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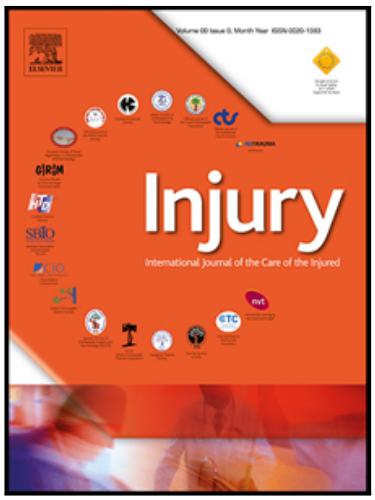

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HIGHLIGHTS

- Off-road motorcycle sports are increasingly popular, however paediatric injuries frequently occur and are associated with significant morbidity.
- Concerns regarding the safety of this sport are highlighted by the death of four children (2010-2017) and the number of children sustaining major trauma.
- While paediatric off-road motorcycle trauma presentations to hospital are less in number compared to other sports, the injury risk and severity is higher.
- Riders and parents need to be aware of these risks, and organised events need to have adequate on-site first aid facilities.

Title: The epidemiology of paediatric off-road motorcycle trauma attended by emergency medical services in Victoria, Australia

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Key words:

paediatric, trauma, motorcycle, motocross, competitive, recreational, injury, pre-hospital, ambulance

ABSTRACT

Background: Paediatric participation in competitive and recreational off-road motorcycle sports is increasing in popularity worldwide, however injuries frequently occur and the sport is associated with significant morbidity.

Objective: This study describes the profile of paediatric off-road motorcycle trauma attended by emergency medical services (EMS) in Victoria, Australia.

Methods*:* A retrospective review included paediatric (<16 years) competitive and recreational off-road motorcycle patients attended by EMS between 2010 and 2017 in the State of Victoria, Australia. Patient characteristics and injuries sustained were described using descriptive statistics. Predictors of EMS transport were identified using multivariable logistic regression analyses.

Results: There were 1,479 paediatric motocross patients attended by EMS between 2010 and 2017. This represents 1.6% of the total state-wide EMS paediatric trauma (<16 years) workload, and equates to an average incidence of 22.2 per 100,000 population. The median age of patients was 13 years (IQR: 10-14) and 89.5% were male. The most common final diagnoses recorded by paramedics were 'fractures' (25.5%, n = 377) and 'unspecified pain' (19.5%, n = 289). Administration of analgesia (76.3%) was the most common EMS management, followed by spinal immobilisation (54.7%) and splinting (33.4%). The vast majority (91.5%) of patients were transported to hospital by EMS. Following admission, 38 (2.6%) patients were confirmed to have sustained major trauma, 78.9% of which had been transported direct from scene to a major trauma centre for definitive care. Median ISS for confirmed major trauma patients was 14 (IQR: 14-22). Four (0.4%) patients received pre-hospital CPR. All four sustained injuries from recreational off-road, motorcycle activities and all four cases died, two at the scene and two in-hospital.

Conclusion: Off-road motorcycle activities are an important cause of death and injury in Victorian children, as highlighted and demonstrated by the four deaths and high EMS transport rates borne out in this study. Riders and parents need to be aware of these risks, and organised events must have adequate on-site medical care resources.

INTRODUCTION

Participation in competitive and recreational off-road motor sports has increased in popularity among adults and children worldwide. Mirroring this global trend, motor sports are now one of the most popular sporting activities in Australia.[1] Junior motocross is a sport that has rapidly increased in popularity in recent times, however it is also an activity where paediatric injuries frequently occur and is associated with significant morbidity.[2-5]

A review of a ten-year incidence of sport and recreation-related injuries previously addressed the contribution of sport to major trauma and death in Victoria, Australia.[6] The report highlighted motor sports as having both the highest rate of major trauma and highest rate of annual growth. This included competitive off-road motorcycling (i.e. 'motocross'), as well as trail and quad bikes.[6]

In Australia and internationally, competitive motocross events organised by governing bodies involve regulated tracks and mandatory participant use of personal protective equipment. Motorcycling Australia stipulates the protective clothing and equipment that is mandatory for participation in organised events across Australia. Different activities have different requirements, however as a general rule protective equipment and clothing includes an approved helmet, clothing constructed of leather or material of similar or greater durability, motorcycle boots, a back protector, body armour, gloves, and shatter-proof goggles or helmet visor.[7] Governing organisations are also required to ensure adequate on-site medical resources (e.g. first aid providers).

In Victoria, motocross events are governed by *Motorcycling Victoria*, a non-profit organisation that represents motorcycle sport across the state. There are 70 affiliated clubs across Victoria with approximately 6,000 members competing in nine disciplines of motorcycle sport.[7] In 2017, there were 22 organised motocross events in Victoria.[2] Motorcycling Victoria caters for paediatric and adult riders, with age categorised into three groups, namely 'kids' (age 4-6 years), 'juniors' (age 7 to under 16 years) and 'seniors' (aged 16 years and over). Kids aged 4 to 6 years require a 'mini licence' and are only permitted to participate in organised recreational non-competitive events (e.g. practice days, trail rides, tuning, coaching). A 'mini licence' permits juniors to participate in recreational events, while a 'junior national' or 'junior restricted' licence is required for competitive events.[7]

Recreational off-road motorcycle activities on private land have also become increasingly popular.[7-10] However, in contrast to the regulated environment and mandated safety requirements of organised motorcycle activities, recreational off-road motorcycle activities are unregulated, lack safety guidelines and are reliant on voluntary use of protective equipment.[9]

In Victoria, off-road motorcycling accounts for 76% of motorcycle-related hospital admissions for children under road licence age (<18 years).[11] While the number of children presenting to hospital following off-road motorcycle trauma is much lower than other sports [e.g. Australian Rules Football (AFL) or cycling], estimated injury rates suggest the injury risk is much higher compared to these other popular sports.[11] Using extrapolated data from the *2010 Exercise Recreation and Sport Survey*,[12] hospital admission rate for off-road motorcycling was 1.5 times higher than AFL and six times higher than cycling.[11] Further, hospital bed days due to off-road motorcycling were 2.6 times higher than AFL and six times higher than cycling. Taken together, these comparisons suggest the relative severity of injury is also greater for off-road motorcycling.[11] The complexity of off-road motorcycling injury is further prejudiced by rural hazards (e.g. wire fencing) and remoteness. Increased time to treatment is common in rural and regional areas, where transfer to metropolitan trauma services is required.[5, 10, 13, 14]

There is concern that the increasing popularity of these motorcycle sports will drive a corresponding increase in associated deaths, injuries and demands on the health system. The profile of injuries, hospital admissions and outcomes for paediatric competitive and recreational off-road motorcycle trauma have been reported previously.[2-5, 8, 9, 14-16] It is well documented in the literature that time critical trauma patients benefit from definitive trauma care within sixty minutes ('golden hour') of traumatic injury.[17-19] The golden hour theory provides the foundation for modern trauma systems and underpins concepts such as 'scoop and run', aeromedical transport, major trauma service designation and prehospital notification of hospital trauma teams. Despite the importance of the pre-hospital phase of trauma management, there is a paucity of literature describing the pre-hospital emergency medical services (EMS) responses and clinical management of off-road motorcycle trauma in children. Understanding the prehospital response and clinical management of this patient group is critical to understanding how off-road motorcycle activities can be better regulated to reduce morbidity and mortality.

This study seeks to address this gap in the literature, by describing the epidemiology, injury profile, pre-hospital management, triage and transport decisions and major trauma outcomes of paediatric off-road motorcycle trauma patients attended by EMS in Victoria, Australia. Predictors of transport to hospital will also be examined to determine whether there is a difference in EMS transport between competitive and recreational motorcycle activity patient groups.

MATERIALS & METHODS

Ethics approval

This study was approved by the Monash University Human Research Ethics Committee.

Study design

This retrospective review included pre-hospital and hospital data for paediatric patients attended by EMS in Victoria, Australia. 'Paediatric' is defined here as aged <16 years, which is consistent with the working definitions of the Victorian State Trauma System. Patients were identified as having sustained off-road motorcycle trauma (competitive motocross vs. recreational activities) between 1 July 2010 and 30 June 2017.

Setting

The study was conducted in Victoria, a State of Australia that covers 227,590 square kilometres[20]. In 2017, the Victorian population was estimated at 6.15 million.[21] Ambulance Victoria provides EMS in the state, and employs approximately 4,500 on-road clinical staff, including advanced life support and intensive care paramedics.[22] Advanced life support paramedics are trained to perform advanced airway management, establish intravenous access, and administer protocolised fluid replacement and analgesia. Intensive care paramedics are authorised to perform more advanced medical procedures (e.g. endotracheal intubation using rapid sequence intubation), and administer a wider range of intravenous drugs. Aeromedical transport is available for severely injured patients, and fire fighter first responders can also be dispatched to suspected cardiac arrest prior to the arrival of Ambulance Victoria paramedics.

The Victorian State Trauma System has defined pre-hospital trauma triage criteria for *potential* major trauma patients on the basis of abnormal vital signs and/or injury profile.[23] Whilst the injury profile criteria of children and adults essentially mirror each other,[23-26] criteria for abnormal heart rate, respiratory rate and systolic blood pressure are dichotomised according to age in recognition of age-based differences in the normal range of vital signs in children; categories used are: 0-3 months, 4-12 months, 1-4 years, 5-12 years, 13-15 years.[23] When a paediatric trauma patient meets one or more of the pre-hospital criteria for major trauma, and ambulance transport time is estimated to be within 45 minutes, the stipulated destination is the paediatric major trauma centre for Victoria, The Royal Children's Hospital, Melbourne.[23-26] If transport time will exceed 45 minutes and air transport is not available, the system dictates that the patient be first transported to the closest, highest level of trauma care available, and secondarily transferred to The Royal Children's Hospital following initiation of emergency management.[23]

Study population, case selection and categorisation

The patients included in this study were children (<16 years) attended by EMS due to injuries sustained in off-road motorcycle activities. The following terms were used to define 'off-road

motorcycle activity': ‘motocross’, ‘motorcycle', 'motorbike’, ‘dirt bike’, ‘trail bike’ ‘mini bike’, ‘monkey bike’ or ‘peewee bike’. Participation in off-road motorcycle activity was determined using the paramedic-recorded cause of trauma on the patient's pre-hospital patient care record, by reference to motorcycle activity in the paramedic-recorded free text narrative ('case description'), and from 000 call taker event codes. Cases that met the inclusion criteria only on call-taker event code were manually reviewed to screen out any non-motorcycle vehicle-related trauma. Included cases were then categorised as either 'competitive' (i.e. motocross) or ‘recreational’ following manual review of the paramedic-recorded case description. Cases were categorised as 'recreational' unless the following free text terms were identified in the case description: 'competition', 'competing', 'competitors', 'race', 'racing', 'official event', 'official race', ‘ motocross’, 'motocross event', 'motocross race' (or a specific race meet name), 'first aid' (or named first aid organisation, e.g. 'St. Johns Ambulance'). Patients were excluded if they were pillion passengers to another motorcycle rider, motorcycle riders requiring training wheels, passengers in a vehicle or pedestrians involved in collisions with motorcycles, or stationary at the time of the traumatic event (e.g. fell off a stationary motorcycle). Figure 1 presents a flowchart of case selection and categorisation.

Data capture

Pre-hospital data included demographic and logistic information (e.g. call received time), types of injury, clinical observations at initial presentation, management procedures and drug administration. Pre-hospital data were sourced from electronic patient care records recorded by paramedics and stored within the Ambulance Victoria data warehouse. Hospital data were sourced from the Victorian State Trauma Registry (VSTR), which collects data for all confirmed ‘major trauma’ cases. A case is considered major trauma if meets any of the following criteria: (1) in-hospital death due to injury; (2) an Injury Severity Score (ISS) > 12; (3) admission to an intensive care unit (ICU) for more than 24 hours and requiring mechanical ventilation for at least part of their ICU stay; and (4) urgent surgery. Hospital data included confirmed major trauma status, major trauma criteria (in-hospital death, ISS, ICU admission, surgery), and AIS injury data by body region (abdominal, head, face, neck, thorax, spine, upper and lower extremities). Hospital data were only available for major trauma patients (see Figure 1). Pre-hospital and hospital data were matched electronically using probabilistic linkage techniques. Record linkage was manually reviewed to ensure accuracy.

Statistical analyses

Statistical analyses were performed using SPSS Version 21.0 for Windows (IBM, Chicago, IL, USA). Patient characteristic data are presented as frequencies and proportions or means (standard deviation) / medians (interquartile range, IQR) as appropriate. Data is presented overall and for recreational and competitive patient groups. For univariate analyses, Fisher's exact test was used to compare categorical variables with the p-value derived from doubling the exact one-tailed probability, while Mann-Whitney tests were used to compare continuous variables. Statistical significance was set at $p < 0.05$. Age specific annual incidence was calculated using Victorian population figures from the Australian Bureau of Statistics 2016 census data (www.abs.gov.au).
To examine factors associated with the outcome variable 'transport to a hospital destination', odds ratios and 95% confidence intervals were calculated using logistic regression. Several logistic regression models were built using the following factors to determine significant predictors of transport to hospital: age, gender, type of motorcycle activity (competitive vs. recreational), major trauma status, potential major trauma status, time of day, MICA attendance, vital signs, injuries, mechanism of injury, treatment procedures and medications and hospital factors including ISS, ICU admission and urgent surgery. The final model is presented in Figure 3 and includes only significant predictors.

RESULTS

Between 1 July 2010 and 30 June 2017 there were 1,479 paediatric motocross and motorcycle incidents attended by EMS in Victoria, Australia, which represents approximately 1.6% of the total EMS paediatric attended workload. Figure 2 presents a summary of paediatric motocross and recreational off-road motorcycle incidents attended by EMS in Victoria between 2010 and 2017. The average age-specific (<16 years) incidence for off-road motorcycle trauma was 22.2 per 100,000 population.

Characteristics of paediatric off-road motorcycle trauma

The characteristics of paediatric off-road motorcycle patients and trauma are presented in Table 1. Males accounted for 89.5% of patients. The median age was 13 years (IQR: 10-14), with ages ranging from two to 15 years, i.e. spanning the full width of possible ages for this population. Consistent with the regulated environment of motocross, 17 out of 18 injured children aged <5 years sustained injuries during recreational activities.
Irrespective of whether in competitive or recreational activity, the majority of off-road motorcycle incidents occurred in a rural setting (Table 1). The proportion of rural scene locations was significantly higher for competitive motocross compared to recreational off-road motorcycle

incidents (81.1% vs. 66.5%, p = 0.001). Motocross incidents were also more often at a public location compared with recreational incidents (91.7% vs. 40.3%, p = 0.001). EMS demand was highest in March (15.0%, n = 72) and May (12.9%, n = 62) for competitive motocross and April (11.7%, n = 118) and January (11.1%, n = 112) for recreational incidents. All case times were significantly longer for recreational off-road motorcycle incidents compared to competitive incidents (Table 1).

The most common final diagnoses recorded by paramedics on patient care records were 'fractures' (25.5%, n = 377), 'unspecified pain' (19.5%, n = 289), 'lacerations' (3.6%, n = 53) and 'soft tissue injuries' (3.4%, n = 51). There was no difference in the proportion of competitive and recreational motocross / motorcycle patients that sustained one or more fracture (26.8% vs. 24.9%, p = 0.421). Fractures were described as 'closed fractures' in 54.9% (n = 207) of fracture cases, while 'open fractures' were observed in 2.4% (n = 9) of cases. Where a body region was recorded for a fracture injury (n = 227), 46.7% (n = 106) were to the upper extremities, 33.5% (n = 76) were to the lower extremities and in 13.2% (n = 30) of cases the clavicle was the site of injury.

A higher proportion of competitive motocross patients had an EMS final diagnosis of 'pain' (25.8% vs. 16.6%, p = 0.001), while a higher proportion of off-road recreational motorcycle patients sustained 'lacerations' (4.8% vs. 1.0%, p = 0.001). Two children (0.1%) died at the scene, both as a result of off-road recreational motorcycle activities.

Potential major trauma and confirmed major trauma status

Of the 1,479 paediatric off-road motorcycle patients, 42.1% (n = 623) met the Ambulance Victoria pre-hospital triage criteria for potential major trauma. A higher proportion of recreational off-road motorcycle patients (44.5%, n = 444) met criteria for potential major trauma compared to competitive motocross patients (37.2%, n = 179) (p = 0.096).

Table 2 presents the characteristics and AIS defined severe injuries for the 38 children who met VSTR criteria for major trauma. Of these, 92.1% (n = 35) had also met the Ambulance Victoria pre-hospital criteria for potential major trauma. Seventy-nine per cent of the confirmed major trauma patients were transported directly from the scene to The Royal Children's Hospital. Of the eight major trauma patients not transported directly to the paediatric major trauma service, six (75%) were transported to a regional trauma service and two (25%) were transferred from their initial receiving hospital to The Royal Children's Hospital by air.

The median ISS for confirmed major trauma patients was 14 (IQR: 14-22), with no significant difference in median ISS between competitive motocross and recreational off-road motorcycle patients (14, IQR: 13-17 vs. 17, IQR: 14-23, p = 0.410). The most common AIS-defined severe injuries

(score ≥ 3) for confirmed major trauma patients were sustained to the thorax (28.9%), lower extremity (26.3%) and the head (23.7%).

Pre-hospital treatment and management

Of the 1,479 injured children attended by EMS following off-road motorcycle trauma, 1,271 (85.9%) received active pre-hospital clinical management (Table 3). Analgesia was administered to 76.3% of patients, 54.7% received spinal immobilisation, 33.4% received splinting and 1.3% were intubated. Four recreational motorcycle patients required CPR and two of these cases resulted in on-scene fatalities.

Transportation

Overall, nine out of every 10 included patients were transported by EMS to a hospital, the full details of which are provided in Table 1. Significantly more motocross patients were transported to hospital compared to recreational off-road motorcycle patients (94.0% vs. 90.3%, p = 0.019). A 'code 1: time critical' (i.e. 'lights and sirens') ambulance response was used for 12.3% of all patients transported to hospital, with a significantly higher proportion of recreational patients transported on a code 1 response compared to motocross patients (14.4% vs. 8.0%, p = 0.001).

Several variables were examined for association with transport to hospital, and eight were predictive of transport at a univariate level. These variables were included in multivariable logistic regression models for the odds of transport to hospital for paediatric motorcycle and motocross patients. The results of the final multivariable logistic regression model are presented in Figure 3. Significant predictors of transport to hospital were: initial pain score (OR, 1.09; 95% CI, 1.01-1.18), analgesia (OR, 3.07; 95% CI, 1.83-5.14), spinal immobilisation (OR, 2.49; 95% CI, 1.61-3.86) and MICA attendance (OR, 0.26; 95% CI, 0.17-0.40).

Patient mortality

Four (0.3%) children died during the study period due to off-road motorcycle trauma, specifically recreational activities in all four cases. Three of the four deceased patients were wearing helmets at the time of the trauma, as documented on their patient care records by paramedics. It is not known from the available documentation if the fourth patient was wearing a helmet. All four children required pre-hospital CPR. Two patients suffered severe head trauma and internal bleeding and were declared deceased on-scene by paramedics. Two other patients achieved return of spontaneous circulation pre-hospital, but died in hospital. The mean ISS score for these two patients

was 48 out of 75. Severe head, abdominal, thoracic and spinal injuries were indicated in these cases according to hospital AIS data.

Discussion

Competitive motocross and recreational off-road motorcycle activities each present a significant risk of injury, morbidity and mortality to Australian children. The burden of trauma due to off-road motorcycle use is borne out by the current study, most particularly by four children who died in Victoria from recreational off-road motorcycle-related trauma during the study period. Moreover, this burden is expressed by the important proportion of paediatric off-road motorcycle patients attended by EMS who met Ambulance Victoria criteria for potential major trauma, and those who were subsequently confirmed to be major trauma following admission to hospital. The severity of injury for confirmed major trauma is reflected by a median ISS of 17 for recreational patients and 14 for competitive patients, with some injured children achieving an ISS as high as 50. Together, the findings of this study provide support for the assertion that, while the number of children presenting to hospital following off-road motorcycle-related incidents is lower compared to other sports, the injury risk and severity is much higher for off-road motorcycle sports.[11, 12]

Consistent with Australian [2, 6] and International [3-5, 10] literature, children injured as a result of off-road motorcycle trauma were predominately young adolescent males. In the competitive motocross group there is an understandable selection bias influencing these demographic findings; *Motocross Australia* stipulate children must be aged 7 to 16 years to receive a junior motocross competition license. Whilst the peri-adolescent age group make up the majority of injured children, it is alarming that children under the age of 5 years are being exposed to the risks of off-road motorcycling. Even more concerning is the recognition that almost all children in this youngest age group were injured during recreational off-road motorcycling, i.e. without any of the safety-focussed provisions required of organised, regulated motocross events. Thus, our most vulnerable age group is being exposed to this high-risk activity, in what our study shows to be the most dangerous and lethal of settings, with no laws or regulations to curb exposure or risk. While no regulatory bodies, or other agencies, preside over recreational off-road motorcycle activities, the lack of a minimum age restriction and licensing for motorcycle activities on private land warrants further investigation. Without regulatory leadership and direction, with the clear and present dangers of off-road motorcycling for children, recreational and unregulated activities for children may well increase in popularity without opportunity for these children or their parents/carers to make decisions

informed by an understanding of the risks involved, including the risk of death demonstrated in this study.

Trauma from competitive motocross was greatest between March and May, which is consistent with existing literature describing seasonal trends in competitive paediatric motocross injuries, directly related to the scheduling of events [5, 27]. Alongside these seasonal trends, location of events in principally non-metropolitan settings, gives rise to predictable risks for smaller rural and regional healthcare services to be overwhelmed by sudden surges in trauma presentations during the competitive season, particularly at those times and places when large scale competitive events are scheduled. Such a scenario was experienced in regional Victoria in October 2017[2], when 24 patients made 26 presentations to Wimmera Base Hospital (WBH), during the week-long Australian Junior Motocross Championship. As outlined by Prabhakaran *et al.* in their report to the Medical Journal of Australia, 7.1% of all competitors in this Australian Junior Motocross Championship presented to WBH, which is a significant proportion of the riders. The authors noted that their estimates likely underestimate the full injury burden, given that some participants with minor injuries may not have presented to hospital.[2]

Like previous studies,[2, 5] the most common pre-hospital diagnosis recorded was ‘fractures’ followed by ‘unspecified pain’ and ‘lacerations’. The proportion of patients with a final diagnosis of ‘pain’ was greater for competitive patients than recreational patients. Whether this is due to competitive patients being presented to first aiders for immediate assessment at organised events or due to actual increased pain associated with competitive trauma is beyond the scope of this study. For recreational patients, presentation to EMS is at the discretion of the parents and may require long distance travel in rural and regional locations. Recreational patients presented with a greater proportion of ‘lacerations’ compared to competitive patients, which were likely the result of rural hazards such as wire fences, not usually found on formal race tracks.

Irrespective of whether competitive and recreational off-road motorcycle trauma, the most frequent treatment provided by EMS to injured children was provision of analgesia. This is consistent with ‘fractures’ and ‘unspecified pain’ being the most common pre-hospital diagnoses. It is important not to underestimate ‘unspecified pain’ as a final pre-hospital diagnosis. The lack of diagnostic imaging equipment in the pre-hospital environment, together with potential communication difficulties with paediatric patients, make pain and trauma assessment very complex, especially for the most severe

injuries (e.g. solid organ injuries).[27] For this reason, there is potential for the most severe injuries being initially underestimated or even missed in the pre-hospital environment.

A higher proportion of paediatric competitive motocross patients were transported by EMS to hospital compared to those injured in recreational off-road motorcycle activity (94.0% vs. 90.3%). However, a higher proportion of recreational patients were triaged pre-hospital as being 'time critical' and required a 'code 1 lights and sirens' emergency response (14.4% vs. 8.0%), suggesting that children injured in this recreational setting sustained potentially more serious injuries. Comparatively, in the competitive setting, the presence of on-scene first aid, stipulation of event regulations, and more immediate access to clinical care may introduce bias resulting in proportionally more patients being transported to hospital.

Limitations

The current paper is not without limitations. Firstly, the categorisation of patients into 'recreational' and 'competitive' groups was applied retrospectively, on the basis of the paramedic-recorded free text 'case description'. Thus, this categorisation is dependent upon interpretation and the detail provided by the individual EMS provider. For example, in some cases it was difficult to determine if patients were riding in competitive races or hiring a professional track for recreational riding. Furthermore, a number of patient care records described patients 'walking home from the track' to meet their parents, in which case it was difficult to categorise the case as competitive or recreational.

A number of patients were excluded from the current analyses, as they were pillion passengers participating in recreational riding activities. Pillion passengers are also at risk of injury, and have not been captured in this study. Hospital data was only available for confirmed major trauma patients, so it was not possible to follow the patient journey of non-major trauma patients beyond the pre-hospital setting. Further, the current study did not have access to specific event related information and as such incidence per event could not be determined.

Conclusion

Competitive motocross and recreational off-road motorcycle activities each present significant risk of morbidity and mortality to children in the state of Victoria. Four deaths between 2010 and 2017 and almost three percent of the sample confirmed as major trauma is suggestive of a significant problem with the safety of this increasingly popular sport. In competitive events, riders and parents need to be aware of these risks and in addition to the mandated safety precautions (e.g. protective clothing and equipment) there needs to be adequate on-site first aid facilities. Further, local

hospitals need to be informed so that preparations are in place for assessment of injured participants. Careful discussions and resource planning in the pre-hospital and hospital settings to cover both competitive motocross events and peak time periods for recreational off-road motorcycle activities is required to mitigate the risk and consequence of childhood injury due to these sports. Ultimately, broadening current regulation of age-based licensing together with mandated safety-focussed provisions for both organised and recreational motorcycle activities may be necessary with the aim of preventing death and severe injury in childhood.

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Conflict of interest

None to declare.

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Figure 1. Case selection and categorisation

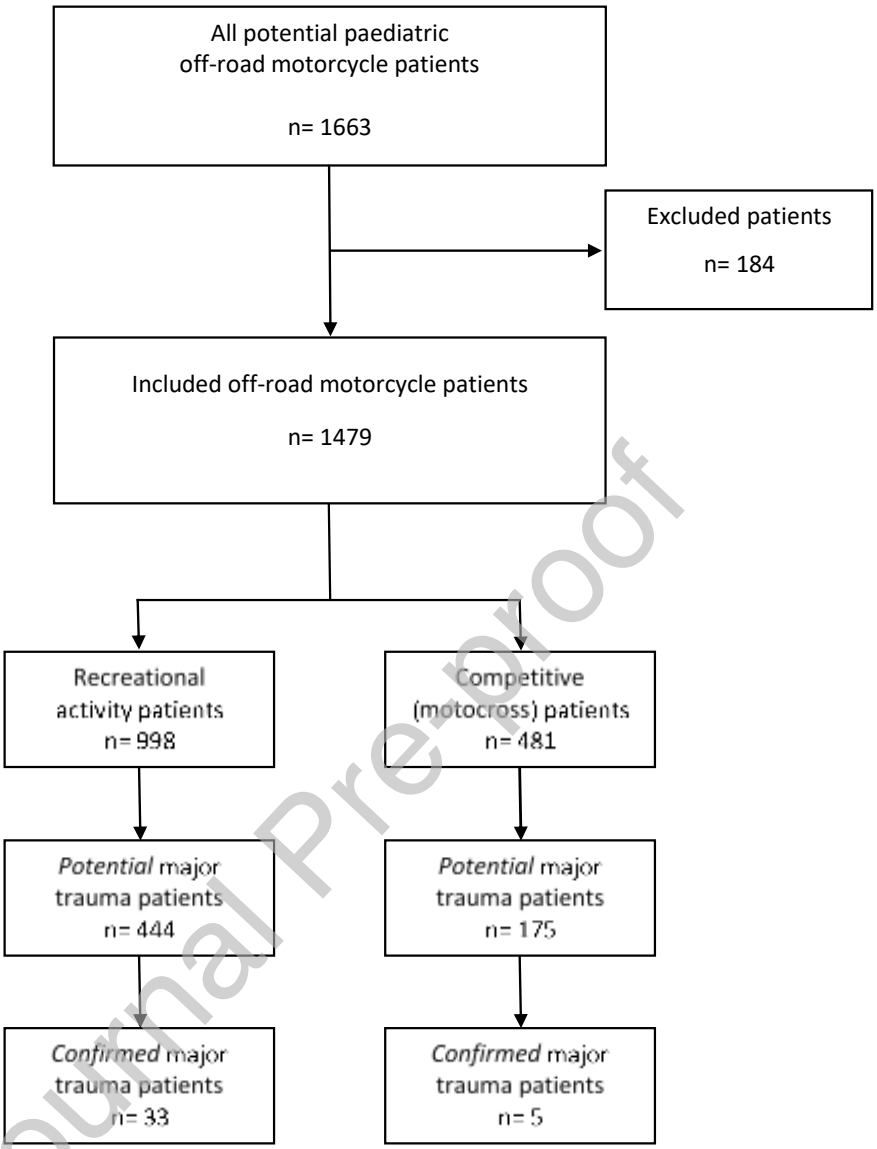

Figure 2. Summary of paediatric off-road motorcycle incidents attended by EMS in Victoria, Australia between 2010 and 2017

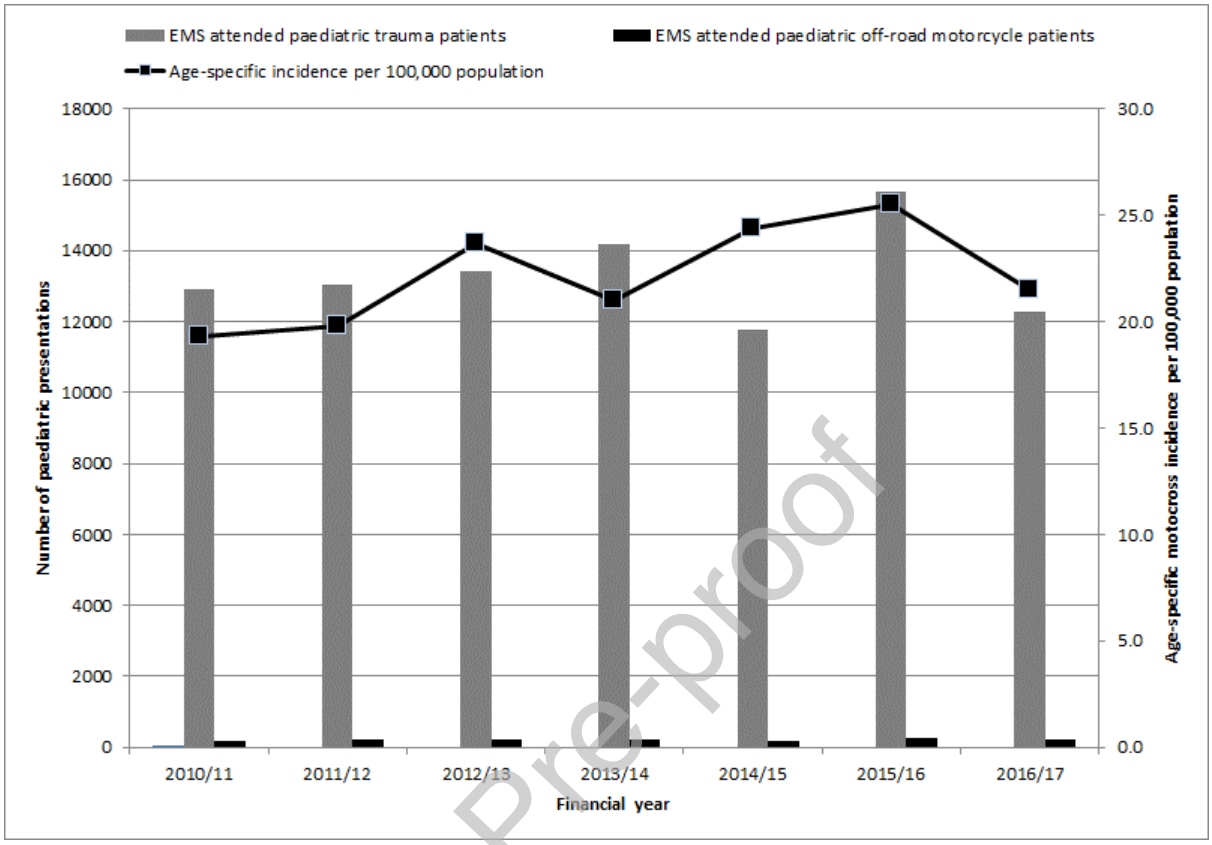

Figure 3. Odds ratios and 95% confidence intervals for predictors of transport to hospital for paediatric competitive motocross and recreational off-road motorcycle patients.

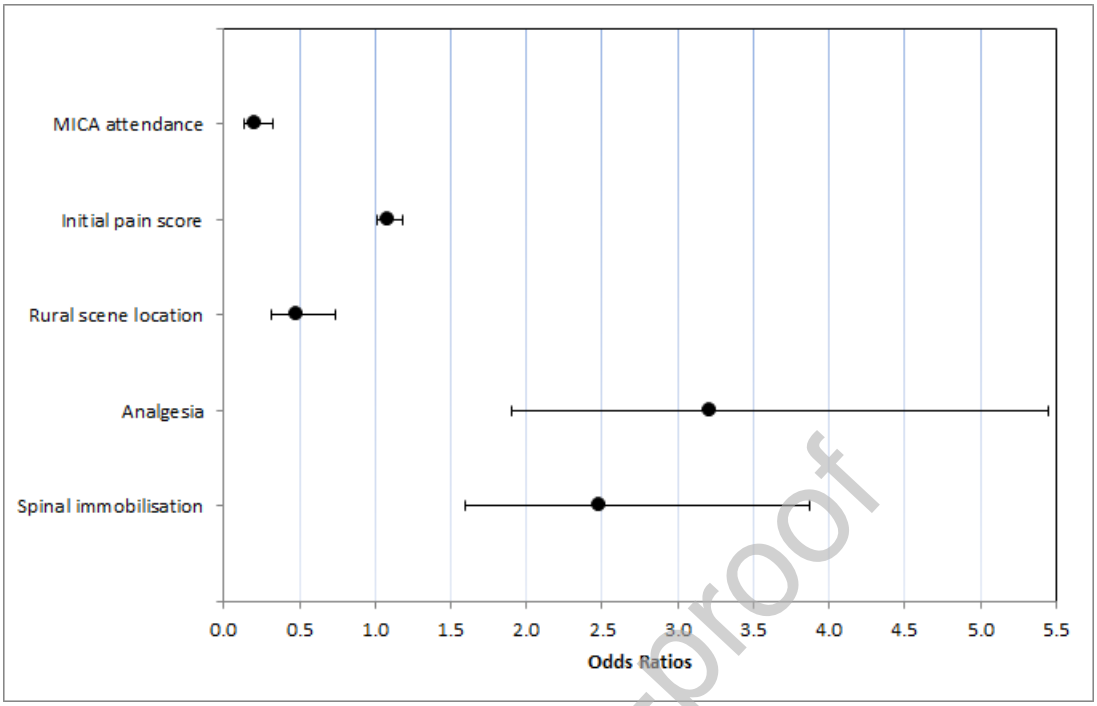

Table 1. Summary of the characteristics of EMS attended paediatric (age ≤ 15 years) off-road motorcycle trauma patients

Characteristics	Overall	Recreational	Competitive	p-value*
EMS attended patients	1,479	998 (67.5)	481 (32.5)	
Rural scene, n (%)	1,054 (71.3)	664 (66.5)	390 (81.1)	0.001
Gender (male), n (%)	1324 (89.5)	888 (89.0)	436 (90.6)	0.375
Age, median (IQR)	13 (10-14)	13 (10-14)	13 (11-14)	0.182
Age category, n (%)				
1 to 4 years	18 (1.2)	17 (1.7)	1 (0.2)	0.016
5 to 12 years	659 (44.6)	461 (45.7)	198 (41.2)	0.077
13 to 15 years	801 (54.2)	520 (51.5)	281 (58.4)	0.026
Scene type, n (%)				
Private residence	403 (27.2)	391 (39.2)	12 (2.5)	0.001
Public place	843 (56.9)	402 (40.3)	441 (91.7)	0.001
EMS transport, n (%)	1,353 (91.5)	901 (90.3)	452 (94.0)	0.019
Transport signal, n (%)				
Signal 1: Time critical	167 (12.3)	131 (14.4)	36 (8.0)	0.001
Signal 2: Acute non-time critical	1,142 (83.9)	748 (82.1)	394 (87.6)	0.054
Signal 3: Non-urgent	49 (3.6)	30 (3.3)	19 (4.2)	0.506
Air transport, n (%)	27 (1.8)	20 (2.0)	7 (1.5)	0.541
Case times (minutes), median (IQR)				
Response time	18 (12-29)	18 (12-30)	17 (12-26)	0.005
Scene time	22 (15-33)	24 (16-34)	20 (14-30)	0.001
Transport time	34 (19-52)	36 (21-54)	28 (16-48)	0.002
Total pre-hospital time	80 (57-110)	82 (59-119)	76 (54-96)	0.016

EMS: Emergency medical service; IQR: Inter-quartile range

*p-values are for the difference between recreational and competitive group proportions. Where frequency counts are < 5, p-values should be interpreted with caution due to the small sample size.

Table 2. Summary of major trauma characteristics and AIS-defined severe injuries (AIS score ≥ 3) for EMS attended paediatric (age <16 years) off-road motorcycle trauma patients

Characteristics	Overall	Recreational	Competitive	p-value*
Confirmed Major Trauma	38	33 (86.8)	5 (13.2)	0.011
Direct transport to a MTS	30 (79)	28 (85)	2 (40)	0.106
AIS severe injuries^, n (%)				
Abdominal	2 (5)	2 (6)	0	1.00
Head	9 (24)	9 (27)	0	0.474
Face	2 (5)	2 (6)	0	1.00
Neck	1 (2)	1 (3)	0	1.00
Thorax	11 (29)	8 (24)	3 (60)	0.332
Spine	5 (13)	5 (15)	0	0.946
Lower extremity	10 (26)	10 (30)	0	0.392
Upper extremity	1 (2)	1 (3)	0	1.00
Deceased in hospital, n (%)	2 (5)	2 (6)	0	1.00
ISS, median (IQR)	14 (14-22)	17 (14-23)	14 (13-17)	0.410
ICU admission with ventilation > 24 hours	9 (24)	8 (24)	1 (20)	1.00
Urgent surgery	5 (13)	5 (15)	0	0.946

^ Severe Injuries: AIS injury score ≥ 3; MTS: Major Trauma Service

* p-values are for the difference between recreational and competitive group proportions. Where frequency counts are < 5, p-values should be interpreted with caution due to the small sample size. Note there was one patient classified as major trauma but was missing AIS injury body region data. The patient's ISS was > 12.

Table 3. Summary of pre-hospital vital signs, injuries and managements for EMS attended paediatric (age <16 years) off-road motorcycle trauma patients

Characteristics	Overall	Recreational	Competitive	p-value*
EMS attended patients	1,479	998 (67.5)	481 (32.5)	-
Vital signs‡, n (%)				
GCS < 15	232 (15.6)	169 (18.7)	61 (14.2)	0.039
SPO2 < 90%	16 (1.1)	12 (1.9)	4 (1.3)	0.728
Aberrant pulse rate^	176 (11.9)	126 (13.1)	50 (10.5)	0.247
Aberrant respiratory rate**	25 (1.7)	20 (2.1)	5 (1.1)	0.434
Aberrant systolic blood pressure~	31 (2.1)	23 (2.4)	8 (1.7)	0.550
Specific injuries‡, n (%)				
Blunt head injury	82 (5.5)	63 (6.3)	19 (4.0)	0.077
Suspected spinal cord injury	56 (3.8)	31 (3.1)	25 (5.2)	0.072
Blunt abdomen	44 (3.0)	30 (3.0)	14 (2.9)	1.00
Blunt chest	33 (2.2)	24 (2.4)	9 (1.9)	0.656
Amputation or limb threat	30 (2.0)	18 (1.8)	12 (2.5)	0.486
Major compound fracture or open dislocation	19 (1.3)	17 (1.7)	2 (0.4)	0.055
≥ 2 fractured long bones	16 (1.1)	14 (1.4)	2 (0.4)	0.133
Other spinal injury	4 (0.3)	3 (0.3)	1 (0.2)	1.00
Burns injury	4 (0.3)	3 (0.3)	1 (0.2)	1.00
Fractured pelvis	3 (0.2)	3 (0.3)	0	0.614
Blunt neck	1 (0.1)	1 (0.1)	0	1.00
Pre-hospital management, n (%)				
Any treatment	1271 (85.9)	852 (85.4)	419 (87.1)	0.413
Analgesia	970 (76.3)	652 (76.5)	318 (75.9)	0.813
Splinting	424 (33.4)	291 (34.2)	133 (31.7)	0.591
Spinal Immobilisation	695 (54.7)	471 (55.3)	224 (53.5)	0.864
Intubation	16 (1.25)	15 (1.75)	1 (0.24)	0.031
CPR	4 (0.27%)	4 (0.40)	0	0.414
Deceased on-scene, n (%)	2 (0.1)	2 (0.2)	0	0.910

‡ Vital signs and Specific injuries as defined in the Ambulance Victoria trauma triage guidelines

^ Aberrant pulse rate: Age 1-4 years: < 90 or > 60; Age 5-12 years: < 80 or > 140; Age 13-15 years: < 60 or > 130

** Aberrant respiratory rate: Age 1-4 years: > 40; Age 5-12 years: > 30; Age 13-15 years: > 30

~ Aberrant systolic blood pressure: Age 1-4 years: < 70 mmHg; Age 5-12 years: < 80 mmHg; Age 13-15 years: < 90 mmHg

* p-values are for the difference between recreational and competitive group proportions. Where frequency counts are < 5, p-values should be interpreted with caution due to the small sample size.