commonly reported primary mechanism of fatality was collisions with fixed or stationary objects, followed by rolling of the quad bike. Falls from the quad bike (no further detail available) were the most frequently reported events among both hospital admissions and ED presentations. The quad bike rolling over accounted for around a fifth of cases of hospital admissions and ED presentations. Work-related activity at the time of the injury was more commonly reported for fatalities than hospital admissions or ED presentations. Farms were the most common locations for quad bike injuries leading to fatalities and hospital admissions, whereas other off-road locations (sports, recreation areas, forests) were the most common locations for injuries leading to ED presentations.

Twenty-nine per cent of all hospital admissions for quad bike-related injury (220) were classified as "serious" (ICISS, ≤ 0.941), compared with 15% of all other admissions for unintentional injury (121 926) over the same time period. Injured quad bike riders were significantly more likely to be "seriously" injured than all other unintentionally injured people ($\chi^2 = 115.2$; $N = 824\,776$; $P < 0.001$), and than other

4 Trend in the frequency of quad bike injury hospital admissions in Victoria for the financial years 2002–03 to 2010–11

Patient details	2002 –03	2003 –04	2004 –05	2005 –06	2006 –07	2007 –08	2008 –09	2009 –10	2010 –11	Total	% Change over period (95% CI)
Sex											
Male	53	52	56	51	59	86	73	63	72	565	53.2%* (11.5% to 104.4%)
Female	27	17	20	21	25	22	19	22	28	201	12.8% (−22.9% to 62.3%)
Age (years)											
0–14	17	15	18	16	19	25	17	18	13	158	0 (−36.0% to 52.9%)
15–29	14	15	18	24	25	26	30	22	40	214	163.1%† (75.2% to 253.7%)
30–44	26	16	24	20	18	29	19	18	14	184	−27.1% (−58.0% to 21.4%)
45–59	12	15	9	5	13	14	20	14	21	123	103.1% (−2.6% to 281.4%)
≥ 60	11	8	7	7	9	14	6	13	12	87	45.3% (−25.3% to 166.0%)
Total	80	69	76	72	84	108	92	85	100	766	41.4%‡ (9.6% to 78.9%)

* Significant at $P < 0.05$. † Significant at $P < 0.0001$. ‡ Significant at $P < 0.01$. ◆

in this study. The VEMD "description of injury event" variable was used for identifying ED presentations. There are no specialist coders allocated to complete VEMD items, so this role falls to busy ED staff, which may increase the potential for inaccuracies in coding and an underestimation of the number of cases. Additionally, the VEMD does not capture data from smaller, often rural hospitals which do not have 24-hour ED services. Given these limitations of the datasets, our findings are likely to be an underestimate of the true number of cases.

Ideally, we would have calculated rates for the trend analysis, but in the absence of reliable estimates of the number of Victorians exposed to quad bikes, we focused on the frequency of admissions. The number of admissions increased significantly over the study period in accordance with findings from international studies.[3-8]

The distribution of injury outcomes in this sample is unusual in that the number of hospital admissions and ED presentations are similar, with about one fatal incident for every 40 admissions and 40 ED presentations. In contrast, US data suggest ratios of one fatal incident per 15 admissions and 137 ED presentations.[3] This variation may be partially explained by underreporting of ED presentation cases in Victoria as mentioned above. Further, as illustrated in our study, children commonly present at ED for treatment, so the higher prevalence of recreational use by children in the US may also contribute to this variation.[20]

Our findings show the significant burden imposed by head and trunk injuries (including asphyxiation and crush injury) among both fatal and admitted cases. This reinforces the need to tackle issues of roll over of quad bikes and subsequent entrapment, along with helmet use.

Previous studies have noted that quad bike-related injuries are more severe than those with other comparative modes of transport such as two-wheeled motorcycles.[21,22] Our study also found a significantly higher severity of injury among people admitted after incidents with quad bikes compared with all other motorcycles. Although data limitations meant it was not feasible to examine severity by mechanism, this variation

is likely to centre on the physical differences between quad bikes (which weigh around 300 kg or more, and are prone to roll over[1]) and other motorcycles. Thus, any contact between a rider and a quad bike is likely to result in greater forces being exerted on the human body and more severe injuries, particularly in the case of roll-overs.[14]

This study highlights the high proportion of children among those with quad bike-related injury. This is of major concern as several notable organisations recommend that children under 16 years of age should not be riding quad bikes.[23,24] There is now evidence to indicate that children do not have the physical size, strength or cognitive capacity to operate these vehicles safely.[9,22,25]

The popularity of quad bikes for both work and recreational use necessitates urgent adoption of a wide range of prevention measures. Work health and safety regulations in Australia set out a hierarchy of risk controls that is equally relevant to injury prevention in a recreational setting.[26] The hierarchy works from the most effective controls (eliminating the hazards) through to controls that limit harms (personal protective equipment).

Prevention efforts have focused predominantly on rider training and the use of helmets. While relevant, these are the least effective approaches within the hierarchy. Recently, efforts addressing higher-order approaches, such as vehicle stability, mandatory fitting of crush protection devices and design changes restricting the capacity of children to operate quad bikes and/or for passengers to be carried have been actively pursued at a national level in Australia. [27]

On a practical level, clinicians can play a pivotal role in discussions with users of these vehicles by providing proactive safety guidance. This could include reinforcing that:

- other safer types of vehicles should be used (particularly in a work setting);

- crush protection devices must be fitted to reduce injuries from roll overs;

- children must not ride quad bikes;

- passengers must not be carried;

- any loads carried must be within manufacturer's guidelines; and

- suitable protective equipment including a helmet must be worn.

There is a clear need to enhance quad bike safety, and failure to act at higher levels of the work health and safety hierarchy of risk controls will lead to a continuing increase in the burden of injury in Victoria.

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