

## ORIGINAL RESEARCH

## Impact of electric scooters to a tertiary emergency department: 8-week review after implementation of a scooter share scheme

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## Abstract

**Objective:** A retrospective audit of presentations to a tertiary trauma centre reviewing the demographics of electric scooter injuries in the first 2 months of the scooter-share scheme, which was commenced in Brisbane in November 2018.

**Methods:** Electric scooter-associated presentations to the Royal Brisbane and Women's Hospital Emergency and Trauma Centre from November 2018 to January 2019 were identified. Data collected included patient demographics, type and location of injuries, helmet use, alcohol consumption, length of stay and disposition. Estimates of costs associated with electric scooter presentation were also obtained.

**Results:** Fifty-four electric scooter encounters were included during the 2-month period. Helmets were worn in 46% and was associated with reduced risk of head injury (odds ratio (OR) 0.18,  $P = 0.029$ ). Alcohol was involved in 27% although this did not impact on admission rates (OR 1.25,  $P = 0.83$ ) or operative management (OR 2.14,  $P = 0.42$ ). Contusions/abrasions and fractures/dislocations were the most common types of injury, whereas upper limb and minor head injuries were the most

common sites of injury. Most patients were discharged home (87%), with 74% completing their emergency visit in under 4 h. Six patients required operative management and 15 patients needed outpatient follow-up. There were no deaths. Average patient cost per presentation was \$542 and ranged from \$285 to \$1345.

**Conclusions:** The findings characterised injury patterns and costs associated with electric scooters in our ED. Given the increasing popularity of electric scooters as an alternate form of transportation, our study may help to inform public policy for future injury prevention.

**Key words:** *electric scooter injury, emergency medicine, head injury, scooter-share scheme.*

## Introduction

In November 2018, Lime (Neutron Holdings Inc., San Francisco, CA, USA) introduced an electric scooter sharing scheme in Brisbane, the first of its kind in Australia.<sup>1</sup> This has resulted in an increase in electric scooter use with over 50 000 trips taken within the first 2 weeks.<sup>2</sup> Electric scooters provide an independent alternative to cars and bicycles. These

## Key findings

- As the number of electric scooters continues to rise, so does the number of injuries to both riders and bystanders.
- Upper limb and head injuries were the most common injuries.
- Emergency Physicians must highlight the impact to the healthcare systems of share-scheme electric scooters, especially the impact of alcohol and riding without helmets.

devices are powered by rechargeable battery with a range of approximately 20–60 km per charge, and a maximum speed of approximately 25 km/h. It offers a feasible solution to the 'last mile' problem, which is the distance that feels strenuous to walk but too short to drive. However, with the increasing use of electric scooters, there is also increased media attention on accidents and injuries associated with electric scooters.<sup>3,4</sup> The exact incidence and type of injuries associated with electric scooter since the roll out of scooter sharing scheme in Brisbane is unclear.

In the USA, electric scooter sharing schemes have operated since 2012. Two studies have examined injuries associated with electric scooters in the USA. Trivedi *et al.*<sup>5</sup> performed a retrospective audit of 249 encounters to a single ED following scooter-related injuries. They found that fractures, head injuries and contusions/sprains accounted for the majority of presentation, with 94% of patient discharged home from the ED. A more recent study by

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Aizpuru *et al.*<sup>6</sup> investigated injuries in 32 400 electric scooter injuries from a national database. The authors confirmed that head injuries were the most common body area injured and fractures or dislocations were the most common diagnosis. Notably, that study showed major orthopaedic injuries and concussions were the strongest predictors of hospital admission.

The present study aimed to examine the demographics and injury characteristics of emergency presentations associated with electric scooter use during the first 2 months since the introduction of a scooter sharing scheme in Brisbane. In addition, the influence of helmet on head injury and alcohol on admission and operative management were also specifically investigated.

## Methods

We conducted a retrospective audit of all patient encounters to the Emergency and Trauma Centre of the Royal Brisbane and Women's Hospital from 23 November 2018 until 23 January 2019. As our hospital was situated in proximity to the city business district where electric scooters were readily available, we were in a unique position to obtain data on injuries associated with electric scooters. The institutional review board reviewed the study and provided an exemption from full ethical review (LNR/2019/QRBW/51754).

### Data collection

A search was conducted of the Emergency Department Information System (EDIS) of all ED encounters with non-case-sensitive terms 'scooter' in the triage field. Medical records were reviewed by one of three ED investigators (TR, JM and GM). Encounters that were not due to electric scooters (e.g. push scooters, mobility scooters) were excluded. Data were included if the injured person(s) was either the rider of the electric scooter or hit by an electric scooter. If the medical records were unclear regarding the type of scooter, then the treating doctor was approached for further clarification. The number of electric scooter

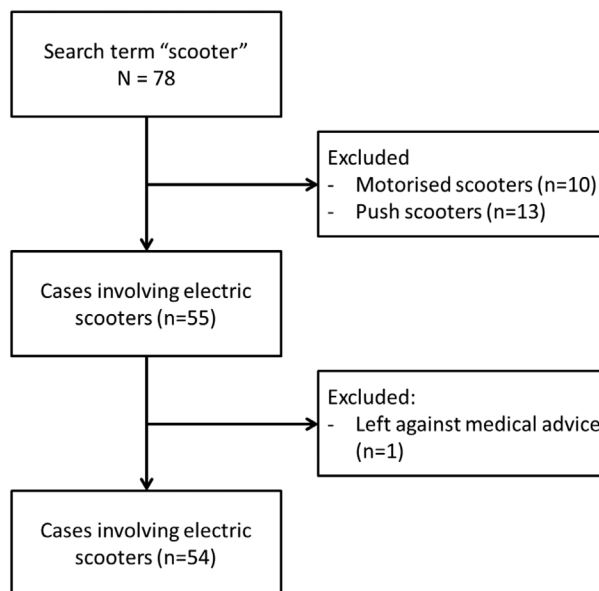


Figure 1. Participant audit flow diagram.

injuries presenting to our ED during the first month in 2018 (23 November to 23 December) was compared with the same period in 2017.

The data were de-identified. Patient demographics (age, gender), mode of presentation (walk in *vs* ambulance), Australasian Triage Scale (ATS), type of injury, helmet use, alcohol use, medical imaging, emergency length of stay, disposition, and whether surgical intervention or outpatient follow-up was required were obtained. In addition, cost analysis for each triage category was also examined. This included government cost for emergency presentation based on ATS category plus cost during hospital admission and/or outpatient follow-up. However, in our audit, it was not possible to include the cost of any required operation or the associated inpatient costs for the length of the hospital admission.

### Statistical analysis

The mean and standard deviations of patients' age and emergency length of stay were calculated. Descriptive statistics of included cases were included in the results. To examine the impact of helmets, odds ratios (ORs) were calculated against the incidence of head injuries. Only cases where there was

documentation of the presence or absence of a helmet were included for OR calculation. To assess the impact of alcohol, ORs were calculated against the incidence of hospital admission and operative management. Statistical significance was set at  $P < 0.05$ .

## Results

The original search yielded 78 encounters, with 23 cases excluded (Fig. 1). This resulted in 55 emergency presentations that involved electric scooters were identified. One case was excluded from analysis and involved a patient who left against medical advice prior to treatment. This resulted in a final sample of 54 cases. One patient was hit by an electric scooter whereas in 53 cases, the rider was the patient. The incidence of electric scooter presentation during the 2 months investigated was ~23 in every 10 000 emergency presentations. The data showed in the first month of the electric scooter share scheme, 29 electric scooters related presentations were encountered. This is in comparison to one encounter during the same period in 2017.

Table 1 shows demographics of the 54 cases included in the final analysis. The data showed that the majority of patients were categorised as ATS 3 ( $n = 18$ , 33%) or

**TABLE 1.** Patient and injury characteristics associated with electric scooter

	<i>n</i> (%)
Gender	
Male	28
Female	26
Age (years)	
16–25	17 (31)
25–35	22 (41)
35–45	9 (17)
>45	6 (11)
ATS category	
1	0
2	11 (20)
3	18 (33)
4	20 (37)
5	5 (9)
Alcohol	
Yes	15 (28)
No	39 (72)
Mode of transport	
Walk in	30 (56)
Ambulance	24 (44)
Helmet	
Yes	25 (46)
No	11 (20)
Undocumented	18 (33)
Imaging	
No imaging	8
X-ray	42
CT	13
MRI	1
Emergency LoS (h)	
0–1	4 (7)
1–2	8 (15)
2–4	28 (52)
>4	14 (26)
Disposition	
Home	47 (87)
Admission	7 (13)

ATS, Australasian Triage Scale; CT, computed tomography; LoS, length of stay; MRI, magnetic resonance imaging.

**TABLE 2.** Type and location of injury associated with electric scooters

Injury	<i>n</i>
Contusions and abrasions	32
Upper limb	18
Lower limb	10
Trunk	4
Fractures/dislocations	16
Upper limb	11
Lower limb	5
Minor head injury	10
Sprains/strains	9
Upper limb	8
Lower limb	1
Thorax injury (including rib fractures)	1

4 ( $n = 20$ , 37%), with 44% ( $n = 24$ ) transported to the ED via ambulance. Of the encounters, 20% ( $n = 11$ ) were documented as not worn a helmet at the time of the incident with 46% ( $n = 25$ ) reported with helmet worn. The presence of a helmet was not documented in 33% ( $n = 18$ ). In addition, 27% ( $n = 15$ ) of patients admitted to alcohol consumption prior to electric scooter use. During their stay in the ED, 78% ( $n = 42$ ) of patients had X-ray imaging, with 24% ( $n = 13$ ) of patients having computed tomography scans as part of their workup. The majority of patients (74%,  $n = 40$ ) completed their ED visit under 4 h, with 87% of patients discharged after their ED visit. Of the patient discharged, 15 patients presented to outpatient clinic for follow-up. There were no deaths.

Table 2 shows the type and location of injuries associated with electric scooter use. The most common type of injury was contusions or abrasions ( $n = 32$ ), followed by fractures or dislocations of the upper and/or lower limbs ( $n = 16$ ) and minor head injury ( $n = 10$ ). Six patients required inpatient operative management, with four patients undergoing open reduction internal fixation of fractures, one

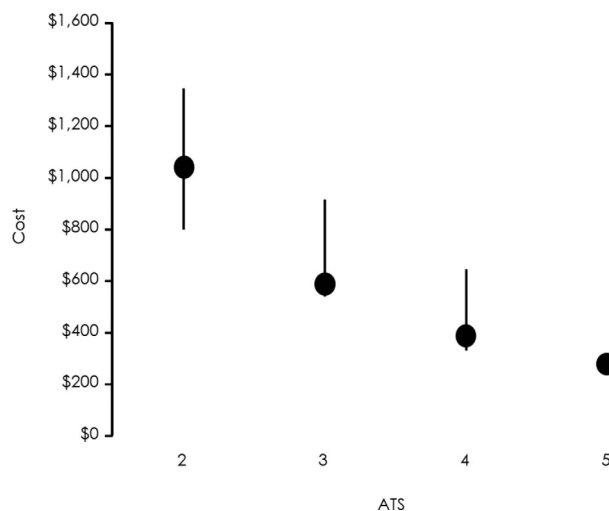
patient requiring joint stabilisation and one undergoing maxillofacial management.

Unsurprisingly, it was found that the presence of a helmet reduced the incidence of head injuries (OR 0.18, 95% confidence interval (CI) 0.04–0.83,  $Z = 2.19$ ,  $P = 0.029$ ). However, the presence of alcohol did not increase the incidence of admissions (OR 1.25, 95% CI 0.17–9.01,  $Z = 0.22$ ,  $P = 0.83$ ) or operative management (OR 2.14, 95% CI 0.34–13.42,  $Z = 0.81$ ,  $P = 0.42$ ).

Figure 2 shows the financial cost as per the ATS category. As expected, cost increased with ATS category. Patients triaged with category of 5 ( $n = 5$ ) incurred a cost to the department of ~\$285 per patient. The average cost of category 4 patient ( $n = 20$ ) is \$372 (minimum \$331; maximum \$645). A category 3 patient ( $n = 18$ ) had an average cost of \$625 (range from \$542 to \$915). Patients who were triaged as an ATS 2 ranged from \$801 to \$1345, with an average cost of \$1048 per patient. This greater cost is associated with increased frequency of admissions to either short stay unit or the hospital, and follow-up outpatient appointments. There were no ED presentations with an ATS category 1 during the data collection period.

## Discussion

Electric scooters were introduced to Brisbane through a trial where Lime was given a temporary pass for up to 500 scooters by the local council, which has now been extended.<sup>7</sup> Since the implementation of this scheme, there has been an increase in the number of presentations to our ED with 54 encounters within the first 2 months. The present study highlighted that contusions/abrasions, limb fractures and minor head injuries were common injuries associated with electric scooters. Notably, the results showed that wearing a helmet was related to reduced risk of head injuries. The findings provide insight into the impact of electric scooter injuries on emergency presentations.



**Figure 2.** Mean and range of financial cost of electric scooter injuries according to Australasian Triage Scale (ATS). Note no patient was categorised as ATS 1.

Electric scooters offer several benefits. The ease of hiring electric scooters via simple app download and sign up, their availability in the city business district, ease of operation and low cost are attractive features to the general public. A recent survey in the USA showed that ~70% of people surveyed viewed electric scooters as a viable transport mode instead of using a private car for short distances or in addition to public transportation.<sup>8</sup> In addition, electric scooters have potential benefits on environmental impact due to low carbon emission rates compared to motor vehicles.<sup>9</sup>

As the use of electric scooters grows, the incidence of injuries sustained has also increased. In our study, we found that the incidence of emergency presentations associated with electric scooters was ~23 in every 10 000. This is greater compared with a previous study<sup>6</sup> that looked at a national database that included tertiary and peripheral EDs, whereas the close proximity of the Royal Brisbane and Women's Hospital to the city business district where electric scooters were mostly situated, meant that we were more likely to encounter these presentations. Similar to previous work, contusions/abrasions and fractures/dislocations were the most common type of injury. This is likely due to the fact that most electric scooter

injuries involved falls off the scooters. However, the mechanism of injury was not specifically examined in the present study. In addition, injuries to the upper limb and head were the most common site and this is consistent with previous work.<sup>5,6</sup>

In our study, 11 of the 54 encountered reported not having a helmet. Importantly, it was noted that patients who wore a helmet were less likely to present with head injury compared to those without. Although all patients with head injuries had minor head injury, we recently encountered a patient (not included in the audit) who sustained a subdural bleed that required intubation and intensive care unit admission. This highlights the potential for significant injuries with electric scooters. There were two reasons why helmets were likely not worn. First, during the first 2 months of electric scooter sharing scheme in Brisbane, helmets were not compulsory although it was encouraged. Second, helmets were not always available with electric scooters. Helmets are now compulsory and failure to comply is an offence punishable by a fine, with the responsibility of wearing a helmet on the user rather than the scooter hire company. Future studies will elucidate whether mandatory helmet laws have an impact on its compliance during electric scooter operation.

In contrast to helmet use, alcohol was not found to be a significant factor that determined the severity of injury, as judged by hospital admissions or the need for surgical operative management. However, in our data, we did not quantify the level of alcohol intoxication. Thus the lack of association could be due to small sample size or heterogeneity of the sample. Future studies should consider quantitative alcohol levels (e.g. blood alcohol level) or functional effects of alcohol intoxication (e.g. ataxic gait, altered cognition).

Electric scooter injuries also incur a cost to the public health system. Recently the Brisbane City Council has proposed a \$5000 flat fee for a 3-month permit, in addition to a \$570 annual fee for each scooter with a 500-scooter limit per permit.<sup>10</sup> This would result in revenue of approximately \$305 000 annually or \$50 833 over a 2-month period. In the present study, the total cost of presentations associated with electric scooters totalled \$32 108. If these numbers continue, it would mean that 63% of revenue from the electric hire scooter scheme would need to be proportioned to cover the costs to the ED alone. This cost analysis is limited to a patient's presentation to the ED, imaging, arranging an outpatient appointment and admission to ED short stay unit or arranging admission to the hospital. The cost analysis does not cover cost for inpatient costs such as the operation, repeat imaging, nor the outpatient follow up with orthopaedics, maxillofacial or physiotherapy. The cost to the Royal Brisbane and Women's Hospital ED is a fraction of the total cost to the hospital. If tertiary ED is utilising almost two-thirds of the revenue of this initiative, it is difficult to see how this venture is beneficial to the local city council. [Correction added on 24 October 2019 after first online publication: some values and information in this paragraph have been updated.]

There were several limitations to the present study. First, the study included a small sample size, was restricted to a single ED and was not adequately powered to look at other risk factors (e.g. age, gender, time of presentation) on patterns on injury.

Future studies with greater sample size and involving multiple EDs will aid to verify our findings and further unravel risk factors be associated with patterns of injury, hospital admission or need for operative management. Second, as our Emergency and Trauma Centre only receives adult patients (that is, over the age of 16 years), it is unclear how many younger patients make up the cohort of electric scooter injuries. Third, as electric scooters were relatively new during the period of our retrospective audit, the study was limited to available clinical documentation. Future work would benefit from improvements in ED clinician documentation of relevant incident characteristics, including mechanism of injury and helmet use, through education of emergency staff and posters at triage.

## Conclusion

Electric scooter sharing schemes such as the one started in Brisbane by Lime are transformative to the way people travel. In the USA alone, there are over 100 cities where electric scooter shared services are reportedly available.<sup>11</sup> With the prospect of electric scooter schemes in other cities of Australia, our findings provide preliminary insight into the injury patterns associated with their use. Given recent media attention of the death of a patient associated with electric scooter accident,<sup>12</sup> further work into the impact of

electric scooters will aid in stronger injury prevention efforts which may aid to minimise injuries.

## Author contributions

HT: data collection, data analysis, manuscript preparation. GM: data collection, data analysis, study coordination, manuscript preparation. TR and JM: study design, data collection, data analysis, study coordination, manuscript preparation. PM: study design, data collection, data analysis.

## Competing interests

None declared.

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