

Victorian Injury Surveillance Unit (VISU)

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Monash University Accident Research Centre (MUARC)



## Off-road *motorcycle* injury among children aged 0-17 years in Victoria

Lesley Day, Angela Clapperton &  
Janneke Berecki-Gisolf

This issue of *Hazard* provides an overview of recreational off-road motorcycle injury incidence among children aged up to seventeen years.

This report is based on Victorian emergency department and hospital admissions data, and deaths recorded in the National Coronial Information System.

Ten-year hospital treated injury trends as well as injury patterns in the three most recent years of available data are presented.

# Off-road *motorcycle* injury among children aged 0-17 years in Victoria

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## Overview

Off-road motorcycle riding is a popular activity among both adults and children in Victoria. The motorcycle licencing minimum age in Victoria is 18 years; however, a motorcycle licence is not required for motorcycling on private land or motorcycle club venues. Motorcycling has been identified as a common cause of hospital-treated injury in children aged up to 17 years. Although hospital-treated injuries due to activities such as pedal cycling and Australian Rules football occur more frequently, injury rates per participant for off-road motorcycling are much higher than for these other popular sports and recreational activities. This edition of Hazard provides a current overview of child off-road motorcycle injury in Victoria, with the aim to guide injury prevention efforts.

This report is focused on children aged 0-17 years who were injured while engaged in off-road two-wheeled motorcycling for recreational purposes; this includes organised sport as well as other recreational motorcycling. Death data were extracted from the National Coronial Information System (NCIS), and hospital admissions and Emergency Department (ED) presentations were extracted from the Victorian Admitted Episodes Dataset (VAED) and the Victorian Emergency Minimum Dataset (VEMD), respectively.

### Deaths: 2003 to 2012

- Over the decade 2003-2012, 11 persons aged under 18 years died from injuries sustained during recreational motorcycle riding in Victoria; the average age was 13 years.
- In eight cases, a collision was the initiating event. In nine cases it was recorded whether protective gear was worn, and in eight of those cases a helmet was worn.

### Admissions: Ten year trends, 2005/6 to 2014/15

- In the ten year period from 2005/6 to 2014/15, there were 2883 admissions: an average of 288 hospital admissions per year for off-road child motorcycle injury. The average annual rate was 23.7 admissions per 100,000 persons per year; rates were 11.5, 36.0 and 60.4 in the age groups 5-9, 10-14 and 15-17 years, respectively.
- There was no statistically significant change in the rate of admissions over the 10-year period.

### Admissions: Three-year patterns, 2012/13 to 2014/15

- In the three year period from 2012/13 to 2014/15, there were 900 hospital admissions for off-road child motorcycle injury. The vast majority were males (90%). Admissions generally increased with age, with those aged 14-17 years comprising more than half (56%) of the admissions. Most (94%) of the admitted persons were Victorian residents; 53% of these lived in regional/rural areas.
- Information regarding the position on the motorcycle was available in 711 of the 900 admissions: only 4% of these were pillion passengers. The majority of cases (77%) involved a non-collision event: the rider fell or was thrown off the motorcycle. Distinction between injuries sustained in organised motorsport events vs. other recreational motorcycling cannot be made based on hospital admission data.
- More than half of admitted cases (53%) sustained two or more injuries. The most frequently injured body region was the upper extremity, followed by

the lower extremity and the head/face/neck. Fractures were the most common type of injury, followed by open wounds and intracranial injury. The five most common specific injuries were forearm fractures (19%), lower leg fractures (11%), shoulder/upper arm fractures (10%), intracranial injuries (8%) and wrist/hand fractures (5%).

### ED presentations: Ten year trends, 2005/6 to 2014/15

- In the ten year period from 2005/6 to 2014/15, there were 12714 ED presentations: an average of 1271 ED presentations per year for off-road child motorcycle injury. The average annual rate was 105 ED presentations per 100,000 persons per year; rates were 13, 60, 166 and 229 in the age groups 0-4, 5-9, 10-14 and 15-17 years, respectively.
- The rate of ED presentations decreased by 4.5% per year during the ten-year period; rates decreased by 4.9%, 4.2% and 3.1% in the age groups 5-9, 10-14 and 15-17 years, respectively. The decrease in rate

in the 0-4 year age group was not statistically significant.

- Annual ED presentations for child off-road motorcycle injury as a proportion of all child injury ED presentations also decreased during this ten-year period, indicating that the observed trend is not just a reflection of an overall decrease in (child) ED presentations.

### ED presentations: Three-year patterns, 2012/13 to 2014/15

- In the three year period from 2012/13 to 2014/15, there were 3469 Victorian ED presentations for off-road child motorcycle injury. The majority were males (85%). ED presentations generally increased with age; those aged 14-17 years comprised approximately half (49%) of presentations. Most (95%) of those presenting to the ED were Victorian residents; 60% of these lived in regional/rural areas.
- The most frequently injured body region was the upper extremity, followed by the lower extremity and the head/face/neck. Fractures were the most common type of injury, followed by dislocation, sprain and strain. The five most common specific injuries were wrist/hand fractures (10%), shoulder/upper arm fractures (8%), lower leg fractures (6%), forearm fractures (6%), and dislocation/sprain/strain of joints/ligaments at ankle and foot level (4%).
- The ED presentation narrative frequently mentioned participation in motorcross and racing. Regarding the cause of the injury, 'jump' was commonly mentioned, generally in the context of landing badly, losing balance, or falling off the motorbike during or after a jump.
- Of 400 cases randomly selected from ED presentations that mentioned any external cause keywords, 83% were non-collision events. Of these 331 non-collision events, most (95%) were falls from the motorcycle.



### Recommendations

1. All off-road motorcycle riders should wear motorcycle helmets meeting the Australian (AS1698) or European Standard (EU 22/05), and wear gloves and boots and other protective clothing appropriate to the type of riding.
2. Parents should be advised not to rely on motorcycle helmets as the only injury prevention precaution: helmets are effective in reducing the risk of head injury but do not protect from all types of head and brain injury.
3. A review of the physical, perceptual and cognitive skills required for off-road motorcycling should be undertaken and compared against paediatric developmental stages to determine if there is an appropriate age for children to commence off-road motorcycling.
4. Children under the age of 5 should not ride motorcycles off-road, until it is ascertained that they have the required skills.
5. Motorcycle retailers are encouraged to adopt a voluntary code of conduct restricting the sale of off-road motorcycles for children less than 5 years of age, in those circumstances where the age of the intended user is clear.
6. Parents of children under the age of 12 should consider allowing their children to develop skills in a supportive and controlled environment, such as that provided by non-competitive events and activities auspiced by Motorcycling Australia.
7. The current laws regarding riding on public land should be enforced.
8. The action plan for off-road motorcycle safety agreed in the Victorian government response to the 2012 Victorian Parliamentary Inquiry into Motorcycle Safety should be developed under VicRoads' leadership without further delay.

## Introduction

Riding a motorcycle off-road is a fun and adventurous activity in which riders pit themselves and their bikes against a range of terrains and conditions, either informally on their own or with friends, or in a more structured way through rides and competitions arranged by motorcycle clubs and organisations. Curiously, some “off-road” riding actually takes place on public roads in State forests, parks and reserves, although many people would not recognise these as roads, and this riding may be better known as trail riding (Department of Sustainability and Environment, 2011). Other locations where off-road motorcycling occurs include public land which is not a road, motorcycling club venues, dedicated competition tracks, and private land. Riders using public roads in State forests, parks and reserves must ride registered bikes, have a current motorcycle licence, wear a helmet, and only ride on those roads that are open (i.e., not signed as closed roads). Riders on unregistered motorcycles or without a motorcycle licence are limited to private land or motorcycle club venues (Department of Sustainability and Environment, 2010). However, those wishing to participate in any Motorcycling Victoria (MCV) or Motorcycling Australia (MCA) event must have a national licence which can be obtained through MCV (Motorcycling Australia, 2014). Riding on public land which is not a road or a road related area is illegal (Department of Sustainability and Environment, 2011).

The nature of off-road motorcycling suggests that the likelihood of injury would be higher than that for on-road motorcycling. In Victoria, off-road motorcycling accounts for 43% of all motorcycle related hospital admissions, and among those under road licencing age (i.e., 17 years and under) it accounts for a higher proportion, 76% of admissions (VAED, 2012/13 to 2014/15). Comparison with other sport and recreational activities provides some context for the injury risk and severity of off-road motorcycling in this age group. A Queensland study showed that injury outcomes were more severe for children (< 16 years of age) injured motorcycle riding compared with those injured riding bicycles, in any location but excluding those hit by a car

from both groups. Children injured riding motorcycles were more likely to require longer operative procedures, open rather than closed reduction of fractures, and were more likely to have permanent disability (Robertson et al., 2008).

While the number of children presenting to hospital for treatment following off-road motorcycle related injury in Victoria is much lower than those for Australian rules football or bicycling for example, estimated injury rates per 100,000 participants suggest that off-road motorcycling has an injury risk that is much higher than these other popular sports and recreational activities (Appendix). Extrapolation from national data from the 2010 Exercise, Reaction and Sport Survey (Australian Sports Commission, 2012) to the Victorian population provided an estimate of the numbers of Victorian children 5-14 years of age participating in a range of sports and recreational activities in the school term prior to interview in 2010. When these participation data are used as denominators to estimate injury rates for 2010, off-road motorcycling had a hospital admission rate 1.5 times higher than that of Australian rules football (598 compared with 403 per 100,000 participants), and 6 times that of cycling (598 compared with 103 per 100,000 participants). Refer to reference.

Not only were the rates higher but so too was the injury severity. Hospital bed-days per 100,000 participants was 2.6 times as high for off-road motorcycling injuries among 5-14 year olds in 2010 compared with Australian rules football, and almost six times as high as that for cycling.

These data indicate that off-road motorcycling in this age group warrants exploration and understanding to guide injury prevention. Indeed, the 2012 Victorian Parliamentary Inquiry into Motorcycle Safety recommended that government motorcycle safety initiatives include activities to improve off-road motorcycling safety, and this recommendation was supported in principle by the Victorian government (Parliament of Victoria 2012, Victorian Government 2013). However, there is little in the published literature to guide local prevention, especially for this age group. Two Queensland studies have highlighted the issue of motorcycle injury in any location for this age group,

comparing it with other causes of injury, and reporting rates, demographic patterns and injury outcomes in terms of type and severity (Robertson et al., 2008; Pym et al., 2013). The data sources did not allow examination of cause of the injury event or the circumstances leading up to the injury, nor was the proportion of cases that were off-road reported. There have been a number of relevant Victorian studies (Haworth et al., 1994; Cassell et al., 2006; Bevan et al., 2008), the latest of which used data up to July 2004. Hence, this review provides an update of the epidemiology of off-road two-wheeled motorcycle injury among those 17 years and younger in Victoria.

## Reference

*These rates are estimates only. Due to data limitations, the difference between Australian rules football injury rates and off-road motorcycling is likely to be conservative. Given the likely higher Australian rules football participation rate in Victoria compared with Australia, the Australian rules football hospital admission rate is possibly an over-estimate. Further, there were no specific off-road motorcycling participation data and we assumed that in this age group the motorsports category, which includes track, trail bike, dirt bike, car, motorbike, motocross, speedway, drag, go-kart and quad bike, would be primarily off-road motorcycling. Consequently, the off-road motorcycling admission rate is possibly an under-estimate.*

## Deaths

Over the 10-year period 2003-2012, 11 persons aged less than 18 years died from injuries sustained while riding a two-wheeled motorcycle for sport or recreational purposes. The average age was 13.1 years, and 7 were 14 years or over (age range 3-17 years). Ten of the decedents were male.

The location of the incident was private property in six cases (two of which were farms), countryside in three cases, and forest or plantation in two cases. No children were participating in formal sports and recreational activities at the time of the incident.

A collision was the initiating event in eight cases. In five cases the deceased collided with stationary objects (three cases involving a tree, two cases involving a fence). In three cases the deceased collided with another vehicle, two of which were cars. Two of the three non-collision initiating events were due to loss of control, after which the rider was thrown from the motorbike. Experience riding off-road was mentioned in six cases, ranging from two to nine years. Engine capacity was recorded in eight cases. The average was 157.5cc and ranged from 50-400 cc. In one additional case the deceased was riding a mini-bike.

Six cases mentioned adult involvement although not all were in the context of direct supervision. Nine cases recorded whether protective gear was worn. Eight cases were wearing protective gear, all of whom were wearing helmets and two of whom were wearing additional gear.

All persons sustained either head injuries or injuries to internal organs or both. Helmet wearing status was recorded for six of the seven cases who had a head injury. Four were wearing helmets at the time of the injury.

## Hospital Admissions

### Ten year trends

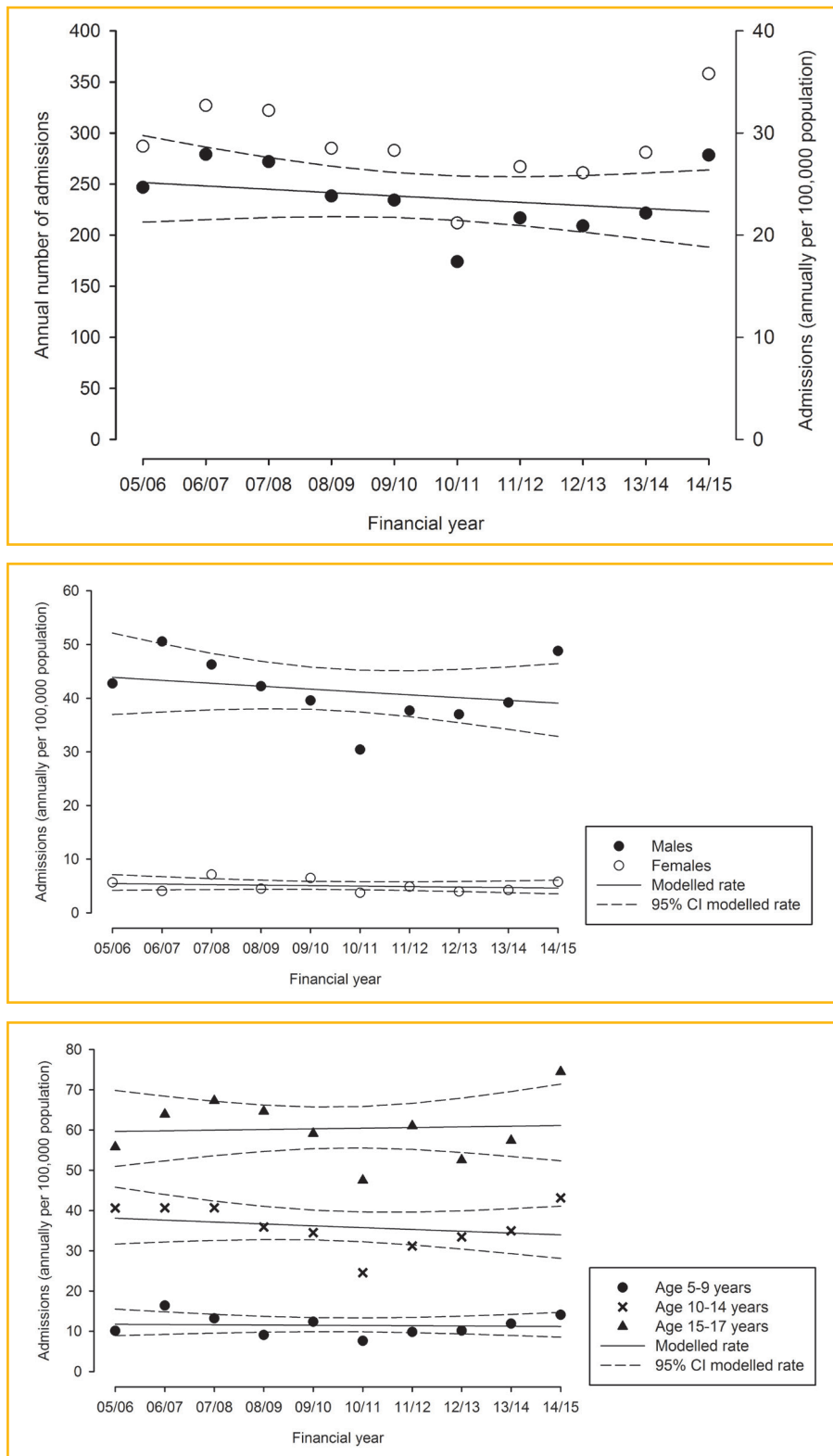
There were 288 admissions on average each year over the 10-year study period 2005/6-2014/5 (Table 1). The majority were over 10 years of age (85.1%), and there were almost equal numbers of 10-14 year olds and 15-17 year olds. Very few were under 5 years of age. The annual average number of admissions increased overall (3.8%), and for each age group with the largest increase among the 5-9 year olds (10.2%) (Table 1); however, the frequency fluctuated over time (Figure 1 top) and the increase was not significant in any of the age groups. This pattern was similar for the population and age-specific rates (Table

1, Figure 1 top and middle panels). The modelled rate per 100,000 population showed an average annual decrease of 1.4% which was not statistically significant (Table 1). Visual inspection of Figure 1 (top and middle panels) shows that prior to June 2011, it appeared that the annual rates per 100,000 population were decreasing. In contrast, since that time the annual rates may be increasing. The highest rate was among the 15-17 year olds, and the lowest was among the 0-4 year olds (Figure 1, middle panel). The rate for males is considerably higher than that for females (Figure 1, bottom panel).

**Table 1: Frequencies and rates of admissions and Emergency Department (ED) presentations for off-road motorcycle injury in children aged 0-17 years, Victoria.**

2005/6 to 2014/15	Age groups				
	0-17 (all)	0-4	5-9	10-14	15-17
<b>Admissions</b>					
Annual average N	288	6	38	120	125
Annual average rate <sup>†</sup>	23.7	*	11.5	36.0	60.4
Annual average % change in N	+3.8%	*	+10.2%	+2.2%	+4.9%
Annual average % change rate <sup>†</sup>	+2.6%	*	+8.6%	+2.0%	+4.6%
Modelled annual % change rate <sup>†</sup>	-1.4% (n.s.)	*	-0.5% (n.s.)	-1.3% (n.s.)	+0.3% (n.s.)
<b>ED presentations</b>					
Annual average N	1271	46	200	552	474
Annual average rate <sup>†</sup>	105	13	60	166	229
Annual average % change in N	-0.2%	-0.6%	+1.5%	-0.1%	-0.1%
Annual average % change in rate <sup>†</sup> (crude)	-1.3%	-2.7%	-0.1%	-0.3%	-0.4%
Modelled annual % change in rate <sup>†</sup>	-4.5% (p<0.0001)	-3.1% (n.s.)	-4.9% (p=0.02)	-4.2% (p=0.0006)	-3.1% (p=0.004)

\*In the 0-4 year age groups, cell counts were too small for calculation of annual rates. N.s.= not statistically significant. <sup>†</sup>Rate per 100,000 persons per year: Victorian residents in the matching age bracket were used as denominator.



**Figure 1.** Trends in admissions for off-road motorcycle injury in Victoria, 2005/06 to 2014/15. In the top figure, results are shown as numbers (open circles) and rates (closed circles). In the middle and bottom figures, results are shown as rates by sex (middle) and age group (bottom). Solid lines are modelled trends; dashed lines are 95% confidence intervals.

**Three-year patterns**

In the three year period 2012/13 to 2014/15, there were a total of 900 admissions to Victorian hospitals for off-road-motorcycle injury, 94.2% of whom were Victorian residents. Among the Victorian residents, 53% lived in regional/rural areas. Admissions peaked in the autumn months of March and April, and were lowest in the winter months of July and August (Figure 2). As might be expected, the weekend was the peak time for admissions (Figure 3).

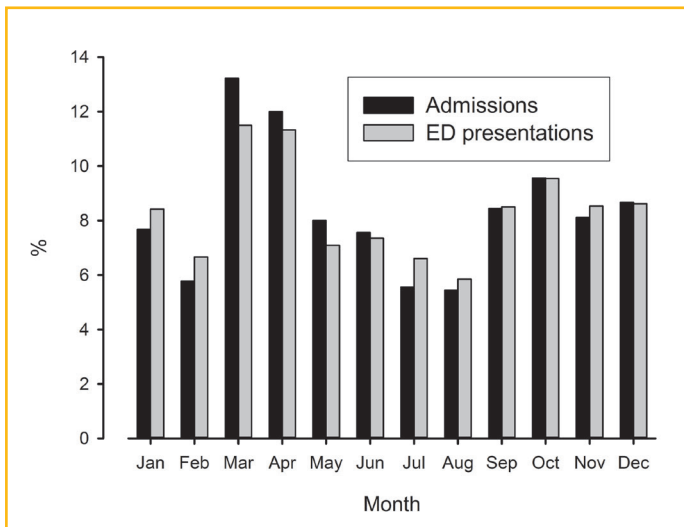
Males comprised 90% of admissions (Table 2). The overall male:female (M/F) ratio was 9.4, however this varied over the age range. In general the M/F ratio was 6 or less up to 8 years of age, after which it was more than 6. The frequency of admission generally increased with each year of age from 4 years, with the more than half of admissions (56.2%) among the 14-17 year olds (Figure 4).

Data regarding the position of the injured person on the motorcycle was available in 711 (86.7%) cases. Among these, there were 29 pillion passengers (4%). Just over half (16) were males, a much lower proportion than for all cases. Nine of the 29 pillion passengers were under 5 years of age (31%).

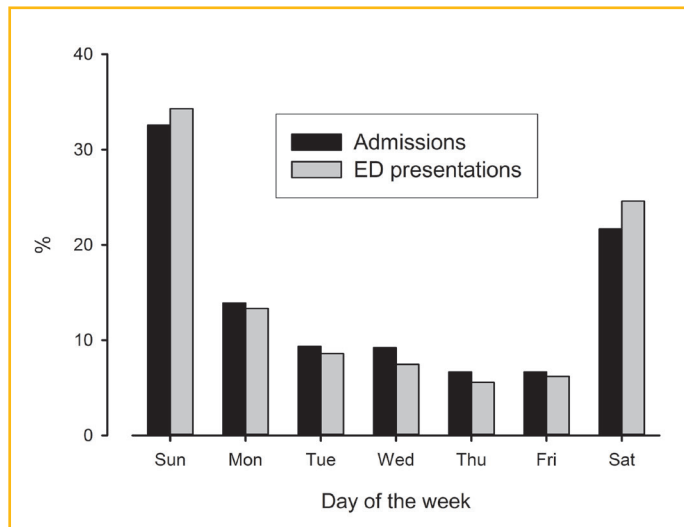
A large percent of cases involved a non-collision event (77.0%), with smaller proportions occurring during collisions with fixed or stationary objects (12.1%), and with two- or three-wheeled motor vehicles (mostly motorcycles) (7.0%). By definition, non-collision events include those in which the rider falls off or is thrown off the motorcycle without a preceding collision, while collisions with fixed or stationary objects would include trees, fences, gates, rocks.

Slightly more than half the cases sustained more than one injury (53.2%). The upper extremity was the most frequently injured body region (39.3%, Figure 5). Fractures dominated the type of injury sustained (56.3%, Figure 6). It is noteworthy that intra-cranial injuries were the third most common type of injury (8.4%, Figure 6). The most frequent specific injury was a fractured forearm (19%, Table 3), followed by a fractured lower leg (11%) and a fractured shoulder or upper arm (10%). Males utilised 92% of bed days while comprising 90% of injured patients, and 15-17 year olds utilised 55% of bed days while comprising 43% of injured patients (Table 2).

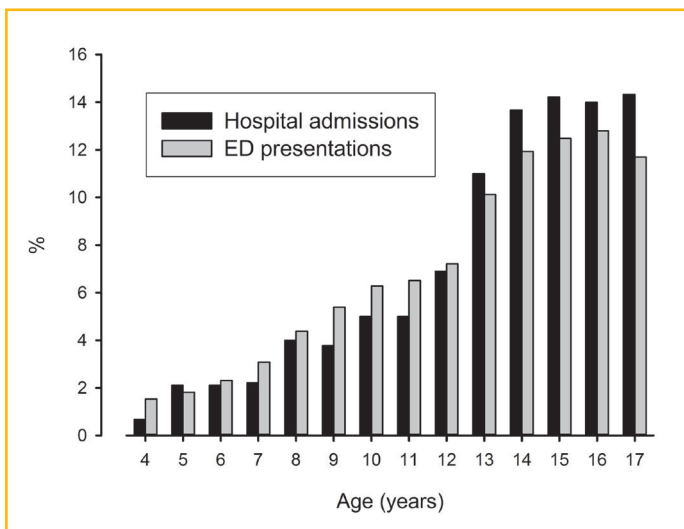
Of the hospital admissions, 78% were public i.e. Medicare-paid, 19% were paid for by private insurance and 3% (n=27) were paid for by the TAC.



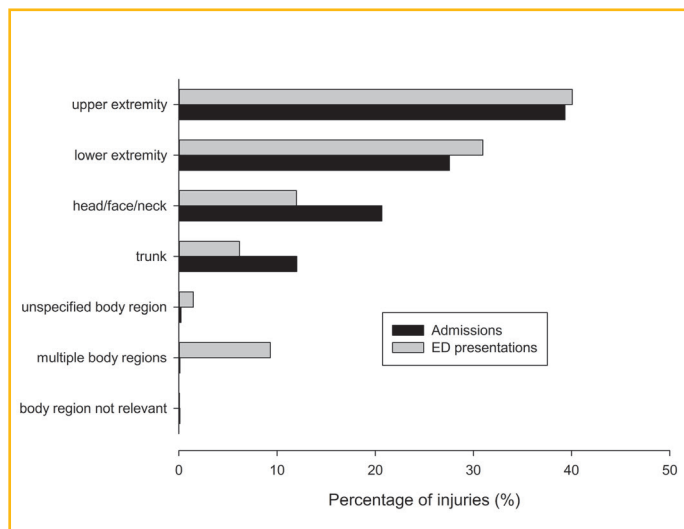
**Figure 2.** Distribution per calendar month of hospital admissions and Emergency Department (ED) presentations for off-road motorcycle injury among children aged 0-17, in 2012/13 to 2014/15, Victoria.



**Figure 3.** Distribution per weekday of hospital admissions and Emergency Department (ED) presentations for off-road motorcycle injury among children aged 0-17, in 2012/13 to 2014/15, Victoria.

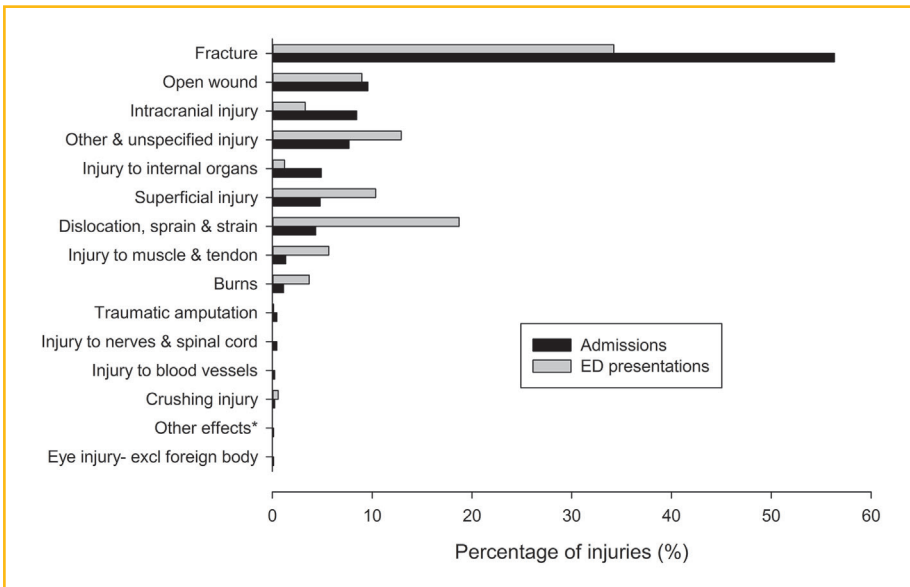


**Figure 4.** Age distribution of hospital admissions and Emergency Department (ED) presentation for off-road motorcycle injury among children aged 0-17 years, in 2012/13 to 2014/15, Victoria. Ages below four years not shown.

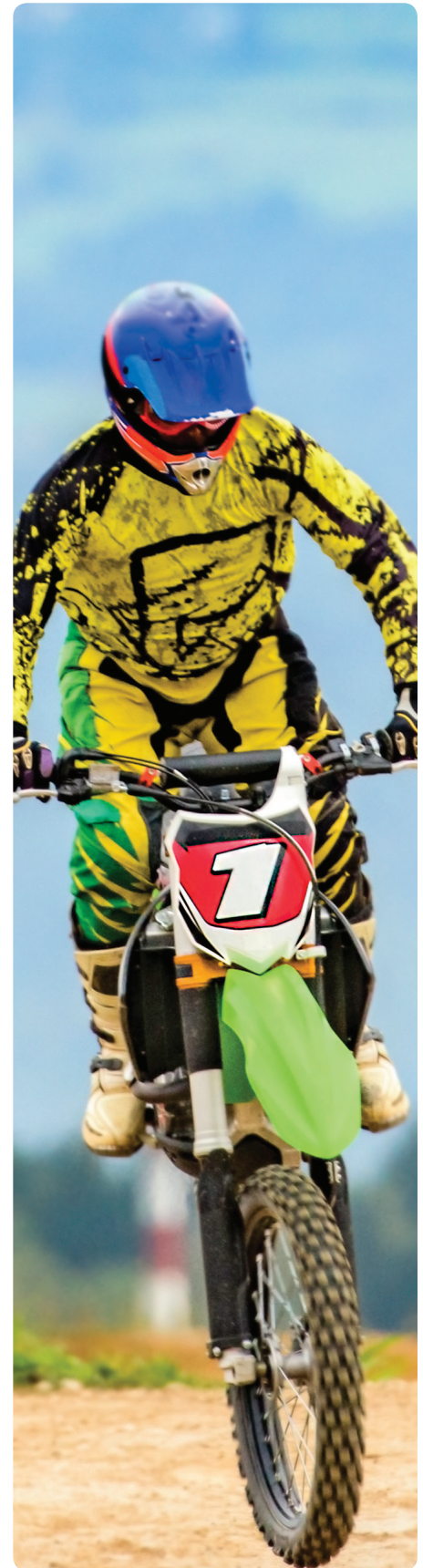


**Figure 5.** Affected body region: hospital admissions and Emergency Department (ED) presentations for off-road motorcycle injury among children aged 0-17, in 2012/13 to 2014/15, Victoria.





**Figure 6.** Injury types: hospital admissions and Emergency Department (ED) presentations for off-road motorcycle injury among children aged 0-17, in 2012/13 to 2014/15, Victoria.  
\*Other effects = other effects of external cause/complications/late effects.



**Table 2: Frequencies of admissions and Emergency Department (ED) presentations by year, sex, and age for off-road motorcycle injury in children aged 0-17 years, Victoria.**

	ED presentations	Admissions (incident)	Total bed days*
<b>Year</b>			
2012/13	1171 (34%)	261 (29%)	885 (42%)
2013/14	1101 (32%)	281 (31%)	542 (26%)
2014/15	1197 (35%)	358 (40%)	657 (32%)
<b>Sex</b>			
Male	2947 (85%)	814 (90%)	1912 (92%)
Female	522 (15%)	86 (10%)	172 (8%)
<b>Age group</b>			
0-4 years	138 (4%)	15 (1.7%)	15 (0.7%)
5-9 years	589 (17%)	128 (14%)	181 (9%)
10-14 years	1459 (42%)	374 (42%)	733 (35%)
15-17 years	1283 (37%)	383 (43%)	1155 (55%)
<b>Total</b>	<b>3469 (100%)</b>	<b>900 (100%)</b>	<b>2084 (100%)</b>

\*Overnight stays. Includes all admissions, not limited to incident admissions

**Table 3: The ten most commonly occurring injuries among admissions and Emergency Department (ED) presentations for off-road motorcycle injury among children aged 0-17 (Victoria, 2011/12 to 2014/15).**

	Admissions	N (%)	ED presentations	N (%)*
1	Fracture of forearm	170 (19%)	Fracture at wrist and hand level	334 (10%)
2	Fracture of lower leg, including ankle	101 (11%)	Fracture of shoulder and upper arm	267 (8%)
3	Fracture of shoulder and upper arm	88 (10%)	Fracture of lower leg, including ankle	208 (6%)
4	Intracranial injury	76 (8%)	Fracture of forearm	197 (6%)
5	Fracture at wrist and hand level	41 (5%)	Dislocation, sprain and strain of joints and ligaments at ankle and foot level	145 (4%)
6	Fracture of femur	39 (4%)	Unspecified multiple injuries	141 (4%)
7	Open wound of lower leg	28 (3%)	Open wound of lower leg	138 (4%)
8	Injury of intra-abdominal organs	24 (3%)	Intracranial injury	127 (4%)
9	Open wound of head	23 (3%)	Dislocation, sprain and strain of joints and ligaments at wrist and hand level	125 (4%)
10	Fracture of skull and facial bones	20 (2%)	Dislocation, sprain and strain of joints and ligaments of shoulder girdle	87 (3%)

## Emergency Department Presentations

### Ten year trends

There were 1,271 ED presentations on average each year over the study period, and there was an apparent decrease in number and rate of presentations over the time period (Figure 7 top panel). The modelled rate per 100,000 population showed an average annual decrease of 4.5% ( $P < 0.0001$ ) (Table 1). Presentations were most frequent among 10-14 year olds (43.4%), followed by 15-17 year olds (37.3%) (Table 1). The average number of presentations each year changed very little for each age group, except for 5-9 years olds among whom there was an average annual increase of 1.5%. The age-specific rates were lowest for the 0-4 year olds and highest for the 15-17 year olds (Table 1, Figure 7 middle panel). The modelled rates decreased for each age-group, reaching statistical significance for all except the 0-4 year olds (Table 1). The rate for males was considerably higher than that for females (Figure 7 bottom panel), and the modelled rates decreased by 4.6% per year for males and 3.8% for females (no significant difference).

It appears that the decreasing trend in

ED presentations for off-road motorcycling injury is not simply a reflection of a decreasing trend in ED presentations for child injury overall. When the trend in the proportion of ED child injury presentations that are due to off-road motorcycling (i.e. the trend in motorcycle injuries as proportion of all child injuries) was modelled, there was an annual decrease of 6.2%. ( $p < 0.0001$ ) (Figure 8).

### Three-year patterns

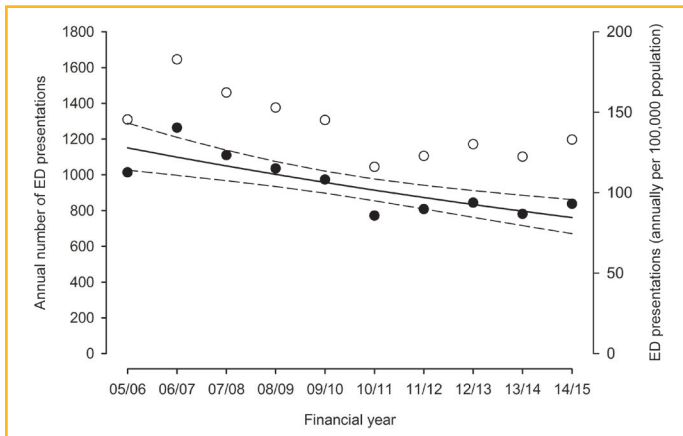
In the three year period 2012/13 to 2014/15, there were a total of 3,469 Victorian ED presentations for off-road-motorcycle injury, 94.5% of whom were Victorian residents. Among the Victorian residents, 59.6% lived in rural areas.

The patterns were very similar to those for hospital admissions. Presentations peaked in the autumn months of March and April, and were lowest in the winter months of July and August (Figure 2). The weekend was the peak time for presentations (Figure 3).

Males comprised 85% of presentations (Table 2). The frequency of presentation generally increased with each year of age from 4 years (Figure 4), with the 14-17 year olds comprising 48.9% of presentations.

The upper extremity was the most frequently injured body region (40.1%, Figure 5). Fractures dominated the type of injury sustained (34.2%, Figure 6). In contrast with hospital admissions, the generally less severe type of injuries, dislocations, sprains and strains, and superficial injuries, were more prominent (Figure 6). The most frequent specific injury was a fractured wrist or hand (10%, Table 3), followed by a fractured shoulder or upper arm (8%).



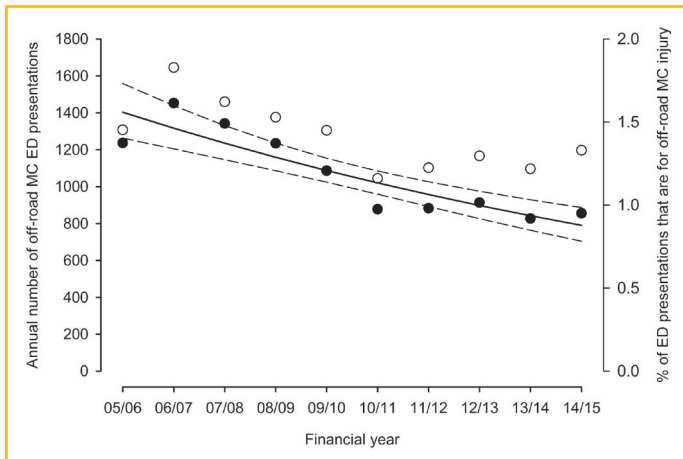
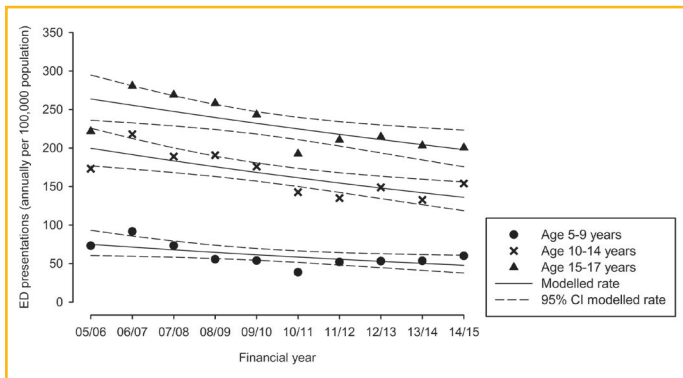
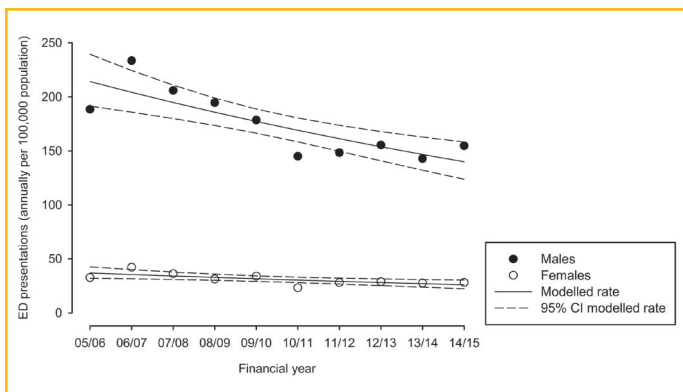


Left:

**Figure 7.** Trends in Emergency Department (ED) presentations for off-road motorcycle injury in Victoria, 2005/06 to 2014/15. In the top figure, results are shown as numbers (open circles) and rates (closed circles). In the second and third figures, results are shown as rates by sex (second) and age group (third). Solid lines represent modelled trends; dashed lines represent 95% confidence intervals.

Bottom left:

**Figure 8.** Trends in off-road motorcycle (MC) injury Emergency Department (ED) presentations as a percentage of all injury ED presentations by persons aged under 18 years, Victoria, 2005/06 to 2014/15. Open circles = MC presentation; closed circles = percentages; solid line = modelled trend in the percentages; dashed lines = 95% confidence intervals.



## VISU definitions

**Injury:** Injury is commonly defined as: ‘any unintentional or intentional damage to the body ... caused by acute exposure to physical agents such as mechanical energy, heat, electricity, chemicals, and ionizing radiation interacting with the body in amounts or at rates that exceed the threshold of human tolerance’.

**Unintentional injury:** Injuries that are unintended, often described as ‘accidents’. We try to avoid using the term ‘accidents’ as it implies that injuries are random events due to chance.

**Intentional injury:** Injuries that are the result of intended acts by people i.e., harm of one person by another (assault, homicide, neglect) or self-harm.

An injury **death** is defined as an injury or poisoning by an external cause (transport crash, fall, suicide, drowning etc.) that results in a person dying either in or out of hospital. In Victoria (and in other Australian States and Territories) all deaths by external causes must be reported to the State Coroner.

An injury **hospital admission** is defined as an injury or poisoning that results in the person being admitted to an inpatient bed (a ward, short stay observation unit, emergency medical unit, medical assessment and planning unit, intensive care bed, mental health bed or coronary care unit) and subsequently discharged alive either on the same day (after at least 4 hours from the time patient management commences) or after one or more nights’ stay in a hospital bed.

An injury **emergency department (ED) presentation** is defined as an injury or poisoning that results in a person presenting to a hospital emergency department for treatment who is triaged (assessed for urgency), including those patients who leave before treatment commences.

## Additional factors derived from the text narrative for emergency department presentations

The VEMD includes a text narrative which is intended to provide information regarding the circumstances of the event during which the injury was sustained. All narratives for cases presenting in the three year period 2012/13 to 2014/15 were examined using syntax to search for key words. Subsequently, a random sample of 400 cases were selected from those cases that included an external cause word such as fall, hit, collision, lost control (n=2051), and these narratives were manually coded to provide detail on the external cause.

### Narrative analysis for the three-year period

#### Activity

281/3469 (8.1%) mentioned specified activity (motocross; racing; competition, trail riding, dirt road riding, touring); the majority of these were motocross (n=221, 6.4%) and racing (n=77, 2.2%). There was some overlap with n=20 (0.6%) mentioning racing and motocross in the same narrative. Motocross was frequently mentioned in the context of 'motocross event' or 'motocross track' (location); occasionally as the use of a 'motocross bike'.

#### What rider was doing

238/3469 (6.9%) mentioned specifically what the rider was doing (uphill, downhill, jump, corner). 'Jump' was mentioned in 200 (5.8%) cases. This was commonly mentioned in the context of landing badly from a jump, losing balance, or falling off the motorbike during/after a jump. Going over the handle bars during a jump was mentioned occasionally. Some of the injuries were due to colliding with the bike during the landing.

#### Location

248/3469 (7.2%) mentioned specific locations (forest; park; reserve; property; farm; home; club; bush track; bike track; motocross track; race track). Most frequently mentioned were home (77, 2.2%), bush/bike/motocross track (74, 2.1%), farm (55, 1.6%) and property (22, 0.6%).

#### Protective equipment

Protective equipment (helmet, boots, shoes, gloves, goggles, guard, armour, Kevlar, jeans, jacket, neck brace, protection) was mentioned in 424/3469 (12.2%) cases. Helmet was mentioned in 376 (10.8%) cases. Helmet was usually mentioned in the context of 'helmet worn', 'helmet intact', 'helmet cracked', or 'helmet in-situ'. Occasionally it was mentioned that a helmet was not worn.

#### Speed

In 565/3469 (16%) speed was referred to (km per hour, mph, slow, fast, speed). Reference to km/hour was made in 335 (9.7%) cases; in most (n=329) of these cases a speed was reported. Among the 329 cases that reported speed, most commonly reported were speed in the 30-59 km/h range (47%), followed by the <30 km/h range (28%) and speeds of ≥60 km/h (26%).

#### Random sample narratives

A sample of 400 cases was randomly selected from ED presentations with any of the specified cause keywords in the narrative. Specified cause keywords were: fall/fell, handle bar, hit, collision/collide, lost control/balance, ditch, fence, tree, post, rock, pothole, gate or wall. Among these 400 selected cases, 331 were non-collision events (82.8%), 47 were collisions (11.8%), and 22 had insufficient information in the narrative to determine collision status (5.5%).

Among the non-collision events, 315 were falls from the bike (95.2%). Among these, 76.2% (n=240) of the narratives contained no further information regarding the circumstances of the fall. Where some details were provided (n=75), common scenarios included being thrown over the handlebars (24), falling from the bike with the bike landing on the injured person (21), and falling during or following a jump (20).

Collisions were the initiating event in 47 cases (11.8%). The majority of these (n=31) were collisions with stationary objects, including fences (12) and trees (8). There were ten collisions with moving objects, nine of which were other motorcycles.

## Discussion of findings

Over the 10 year study period 2005/6 to 2014/15, there was an annual average of 1 death, 288 hospital admissions and 1,271 emergency department presentations of children 17 years and under injured while off-road motorcycling in Victoria.

Rates of both hospital admissions and emergency department presentations were highest for males, and males comprised the majority of cases across all data sources. Rates of both hospital admissions and emergency department presentations increased with age, and the 15-17 year olds had the highest rates, likely reflecting their greater participation in off-road motorcycling. While the majority of cases were 10 years and over, there were two deaths and an annual average of 42 hospital admissions and 246 emergency department presentations of children under 10 years of age, including some under 5 years of age. These demographic patterns are similar to those reported previously for Victoria and Queensland

(Cassell et al., 2006; Bevan et al., 2008; Pym et al., 2013).

Unlike two previous Victorian studies using similar data sources for the periods 2000/01 to 2003/04 (Bevan et al., 2008), and 2002/03-2004/05 (Cassell et al., 2006), we did not find consistent evidence for an increasing problem in hospital treated injury. There was a decrease in the number and population rate of emergency department presentations over the ten-year period which was not evident in the hospital admission rates, which did not change significantly. During the ten-year study period, off-road motorcycle sales in Australia have been generally decreasing since a peak in 2010 (Federal Chamber of Automotive Industries). It remains possible though that the relative proportion of sales comprised by smaller bikes, appropriate for younger age groups, may have increased. Despite the decreasing sales, anecdotal evidence from Motorcycling Australia indicates that participation in recreational off-road motorcycling has been increasing over recent years across

all age groups, including juniors (Peter Doyle, Motorcycling Australia, personal communication).

Collision events with stationary objects and other vehicles were the cause of the majority of the deaths, and all cases had head injuries, injuries to internal organs in the chest or abdomen, or both. The fact that at least four of the seven head injured cases were wearing motorcycle helmets highlights the fact that although motorcycle helmets reduce head injury (Liu et al., 2009), they do not protect from all forms of brain injury (Whyte et al., 2016). Intracranial lesions and basilar skull fractures do occur among helmeted riders (Richter et al., 2001; Whyte et al., 2016). Motorcycle helmets protect the head from most external physical impacts, but may not protect the brain and associated blood vessels for example from the forces involved in rapid deceleration that occurs when a rider hits a stationary object at some speed.

In contrast with fatalities, non-collision events, primarily falls from the motorcycle,


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were the cause of the majority of both hospital admissions and emergency department presentations. Fractures dominated the injury patterns for hospital treated injury, although a small but noteworthy proportion of hospital admissions were for intra-cranial injury. The older children (15-17 year olds) appeared to sustain more serious injuries as this group utilised a greater proportion of hospital bed days than would be expected. The injury patterns observed in this study were similar to those reported previously for Victoria and Queensland (Bevan et al., 2008; Pym et al., 2013).

### Age-considerations

Given the injury cases for under 5 year olds, a matter for serious consideration is the age at which children acquire the physical and cognitive skills necessary for safe off-road motorcycling. These skills would include gross motor co-ordination, strength, balance and righting reactions; cognitive anticipation; executive functions involving judgement, planning, and problem solving; and visual perception and proprioception. A systematic appraisal of the required skills for off-road motorcycling matched against developmental stage does not appear to have been undertaken. There are suggestions in the literature that children may not have the necessary skills (Bevan et al., 2008; Pym et al., 2013), and the American Academy of Pediatrics recommends prohibiting children less than 16 years of age from using 2-wheeled off-road motorcycles (Lace and Goldstein, 2005). Evidence given by a paediatrician specialising in development behavioural paediatrics at a Coronial inquest in Victoria indicated that young children would not have reached a developmental stage to safely ride a motorcycle, and while they may be able to show they can manage a motorcycle in controlled circumstances, they are likely to make errors (Coroners Court of Victoria., 2009). Australian Institute of Sport motorcycle racing coach,

Stephen Gall, concurs that most children 5 years and under would not have the required skill set (personal communication). Mr Gall further advised that parents of children under the age of 12 should consider allowing their children to develop skills in a supportive environment, such as the non-competitive events auspiced by Motorcycling Australia, and restrict competition participation until after the age of 12. It is important to note that based on the hospital admissions (VAED) data used in this Hazard, distinction could not be made between injuries sustained during organised sporting events vs. other recreational motorcycling activity.

Until a systematic appraisal of the required skills and child development stage has been conducted it would seem prudent to recommend that children aged 5 years or less not ride a motorcycle off road, and that motorcycle retailers adopt a voluntary code of conduct restricting the sale of off-road motorcycles for children of this age, where the age of the intended user is clear. Parents of children between 6 and 17 years of age should be advised of the increased risk of injury associated with off-road motorcycling relative to those for other popular sport and recreational activities such as Australian Rules Football and cycling to assist them in making an informed decision about their child's participation.

### Protective equipment

The descriptions of the injury event in the text narratives clearly indicate that off-road motorcycling creates the potential for falls from the motorbike, sometimes at higher speeds and from above ground level, onto unforgiving objects and surfaces. Training and experience may reduce the likelihood of these events; however, effective protective clothing and equipment are a necessity to prevent injury

when participating in this activity. Due to limitations with the data, we are not able to accurately comment on the prevalence of protective equipment, nor on the type used. There is good evidence for the effectiveness of motorcycle helmets and protective clothing (jacket, gloves, pants, body armour, boots) in preventing, and reducing the severity of, injury among on-road motorcyclists (Liu et al., 2008; de Rome et al., 2012). Further, protective clothing has been associated with less severe pain, impairment and disability in the two months post-crash (de Rome et al, 2012). Motorcycling Australia recommends that all junior riders wear a motorcycle helmet, gloves and boots, and depending on the type of riding, some riders will also require goggles or visor, a back protector, body armour and a race suit (Motorcycling Australia, 2014). The Manual of Motorcycle Sport recommends appropriate types of protective equipment for the different riding types (Motorcycling Australia, 2016).

### Laws and regulations

Riding on public land, including public tracks, roads and road related areas, requires a motorcycle licence (or learner permit) from VicRoads and a registered motorcycle. Therefore, it is illegal for children under 18 years of age to ride motorcycles on public tracks through State forests, parks and reserves. It is also illegal to ride on public land that is not a road. Greater enforcement of the current laws would be a useful injury prevention strategy, although widespread enforcement is an acknowledged challenge for the available police resources (Parliament of Victoria, 2012).



Riding in Motorcycling Australia auspiced events and competitions requires a national licence issued by a state controlling body (Motorcycling Australia, 2014). Children aged 4-6 years may obtain a recreational non-competition licence which enables them to ride for recreational purposes only and on an automatic motorcycle with maximum 50cc in controlled conditions under supervision. Children under the age of 7 years are not eligible to obtain competition licence. This licence requires a minimum of 5 hours coaching and a completion of a 25 item written test. Applicants may be helped with this test by their parent or guardian. Progressing to larger capacity motorcycles requires a competency based assessment by an accredited coach.

Riding on private land does not require a licence, and therefore no kind of training. There are, however, a number of motorcycle training providers who run courses for off-road motorcycle riding, although some require participants to be 18 years or over.

### Leadership

The lack of a lead agency to take responsibility for off-road motorcycle safety in Victoria was identified in 1994 (Haworth et al., 1994). Since then this has been repeatedly observed in coronial inquests, injury prevention publications (Cassell et al., 2006), and most recently in the Victorian Parliamentary Inquiry into Motorcycle Safety (Parliament of Victoria, 2012), although the Inquiry did recognise the activities of the Department of Sustainability and the Environment, and Victoria Police in attempting to address off-road motorcycle safety. In response to that Inquiry, VicRoads agreed to take the lead role in developing an action plan in consultation with other relevant government agencies and off-road motorcycle stakeholders (Victorian Government, 2013). The action plan is yet to be developed.

## Recommendations

The following recommendations are made in light of the data presented, which outline a range of opportunities to prevent off-road motorcycling injury among children under the age of 17 years.

- 1 All off-road motorcycle riders should wear motorcycle helmets meeting the Australian (AS1698) or European Standard (EU 22/05), and wear gloves and boots and other protective clothing appropriate to the type of riding.
- 2 Parents should be advised not to rely on motorcycle helmets as the only injury prevention precaution: helmets are effective in reducing the risk of head injury but do not protect from all types of head and brain injury.
- 3 A review of the physical, perceptual and cognitive skills required for off-road motorcycling should be undertaken and compared against paediatric developmental stages to determine if there is an appropriate age for children to commence off-road motorcycling.
- 4 Children under the age of 5 should not ride motorcycles off-road, until it is ascertained that they have the required skills.
- 5 Motorcycle retailers are encouraged to adopt a voluntary code of conduct restricting the sale of off-road motorcycles for children less than 5 years of age, in those circumstances where the age of the intended user is clear.
- 6 Parents of children under the age of 12 should consider allowing their children to develop skills in a supportive and controlled environment, such as that provided by non-competitive events and activities auspiced by Motorcycling Australia.
- 7 The current laws regarding riding on public land should be enforced.
- 8 The action plan for off-road motorcycle safety agreed in the Victorian government response to the 2012 Victorian Parliamentary Inquiry into Motorcycle Safety should be developed under VicRoads' leadership without further delay.



## Data sources, case selection and analysis methods

### Deaths

Death data have been extracted from the National Coronial Information System (NCIS). The NCIS is an international internet based data storage and retrieval system for Australian and New Zealand coronial cases. VISU only has access to closed Australian cases on the system and there is a substantial lag between the death occurring, the closing of the case by the coroner and the eventual coding and closing of the case on the NCIS. For this reason analysis was confined to the 10-year period 2003-2012 as at the time of data extraction (1/3/2016) over 95% of Coroner's cases in each of those years were closed in the NCIS.

Cases were selected if the person was aged 0-17 years, the death occurred in Victoria, and the mechanism of injury was a transport injury event including a motorcyclist/motorcycle rider (level 3 mechanism of injury code) (n=17). The focus is recreational 2-wheel motorcycle riding deaths and as such the Coroner's findings and police summaries were used to exclude cases where the decedent was riding a quad bike (n=2) or was clearly not engaging in organised sport or recreational motorcycling - that is they were riding on the road for the purpose of transportation (n=3). A further case was deleted as the decedent was outside the age range of interested due to a coding error on the NCIS. There were no work-related cases identified.



### Hospital admissions

Hospital admission data were extracted from the Victorian Admitted Episodes Dataset (VAED). The VAED records all hospital admissions in public and private hospitals in the State of Victoria.

Motorcycle rider injury incident cases were selected for persons aged 0-17 years at the time of admission, with a principal diagnosis in the ICD-10-AM coding range of S00-T98 and a first recorded external cause code in the range of V20-V29 (motorcycle rider injured in transport accident). The main analysis was focused on off road/recreational motorcycle riding accidents. Off road accidents were identified as those that were not coded as having taken place on the road, street or highway; those that were coded as 'nontraffic accident' in the external cause code were included. Cases would have included those participating in organised motorcycle sport as well as those participating in recreational riding. Work-related accidents were excluded: these were identified as admissions with activity code: working for income or other types of work-unpaid. In addition, statistical admissions (change in care type within the same hospital) and transfers from acute/ extended care/ rehabilitation/ geriatric centres were excluded to avoid over-counting. All motorcycle rider accident sub-categories

were defined using external cause codes.

Prior to July 2012, Emergency Department stay of longer than four hours could be categorised as a hospital admission. In July 2012 the Victorian Hospital Admission Policy changed significantly so that episodes of care delivered entirely within a designated emergency department or urgent care centre could no longer be categorised as an admission regardless of the amount of time spent in the hospital. This has had an effect on observed trends in injury admissions. To understand the trend in injury, the effect of the admission policy change needs to be separated from the underlying injury admission trend. This was done by identifying admissions prior to July 2012 that took place in the ED only, i.e. the patient received care in the ED only, throughout the recorded admission. These cases were identified and excluded from the admissions data, for this edition of *Hazard*.

Statistical admissions and transfers were included when providing estimates of the number of hospital bed days as their inclusion provides a more accurate estimate of the burden of injury.

*Note: Frequencies less than 5 and rates based on frequencies less than 10 are suppressed and appear with an "\*" in the tables provided.*



### Emergency department (ED) presentations

ED presentations data were extracted from the Victorian Emergency Minimum Dataset (VEMD). The VEMD records all presentations to Victorian public hospitals with 24-hour emergency departments (currently 39 hospitals – 100% state-wide coverage of these hospitals applies from 2004). ED presentations were selected if the cause was coded as a motorcycle driver or passenger or if the text variable (VEMD narrative) mentioned terms relevant to motor cycles (motor bike, mba, dirtbike, trail bike, motor cross, ag bike, vespa, pee wee, mini bike, quad bike, 4 wheel bike, scooter side-car etc). 'Scooter' was only used as keyword for persons aged 18 to 59, as for persons aged under 18 years these are likely to refer to non-motorised children's scooters and for persons aged 60 or over they are likely to refer to mobility scooters. Cases that were insect bites, or foreign body entering while riding were excluded. Cases that mentioned the injured person was "working on the motor bike" or "fixing it" were also excluded. Cases were coded as on-road if the location code was "road" or the text narrative indicated it was on a road/street/highway etc. Others were coded as off-road depending on the location code or information in the text variable, for example

if it indicated that the incident occurred on a farm.

Motorcycle cases were selected for persons aged 0-17 years at the time of presentation; quad bikes and side-cars were excluded. Cases where the incident took place on the road were excluded, as were work-related incidents. Cases would have included those participating in organised motorcycle sport as well as those participating in recreational riding. Only initial ED presentations were analysed: return visits for follow-up care were excluded to avoid over counting. *Note: Frequencies less than 5 and rates based on frequencies less than 10 are suppressed and appear with an "\*" in the tables provided.*

## Analysis methods

### Rates

Crude and age-specific rates (per 100,000) were calculated using ABS Estimated Resident Population (ERP) figures for Victorians aged 0-17 years in the corresponding years of injury [3101.0 Australian Demographic Statistics; Table 52. Estimated Resident Population By Single Year of Age, Victoria. Australian Bureau of Statistics].

### Trend Analysis

Population based trends in the rates of Victorian Emergency Department presentations and hospital admissions due to motorcycle accident injuries in children (aged 0-17 years) are shown in figures as the injury incidence rate over time. Crude rate and 95% confidence interval of the crude rates are shown, for ED presentation rates and hospital admission rates. Confidence intervals were calculated as:

$$\frac{100,000}{\text{population}} \times (\text{events} \pm [1.96 \times \sqrt{\text{events}}])$$

Crude annual average % change was calculated as the average of the annual percentage changes (in frequency, and in rate) in the data series. Trends were modelled using Poisson models, as trends in the annual number of events, with the log of the annual Victorian residential population as offset. Trends were modelled for the years 2005/06 to 2014/15, for ED presentations and admissions (separately). The results are presented in a table as the modelled annual % change in rate, calculated as:

$$\text{percentage change} = [e^a - 1] \times 100\%$$

where  $a$  is the estimated value from the Poisson model. The analyses were conducted using the PROC GENMOD procedure in SAS V9.4.

**Appendix**

Sport participation and hospital-treated injury: ages 5-14 years only, 2010.

	Participation		Emergency Department (ED) presentations		Hospital admissions			
	Australian participation rates*	Estimated participants in Victoria†	ED presentations for injury	ED presentations per 100,000 participants (2010)	Hospital admissions for injury ‡	Hospital admissions per 100,000 participants (2010) ‡	Hospital days (2010) §	Hospital days per 100,000 participants (2010) §
Australian Rules Football	8.7%	57747	2266	3924	233	403	321	556
Tennis	10.6%	70358	95	135	8	11	10	14
Cycling	48.1%	319265	1039	325	329	103	774	242
Motorcycle riding/ motorsports	3.0%	19913	657	3299	119	598	285	1431

\* Relates to persons aged between 5 and 14 years who participated in a specific physical activity for exercise, recreation and sport in the school term prior to interview

† 2010 Australian participation percentages for ages 5-14 years are projected onto the Victorian population in that age group. There were 663753 persons aged 5-14 in Victoria in 2010 (3235.0 Population by Age and Sex, Regions of Australia)

‡ Incident cases only

§ Overnight stays; not limited to incident cases

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## Participating hospitals

*From October 1995*

Austin & Repatriation Medical Centre  
Ballarat Base Hospital  
The Bendigo Hospital Campus  
Box Hill Hospital  
Echuca Base Hospital  
The Geelong Hospital  
Goulburn Valley Base Hospital  
Maroondah Hospital  
Mildura Base Hospital  
The Northern Hospital  
Royal Children's Hospital  
St Vincents Public Hospital  
Wangaratta Base Hospital  
Warrnambool & District Base Hospital  
Western Hospital - Footscray  
Western Hospital - Sunshine  
Williamstown Hospital  
Wimmera Base Hospital

*From November 1995*

Dandenong Hospital

*From December 1995*

Royal Victorian Eye & Ear Hospital  
Frankston Hospital

*From January 1996*

Latrobe Regional Hospital

*From July 1996*

Alfred Hospital  
Monash Medical Centre

*From September 1996*

Angliss Hospital

*From January 1997*

Royal Melbourne Hospital

*From January 1999*

Werribee Mercy Hospital

*From December 2000*

Rosebud Hospital

*From January 2004*

Bairnsdale Hospital  
Central Gippsland Health Service (Sale)  
Hamilton Base Hospital  
Royal Women's Hospital  
Sandringham & District Hospital  
Swan Hill Hospital  
West Gippsland Hospital (Warragul)  
Wodonga Regional Health Group

*From January 2005*

Mercy Hospital for Women

*From April 2005*

Casey Hospital

*From July 2011*

Bass Coast Regional Health



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## How to access VISU data

VISU collects and analyses information on injury problems to underpin the development of prevention strategies and their implementation. VISU analyses are publicly available for teaching, research and prevention purposes. Requests for information can be lodged via the data request form on the VISU website or by contacting the VISU office by phone.