7-year retrospective review of quad bike injuries admitted to Starship Children’s Hospital

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ABSTRACT

AIMS: To ascertain morbidity and mortality of children who presented to Starship Children’s Hospital with injuries from a quad bike incident from 2007 to 2014, and to review whether current guidelines are sufficient to prevent injury.

METHODS: A retrospective case note review of all children under the age of 16 years who presented to Starship Hospital with an injury sustained whilst riding a quad bike between January 2007 and July 2014.

RESULTS: Twenty-seven patients were identified through both the Starship Children’s Hospital Trauma and Paediatric Intensive Care databases with injuries resulting from a quad bike incident. Fifteen patients (56%) had multisystem injuries. The average injury severity score (ISS) was 14 (range 1-75). ISS was higher in those of younger age (<5 years), lower body weight (<20kg), requiring PICU admission and those sustaining head injuries with no helmet. Seven (25.9%) patients required PICU admission, two patients died (7.4%) and three patients (12%) survived to discharge with disability.

CONCLUSIONS: This study supports current published guidelines which recommend limiting the use of quad bikes by children. Current guidelines do not, however, prevent injury in the paediatric population.

All-terrain vehicles (ATVs), including quad bikes, are commonly used in New Zealand, with most of the estimated over 100,000 ATVs in New Zealand being used on farms.1 Quad bikes are defined as vehicles designed for off-road use with three or more wheels, an engine capacity exceeding 50cc and a gross weight of less than 1000kg.1 Adult-sized quad bikes are often defined by manufacturers as having an engine capacity exceeding 90cc and the weight of these vehicles ranges from 180-400kg.2

Quad bikes are often favoured as the primary form of farm transport,3 as they can carry significant weights and are faster than tractors or horses and have the ability to traverse inaccessible places.4 They are also increasingly being used for recreation and tourism. Although depicted as being fun and easy to use, they are motorised vehicles which have inherent risks and require skill and maturity to manoeuvre.

ATV accidents (including quad bikes) result in significant morbidity and mortality in all age groups.3,4,5 Due to safety concerns, three-wheeled ATVs are no longer sold in New Zealand, therefore this study is focused on quad bikes.2 These vehicles are designed for use by a single rider skilled in depth perception, navigation, distribution of weight and balance, and the Road Code. These specific skills differ from those required to ride a bicycle or other motorised vehicles and many (60.8%) accidents occur because of loss of driver control.5,7,8 Quad bikes are inherently unstable due to their high centre of gravity, short wheel base and narrow track width.5 An active riding technique involving movement,
strength and frequent weight adjustments is required to maintain stability, particularly when turning corners and to prevent rolling over on uneven terrain and slopes.\textsuperscript{7,8} Children lack the strength, weight and prerequisite skills required to handle quad bikes. Previous studies have demonstrated a disproportionate number of children involved in quad bike accidents sustain serious or fatal injuries.\textsuperscript{9}

In New Zealand, quad bikes are involved in approximately 28\% of all work-related farm deaths every year.\textsuperscript{10} The risk of injury due to quad bikes is 2.5 times higher in children than adults.\textsuperscript{10}

There are multiple recommendations published by New Zealand advisory bodies (Safekids, the Accident Compensation Corporation (ACC), Federated Farmers and Worksafe NZ) and quad bike manufacturers which strongly advise against the use of quad bikes by those less than 16 years of age. All new quad bikes in New Zealand have prominent warning labels which state that children under the age of 16 years should not ride an adult-sized quad bike, and manufacturers warn riders never to carry passengers. Despite this, children continue to be injured in quad bike accidents and New Zealand has not passed legislation to ensure safety guidelines are adhered to, as countries such as the United States and Canada have done.\textsuperscript{11}

Previous studies, including Anson et al,\textsuperscript{5} have demonstrated that the paediatric population is at higher risk of injuries from quad bike accidents and advocated for a change in legislation. Since publication of Anson’s paper, there have been changes to guidelines which recommend limiting the use of adult-sized quad bikes in children less than 16 years of age.\textsuperscript{1,8,12}

The aim of this study was to provide ongoing and updated information regarding morbidity and mortality of children involved in quad bike incidents over the last seven years, when the previous review (by Anson et al) was completed. The intention of a further review of children admitted to Starship Hospital with quad bike related trauma is to inform those tasked with ensuring legislation is effective in promoting child safety and injury prevention.

Methods

Ethics approval was obtained from the Ethics department of the Auckland District Health Board Research Review Board. Starship Hospital’s Paediatric Intensive Care Database, Trauma Database and hospital records were used to identify cases coded for ATV or quad bike trauma, admitted to Starship hospital between January 2007 and July 2014 and a retrospective case note review was undertaken of children under the age of 16 years requiring admission to Starship Hospital with confirmed ATV injuries.

A standardised questionnaire was completed by a single investigator. Data collected comprised weight, gender, ethnicity, age at the time of incident, type of ATV incident and engine size of ATV (if available), type and severity of injury as measured by the Injury Severity Score (ISS), the need for surgical or procedural intervention, the need for admission to the Paediatric Intensive Care Unit (PICU) and length of hospital stay (LOS). Morbidity (including long term disability) and mortality were reviewed. Data relating to environmental factors included the location of the incident (farm/recreational) and the position of the injured patient on the quad bike (rider, passenger, pedestrian).

Patients were further divided into age groups to assess injury, ISS, helmet use, long-term morbidity and mortality. The use of helmets in prevention of head injuries in quad bike accidents was also analysed.

Differences between groups were analysed with the Chi-square test for proportions and the Wilcoxon rank-sum test for continuous measures. A $p<0.05$ was deemed significant. Analysis was performed using Stata 13.1.

Results

Thirty-nine patients under the age of 16 years were identified as having a traumatic injury secondary to a possible quad bike incident. After review of case notes, 27 patients were confirmed with injuries resulting from a quad bike incident and 12 patients excluded due to non-quad bike related injuries.
The average age was 9.7 years (range: 1.8–14.5 years) and average weight 38.6kg (range 14.7–68kg). 51.8% of patients were aged 10 years or younger and 22.2% were aged less than 5 years (Table 1). The majority of patients were New Zealand European (Caucasian) (Figure 1).

Table 1: Demographics

<table>
<thead>
<tr>
<th>Gender</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>18</td>
<td>67</td>
</tr>
<tr>
<td>Female</td>
<td>9</td>
<td>33</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;5y</td>
<td>6</td>
<td>22.2</td>
</tr>
<tr>
<td>5-10y</td>
<td>8</td>
<td>29.6</td>
</tr>
<tr>
<td>&gt;10y</td>
<td>13</td>
<td>48.1</td>
</tr>
</tbody>
</table>

Documentation relating to the quad bikes was limited, with only 16 of the 27 (59.2%) patient notes recording details apart from wheel number, such as engine size. Of these 16 case notes, 10 (62.5%) had an adult-sized quad bike listed, six (37.5%) were described as a ‘children’s quad bike’ or ‘mini-quad bike.’ When compared to age, those in the <5 and >10 year groups were more likely to have sustained injuries on an adult-sized quad bike compared to those in the 5-10 year age group, with 67% of those in the under 5 year group on an adult-sized quad bike, 25% of those aged 5-10 years and 85% of those in the over 10 year group on an adult-sized quad bike, however, this result was not statistically significant ($p=0.141, \chi^2 = 3.91$).

The average injury severity score tended to be higher in those aged under 5 years (22.3 compared with 10.5 in those 5-10 years and 13.1 in those over 10 years) ($p=0.347$). Weight was demonstrated to have an inverse relationship in terms of injury severity score, with those weighing under 20kg having a higher ISS (23.9) compared with those weighing >20kg (12.1) (20-50kg – 5.2 and >50kg 17.5). This was a trend only and not significant ($p=0.116$).

Figure 2 demonstrates the mechanisms of injury resulting from quad bike accidents in our data group. In two incidents (7.4%), there was more than one mechanism involved in the accident, involving a fall from the quad bike and being run over by a quad bike (either the quad bike the patient was on or another quad bike).

70.4% of patients were injured while driving the quad bike with six (22.2%) being injured whilst a passenger, and one patient (3.7%) sustaining injuries whilst a bystander and there was no documentation available for one patient (3.7%). In 29.6% of cases, there was more than one person on the quad bike.

The majority of incidents occurred on a farm or at home (85.2%) with two incidents (7.4%) occurring at a recreational area and two (7.4%) not having the location recorded. The majority of patients were local to where the incident occurred (67%). The majority of accidents occurred on an off-road location (88.9%); two accidents (7.4%) occurred on road and in one (3.7%) incident, the location was not documented.

Helmets were documented as being worn in 33% of cases, a further third of cases were not wearing a helmet and another third had no documentation of a helmet being worn. Of the seven patients who sustained a documented head injury (25.9%; average ISS 19.4 (range 5-43), only one was wearing a helmet (14.2%; ISS 5) ($p=0.016, \chi^2 =5.844$). The other six not wearing a helmet had a demonstrated a higher average ISS of 21.8 (range 9-43) ($p=0.13$), although due to small patient numbers, this was not significant. 7.4% had documentation of other safety clothing being worn at the time of the incident.
Twenty patients sustained multiple injuries (74%) with 15 patients (75% of this subset and 55.6% overall) having more than one body system injured. The average injury severity score was 14 (range 1–75) and average length of hospital stay was 8.9 days (range 1–46 days).

Table 2 indicates the types of injuries incurred.

**Table 2: Anatomical distribution of injuries incurred in quad bike incidents**

<table>
<thead>
<tr>
<th>Type of injury</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>7</td>
<td>25.9</td>
</tr>
<tr>
<td>Face</td>
<td>3</td>
<td>11.1</td>
</tr>
<tr>
<td>Upper Limb</td>
<td>14</td>
<td>51.9</td>
</tr>
<tr>
<td>Chest</td>
<td>10</td>
<td>37</td>
</tr>
<tr>
<td>Abdomen/Pelvis/Genitalia</td>
<td>6</td>
<td>22.2</td>
</tr>
<tr>
<td>Lower limb</td>
<td>9</td>
<td>33.3</td>
</tr>
<tr>
<td>Back</td>
<td>10</td>
<td>37</td>
</tr>
</tbody>
</table>

Surgical or procedural interventions were required in 16 patients (59.2%). The most common operative intervention was orthopaedic (56%), followed by neurosurgical (25%) and general surgical (19%).

Seven patients (25.9%) required admission to the Paediatric Intensive Care Unit (PICU) of which two patients died, giving a mortality rate of 28.6% of PICU admissions due to quad bike injury and 7.4% of the patient group. Average length of PICU stay was 9.6 days (range 1–42 days) with one patient requiring readmission due to respiratory collapse. The length of hospital stay for patients requiring PICU admission was 21.4 days (range 5–42 days) compared with 4.5 days (range 1–46 days; median two days) for those not requiring PICU admission. The average injury severity score of PICU admissions due to quad bike injury was 33.8 (range 9–75). All patients admitted to PICU required intubation. The average length of intubation was 220 hours (range 18–923 hours). 57% of patients (14.8% of study group) admitted to PICU required inotropic support, with the average duration of inotropic support being 274 hours (range 24–732 hours).

Twenty-five (92.5%) patients survived to hospital discharge. Twenty-three patients (92%) were discharged directly home, and two patients (8%) were discharged to another care facility: one patient (4%) required discharge to a rehabilitation centre due to spinal injury and a further patient was transferred to another hospital for on-going care closer to the family home.

Of all 25 patients who survived to hospital discharge, three (12%) had ongoing disability. One patient had severe disability due to permanent spinal cord damage (4%), one patient had moderate disability with ongoing problems relating to balance and blank spells resulting from traumatic brain injury, and one had mild disability with concentration and fatigue issues from a traumatic brain injury.

Of those admitted to PICU, four (71.4%) survived to discharge, two of these patients were discharged home directly from Starship Hospital after a period out of PICU on the ward; one patient (14.3%) required rehabilitation and another was discharged to a peripheral hospital prior to going

**Figure 3: Type of quad bike injuries**

![Graph showing the distribution of injuries](image-url)
Three (42.9%) patients requiring PICU admission had an ongoing disability and 28.6% died in PICU. One patient required in-patient rehabilitation due to a spinal cord injury, and two required outpatient occupational review and follow-up due to head injuries.

There were two in-hospital deaths in our study group. The first was a 12-year-old child with severe crush injuries, who had a prolonged PICU admission complicated by renal failure, rhabdomyolysis and resistant soft tissue fungal infection culminating in overwhelming sepsis. The second was a 4-year-old passenger who was garrotted by wire strung between two trees and died from high cervical spine injury.

Discussion

Despite recent changes to guidelines, this study highlights the need for ongoing focus on the use of quad bikes by children. As shown previously,5,6,13,14 this study demonstrates that most of the children injured in quad bike accidents were Caucasian boys under the age of 10, injured at home or on a farm in their familiar environment.

This study focused on injuries leading to hospital admission, which comprise only a fraction of the injuries and deaths that occur overall. Although injuries requiring hospitalisation result in significant morbidity and mortality, it does not take into account those who died prior to hospital admission.

New Zealand’s Health Quality and Safety Commission’s Child and Youth Mortality Review Committee (CYMRC) released a report in December 2014 which reviewed injuries and deaths in children aged 15 years and under, associated with off-road accidents involving quad bikes, motorcycles and motorised agricultural vehicles from 2002–2012.10 Twelve deaths associated with quad bike incidents were identified over this time.

Many international groups, including The American Academy of Pediatrics’ Committee on Injury and Poison Prevention, the Canadian Pediatric Society’s Injury Prevention Committee, and Farmsafe Australia, have recommended that children aged less than 16 years be prohibited from operating any quad bike, including those designed and marketed for children.15,16,17 This is in contrast to New Zealand, where the Accident Compensation Corporation (ACC), Ministry of Business, Innovation and Employment (MBIE) and Safekids Aotearoa have recommended children aged under 16 years should not ride adult-sized quad bikes (those with an engine capacity exceeding 90cc).1,8,12 Currently, in New Zealand, there is no formal recommendation that children should not ride smaller quad bikes. It is difficult to make categorical recommendations relating to smaller quad bikes, despite the findings of this study and that of the CYMRC due to the lack of documentation regarding engine size of the quad bikes involved in accidents. Improvement in data collection from all off-road vehicle crashes would allow an evidence-based decision to be made on this issue.10 However, in keeping with overseas recommendations and consistent with current New Zealand legal driving age for on-road vehicles, we would favour a more cautious approach, in which no child under the age of 16 years be allowed to ride a quad bike of any size.

New Zealand has a mandatory toy safety standard that applied for all toys sold for use which are designed for children up to the age of three.18 It protects against unintentionally giving young children products that can harm or kill them. In contrast, once a child turns four years of age, they can be given a child-sized quad bike to ride. This demonstrates a dangerous gap between the reality of what we know harms children and what children can manage and a perception of what is a safe toy for children over the age of three.

Safety standards do need to be mandated. Although there could be a focus on making quad bike design safer, this does not take into account that children lack the appropriate developmental ability to manage any form of quad bike. Children do not possess the skill-set required to handle quad bikes adequately and are unlikely to understand how to respond to specific situations, such as correcting driving errors and avoiding potential accidents. By allowing children to ride quad bikes, which are inherently unstable and powerful, children are at risk of significant injury or death, which occur despite the recommendations by multiple
groups including manufacturers, Federated Farmers, ACC and SafeKids. Although a positive step, current guidelines are not reducing morbidity and mortality for children. Legislation prohibiting the paediatric population riding quad bikes is the appropriate next step if we are to prevent ongoing injuries from quad bikes. Although difficult to enforce such legislation, particularly when off-road or on private property, there is increasing focus on the importance of this.11,19 In 2014, WorkSafe NZ took legal action against those who display risky behaviours on quad bikes, despite repeated warnings by regulatory bodies.20 Despite recommendations, children continue to ride adult-sized quad bikes.

Guidelines also preclude carrying passengers on quad bikes, but 22.2% of our patients were passengers and 29.6% were on a quad bike with one or more passengers. Many guidelines strongly state quad bikes are to be used for off-road purposes only and in our study 7.4% were used on-road.

If current guidelines had been adhered to in our study group, such that no children aged less than 16 years of age were riding an adult quad bike (engine size >90cc), none were carrying passengers and all were off-road, there would have been a 56% reduction in injury and a 71% reduction in PICU admission. There would have been a 67% reduction in long-term disability and a 100% reduction in mortality. Although helpful, recommendations are simply not sufficient if we are to prevent ongoing injury to children due to the lack of adherence to guidelines by those supervising them.

There is no law requiring quad bike riders to wear helmets off-road, but a number of government agencies highly recommend that a helmet be worn at all times.1,4,7,8,12,21 This study (as in previous studies5,6,22) supports the use of helmets to reduce head injury.

There are several limitations of this study. As a retrospective study of a single institution, it may not give a good representation of the admissions for quad bike injuries that occur nationally. However, Starship Hospital is a tertiary referral centre with the only Paediatric Intensive Care Unit in the country. It would therefore be anticipated that the most severely injured patients would present or be transferred to our institution. We, therefore, would expect to see the vast majority of the most severely injured patients from quad bike accidents. This study did not include pre-hospital deaths or deaths occurring at another hospital before transport to our PICU could be arranged and as such would underreport the paediatric mortality from quad bike accidents. The CYMRC reported that there were 12 deaths due to quad bikes in the paediatric population in New Zealand between 2002-2012.10 This included all pre- and in-hospital deaths, however they did not detail the percentage of deaths occurring in the pre-hospital setting.

**Conclusion**

A significant number of paediatric patients require hospitalisation due to preventable severe injuries sustained from quad bikes in New Zealand, with age and weight inversely related to severity of injury.

Current recommendations advocate against children under the age of 16 years driving or being passengers on quad bikes. Despite this, there has been no decrease in the numbers of children and adolescents riding quad bikes. This study provides support to the growing body of evidence to support legislation mandating against children under the age of 16 riding quad bikes to prevent further injury and deaths.

Enforcing such a mandate may be difficult, but legally defining age limits for quad bike use may in itself lead to decreased use of quad bikes by children in New Zealand. Until such a mandate is in place, it will be important to assess ongoing injury rates and advocate for our children’s safety.
ARTICLE

Competing interests: Nil

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REFERENCES:
3. Basham M, Nicholis M, Campbell M. The ABCs of ATVs: factors implicated in child deaths and injuries involving all terrain vehicles on New Zealand farms. Project from the Department of Societies and Cultures, Faculty of Arts and Social Sciences, The University of Waikato. 2006.
8. New Zealand Land Transport Authority. Available at: www.ltsa.govt.nz
10. Health Quality & Safety Commission New Zealand – Child and Youth Mortality Review Committee (Dec 2014): Child and youth mortality from motorcycle, quad bike and motorised agricultural vehicle use with a focus on deaths under age 15 years.