TITLE PAGE

Title: Paediatric recreational vehicle-related head injuries presenting to the Emergency Department of a major paediatric trauma centre in Australia: is there room for improvement?

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ABSTRACT

Objective: This study examines clinical characteristics and helmet use of children presenting to the ED with a recreational vehicle (RV)-related head injury (HI).

Methods: Observational retrospective study of children <18 years presenting with an RV-related HI to the ED of a state-wide paediatric trauma centre in Australia between April 2011 and January 2014.

Results: In the 647 presentations identified, corresponding to 7.5% (95%CI 7.0-8.1%) of all HI presentations, RVs involved were bicycles (36.3%), push scooters (18.5%), motorcycles (18.4%), horses (11.7%), skateboards (11.6%), quadbikes (2.8%), and go-karts (0.6%). Recorded helmet use was the highest in motorcycle, horse and bicycle riders (83.2%, 82.9% and 65.1% respectively), and the lowest for push scooter (25.8%) and a skateboard riders (17.3%). Overall 23% underwent a CT scan, 8.8% had intracranial injuries on CT, 30.6% were admitted and 2.2% underwent neurosurgery. Push scooter-related HIs were the least severe. Age (in years), riding a motorised vehicle, and not wearing a helmet were independently associated with intracranial injuries on CT on multiple logistic regression (OR 1.1, 95%CI 1.0-1.2; OR 2.4, 95%CI 1.3-4.6 and OR 6.0, 95%CI 3.2-11.2 respectively).

Conclusion: RV-related HIs accounted for a non-negligible proportion of paediatric HIs presenting to the ED and for significant morbidity and use of hospital resources. Interventions such as introduction of mandatory helmet use for off-road motorised vehicle riding as well as skateboard riding in children, enhanced injury prevention campaigns and strict adult supervision during motorised vehicle riding may reduce the morbidity and health care costs associated with paediatric RV-related HIs.

Keywords: accident and emergency department, head trauma, paediatrics, off-road motor vehicles.

MAIN TEXT

INTRODUCTION

Head injuries (HI) are one of the most common reasons for presentation to the paediatric ED and the leading cause of death and disability in children older than 1 year.[1] Trauma associated with the use of recreational vehicles (RV) represents a growing cause of HIs.[2-4] Of all RV-related injuries, HI is associated with the highest rates of admission, long-term disability and death.[3,5]

Helmet use reduces the risk of death and severe HI in both non-motorised[5-7] and motorised[2,4] RV-related incidents. Introduction of mandatory helmet laws has proven effective in increasing helmet use in bicycle riders in a number of jurisdictions (in Australia, Canada, and the United States).[8,9] In jurisdictions without helmet legislation, community based observational studies of children riding bicycles, push scooters or skateboards have found rates of helmet use to be less than 50%.[10,11]

In Australia, RV-related helmet use is mandated across a spectrum of activities and settings and in a variety of ways. The state of Victoria was the first state in the world to legislatively mandate on-road helmet use for motorcycles in 1961.[12] In 1990, helmet use became mandatory for cyclists and their passengers. However, according to the Australian Road Rules, a person in or on a wheeled recreational device or wheeled toy (i.e. skateboard or scooter) is a pedestrian, and helmet use is not compulsory.[13] For horse riders younger than 18 years of age, helmet use is compulsory when riding on a road.[14] The use of helmet is also mandated in many competition settings, particularly motorcycle and equestrian events.[15,16]

Little is known about the frequency of ED presentations of children with RV-related HI, their clinical characteristics and helmet use, both in settings with and without mandatory helmet laws. Most studies include data on a mixed paediatric and adult populations,[4,11,17,18] focus on broader paediatric HI populations,[18] on specific RVs,[4,7,17,19] or examine helmet use alone.[10,11]

The aim of our study was to describe the frequency, clinical characteristics and helmet use of children presenting with an RV-related HI to the paediatric tertiary care ED of the sole paediatric trauma centre in the state of Victoria, Australia.

MATERIALS AND METHODS

Study design and setting

Single-centre retrospective study of patients presenting to the ED of the Royal Children's Hospital (RCH), Melbourne, Australia for HIs related to the use of an RV. The RCH is a tertiary-care teaching hospital and the only paediatric trauma centre in the state of Victoria, with a yearly census of 82,000 visits of children less than 18 years.

Study Population

We included children under 18 years who presented to the ED between April 2011 and January 2014 with an RV-related HI. Study subjects were identified by searching the field "triage presentation complaint" of the electronic ED database (ED Information System, EDIS, version 12.1.1B5, Australia) for the following keywords: bike (for bike, motorbike), quad, all-terrain vehicle, kart (for go-kart or karting), cycle (for bicycle and motorcycle), cyclist, bmx, scooter, skateboard, horse, pony, ride, riding, rodeo, gymkhana, and helmet. Cases identified through the search strategy were manually reviewed.

Exclusion criteria were: presentation not due to an RV-related injury, presentation for an RV-related injury not associated with an impact to the head, medical charts not retrievable, patients left without being seen by the ED physician, or representation for the same HI. The final study population was cross-matched with the database of a prospective study on HIs, running at the RCH ED since April 2011, the Australasian Paediatric Head Injury Rules Study(APHIRST).[20] For patients also enrolled in APHIRST, clinical data were retrieved by the prospectively completed clinical report forms. In order to ensure consistent data collection for patients satisfying inclusion criteria for our study, but not enrolled in APHIRST, APHIRST clinical report forms were used. Additional data on helmet use and type of RV involved were extracted from chart review for all patients.

Chart review guidelines were followed.[21] The primary data abstractor (MD) received formal training in medical records review, but was not blinded to the study objectives. Ambiguous data were discussed with two other investigators (SB and FB). In order to minimize possible selection bias, 20% of the overall retrieved records not included in APHIRST were randomly selected and reviewed by a second investigator (SB) for inter-rater agreement with respect to meeting study exclusion criteria.

Definitions

Recreational vehicle: for the purpose of this study RVs include bicycles, push scooters, skateboards, horses, motorcycles, quadbikes, and go-karts.

Helmet use: defined as "yes" when its use was documented, "no" when clinical notes reported that a helmet was not used, and "not documented" if no information on helmet use was recorded.

Head injury: any trauma involving the head.

RV-related injuries other than HI – isolated or combined facial/torso/limb injuries: chin, lips or dental injuries and injuries below the nasal bridge and the zygomatic prominences/injuries to the chest, abdomen, pelvis/upper or lower limb(s), without HI as per clinical notes.

Statistical Analysis

Categorical variables were reported as percentages and 95% confidence intervals (CI). Continuous variables were described using medians and interquartile ranges (IQR). Group comparisons were performed by means of Chi-squared tests for categorical variables, or Mann-Whitney U-tests for continuous variables with non-parametric distributions. The κ statistic was used to determine inter-rater agreement. Logistic regression, including multiple logistic regression analysis, was used to assess associations between categorical dependent variables and one or more independent variables. Odds Ratios (ORs) were reported. Data were entered into a REDCap database (version 5.10.2) and were analysed using Stata (version 13.0, StataCorp, College Station, Tex, USA).

The study was approved by the hospital ethics committee.

RESULTS

A total of 647 presentations were included (Figure1), corresponding to 7.5% (95%CI 7.0-8.1%) of all HI presentations during the study period. The k value for inter-rater agreement on the selection process of retrieved records was 0.9 (95%CI 0.9-0.9).

The majority of patients, 506 (78.2%, 95%CI 74.8-81.3), sustained a HI while riding a non-motorised vehicle (bicycle, n=235; scooter, n=120; horse, n=76; and skateboard, n=75), while 141 (21.8%, 95%CI 18.7-25.2) were riding a motorised vehicle (motorcycle, n=119; quadbike, n=18; and go-kart, n=4) at the time of the incident (Table 1). The median age of the total population was 11.8

years (IQR 7.5-14.5), and the majority overall and in all subgroups except horse riding, were males, 469 (72.5%, 95%CI 68.9-75.9).

Overall 13% of patients were transferred from another hospital, 8.7% had a GCS<14 on arrival, 23% underwent a CT scan, 8.8% had intracranial injuries other than isolated skull fractures on CT, 30.6% were admitted to the hospital and 2.2% needed neurosurgery.

Helmet use was documented in 552 (85.3%, 95%CI 82.4-88.0) patients, with 368 (66.7%, 95%CI 62.6-70.6) wearing a helmet at the time of injury. Patients with no documentation of helmet use had a less severe HI, higher GCS, lower rate of traumatic injuries on CT and shorter length of stay (LOS) (Table 2). Recorded helmet use was the highest for motorcycle and horse-riders and the lowest for push-scooter and skateboard-related HIs. Push scooter-related HIs affected the youngest age group, had the lowest CT rate (14.2%), were most often discharged from the ED and had the shortest LOS. In contrast, skateboard-related HIs more commonly affected teenage boys, had the highest CT rate (32%), but similar neurosurgery rate and LOS compared with the other non-motorised RVs.

Overall patients who did not wear a helmet were more likely to undergo head CT scan (OR 2.4, 95%CI 1.6-3.4), to have traumatic injuries on CT (OR 4.0, 95%CI 2.3-6.9), and to undergo neurosurgery (OR 7.0, 95%CI 1.9-25.7). Demographics and clinical characteristics of children with and without helmet use are reported in Table 2. The only death in our population was a 15-year-old male who had an off-road motorcycle crash against a fixed object whilst reportedly wearing a helmet. He sustained unsurvivable head and cervical spinal cord injuries.

Patients who sustained a HI while riding a motorised vehicle were more severely injured (lower GCS, higher proportion of associated extra-cranial injuries, higher rates of transfer from other facilities, of admissions to ICU, and LOS) (Table 3). They were also more likely to undergo head CT scan (OR 1.9, 95%CI 1.2-2.9), to have traumatic injuries on CT (OR 3.7, 95%CI 1.2-11.6) and undergo neurosurgery (OR 5.0, 95%CI 1.7, 14.7). Within the motorised vehicle group children riding quadbikes were younger and had lower rates of helmet use. Despite this, quadbike-related accidents were not more likely to be associated with traumatic injuries on CT compared with motorcycles (OR 0.9, 95%CI 0.4-2.1 and OR 0.6, 95%CI 0.1-2.6 respectively, adjusted by age, gender and helmet use).

Clinical characteristics of patients with and without intracranial injuries on CT (excluding isolated skull fractures) are reported in Table 4. A multiple logistic regression model including patient risk factors for intracranial injury (age, sex, recreational vehicle type and helmet use) found that age (in years), riding a motorised vehicle, and not wearing a helmet were independently associated with intracranial injuries on CT (OR 1.1, 95%CI 1.0-1.2; OR 2.4, 95%CI 1.3-4.6 and OR 6.0, 95%CI 3.2-11.2 respectively).

DISCUSSION

Our study shows that RV-related HIs account for a non-negligible proportion of all HIs presenting to the ED of a paediatric trauma centre and for a significant morbidity and use of hospital resources. Although the majority of HIs occurred whilst riding non-motorised RVs, motorised RVs accounted for the most severe cases. As expected, helmet use was associated with less severe HIs. On multivariate logistic regression analysis age, riding a motorised vehicle and not wearing a helmet resulted independent risk factors for intracranial injuries on CT.

In our study documentation of helmet use in the clinical notes overall was high, considering the retrospective nature of the dataset. Documentation was mostly missing for children injured whilst riding a push-scooter or a skateboard, where there is no legal obligation or code requiring helmet use in the local setting. For bicycles and motorcycles, where on-road helmet use is nationally legislated, the documentation was greater than 95% and was higher than previously reported documentation rates (between 50 and 70%).[3,11,19] This is despite the fact that for the paediatric population, motorcycle use is almost exclusively off-road, where the Australian Road Rules do not apply.[11] In Victoria, children younger than 18 years are unable to obtain a motorcycle licence for on-road use.[22,23] Whilst helmet use is also legislated for on-road horse riding, the majority of time is spent riding off-road.[14,24] However, there is a strong culture both within the horse and motorcycle-riding communities of helmet use, particularly in competition settings where there are rules regarding helmet use.[15,16]

In our study population helmet use varied by RV type and within subgroups of motorised and non-motorised RVs. We found a very high rate of positive helmet use for motorcycle and horse riders, with an increase over time compared to previous studies conducted at our institution (from 73% to 83% for motorcycles and from 50% to 83% for horse-related HIs).[18,19] In contrast, a helmet was worn in less than 40% of children who sustained a quadbike-related HI. Quadbikes may be conditionally registered for on-road use, predominantly for movements between properties; however, the majority of riding time occurs off-road, where the helmet requirements of the Australian Road Rules do not apply.[13] In addition, the false community perception that quadbikes are more stable and therefore less dangerous vehicles may explain the low rate of helmet use. Quadbike riding in Australia is still predominantly related to work or informal recreational use rather than competition-related, where again, competition codes might encourage helmet use. Despite a lower rate of helmet use quadbikes were no more likely to be associated with traumatic injuries on cranial CT compared with motorcycles. It is unclear whether this might be related to the different mechanism of injury (with higher impact energy transmitted to the head in motorcycle-related incidents) or whether the low number of quadbikes related HIs in our study may account for the non-significant finding.

Helmet use amongst children presenting with a bicycle-related HI was only 65%, and lower than the estimated 75% usage rate reported in the year following the introduction of mandatory helmet wearing regulation in 1990.[22] However our data may not be representative of the general population, as children who present to the ED of a tertiary-care and sole state trauma centre, may be more severely injured as a consequence of not wearing the helmet.

While studies on push-scooter-related injuries showed that a HI is sustained in approximately 30% of patients,[25] scarce data are available on the severity of scooter-related HIs relative to helmet use. In our study push-scooter-related HIs were less severe compared with other RVs. They occurred in younger children who probably sustained a lower energy mechanism of injury, as they are less likely to be riding on-road or engaged in stunt riding. However, helmet use was not documented in more than one third of these patients.

Presentations due to skateboard and horse-related HIs were similar in number in our sample. Compared with horse-related HI presentations, skateboarders had a higher rate of CT scan and traumatic injuries on CT. This may be explained by a lower rate of helmet use in this group of patients, the impact surfaces (concrete coping and curbs compared to natural surfaces), and the risk-taking behaviour typical of adolescent males that may lead to higher energy mechanisms of injury.

Our ED data including a broad spectrum of paediatric RV-related HIs highlight opportunities for targeted injury-prevention strategies to further reduce related morbidity and use of hospital resources. ED physicians may also play an important role in enhancing injury-prevention education for these children and their families.

Limitations

Children wearing helmets may, in the event of a HI, be less likely to present to ED, particularly if the incident involved a HI in isolation with only mild symptoms. This presentation bias may select for children not wearing helmets, and may account for the lower than expected positive helmet use particularly amongst young cyclists. However the aim of our study was to examine the burden and clinical characteristics of RV-related HIs presenting to the ED of a paediatric trauma centre and not to provide estimates of helmet use in the general paediatric population.

The sensitive search strategy used to identify children who sustained an RV-related HI ensured broad data capture and reduced the possibility of selection bias. In addition, as the majority of our cases were also prospectively identified through the APHIRST study,[20] which was designed to capture HI of any severity, we believe this selection bias may be less significant than compared with an entirely retrospective cohort.

While we followed recommendations for high quality medical record review[21] our retrospective single-centre design has limitations, in particular with regards to accuracy of data reporting and generalizability.

CONCLUSIONS

RV-related HIs accounted for a non-negligible proportion of paediatric HIs presenting to the ED of the sole paediatric trauma centre in Victoria and for significant morbidity and use of hospital resources. Interventions such as introduction of mandatory helmet use for off-road motorised vehicle riding as well as skateboard riding in children, enhanced injury prevention campaigns and strict adult supervision during motorised vehicle riding may reduce the morbidity and health care costs associated with paediatric RV-related HIs.

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Conflict of Interest: Franz Babl is a Section Editor, Paediatrics Emergency Medicine, for EMA. .

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Figure legends

Figure 1. Flow chart of medical record selection

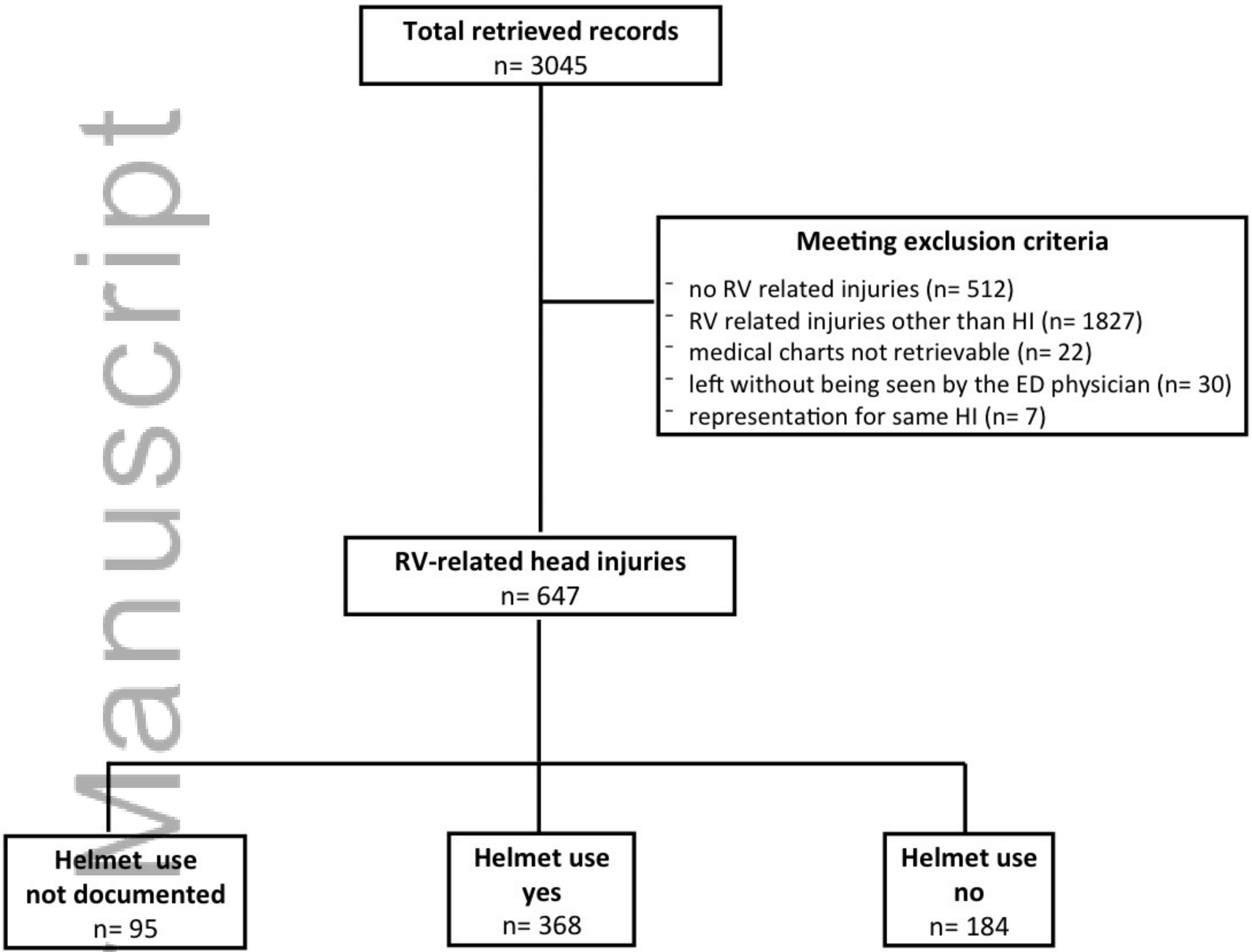

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Table 1. Demographics and clinical characteristics of patients according to type of RV involved

	Total n=647	Bicycle n=235	Scooter n=120	Motorcycle n=119	Horse n=76	Skateboard n=75	Quad n=18	Go-kart n=4
Age (median, IQR)	11.83 (7.41-14.52)	10.92 (5.87-14.63)	7.66 (4.64-10.59)	13.47 (11.45-15.15)	12.80 (9.95-15.17)	13.55 (11.11-15.23)	10.83 (7.53-13.22)	13.39 (9.43-15.07)
Age group % (n)								
- < 5 years	13.8 (89)	20.0 (47)	29.2 (35)	1.7 (2)	1.3 (1)	1.3 (1)	16.7 (3)	0.0 (0)
- ≥ 5 and < 10 years	26.3 (170)	27.2 (64)	44.2 (53)	14.3 (17)	23.7 (18)	16.0 (12)	27.8 (5)	25.0 (1)
- ≥ 10 and <15 years	40.0 (259)	32.8 (77)	23.3 (28)	57.1 (68)	47.4 (36)	54.7 (41)	38.9 (7)	50.0 (2)
- ≥ 15 and < 18 years	19.9 (129)	20.0 (47)	3.3 (4)	26.9 (32)	27.6 (21)	28.0 (21)	16.7 (3)	25.0 (1)
Sex % (n)								
- Male	72.5 (469)	79.6 (187)	75.0 (90)	84.9 (101)	14.5 (11)	90.7 (68)	66.7 (12)	0.0 (0)
- Female	27.5 (178)	20.4 (48)	25.0 (30)	15.1 (18)	85.5 (65)	9.3 (7)	33.3 (6)	100.0 (4)
Helmet use % (n)								
- YES	56.9 (368)	65.1 (153)	25.8(31)	83.2 (99)	82.9 (63)	17.3 (13)	38.9 (7)	50.0 (2)
- NO	28.4 (184)	29.4 (69)	37.5 (45)	14.3 (17)	9.2 (7)	48.0 (36)	55.6 (10)	0.0 (0)
- Not documented	14.7 (95)	5.5 (13)	36.7 (44)	2.5 (3)	7.9 (6)	34.7 (26)	5.6 (1)	50.0 (2)
Associated extra-cranial injuries								
- Face/neck	27.2 (176)	27.2 (64)	28.3 (34)	28.6 (34)	35.5 (27)	12.0 (9)	27.8 (5)	75.0 (3)
- Upper limbs	11.0 (71)	8.9 (21)	7.5 (9)	16.8 (20)	6.6 (5)	18.7 (14)	11.1 (2)	0.0 (0)
- Torso	7.4 (48)	6.4 (15)	3.3 (4)	17.7 (21)	4.0 (3)	1.3 (1)	16.7 (3)	25.0 (1)
- Lower limbs	6.5 (42)	1.7 (4)	4.2 (5)	21.9 (26)	1.3 (1)	4.0 (3)	11.1 (2)	25.0 (1)
GCS † % (n)								
- 14-15	90.3 (584)	94.0 (221)	94.2 (113)	84.0 (100)	90.8 (69)	85.3 (64)	72.2 (13)	100.0 (4)
- 9-13	7.1 (46)	4.7 (11)	5.0 (6)	9.2 (11)	7.9 (6)	10.7(8)	22.2 (4)	0.0 (0)
- 3-8	2.6 (17)	1.3 (3)	0.8 (1)	6.7 (8)	1.3 (1)	4.0 (3)	5.6 (1)	0.0 (0)
Transfers from other hospital % (n)	13.0 (84)	11.5 (27)	6.7 (8)	19.3 (23)	14.7 (11)	14.7 (11)	16.7 (3)	25.0 (1)
CT scan performed % (n)								
- at referring hospital	6.0 (39)	5.5 (13)	1.7 (2)	6.7 (8)	7.9 (6)	12.0 (9)	5.6 (1)	0.0 (0)
- at RCH ED	17.0 (110)	13.2 (31)	12.5 (15)	26.1 (31)	14.5 (11)	20.0 (15)	38.9 (7)	0.0 (0)
Traumatic injuries on CT % (n)								
- Isolated Skull Fractures	1.4 (9)	2.6 (6)	1.7 (2)	0.0 (0)	0.0 (0)	1.3 (1)	0.0 (0)	0.0 (0)
- Intracranial injuries	8.8 (57)	4.7 (11)	4.2 (5)	12.6 (15)	9.2 (7)	20.0 (15)	22.2 (4)	0.0 (0)
Disposition % (n)								
- Discharged from ED	69.0 (446)	78.3 (184)	85.0 (102)	40.3 (48)	65.3 (49)	69.3 (52)	50.0 (9)	50.0 (2)
- Admitted to WARD only	27.5 (178)	19.6 (46)	14.2 (17)	50.4 (60)	32.9 (25)	28.0 (21)	38.9 (7)	50.0 (2)
- Admitted to PICU	3.1 (20)	1.7 (4)	0.0 (0)	8.4 (10)	2.6 (2)	2.7 (2)	11.1 (2)	0.0 (0)
Neurosurgical intervention % (n)	2.2 (14)	1.3 (3)	0.8 (1)	5.9 (7)	1.3 (1)	1.3 (1)	5.6 (1)	0.0 (0)
Total LOS hours (median, IQR) (n=646)	4.29 (2.50-23.81)	3.96 (2.37-15.69)	2.90 (1.67-4.88)	24.07 (4.38-88.83)	5.51 (2.63-23.81)	3.95 (2.35-25.58)	34.28 (4.31-76.02)	26.87 (4.31-81.70)

IQR = Interquartile Range; GCS = Glasgow Coma Scale; CT = Computed Tomography; RCH = Royal Children's Hospital; ED = Emergency Department; PICU = Paediatric Intensive Care Unit; LOS= Length of Stay

† At time of initial hospital assessment (RCH ED for direct access patients, referring centre for transferred patients)

Table 2. Demographics and clinical characteristics of patients with and without documentation of helmet use

	Helmet use documented n=552			Helmet use NOT documented n= 95	
	Helmet YES n = 368	**Helmet NO n= 184**	**p** *		**p** **
Age (median, IQR)	12.33 (8.85 – 14.81)	11.49 (6.90 – 14.41)	0.046	9.12 (5.71 – 12.48)	<0.001
Age group % (n)					
- < 5 years	12.2 (45)	14.1 (26)		19.0 (18)	
- ≥ 5 and < 10 years	21.2 (78)	28.8 (53)		41.1 (39)	
- ≥ 10 and <15 years	43.5 (160)	38.0 (70)		30.5 (29)	
- ≥ 15 and < 18 years	23.1 (85)	19.0 (35)	0.162	9.5 (9)	<0.001
Sex % (n)					
- Male	70.4 (259)	76.6 (141)		72.6 (69)	
- Female	29.6 (109)	23.4 (43)	0.121	27.4 (26)	0.973
Recreational vehicle type % (n)					
- Bicycle	41.6 (153)	37.5 (69)		13.7 (13)	
- Scooter	8.4 (31)	24.5 (45)		46.3 (44)	
- Motorcycle	26.9 (99)	9.2 (17)	<0.001	3.2 (3)	<0.001
- Horse	17.1 (63)	3.8 (7)		6.3 (6)	
- Skateboard	3.5 (13)	19.6 (36)		27.3 (26)	
- Quadbikes	1.9 (7)	5.4 (10)		1.1 (1)	
Transfers from other hospital % (n)	14.7 (54)	12.0 (22)	0.382	8.4 (8)	0.152
Time from injury to hospital presentation in hours (median, IQR)	1.93 (1.18 – 3.45)	1.61 (1.11 – 3.21)	0.289	1.57 (1.03 – 3.32)	0.203
Time of presentation (n, %)					
- 8:00-15:59	42.9 (158)	29.4 (54)		31.6 (30)	
- 16:00-23:59	55.2 (203)	67.9 (125)		64.2 (61)	
- 24:00-7:59	1.9 (7)	2.7 (5)	0.008	4.2 (4)	0.262
Associated extra-cranial injuries					
- Face/neck	29.9 (110)	23.9 (44)	0.140	23.2 (22)	0.338
- Upper limbs	12.8 (47)	7.6 (14)	0.068	10.5 (10)	0.880
- Torso	9.8 (36)	6.0 (11)	0.131	1.1 (1)	0.497
- Lower limbs	7.9 (29)	4.9 (9)	0.191	4.2 (4)	0.005
GCS† % (n)					
- 14-15	90.2 (332)	86.4 (159)		97.9 (93)	
- 9-13	7.6 (28)	9.8 (18)		0.0 (0)	
- 3-8	2.2 (8)	3.8 (7)	0.351	2.1 (2)	0.002
CT scan performed % (n)					
- at referring hospital	5.4 (20)	9.8 (18)	0.057	1.1 (1)	0.032
- at RCH ED	14.7 (54)	27.2 (50)	<0.001	6.3 (6)	0.003
Traumatic injuries on CT % (n)					
- Isolated Skull Fractures	1.4 (5)	2.2 (4)	0.476	0.0 (0)	0.210
- Intracranial injuries	5.2 (19)	19.6 (36)	<0.001	2.1 (2)	0.013
Disposition % (n)					
- Discharged from ED	66.0 (243)	62.5 (115)	0.389	92.6 (88)	<0.001
- Admitted to WARD only	30.7 (113)	33.2 (61)	0.560	4.2 (4)	<0.001
- Admitted to PICU	2.7 (10)	4.4 (8)	0.309	2.1 (2)	0.753
Neurosurgical intervention % (n)	0.8 (3)	5.4 (10)	<0.001	1.1 (1)	0.705
Total LOS (median, IQR) (n=646)	4.80 (2.79-24.50)	4.74 (2.53-40.95)	0.896	2.88 (1.50-4.53)	<0.001

IQR = Interquartile Range; GCS = Glasgow Coma Scale; CT = Computed Tomography; RCH = Royal Children's Hospital; ED = Emergency Department; PICU = Paediatric Intensive Care Unit; LOS = Length of Stay

* for the comparison between helmet worn and not worn

** for the comparison between helmet documented and not documented

† At time of initial hospital assessment (RCH ED for direct access patients, referring centre for transferred patients)

Table 3. Demographics and clinical characteristics of head injury patients riding motorised or non-motorised RV

	Motorised RV n= 141	**Non-motorised RV n=506**	**p**
Age (median, IQR)	13.16 (11.13—15.02)	10.94 (6.59-14.30)	<0.001
Sex % (n)			
- Male	80.1 (113)	70.4 (356)	
- Female	19.86 (28)	29.6 (150)	0.021
Helmet use % (n)			
- YES	76.6 (108)	51.4 (260)	
- NO	19.2 (27)	31.0 (157)	
- Not documented	4.3 (6)	17.6 (89)	<0.001
Associated extra-cranial injuries			
- None	39.0 (55)	59.7 (302)	
- Face/neck	19.9 (28)	24.5 (124)	
- Upper limbs	6.4 (9)	8.9 (45)	
- Torso	17.0 (24)	2.4 (12)	
- Lower limbs	17.7 (25)	4.6 (23)	<0.001
GCS † % (n)			
- 14-15	83.0 (117)	92.3 (467)	
- 9-13	10.6 (15)	6.1 (31)	
- 3-8	6.4 (9)	1.6 (8)	0.001
Transfers from other hospital % (n)	19.2 (27)	11.3 (57)	0.014
CT scan performed % (n)			
- at referring hospital	6.4 (9)	5.9 (30)	
- at RCH ED	27.0 (38)	14.2 (72)	0.005
Traumatic injuries on CT % (n)			
- Isolated Skull Fractures	0.0 (0)	1.8 (9)	0.111
- Intracranial injuries	13.5 (19)	7.5 (38)	0.027
Disposition % (n)			
- Discharged from ED/SSU	41.8 (59)	76.5 (387)	
- Admitted to WARD only	48.9 (69)	21.5 (109)	
- Admitted to PICU	8.5 (12)	1.6 (8)	<0.001
Neurosurgical intervention % (n)	5.7 (8)	1.2 (6)	0.001
Total LOS hours (median, IQR) (n=646)	24 (4.4-87.7)	3.8 (2.2-17.1)	<0.001

CT = Computed Tomography; ED = Emergency Department; GCS = Glasgow Coma Scale;
IQR = Interquartile Range; ICU = Intensive Care Unit; LOS = Length of Stay; RV = Recreational Vehicles
† At time of initial hospital assessment (RCH ED for direct access patients, referring centre for transferred patients)

Table 4. Demographics and clinical characteristics of patients with and without intracranial injuries on CT (excluding isolated linear skull fractures)

	Intracranial injuries on CT n= 57	**No intracranial injuries on CT n=590**	**p**
Age (median, IQR)	12.5 (10.3—14.4)	11.6 (7.0-14.5)	0.031
Sex % (n)			
- Male	71.9 (41)	72.5 (428)	
- Female	28.1 (16)	27.5 (162)	0.021
Recreational vehicles % (n)			
- Motorised	33.3 (19)	20.7 (468)	
- Non-motorised	67.7 (38)	79.3 (122)	0.027
Recreational vehicle type % (n)			
- Bicycle	19.3 (11)	38.0 (224)	
- Scooter	8.8 (5)	19.5 (115)	
- Motorcycle	26.3 (15)	17.6 (104)	
- Horse	12.3 (7)	11.7 (69)	
- Skateboard	26.3 (15)	10.2 (60)	
- Quadbike	7 (4)	2.4 (14)	
- Go-cart	0 (0)	0.7 (4)	<0.001
Helmet use % (n)			
- YES	33.3 (19)	59.2 (349)	
- NO	63.2 (36)	25.1 (148)	
- Unknown	3.5 (2)	15.7 (93)	<0.001
Associated extra-cranial injuries			
- Face/neck	17.5 (10)	28.1 (166)	0.086
- Upper limbs	7.0 (4)	11.4 (67)	0.317
- Torso	3.5 (2)	7.8 (46)	0.866
- Lower limbs	7.0 (4)	6.4 (38)	0.238
GCS† % (n)			
- 14-15	56.2 (32)	93.6 (552)	
- 9-13	26.3 (15)	5.3 (31)	
- 3-8	17.5 (10)	1.2 (7)	<0.001
Transfers from other hospital % (n)	33.3 (19)	11.0 (65)	<0.001
Disposition % (n)			
- Discharged from ED/SSU	1.7 (1)	76.5 (387)	
- Admitted to WARD only	79 (45)	21.5 (109)	
- Admitted to PICU	19.3 (11)	1.5 (9)	<0.001
Total LOS hours (median, IQR)	85.6 (44-135.8)	4.0 (2.4-19.2)	<0.001

CT = Computed Tomography; ED = Emergency Department; GCS = Glasgow Coma Scale;
IQR = Interquartile Range; ICU = Intensive Care Unit; LOS = Length of Stay;
† At time of initial hospital assessment (RCH ED for direct access patients, referring centre for transferred patients)