The cost of electric-scooter related orthopaedic surgery

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ABSTRACT

AIM: To highlight the growing cost of electric-scooter (e-scooter) related injuries necessitating surgical intervention by the Auckland City Hospital Orthopaedic Department.

METHODS: Retrospective audit of operations by the Auckland City Hospital Orthopaedic Department from 15 October 2018 up to and inclusive of 22 February 2019. Inclusion criteria was that the direct cause of injury necessitating surgery was secondary to an e-scooter accident. Further demographic data was collected including injury sustained and operation details. The surgical costs were calculated, including anaesthetic time, surgical time, staffing, implants used and inpatient stay as well as clinic follow-up.

RESULTS: Over the 19-week period of this study there were 21 patients requiring 23 operations as a direct result of e-scooters. The summative anaesthetic, theatre suite and staffing costs of these operations was $162,901. Implants required to fix the fractures totalled $39,898. Ninety-three inpatient nights and 61 follow-up clinic appointments were required incurring an additional expense of $141,639 and $16,119 respectively. Overall, these 23 cases cost a total of $360,557. The extrapolated loss of income was $44,368 secondary to these injuries. This represents a total economic cost of $404,925, or $19,282 per person.

CONCLUSION: This study highlights that there can be serious consequences of e-scooter travel. High energy trauma not previously associated with scooter injuries is becoming increasingly prevalent as a result of readily available e-scooters. Many of the injuries identified represent significant morbidity to patients in terms of pain, lengthy rehabilitation and loss of income. Furthermore, the socioeconomic costs for DHBs continues to climb and adds to the acute surgical burden in an already busy healthcare system. The hazards of e-scooters should not be underestimated by both the general public and policy-makers.

E-scooters have become a popular mode of transport, particularly since the release of Lime e-scooters in Auckland and Christchurch. They are electric scooters that allow speeds of up to 27km/h on flat surfaces, and even greater velocity when travelling downhill.[1,2] There have been multiple articles and television segments on this new mode of transportation, available in over 100 locations globally.[1] It is becoming increasingly apparent that e-scooters are presenting a growing public health issue with a rising cost, both to the individuals themselves and financially to the New Zealand taxpayer and healthcare system. This study aims to outline the rising burden of e-scooter injuries and highlight the high energy trauma possible with their use.

Methods

A retrospective audit of orthopaedic operations conducted by the Auckland City Hospital Orthopaedic Department from 15 October 2018 to 22 February 2019 (when Lime e-scooters were temporarily suspended from public use),[3] were examined. Emergency department assessments, ward round notes, operation notes and discharge paperwork were all assessed to ascertain the direct cause of injury resulting in the requirement for orthopaedic surgery.

Both acute and elective orthopaedic operations were included to ensure patients who had an injury that was either initially managed non-operatively or not suitable for acute surgery and brought back to an elective list were not missed.

For the patients who had an injury noted to be secondary to e-scooters, data collected included patient demographics, type of injury, body part injured, surgery required, length of hospital stay and number of follow-up clinic appointments incurred. The number of operations related to other wheeled vehicles (excluding cars), such as bikes, skateboards, motorbikes and mopeds was also collected.

The total cost of the patient's care was calculated by totalling the average cost of hospital stay ($1,523 per night), the cost of using the operating theatre, implant expenses and the cost of each follow-up clinic appointment ($264). Keeping the theatre suite operational and anaesthetic agents costs $41 per minute of anaesthetic time. All the staff required costs $152 per 15 minutes of operating time.

Table 1: Description of e-scooter patients (n=21 patients).

	n	%
Age		
<20	3	14.3
20–29	6	28.6
30–39	5	23.8
40–49	1	4.7
≥50	6	28.6
Gender		
Female	9	42.9
Male	12	57.1
Day injury was sustained		
Weekday	15	71.4
Weekend	6	28.6
Time of day injury was sustained		
Morning (12am–11am)	6	28.6
Midday (12pm–2pm)	5	23.8
Afternoon (2pm–5pm)	1	4.7
Evening (6pm–12am)	9	42.9
Employment status		
Employed	16	76.2
Unemployed	5	23.8
Citizenship		
NZ citizen/resident	20	95.2
Tourist	1	4.8

All expense dollar amounts used in this study were quoted by the Auckland City Hospital Business Manager Surgical Directorate.

Results

From 15 October 2018 to 22 February 2019, there were 708 acute orthopaedic operations at Auckland City Hospital. Ninety-eight of these operations occurred secondary to wheeled vehicles (excluding cars)—34 bikes, 11 skateboards, 20 motorbikes, 10 mopeds, 23 e-scooters (Figure 1).

There has been a linear increase in cumulative number of operations secondary to e-scooters (Figure 2). There were 21 patients who had operations secondary to e-scooter injuries during our study period (Table 1). Nineteen of these patients reported being on a Lime e-scooter at the time of injury. The remaining two were on private e-scooters. Two of these patients required revision operations (Table 2). The median age of patients was 31 with a range of 17 years to 66 years of age (Table 1). More males than females required surgery. The majority of e-scooter injuries occurred on a weekday, where the peak incidence of injuries occurred between 8–9am and after 6pm. Sixteen e-scooter patients had full-time employment. Three out of the five who were unemployed were students, while one was a tourist (Table 1). Fourteen out of 21 patients sustained injuries from losing control due to travelling at maximum speed or due to the wheel getting caught on an uneven surface (Table 2).

All operations carried out were for fracture fixation: six ankles/foot, five wrists, two femurs, five tibias, two patellas and one humeral fracture. The Injury Severity Scores (ISS) for each patient were calculated.[4] These scores ranged from 4 to 13, where the median score was 9 for isolated serious fractures (Table 2).

These 23 operations required a total of 3,276 minutes. The longest operation took 225 minutes to complete for a tibial plateau fracture (Table 2).

Totalling expenses associated with merely the surgical time —anaesthetic agents ($41 per minute) and theatre staff ($152 per 15 minutes), these 23 operations cost $162,901. Additionally the requirements of

Figure 1: Derivation of study population (n=23 operations).

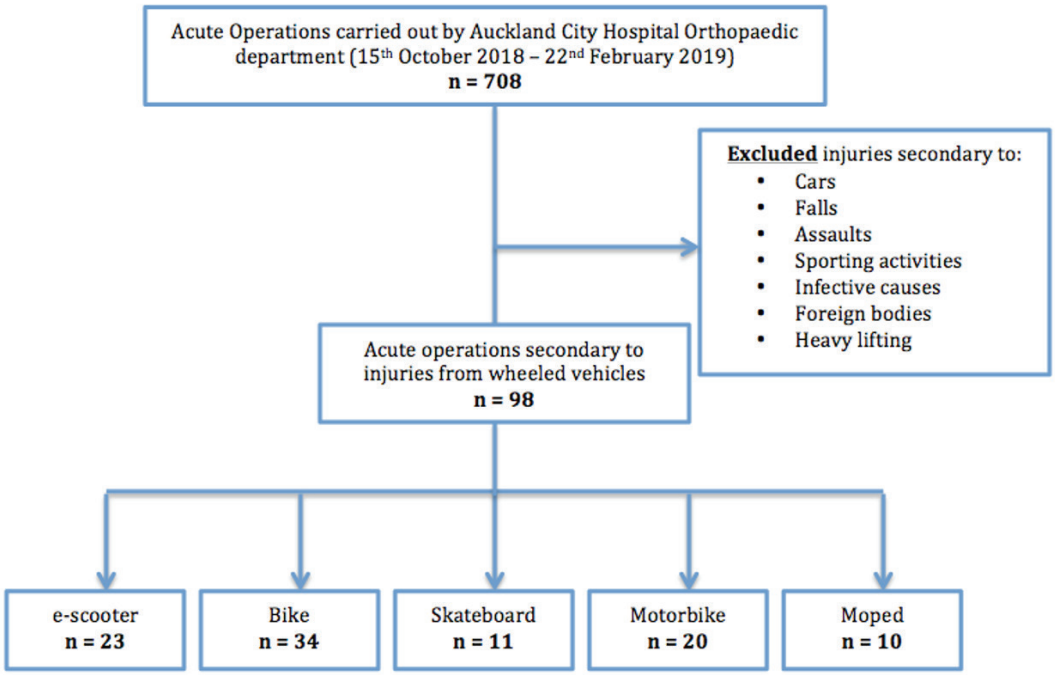


Table 2: Description of e-scooter injuries and resulting operation(s).

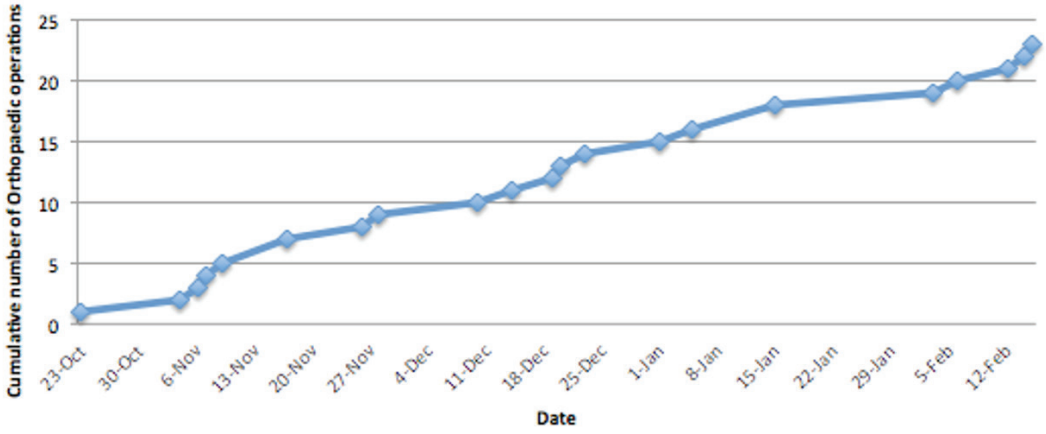
	Resulting injuries	ISS	Operation	Anaesthetic duration	Duration of hospital stay	No. of follow-up clinics
1	Distal radius fracture	4	Open reduction and internal fixation (ORIF)	1h 34mins	2 days	3
2	1. Distal radius fracture 2. Fracture of inferior orbital floor and lateral wall of maxillary sinus	13	ORIF	2h 20mins	3 days	3
3	1. Distal radius fracture 2. Forearm abrasion	5	a) ORIF b) Revision ORIF	a) 3h 3mins b) 2h 3mins	4 days	3+
4	1. Bimalleolar ankle fracture 2. Avulsion fracture of dorsal aspect of navicular	4	ORIF with diastasis screw	1h 33mins	1 day	6
5	Trimalleolar ankle fracture dislocation	9	ORIF	2h 49mins	3 days	4
6	Trimalleolar ankle fracture dislocation	9	ORIF	2h 45mins	2 days	1

Table 2: Description of e-scooter injuries and resulting operation(s) (continued).

7	1. Lateral femoral condyle and lateral tibial plateau fractures 2. Humeral greater tubercle fracture	9	Arthroscopy of knee + ORIF of right distal femur	3h 4mins	4 days	0
8	Mid-shaft femoral fracture	9	Closed reduction internal fixation	3h 7mins	5 days	4+
9	Distal radius fracture	4	ORIF	2h 5mins	1 day	2
10	Maisonneuve injury with medial malleolus abrasion	5	ORIF	1h 17mins	2 days	4+
11	1. Grade 2 compound mid-shaft tibia- fibula fracture 2. Elbow and knee grazes	10	Washout and debridement of compound wound + IM nail of tibia	1h 58mins	2 days	3+
12	Trimalleolar ankle fracture and subtalar dislocation with comminuted fractures of calcaneus and cuboid	9	a) ORIF + application of external fixator b) Removal of external fixator	a) 3h b) 30mins	13 days	6+
13	1. Distal radius fracture 2. Grazes to hand and elbow	5	ORIF	2h 27mins	4 days	4
14	1. Tibial plateau fracture	9	ORIF	3h 3mins	7 days	3+
15	1. Mid-shaft Tibia-fibula fracture 2. Forearm abrasion	10	Closed reduction and IM nail tibial shaft	2h 23mins	3 days	2
16	1. Talus fracture 2. Elbow abrasion	5	ORIF	1h 8mins	3 days	2+
17	Tibial plateau fracture	9	ORIF	3h 45mins	6 days	2+
18	1. Humeral head fracture 2. Facial contusion	5	Proximal humeral head ORIF	2h 37mins	3 days	2+
19	Distal tibia fracture	9	ORIF	3h 36mins	16 days	2+
20	Patella fracture	4	Open reduction and tension band wiring	1h 55mins	2 days	2+
21	Patella fracture	4	Open reduction and tension band wiring	1h 34mins	7 days	3+

More clinics anticipated, as patient is yet to be discharged from clinic.

Figure 2: Cumulative number of e-scooter operations from 15 October 2018–22 February 2019.



implants was a further $39,898. Thus, the average surgical cost was $8,817 for these 23 operations.

A total of 93 nights of inpatient stay and 61 follow-up clinic appointments (and counting, as at 22 February 2019), summated to an extra cost of $141,639 and $16,119 respectively. By the end of our study period, 12 out of 21 patients are yet to be discharged from clinic.

The average annual salary for New Zealanders was $41,200 before tax in 2017.[4] For upper limb injuries we estimated the average time off an office-based job would be two weeks. For lower-limb injuries this usually requires at least four weeks off work, and six weeks for femoral fractures. For more physical work this would often be much longer but we chose to take the lower limits in order to calculate the minimum estimated income lost. With these parameters the estimated income lost totalled to an average of $1,585, $3,169, $4,753 per patient for upper limb, ankle and femoral/tibia fractures respectively. For the 16 patients employed full-time, a conservative estimate of total income lost would work out to be $44,368 ($7,925 for upper limb, $31,690 for lower limb, $4,753 for femoral fractures) for merely this 19-week period. This represents a total economic cost of $404,925, or $19,282 per person.

Discussion

It is a well-documented phenomenon that there is an increased burden on the healthcare system following the introduction of new transport crazes or gadgets.[6–8] Since their release in October 2018, over 185,000 riders have totalled nearly one million trips on Lime e-scooters in the Auckland region alone, showing a growing trend towards using public-share e-scooters.[3]

Our data has shown that in the 19 weeks since their release, (Lime and non-Lime) e-scooters have directly contributed to 23 additional orthopaedic operations. The average cost of each e-scooter operation was $8,817.

In addition to the financial cost of these operations and clinics, there are wider costs to society as a whole. Firstly, the increased burden on acute operating time (54 hours, 36 minutes) lengthens the waiting times for other patients requiring acute operations. Secondly, there is an opportunity cost of requiring time away from work post-operatively.

During our study period, E-scooters resulted in the second highest wheeled-vehicle related injuries requiring orthopaedic operations, excluding cars. E-scooters appear to pose an increased risk compared to other wheeled vehicles; likely due in part to the speeds possible and their inherent instability.[9,10] There has been at least one reported death in September of last year directly as a result of a Lime scooter accident in California.[11]

Our data shows that most e-scooter injuries were sustained between 8–9am and after 6pm. This problem could be remedied by restricting public-use e-scooters such as Lime's availability to certain times of the day so that fewer e-scooters are available during predicted peak injury incidence times.

Most injuries occurred due to riders losing control while riding on an uneven surface or due to travelling at maximum speed.

A possible solution exists that e-scooters may require modifications to reduce the maximum speed attainable and to increase stability.

Finally, one patient was 17 years old. Public-use e-scooters are marketed as only available to users 18 years and older.[1] Stricter age restrictions should therefore be reinforced for those who would like to ride public-use e-scooters.

The severity of trauma seen with these injuries has been notable. Three of the four ankle fractures were pilon fracture-dislocation varieties which are usually resulting from high energy injuries such as motor vehicle collisions or falls from substantial heights. Similarly, comminuted tibia and femur fractures are usually seen in multi-trauma, yet represent a significant proportion of injuries in this study. E-scooters are not only causing increased injuries necessitating surgery, but perhaps more noteworthy, is the severity of these injuries, manifesting the destructive forces possible with their use. The complexity of some of these operations reflected in the prolonged operating times.

Furthermore, 29% of our study population were over the age of 50, exposing more physiologically vulnerable patients to high-trauma injuries. To the general public the accessibility of e-scooters and ease of use perhaps belies the potential dangers of riding them.

It is of note that this audit does not include non-operated injuries. There is a significant additional burden on the Auckland City Hospital Emergency Department as a result of e-scooter related injuries that are not included in this report. This audit only reports the cost incurred by the Auckland City Hospital Orthopaedic Department, but does not include operations required by other specialties, patients who had operations carried out in the private sector or patients presenting to general practice or urgent care clinics with contusions, sprains, concussions, lacerations, dislocations and numerous other injuries as a result of e-scooters. ACC data shows there have been 716 new injury-related claims in the Auckland region over the duration of our study period merely secondary to Lime scooters.[3] While this audit examines orthopaedic surgical cases, the greater burden on resources lies in the multitude of injuries managed nonoperatively.

Conclusion

The burden of injuries secondary to e-scooters in this short period of time since the release of these devices reflects a significant cost to the patients and the Auckland District Health Board. The numbers of these injuries, as well as the extent of high-energy trauma, not usually associated with scooter use, warrants greater public awareness and further studies on preventative measures. This is pertinent to both the wider public and health policy-makers in reducing ongoing injuries from an increasingly accessible device, as e-scooter use continues to become more popular.

Competing interests:
Nil.
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REFERENCES:

1. Lazo L. Lime scooters: All the answers one needs for the latest transportation trend. New Zealand Herald. 11 November 2018. http://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=12158283 Accessed 28 May 2019.
2. Lockup at 40kmh: More terrifying Lime scooter stories. Otago Daily Times. 28 May 2019. http://www.odt.co.nz/news/national/lockup-40kmh-more-terrifying-lime-scooter-stories Accessed 28 May 2019.
3. Dougan P. E-scooter ACC claims fall off. Otago Daily Times. 27 February 2019. http://www.odt.co.nz/news/national/e-scooter-acc-claims-fall Accessed 28 April 2019.
4. Baker SP, O'Neill B, Haddon Jr W, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. Journal of Trauma and Acute Care Surgery. 1974; 14:187–196.
5. Statistics NZ. Labour Market Statistics: June 2017 Quarter. http://www.stats.govt.nz/information-releases/labour-market-statistics-june-2017-quarter Accessed 14 December 2018.
6. Boniface K, McKay MP, Lucas R, et al. Serious injuries related to the Segway® personal transporter: a case series. Ann Emerg Med. 2011; 57:370–4.
7. Du W, Yang J, Powis B, et al. Epidemiological profile of hospitalised injuries among electric bicycle riders admitted to a rural hospital in Suzhou: a cross-sectional study. Inj Prev. 2014; 20:128–33.
8. Weingart GS, Glueckert L, Cachaper GA, et al. Injuries associated with hoverboard use: a case series of emergency department patients. West J Med. 2017; 18:993.
9. Trivedi TK, Liu C, Antonio AL, Wheaton N, Kreger V, Yap A, Schriger D, Elmore JG. Injuries associated with standing electric scooter use. JAMA Netw Open. 2019; 2:e187381.
10. Siman-Tov M, Radomislensky I, Israel Trauma Group, Peleg K. The casualties from electric bike and motorized scooter road accidents. Traffic Inj Prev. 2017; 18:318–23.
11. Holley P. Fatal e-scooter accident emerges just as California legalizes riding without a helmet. The Washington Post. 20 September 2018. http://www.mercurynews.com/2018/09/20/fatal-e-scooter-accident-emerges-just-as-california-legalizes-riding-without-a-helmet/ Accessed 21 December 2018.