Bicycle-Related Injuries in Paediatric Patients

Dear Editor,

Cycling is becoming increasingly popular in Singapore. Government bodies are encouraging cycling with the expansion of cycling infrastructure.[1,2] There was an increase in bicycle-related accidents in Singapore by 13% from 2013 to 2014 and by a further 21% from 2014 to 2015.[3] Previous work by Nakayama et al showed that bicycle-related injuries can result in significant disabilities in children, while Shah et al highlighted the large economic costs of such injuries. However, these studies were conducted in countries that do not necessarily share local traffic and road characteristics. We aimed to outline the epidemiology of paediatric bicycle-related injuries in Singapore. The secondary aims of the study were to identify trends with respect to the mechanisms and management of these injuries.

Materials and Methods

This was a retrospective study which utilised data prospectively collected for the purposes of the trauma registry at our institution, which is a level 1 trauma centre in Singapore. The local institutional review board approved the study with a waiver of informed consent. The Domain Specific Review Board number is 2016/00446.

Data regarding paediatric patients (age <18 years) who presented to the Emergency Department (ED) from January 2012 to December 2015 for bicycle-related injuries was reviewed. Only riders or pillions on bicycles were included, while pedestrians were excluded. Data was reviewed for demographics, mechanism and type of injury, pain score, Glasgow Coma Scale (GCS) score, Revised Trauma Score (RTS), imaging investigations, diagnosis, treatment, length of stay (LOS) and survival. Mechanism of injury was classified according to whether a collision occurred.

Results

A total of 733 patients presented to the ED for bicycle-related injuries during the study period; 81 (11.1%) of these patients were paediatric patients. There were 72 males and 9 females. The mean age was 13 years (standard deviation [SD] 4, range 1-17) with a median of 14 years and interquartile range (IQR) of 11 to 15 years (Table 1).

Collisions were the mechanism of injury for 64 patients (79.0%). Collisions with other vehicles being the commonest mechanism, accounted for 56 (69.1%) injuries, 4 of which took place on pedestrian crossings. A small proportion of collisions involved stationary objects (12.5%). The commonest reason for injury without collision was losing balance while riding downhill (6.2%). Within the available data, only 31.3% of patients had worn helmets. There were 8 patients who were pillion riders (9.9%). No patients reported alcohol consumption prior to cycling. However, 1 patient had consumed carbamazepine prior to cycling (Table 1).

Patients who arrived at the ED during the day (0700 hrs to 1900 hrs) made up 58% of the study group. All but 4 patients had a GCS score of 15 at presentation. The remaining patients had GCS scores of 14, 13, 9 and 7, respectively. All patients had a RTS of 7.841, except 3 patients who had scores of 5.967, 6.940 and 7.108. The mean pain score was 3 (SD 3, range 0-10).

Plain films were obtained for 60 (74%) patients, of whom 19 (31.7%) had positive findings of fractures. Computed tomography (CT) scans were required for 11 (14%) patients. This consisted of 4 (5%) patients who required CT scans of only the brain and 7 (9%) patients who required CT scans for multiple regions (Fig. 1). Of the 11 patients who underwent CT scans, 6 (54.5%) had positive findings. The positive findings on CT imaging consisted of intracranial haemorrhage or skull fractures, which had not been already established on physical examination or plain film imaging.

Specialist management was required for 34 (42%) patients. The majority of injuries requiring specialist review were orthopaedic in nature (Table 2). The remaining patients had minor injuries not requiring specialist review. Inpatient admission was required for 20 (24.7%) patients. The patients falling within the 12 to 14 and 15 to 17 age groups contributed to 90% of the admissions. Admission to high dependency (HD) or intensive care unit (ICU) was necessary for 7 (8.6%) patients, of whom 2 required intubation at the ED. The mean LOS among the patients admitted was 4.9 days (SD 5.1, range 1-20) with a median of 3 days and IQR of 2 to 6 days. Surgical management was undertaken for 10 (12.3%) patients during their admission. This consisted of 7 (8.6%) patients who underwent surgery by orthopaedic surgeons, 2 patients by neurosurgeons and 1 patient by plastic surgeons. Of the 10 patients who were admitted but did not undergo surgery, 8 patients had minor head injuries or small volume intracranial haemorrhage and were admitted for neurological monitoring, while 2 patients

Table 1. Patient Demographics and Mechanisms of Injury

Gender	n (%)
Male	72 (88.9%)
Female	9 (11.1%)
Total	81
Age	
1 – 5	8 (9.9%)
6 – 8	7 (8.6%)
9 – 11	6 (7.4%)
12 – 14	24 (29.6%)
15 – 17	36 (44.4%)
Mean (SD)	13 (4%) years
Range	1 – 17 years
Ethinicity	
Chinese	45 (55.6%)
Malay	23 (28.4%)
Indian	9 (11.1%)
Caucasian	3 (3.7%)
Unknown	1 (1.2%)
Collisions	64 (79%)
Car	37 (45.7%)
Heavy vehicle	13 (16%)
Motorcycle	3 (3.7%)
Other bicycle	3 (3.7%)
Non-vehicles	8 (9.9%)
Tree	3 (3.7%)
Lamppost	2 (2.5%)
Other road fixture	3 (3.7%)
No collision	17 (21%)
Riding downhill	5 (6.2%)
Uneven road	3 (3.7%)
No known cause	3 (3.7%)
Foot caught in front wheel	2 (2.5%)
Avoiding other vehicle	2 (2.5%)
Hit by small object (ball)	1 (1.2%)
Slippery ground	1 (1.2%)
Type of bicycle	
Unpowered	80 (98.8%)
Electric	1 (1.2%)
Patient activity	
Rider	73 (90.1%)
Pillion	8 (9.9%)
Helmet use	
Yes	5 (6.2%)
No	11 (13.6%)
Data unavailable	65 (80.2%)
Drugs/alcohol	
Carbamazapine	1 (1.2%)
No	80 (98.8%)

SD: Standard deviation

had fractures not requiring surgery and were admitted for immobilisation of the fractures and management of pain. There were no limb amputations or mortalities among the patients in the study. Further details on injury types and management are summarised in Table 3 and Figure 2.

Discussion

To the best of our knowledge, this is the first study to analyse the epidemiology of paediatric bicycle-related injuries in Singapore.

In our study, paediatric patients contributed to 11.1% of all bicycle-related injuries. Most patients (88.9%) were male, with patients of the 15 to 17 age group accounting for 47.2% of the males. The 12 to 14 and 15 to 17 age groups contributed to form 90% of the patients requiring admission despite only representing 74.1% of the cohort. These findings provide information on the demographic groups that would likely benefit most from targeted interventions aimed at injury prevention. Such interventions can be legislative and non-legislative in nature. Legislative means of injury prevention could include mandatory use of helmets and other safety gear for children aged 12 or older. Such laws have been shown to increase the use of safety gear.[4] In the local context, non-legislative interventions aimed at injury prevention could take the form of compulsory bicycle safety education as a part of the 'Physical Education' syllabus in secondary school. Health education software may be another avenue of intervention in these age groups, with increasing smartphone usage. Such software has been shown to be an effective and low cost means of safety education.[5]

The majority of patients (58.0%) arrived at the ED during the day. Saturday was the commonest day of presentation. The proportion of accidents that took place during national school term breaks was only 21%, despite the term breaks making up approximately 25% of each year. This demonstrates that bicycle injuries among paediatric patients is a perennial problem. We believe that this may be secondary to the use of bicycles for daily transportation purposes as opposed to solely leisure purposes.

In our study, 87.5% of collisions involved another vehicle, of which 7% occurred on pedestrian crossings. This is in contrast to figures from a study conducted in Hong Kong, in which only 31.4% of collisions involved another vehicle.[6] Published figures from a study conducted in Canada reported that 86.2% of bicycle collisions involved another vehicle, which was more similar to figures from our own study. In addition, 4.9% of our patients sustained collisions while cycling across pedestrian crossings. No similar circumstances were reported in the other studies.[6,7] The high proportion of collisions involving other vehicles and collisions occurring on pedestrian crossings in our study—which exceeds those observed in other studies—may

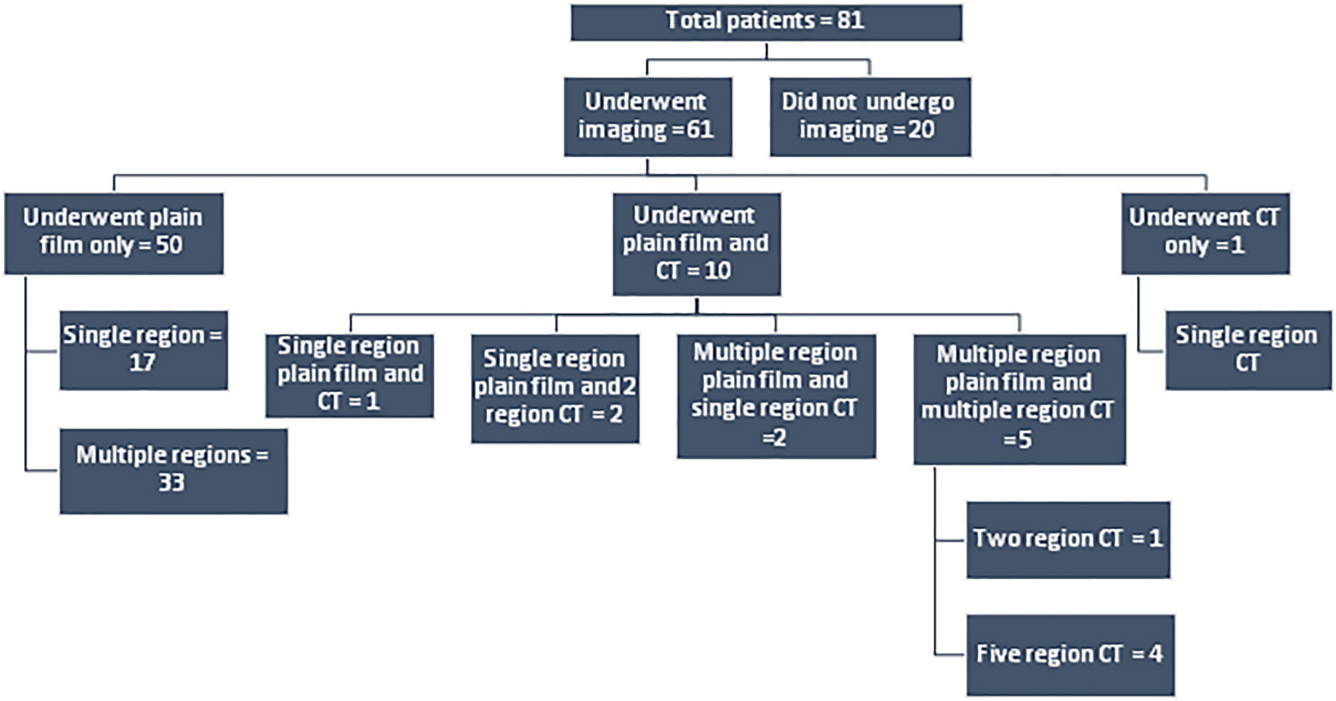

Fig. 1. Chart illustrating the imaging studies. All patients who underwent CT of a single region underwent CT brain. All patients who underwent CT of 2 regions underwent CT brain and cervical spine. All patients who underwent CT of 5 regions underwent CT brain, cervical spine, thorax, abdomen and pelvis. CT: Computed tomography.

Table 2. Orthopaedic Injuries

			Management	
Fractures	**Closed**	**Open**	**Non-Surgical**	**Surgical**
Upper limb				
Clavicle	5	0	5	0
Humerus	2	0	1	1
Humerus and forearm	1	0	0	1
Forearm	3	0	1	2
Hand	0	1	0	1
Lower limb				
Femur	1	0	0	1
Leg	0	1	0	1
Foot	4	0	4	0
Others	**Closed**	**Open**	**Non-Surgical**	**Surgical**
Ankle sprain	-	-	2	0
Posterior cruciate ligament tear	-	-	1	0

be attributed to the density of motor vehicles in Singapore. Another possible contributory factor is that drivers of motor vehicles in Singapore—where bicycles have not yet become a regular mode of transportation—may be less accustomed to sharing roads with bicycle users.

Data on helmet wear was only available for 19.8% of patients. For these patients, over two-thirds had not used helmets. Only 1 of these patients was documented to have been given advice to wear a helmet in future. A recent systematic review showed that bicycle helmet use was associated with reduced odds of head injury, fatal head injury and facial injury.[8] The American Academy of Pediatrics recommends counselling parents and children about the prevention of common childhood injuries, including bicycle safety and helmet use as part of 'The Injury Prevention Program'.[9] It could be beneficial to ensure

Table 3. Surgical Management and Indications

	Indication	Surgery
Orthopaedic surgery		
	Closed left supracondylar fracture	Closed reduction and K-wire fixation
	Closed left olecranon and medial epicondyle fractures with elbow dislocation	Closed reduction and internal fixation
	Closed right radius and ulna fracture	Closed reduction and titanium elastic nail system nailing
	Closed left radius and ulna fracture	Closed reduction and titanium elastic nail system nailing
	Open right ring finger middle phalanx fracture	Wound debridement and K-wire fixation
	Closed right femur shaft fracture	Closed reduction and intramedullary nailing
	Open right tibia and fibula fractures	Wound debridement and external fixation
Neurosurgery		
	Skull fracture with extradural haemorrhage	Posterior fossa craniectomy and evacuation of extradural haemorrhage
	Skull fracture with extradural and subdural haemorrhage	Intracranial pressure monitor insertion
Plastic surgery	Columella laceration	Toilet and suture

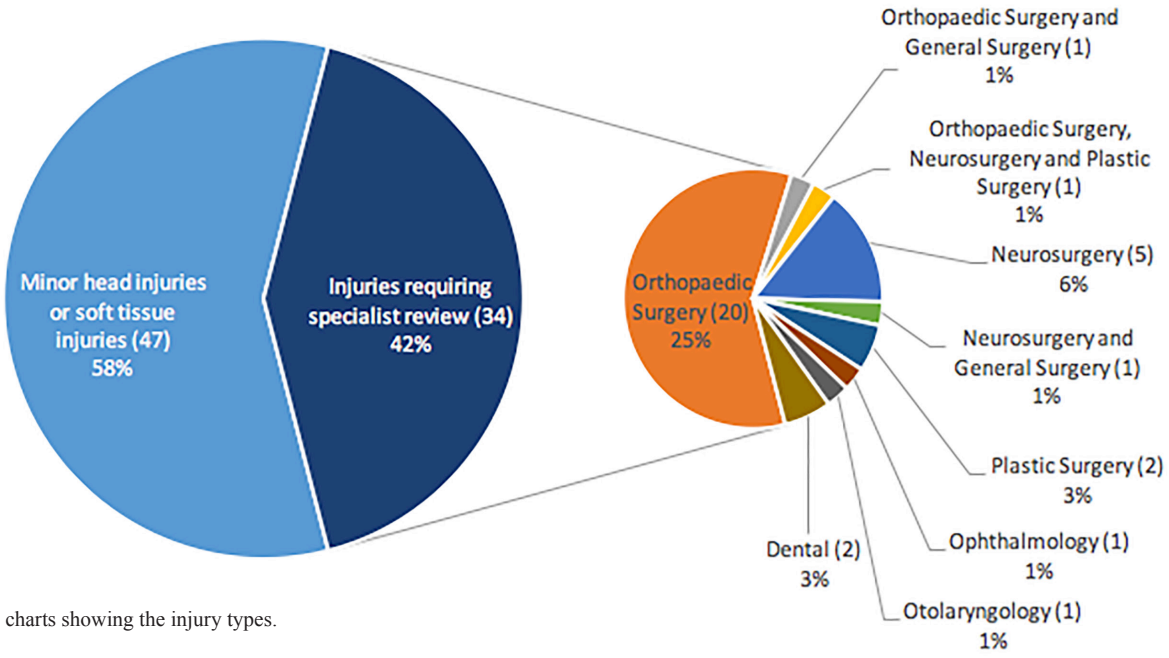

Fig. 2. Pie charts showing the injury types.

that patients and parents are educated on helmet use, in the setting of paediatric patients presenting to the ED for bicycle-related injuries.

Pillion riders contributed to 9.9% of the patients. The majority of these patients were of younger age groups. Only 1 pillion rider was older than 9 years of age. The injury mechanism for all these patients was collisions with other vehicles. These injuries are particularly concerning as the Road Traffic Act in Singapore prohibits pillion riders on bicycles unless the bicycle is designed with an extra seat for the pillion rider.[10] Unfortunately, our data did not include information on the presence or absence of an extra seat on the bicycles involved in the abovementioned accidents. This is an area that warrants further investigation.

The majority of patients (74%) required imaging investigations for further evaluation. A significant proportion of patients in our study (14%) required CT imaging. Of these patients, 54.5% had positive findings that were not already established. CT imaging as part of evaluation following bicycle-related injuries is important but is associated with high levels of radiation and contributes to healthcare system burden. In addition, CT imaging in paediatric patients has been shown to increase risk of certain malignancies.[11] Our figures compared favourably with figures from studies by Fenton et al and Muhm et al, which reported lower figures of 46% and 33.8% for positive CT findings in paediatric trauma patients.[12,13] This demonstrates that CT scans are being used judiciously in our institution in this context,

which may help to ameliorate the burden of paediatric bicycle injuries on the healthcare system and on patients who sustain these injuries.

A quarter of our patients required inpatient admission, with 7 (8.6%) patients being admitted to either HD or ICU. There was a total of 29 days of HD or ICU stay among all the patients. Half of the patients who were admitted underwent surgery. Fixation of limb fractures accounted for 70% of the surgeries performed. A previously conducted study in Singapore on trauma admissions to the surgical ICU demonstrated a mortality rate of 35.7% for patients who had sustained bicycle injuries.[14] Although we had no mortalities among our study population, these findings demonstrate the potential severity of such injuries and further illustrates the burden that such injuries can place on the healthcare system.

Our study is limited by its retrospective nature and data from a single centre. The study cohort may not be representative of affected paediatric patients in the entire country. Despite these limitations, the strength of this study is in its contribution of new information to a topic of growing importance but with little existing data.

Conclusion

Bicycle injuries are a significant cause of morbidity in the paediatric population in Singapore. Males of the 15 to 17 age group have a higher incidence of bicycle-related injuries and may benefit from targeted interventions. Helmet use while cycling is a potential area of education and injury prevention. A notable proportion of injuries require investigations that involve high levels of radiation, admission and surgical management.

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Luke Peter, [1]*BMedSci, MBBS, MRCS*, Choon Chiet Hong, [1]*MBBS, MRCSEd, MMed*, Peter Daniel, [2], Rie Aoyama, [3]*MBBCh BAO*, Diarmuid Murphy, [1]*MBBCh, FRCSI, FRCS*, Win Sen Kuan, [4]*MBBS, MRCSEd (A&E), FAMS*

[1]University Orthopaedic, Hand and Reconstructive Microsurgery Cluster, National University Health System, Singapore
[2]Yong Loo Lin School of Medicine, National University of Singapore, Singapore
[3]Khoo Teck Puat-National University Children's Medical Institute, Singapore
[4]Department of Emergency Medicine, National University Health System, Singapore

Address for Correspondence: Dr Luke Peter, University Orthopaedic, Hand and Reconstructive Microsurgery Cluster, National University Health System, Singapore, 1E Kent Ridge Road, Singapore 119228.
Email: peter_luke@nuhs.edu.sg