

E-Scooter Injuries



Literature Review

January 2021

Public Health Ontario

Public Health Ontario is a Crown corporation dedicated to protecting and promoting the health of all Ontarians and reducing inequities in health. Public Health Ontario links public health practitioners, frontline health workers and researchers to the best scientific intelligence and knowledge from around the world.

Public Health Ontario provides expert scientific and technical support to government, local public health units and health care providers relating to the following:

- communicable and infectious diseases
- infection prevention and control
- environmental and occupational health
- emergency preparedness
- health promotion, chronic disease and injury prevention
- public health laboratory services

Public Health Ontario's work also includes surveillance, epidemiology, research, professional development and knowledge services. For more information, visit publichealthontario.ca.

How to cite this document:

Ontario Agency for Health Protection and Promotion (Public Health Ontario), Berenbaum E. E-scooter injuries. Toronto, ON: Queen's Printer for Ontario; 2021.

ISBN: 978-1-4868-4724-2

©Queen's Printer for Ontario, 2021

Authors

Erin Berenbaum
Research Coordinator
Health Promotion, Chronic Disease and Injury Prevention
Public Health Ontario

Reviewer

Sarah A. Richmond
Applied Public Health Science Unit, Injury Prevention
Health Promotion, Chronic Disease and Injury Prevention
Public Health Ontario

Disclaimer

This document was developed by Public Health Ontario (PHO). PHO provides scientific and technical advice to Ontario's government, public health organizations and health care providers. PHO's work is guided by the current best available evidence at the time of publication.

The application and use of this document is the responsibility of the user. PHO assumes no liability resulting from any such application or use.

This document may be reproduced without permission for non-commercial purposes only and provided that appropriate credit is given to PHO. No changes and/or modifications may be made to this document without express written permission from PHO.

Background

- The province of Ontario passed legislation on January 1, 2020 that allows municipalities to participate in a five-year e-scooter ride sharing pilot program.¹ E-scooters or electronic scooters, are motorized, stand up scooters used both as a mode of transport and as a recreational device. There are several e-scooter businesses that provide dockless e-scooter devices to municipalities as part of a ride share program. E-scooter users access the devices through a mobile application.
- Currently, there are no summaries of evidence on the burden, mechanism and type of injuries most commonly reported from e-scooter use. There is a need for information specific to e-scooter injuries and recommendations for safe use of e-scooters to inform potential pilot programs and for pilot program evaluation.
- There is also a need for a summary of recommendations for use (e.g., restricted areas, permitted areas, speed limits, user restrictions, etc.) towards informing the implementation of local pilot programs from other e-scooter jurisdictions.
- Two documents have been created to support these needs. This document summarizes the evidence on the burden, mechanism and type of injuries most commonly reported in the peer-reviewed literature. The second document, E-scooter jurisdictional scan: Rideshare program policies, summarizes current municipal policies and/or recommendations for e-scooter rideshare programs (e.g., restricted areas, permitted areas, speed limits, user restrictions, etc.).

Methods

- A search for published literature was conducted by Public Health Ontario (PHO) Library Services on January 14, 2020. The search was conducted in MEDLINE, Embase, CINAHL, ProQuest Public Health, Scopus and TRID using relevant vocabulary and subject headings. All database results were integrated and duplicates removed. Search terms included, but were not limited to: “e-scooter,” “power scooter,” “motorized scooter,” “injuries,” “accidents,” “morbidity,” “emergency services,” “trauma centre,” “safety” and “public health.” The search strategy is available upon request.
- All titles, abstracts and full text were screened by a single reviewer using inclusion and exclusion criteria. Articles were included if they examined burden, mechanism or injury type related to e-scooter use. Editorials, letters, commentaries and conference abstracts were excluded. For all relevant papers, one PHO staff extracted data and summarized content (see [Appendix A](#) for data extraction).

Findings

- The search strategy identified 75 articles; 20 articles were relevant and included in this review.²⁻²¹ All of the articles that were included were published in 2019 with the exception of two.^{11,19} The majority of articles were from the US: four were national,^{2,7,10,11} one was from Texas,²⁰ one was from Salt Lake City,³ two were from California,^{12,21} one was from Washington,¹⁸ and two were from unspecified locations in the US.^{13,17} There were also four articles from Auckland, New Zealand,^{5,8,9,15} one from Dunedin, New Zealand,⁴ one from Denmark,⁶ one from Singapore,¹⁴ one from Brisbane, Australia¹⁶ and one from Israel.¹⁹ All studies were retrospective and four were case series.^{13,18,20,21} A summary of the findings for each of these studies can be found in a table in [Appendix A](#).

Mechanisms

- Across all studies, the mechanisms of injury most commonly reported for e-scooter riders included: falls,^{6,8,12,21} loss of balance/control,^{5,9,14,18} collision with a vehicle,^{5,6,12,14,18,21} collision with an object (e.g., pole, gate),^{6,8,14,18,21} collision with pedestrians,^{8,14} excessive speed,^{5,9} road condition (e.g., uneven surface),^{9,14} medical event,⁸ scooter malfunction^{8,14} and dual riders.⁴
- For non-riders, the mechanisms of injury most commonly reported included being hit/struck by a scooter^{4,12,16,18,21} or tripping over a scooter.^{6,21} For many studies, helmet use was not recorded/documented; where documented, findings show that helmets were rarely worn by e-scooter riders.^{3,4,7,8,13,20,21} Eight studies reported that alcohol use^{3,5,6,8,13,16,20,21} or illicit substances^{6,13} were involved in some cases.

Injury Type

- Commonly-reported injuries, in order from most frequently cited in the included studies were: fractures (e.g., including ankle/foot, wrist, femur, tibia, patella, humerus, skull, ribs), lacerations, dislocations (e.g., ankle, elbow, chest, femur, foot, knee, shoulder, tibia/fibula, wrist, forearm, humerus, pelvis, ribs, head, maxillofacial, wrist), concussions or brain injuries, head injuries, sprains/strains, contusions, spinal injuries, intra-cranial hemorrhage, internal/abdominal/intrathoracic injuries, dental injuries, abrasions, musculoskeletal/soft-tissue injuries, hematoma, chest/torso/thorax injuries, burns, amputations, avulsions and foreign body injuries. See [Appendix A](#) for a full description of the injury findings.

Costs Associated with E-Scooter Injuries

- Three studies from Australia and New Zealand examined health-care costs associated with e-scooter injuries.^{5,9,16} Mitchell et al., (2019) found the cost of injuries from e-scooters in Brisbane, Australia ranged from \$285 to \$1,345 per injury (emergency room presentation). The average cost per injury presentation was \$542.¹⁶ Two additional studies examined the costs associated with e-scooter injuries in Auckland, New Zealand.^{5,9} Bekhit et al., (2019) identified 770 patient presentations associated with e-scooters during their study period (i.e., September 2018 to April 2019) and reported the combined cost attributable to those injuries was \$608,843 (NZD) for Auckland City Hospital and \$1,303,155 for the entire region of Auckland.⁵ Campbell et al., (2019) identified 21 e-scooter patients (requiring 23 surgeries) during their study period (i.e., October 2018 to February 2019) in Auckland, New Zealand.⁹ They found that the operative cost of the 23 cases was of \$360,557 (NZD).⁹ These injuries were also associated with a loss of income of \$44,368, representing a total cost of \$404,925 (NZD) or \$19,282 (NZD) per person.⁹

References

1. Ontario. Ministry of Transportation. Electric kick-style scooters (e-scooters) [Internet]. Toronto, ON: Queen's Printer for Ontario; 2019 [modified 2019 Nov 27; cited 2020 Mar 9]. Available from: <http://www.mto.gov.on.ca/english/vehicles/electric/electric-scooters.shtml>
2. Aizpuru M, Farley KX, Rojas JC, Crawford RS, Moore TJ Jr, Wagner ER. Motorized scooter injuries in the era of scooter-shares: a review of the national electronic surveillance system. *Am J Emerg Med*. 2019;37(6):1133-8. Available from: <https://doi.org/10.1016/j.ajem.2019.03.049>
3. Badeau A, Carman C, Newman M, Steenblik J, Carlson M, Madsen T. Emergency department visits for electric scooter-related injuries after introduction of an urban rental program. *Am J Emerg Med*. 2019;37(8):1531-3. Available from: <https://doi.org/10.1016/j.ajem.2019.05.003>
4. Beck S, Barker L, Chan A, Stanbridge S. Emergency department impact following the introduction of an electric scooter sharing service. *Emerg Med Australas*. 2020;32(3):409-15. Available from: <https://doi.org/10.1111/1742-6723.13419>
5. Bekhit MNZ, Le Fevre J, Bergin CJ. Regional healthcare costs and burden of injury associated with electric scooters. *Injury*. 2020;51(2):271-7. Available from: <https://doi.org/10.1016/j.injury.2019.10.026>
6. Fasmer Blomberg SN, Moeller Rosenkrantz OC, Lippert F, Collatz Christensen H. Injury from electric scooters in Copenhagen: a retrospective cohort study. *BMJ Open*. 2019;9(12):e033988. Available from: <https://doi.org/10.1136/bmjopen-2019-033988>
7. Bresler AY, Hanba C, Svider P, Carron MA, Hsueh WD, Paskhover B. Craniofacial injuries related to motorized scooter use: a rising epidemic. *Am J Otolaryngol*. 2019;40(5):662-6. Available from: <https://doi.org/10.1016/j.amjoto.2019.05.023>
8. Brownson AB, Fagan PV, Dickson S, Civil ID. Electric scooter injuries at Auckland City Hospital. *N Z Med J*. 2019;132(1505):62-72.
9. Campbell A, Wong N, Monk P, Munro J, Bahho Z. The cost of electric-scooter related orthopaedic surgery. *N Z Med J*. 2019;132(1501):57-63.
10. DiMaggio CJ, Bukur M, Wall SP, Frangos SG, Wen AY. Injuries associated with electric-powered bikes and scooters: analysis of US consumer product data. *Inj Prev*. 2019 Nov 11 [Epub ahead of print]. Available from: <https://doi.org/10.1136/injuryprev-2019-043418>
11. Griffin R, Parks CT, Rue LW 3rd, McGwin G Jr. Comparison of severe injuries between powered and nonpowered scooters among children aged 2 to 12 in the United States. *Ambul Pediatr*. 2008;8(6):379-82. Available from: <https://doi.org/10.1016/j.ambp.2008.08.002>
12. Ishmael CR, Hsiue PP, Zoller SD, Wang P, Hori KR, Gatto JD, et al. An early look at operative orthopaedic injuries associated with electric scooter accidents: bringing high-energy trauma to a wider audience. *J Bone Joint Surg Am*. 2020;102(5):e18. Available from: <https://doi.org/10.2106/jbjs.19.00390>
13. Kobayashi LM, Williams E, Brown CV, Emigh BJ, Bansal V, Badiee J, et al. The e-merging e-pidemic of e-scooters. *Trauma Surg Acute Care Open*. 2019;4(1):e000337. Available from: <https://doi.org/10.1136/tsaco-2019-000337>
14. Liew YK, Wee CPJ, Pek JH. New peril on our roads: a retrospective study of electric scooter-related injuries. *Singapore Med J*. 2020;61(2):92-5. Available from: <https://doi.org/10.11622/smedj.2019083>
15. Mayhew LJ, Bergin C. Impact of e-scooter injuries on emergency department imaging. *J Med Imaging Radiat Oncol*. 2019;63(4):461-6. Available from: <https://doi.org/10.1111/1754-9485.12889>
16. Mitchell G, Tsao H, Randell T, Marks J, Mackay P. Impact of electric scooters to a tertiary emergency department: 8-week review after implementation of a scooter share scheme. *Emerg Med Australas*. 2019;31(6):930-4. Available from: <https://doi.org/10.1111/1742-6723.13356>

17. Nellamattathil M, Amber I. An evaluation of scooter injury and injury patterns following widespread adoption of e-scooters in a major metropolitan area. *Clin Imaging*. 2019;60(2):200-3. Available from: <https://doi.org/10.1016/j.clinimag.2019.12.012>
18. Schlaff CD, Sack KD, Elliott RJ, Rosner MK. Early experience with electric scooter injuries requiring neurosurgical evaluation in District of Columbia: a case series. *World Neurosurg*. 2019;132:202-7. Available from: <https://doi.org/10.1016/j.wneu.2019.08.237>
19. 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(3):318-23. Available from: <https://doi.org/10.1080/15389588.2016.1246723>
20. Trivedi B, Kesterke MJ, Bhattacharjee R, Weber W, Mynar K, Reddy LV. Craniofacial injuries seen with the introduction of bicycle-share electric scooters in an urban setting. *J Oral Maxillofac Surg*. 2019;77(11):2292-7. Available from: <https://doi.org/10.1016/j.joms.2019.07.014>
21. Trivedi TK, Liu C, Antonio ALM, Wheaton N, Kreger V, Yap A, et al. Injuries associated with standing electric scooter use. *JAMA Netw Open*. 2019;2(1):e187381. Available from: <https://doi.org/10.1001/jamanetworkopen.2018.7381>

Appendix A: Data Extraction Table

Table 1: Data Extraction Table

Author	Jurisdiction, Data Source, Study Design	Injury Type	Findings/Burden	Mechanism of Injury
Aizpuru (2019) ²	National, US National Electronic Injury Surveillance System (NEISS) (Retrospective study)	Head injuries, fractures (e.g., wrist/lower arm), dislocations, contusion, laceration/ avulsion, internal organ injury, sprain or strain, dental injury, concussions, burn, hematoma, amputation, crush	<ul style="list-style-type: none"> • Estimated 32,400 motorized scooter injuries from 2013 to 2017. • Estimated incidence did not change significantly over time (i.e., 1.9 cases/100,000 in 2013 and 2.6 cases/100,000 in 2017). • A 77.0% increase in scooter injuries was found for 23 – 39 year olds from 2016 to 2017. • Head injuries were the most common body area injured (27.6%). • Fractures or dislocations (25.9%) were the most common diagnosis. • The most common site of fracture was the wrist and lower arm (35.4%). • There were no deaths. • The strongest independent predictor of hospital admission were major orthopaedic injury and concussion. • Other injuries types: Contusion (25.8%), laceration/avulsion (15.2%), internal organ injury (10.9%), other/unreported (10.2%), sprain/strain (7.3%), concussion (2.5%), dental injury (0.8%), burn (0.8%), hematoma (0.4%), amputation (<0.1%), crush (<0.1%) 	Not reported.
DiMaggio (2019) ¹⁰	National, US National Electronic Injury Surveillance system (NEISS)	Concussions, fractures, internal and soft tissue injuries	<ul style="list-style-type: none"> • No evidence that powered scooters were more likely to be involved in a collision with a pedestrian compared to bicycles [Odds Ratio (OR)= 1.0, 95% CI 0.3 to 3.1]. • The proportions and 95% confidence intervals (CIs) for types of injuries due to powered scooters were: Soft tissue injuries 53.6% (51.3 to 55.8), fractures 26.5% (24.6 to 28.5), internal injuries 7.5% (6.4 to 8.7) and concussions 3.0% (2.3 to 3.8). 	Not reported.

Author	Jurisdiction, Data Source, Study Design	Injury Type	Findings/Burden	Mechanism of Injury
	(Retrospective study)		<ul style="list-style-type: none"> Powered scooter injuries are reported to have a higher proportion of concussion diagnoses compared to e-bike injuries (3% of scooter injuries vs 0.5% of e-bike injuries). During the 18-year study period (2000 to 2017) there were 130,797 powered scooter injuries (95% CI 121,528 to 140,065) accounting for 5.3 injuries/10,000 (95% CI 5.0 to 5.7) total US emergency department injuries. 	
Bresler (2019) ⁷	National, US National Electronic Injury Surveillance system (NEISS) (Retrospective study)	Fractures, lacerations, head injuries, concussions, foreign body, hematoma, dental injury, cervical strain/sprain	<ul style="list-style-type: none"> Between 2008 and 2017, there were 990 recorded events of craniofacial injuries due to motorized scooters (extrapolating to an estimated 32,001 emergency department visits). The annual incidence tripled over the 10-year period (2008 – 2017) (from 2,325 (95% CI 1,379 to 3,271) in 2008 to 6,947 (95% CI 4,921 to 8,974) in 2017). The most common injury type reported was a closed head injury (36.1%) followed by lacerations (20.5%). Facial fractures were only present in 5.2% of cases. The most common fracture sites observed were skull (27%), nose (27%) and cervical spine (14%). 	Where helmet use was recorded, 66% of patients were not wearing a helmet.
Griffin (2008) ¹¹	National, US National Electronic Injury Surveillance System (NEISS) (Retrospective Study)	Concussions, contusions, lacerations, fracture, strains/sprains	<p>Note: The purpose of the study was to compare demographics and injury characteristics between scooter types (electric vs. non-electric), focusing on the differences in injury severity. The current study included children ages 12 and younger.</p> <p>Note: It is possible that some injuries classified as related to powered scooters may actually be due to street transport motor scooters (i.e., Vespa scooters, mopeds and miniature motorcycles—all of which have separate NEISS product codes). Previous research suggests that this occurs for approximately 20% of injuries classified as related to powered scooters across all ages.</p>	Not reported.

Author	Jurisdiction, Data Source, Study Design	Injury Type	Findings/Burden	Mechanism of Injury
			<ul style="list-style-type: none"> From 2002 to 2006 (in children ages 2 to 12 years) there were 484 powered scooter-related emergency department visits, representing an estimated 15,752 powered scooter-related injuries. Powered scooter-related injuries were over three times more likely to be severe (OR 3.57, 95% CI 1.91 to 6.65) compared to non-powered scooters. This association was more prominent among females (OR 5.80, 95% CI 2.02 to 16.63) than males (OR 2.90, 95% CI 1.44 to 5.82). There was a statistically significant association between scooter type and body region injured ($p = .02$), with powered scooter-related injuries occurring more frequently to the hip and lower extremities (28.3% vs. 21.7%) and less frequently to the shoulder and upper extremities (32.9% vs. 41.1%) compared to non-powered scooters. For powered scooters, 33.5% of injuries were to the head/neck, 32.9% were shoulder and upper extremity injuries, 28.3% were in the hip and lower extremity region and 5.3% were trunk injuries. Concussions were diagnosed nearly twice as often for powered scooters compared with non-powered scooters (30.8% vs. 16.9%; $p = .03$) and contusions or lacerations were diagnosed less often (58.6% vs. 73.2%; $p = .03$). 	
Trivedi (2019) ^{a20}	Dallas, Texas Baylor University Medical Center (Retrospective case series)	Craniofacial, including fracture, abrasions, lacerations, concussions, internal/intracranial hemorrhage, dental injuries	Note: In Dallas, Texas, standing rental e-scooters have been available for public use since July 1, 2018, with four major e-scooter companies in the metropolitan area. <ul style="list-style-type: none"> In the first seven months after the introduction of e-scooters in Dallas, a total of 90 patients (56 males, 34 females; mean age 31.8 years) presented to the emergency department with an e-scooter-related trauma. 52 admissions (58% of all admissions) involved injuries to the head and face. 	Alcohol use was involved in 18% of all scooter-related trauma admissions. No rider reported wearing a helmet.

Author	Jurisdiction, Data Source, Study Design	Injury Type	Findings/Burden	Mechanism of Injury
			<ul style="list-style-type: none"> Patients had a range of craniofacial trauma, from abrasions, lacerations, and concussions to intracranial hemorrhage and Le Fort II and III fractures. Of the 52 craniofacial injuries, 30 (58%) were considered severe (i.e., fracture, internal hemorrhage, concussion, loss of consciousness), and 22 (42%) were considered minor (i.e., lacerations, contusion, abrasion, dental). 	
Badeau (2019) ³	Salt Lake City, US University of Utah and Salt Lake Regional Medical Center (Retrospective study)	Head injury, musculoskeletal injury, superficial soft tissue injury	Note: The 2017 data pre-dated the launch of the e-scooter share/rental programs in Salt Lake City and served as a control period. <ul style="list-style-type: none"> There were eight e-scooter related injuries in 2017 and 50 in 2018. Injury types presented to emergency department in the 2018 period included: superficial soft tissue injury (40%), major musculoskeletal injury (36%), minor musculoskeletal injury (34%), minor head injury (12%), and major head injury (8%). 	16% of patients reported alcohol intoxication. No patients reported wearing a helmet at the time of injury.
Trivedi (2019) ^{b21}	California, US University of California, Los Angeles (UCLA), Ronald Reagan UCLA Medical Center and UCLA Medical	Fractures, head injuries, contusions, sprains, lacerations, intracranial hemorrhage, dislocations, major intra-abdominal or intra-thoracic injuries, cervical spine injuries	<ul style="list-style-type: none"> There were 249 patients (mean age 33.7) that presented to the emergency department with injuries associated with standing e-scooter use during the study period. Over 90% (n=228) were injured as riders and 8.4% (n=21) as non-riders. 27 patients were younger than 18 years (10.8%). Injury types included head injury (n=100, 40.2%), fractures (n=79, 31.7%) and contusions, sprains, and lacerations without fracture or head injury (n=69, 27.7%). The majority of patients (n=234, 94.0%) were discharged home from the emergency department; of the 15 admitted patients, two had severe injuries and were admitted to the intensive care unit. 	The most common mechanism of injury was a fall (183 riders, 80.2%), followed by a collision with an object (25 riders, 11.0%), and being hit by a moving vehicle or object (20 riders, 8.8%).

Author	Jurisdiction, Data Source, Study Design	Injury Type	Findings/Burden	Mechanism of Injury
	Center–Santa Monica (Retrospective cohort/case series)			<p>Injured non-riders reported being hit by a scooter (n=11), tripping over a scooter in the road (n=5) or other.</p> <p>10 riders were documented as wearing a helmet (4.4% of all riders or 11.9% of riders whose helmet use status was documented).</p> <p>12 riders (4.8%) reported a blood alcohol level greater than 0.05% or physician documented intoxication.</p>
Ishmael (2019) ¹²	<p>California, US</p> <p>Three trauma centres in Los Angeles</p> <p>(Retrospective study)</p>	Fractures (various locations, including hip fractures), ligament ruptures, dislocations, contusions, sprains, and lacerations	<ul style="list-style-type: none"> • There were 75 operative injuries identified in 73 patients during the study period. • The most common injuries included head injuries (40.2%), fractures (31.7%) and contusions, sprains, lacerations without fracture or head injury (27.7%). • The majority of patients (n= 42, 57.5%) had lower extremity injuries; 32 patients (43.8%) had upper extremity injuries, one patient had both upper and lower extremity injuries. Nine patients (12.3%) were reported to have open fractures. • There were seven hip fractures reported in patients with an average age of 42.4 years (range 28 to 68 years). • The majority of patients were e-scooter riders (n= 71, 97.3%) of 73 patients, and two (2.7%) were pedestrians who were hit by e-scooters. 	<p>E-scooter riders were struck by automobiles in eight cases. The remaining 65 cases were due to falls from e-scooters.</p> <p>Two patients were struck by e-scooter riders and sustained injuries requiring operation.</p> <p>There were four underage riders and two pedestrians in</p>

Author	Jurisdiction, Data Source, Study Design	Injury Type	Findings/Burden	Mechanism of Injury
			<ul style="list-style-type: none"> There were 68 patients with fractures and/or dislocations, and the remaining five patients reported anterior cruciate ligament (ACL) ruptures. 	the cohort, suggesting that rules are not always followed.
Schlaff (2019) ¹⁸	Washington, US George Washington University Hospital (Case Series)	Brain and spinal injuries, including, subarachnoid hemorrhage, vertebral compression fracture, skull fracture, central cord syndrome	Note: From September 2017 through November 2018, Washington, DC launched a 15-month dockless e-scooter pilot program to allow for the rapid entry and growth of e-scooters within the metropolitan area. <ul style="list-style-type: none"> There were 13 patients reported to have sustained injuries serious enough to require neurosurgical consultation, including one patient whose symptoms required procedural intervention by a neurointerventional radiologist. Another patient was pronounced dead soon after arrival to the hospital. 	One patient collided with the rear end of another vehicle. One patient struck a pedestrian with an e-scooter. One patient slammed into a gate and fall over the handlebars. One patient lost balance and fell off the e-scooter.
Nellamattathil (2019) ¹⁷	US, (Specific location not reported) (Retrospective study)	Fractures, dislocations (locations included ankle, elbow, chest, femur, foot, knee, shoulder, tibia/fibula, wrist, forearm, humerus, pelvis, ribs, head, maxiofacial, wrist)	E-scooters were first introduced to the area on September 1, 2018. <ul style="list-style-type: none"> There were a total of 54 patients (radiology imaging reports) presenting with musculoskeletal injuries; the majority reported in the upper extremity. There were no cases of visceral or neurotrauma injury. Injuries included: eight upper extremity fractures/dislocations, three lower extremity fractures, two rib fractures and one nasal bone fracture. One patient suffered two separate upper extremity injuries and three patients required surgery. 	Not reported.

Author	Jurisdiction, Data Source, Study Design	Injury Type	Findings/Burden	Mechanism of Injury
Kobayashi (2019) ¹³	US, (Specific location not reported) (Retrospective case series)	Fractures, intracranial hemorrhage, hemothorax, cervical spine injuries	<ul style="list-style-type: none"> • There were 103 patients admitted (hospitalized) during the study period, and monthly admissions increased significantly over time. • Extremity fractures were the most frequently reported injury (42%), followed by facial fractures (26%) and intracranial hemorrhage (18%). • Lower extremity fractures of the tibia, fibula, and medial and lateral malleoli were the most frequent. Upper extremity fractures of the clavicle, scapula, radius, and ulna were also common. Facial fractures were the second most common injury found in this population, occurring in 27 patients (26%) of whom eight (30%) had mandible fractures. • Median Injury Severity Score was 5.5 [Interquartile range (IQR) 5–9]. • One-third of patients (n=34) required surgical intervention, the majority were open fixations of the extremities and facial fractures. • Intracranial hemorrhage (ICH) occurred in 19 patients (18%). • Other significant injuries included one hemothorax requiring chest tube placement, two splenic lacerations (one Grade 1, one Grade 2), one Grade 2 renal injury, and one multi-level cervical spine injury. • No patients died during the study. 	<p>Alcohol and illicit substance use among patients was common (e.g., 79% of patients were tested for alcohol and 48% had a blood alcohol level >80 mg/dL. 60% of patients had a urine toxicology screen, of which 52% were positive.)</p> <p>Helmet use was extremely rare.</p>
Beck (2019) ⁴	Dunedin, New Zealand Dunedin Hospital (Retrospective cohort study)	Head injury, musculoskeletal injuries (e.g., contusions, sprains and lacerations, fractures, dislocations)	<p>Note: E-scooters were introduced in Dunedin, NZ in January, 2019.</p> <ul style="list-style-type: none"> • In 2018 (pre-introduction of e-scooters in Dunedin), there were no e-scooter related emergency department presentations identified. <ul style="list-style-type: none"> • In 2019, there were 56 e-scooter related emergency presentations (p <0.001) representing 54 events. • The majority of e-scooter presentations were for minor injuries. Fractures or dislocations were found in 17 (32%) patients and 14 (26%) patients had a head injury, one of which was severe. Isolated minor musculoskeletal injuries were seen in 25 (46%) patients. • On average, one emergency department bed was occupied by an e-scooter patient for 2 h and 44 min each day during the six-week study period in 2019. 	<p>One patient was a non-rider (struck by scooter).</p> <p>Of the 53 patients injured while riding, four (8%) of were dual riders.</p> <p>Helmet use was documented in 11 (21%) of 53 cases. Of these, one used a helmet</p>

Author	Jurisdiction, Data Source, Study Design	Injury Type	Findings/Burden	Mechanism of Injury
				and 10 (91%) did not use a helmet.
Mayhew (2019) ¹⁵	Auckland, New Zealand Auckland City Hospital PACS (Picture archive communication system) (Retrospective study)	Fractures, dislocations, spinal injuries, concussions, extra-dural bleeding, facial/skull fractures, soft tissue injuries, chest injury	Note: The first shared e-scooter company was introduced to Auckland, NZ on October 15, 2018. <ul style="list-style-type: none"> 64 patients met the inclusion criteria, only one of these was prior to introduction of shared e-scooters on October 15, 2018. There were 27 limb fractures, three dislocations, a fractured spine, and 12 patients with concussion. One extra-dural bleed, nine facial/skull fractures and multiple soft tissue injuries. 25.4% of patients required surgery. 	Not reported.
Bekhit (2019) ⁵	Auckland, New Zealand Accident Compensation Corporation (ACC) Claims data and Auckland City Hospital Data (Retrospective Study)	Lacerations, concussions, brain injuries, fractures, burns, dental injuries, soft tissue injuries	<ul style="list-style-type: none"> 770 patient presentations associated with e-scooters were identified during study period. 246 hospital presentations used a total of 5,569 hospital bed-hours with 75 patients (30.5%) requiring admission and inpatient care. Of the hospital presentations, 49 patients (19.9%) required at least one operation, and 105 (42.7%) required specialist follow up care. The estimated injury rate was 60 per 100,000 trips and hospital presentation rate was 20 per 100,000 trips. The combined cost attributable to these injuries was \$608,843 (NZD) for Auckland City Hospital and \$1,303,155 for the whole Auckland region. Most common injuries were lacerations and soft tissue injuries. Five percent of all injuries were reported to be a concussion or brain injury. 99 (40.2%) hospital presentations involved at least one fracture, with a total of 132 fractures in 99 presentations. 	26.8% of injuries were thought to be associated with alcohol use. Of the 246 hospital presentations, over 90% were recorded as loss of balance, including injuries related to excessive speed. 1.6% of presentations were caused by a vehicle collision.

Author	Jurisdiction, Data Source, Study Design	Injury Type	Findings/Burden	Mechanism of Injury
Brownson (2019) ⁸	Auckland, New Zealand Auckland City Hospital (Retrospective Study)	Contusions, abrasions, lacerations, fractures, dislocations, sprains, and concussions, intra-cerebral hemorrhage	Note: The first shared e-scooter company was introduced to Auckland on October 15, 2018. <ul style="list-style-type: none"> Between October 15, 2018 and February 22, 2019, there were 180 patients identified from emergency department records, 60.0% were male. Common injuries included contusions, abrasions and lacerations (65.6%), fractures (41.7%) and head injuries (17.2%). One in five patients (22.2%) required surgical intervention. Injury location: 17.2% head, 10.6% face, 3.3% chest, 51.1% extremities, 65.6% external. 	Of all patients, 23.3% had consumed alcohol. Of those with head injuries; 41.9% had consumed alcohol. For the majority of patients (140/180, 77.8%) helmet use was not documented. Of those documented, three patients (1.7%) wore a helmet (one was a workplace hard hat). The mechanisms of injuries reported included: isolated fall, scooter malfunction, collision with a vehicle, pole/bus stop, or pedestrian, and medical event.
Campbell (2019) ⁹	Auckland, New Zealand	Fractures (e.g., ankle/foot, wrist,	<ul style="list-style-type: none"> From October, 2018 to February, 2019, there were 21 patients requiring 23 operations as a direct result of e-scooter use. All operations carried out were for fracture fixation: six ankles/foot, five wrists, two femurs, five tibias, two patellas and one humeral fracture. The 	14/21 patients sustained injuries from losing control due to travelling at high speed or the e-scooter

Author	Jurisdiction, Data Source, Study Design	Injury Type	Findings/Burden	Mechanism of Injury
	Auckland City Hospital Orthopaedic Department (Retrospective study)	femur, tibia, patella, humerus)	<p>Injury Severity Scores (ISS) ranged from four to 13, where the median score was nine for isolated serious fractures.</p> <ul style="list-style-type: none"> • 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. • The summative anaesthetic, theatre suite and staging costs of these operations was \$162,901. • Implants required to fix the fractures totalled \$39,898. • 93 inpatient nights and 61 follow-up clinic appointments were required incurring an additional expense of \$141,639 and \$16,119 respectively. 	wheel(s) getting caught on an uneven surface.
Blomberg (2019) ⁶	Denmark Contacts to the Copenhagen EMS (Retrospective cohort study)	Contusions, sprains and lacerations, head injury, intracranial hemorrhage, fractures, dislocations	<p>Note: The e-scooter sharing program was launched in Denmark in January, 2019.</p> <ul style="list-style-type: none"> • This study reports that riders of e-scooters sustained facial bruising and lacerations requiring sutures. • The proportion of non-riders injured by e-scooters was 17%. • The most common injuries reported were contusions, sprains and lacerations (without minor head injury). • Distal upper extremity injuries occurred in 23 (20.5%) e-scooter riders. 	<p>Riders of e-scooters were likely to be under the influence of alcohol or drugs.</p> <p>Injured non-riders of e-scooters were mostly elderly people who tripped over scooters.</p> <p>Among riders, the most common injury was from falling off the scooter (86.6%).</p> <p>A few riders collided with an object (4.5%) and the rest were hit by a vehicle or moving object (8.9%).</p>

Author	Jurisdiction, Data Source, Study Design	Injury Type	Findings/Burden	Mechanism of Injury
Liew (2019) ¹⁴	Singapore Singapore General Hospital (Retrospective study)	Soft tissue injuries such as contusions, abrasions and lacerations, and extremity injuries (e.g., fractures or dislocations)	<ul style="list-style-type: none"> • There were 36 e-scooter related emergency room visits. • There was a 2.3-fold increase in the number of e-scooter injury cases from 2015 to 2016. In 11 (30.6%) cases, another road user was implicated. • There were two cases that reported the use of protective equipment. • External injuries were most common (72.2%), followed by extremity injuries (33.3%). • External injuries included soft tissue injuries such as contusions, abrasions and lacerations, followed by extremity injuries involving fractures or dislocations. • There were nine patients that were admitted to hospital with three requiring surgery. The median length of stay was two (range 1–6) days. 	Cause of injury: Rider (e.g., loss of balance/control) (38.9%), collision with vehicle (27.8%), collision with object (e.g., lamppost, kerb) (16.7%), road condition (e.g., slope, uneven surface) (11.1%), collision with person (2.8%), device (e.g., brake failure) (2.8%).
Mitchell (2019) ¹⁶	Brisbane, Australia Royal Brisbane and Women's Hospital Emergency and Trauma Centre (Retrospective study)	Contusions, abrasions, fractures, dislocations, minor head injury, strains/sprains, thorax injury (including rib fractures)	<p>Note: The e-scooter sharing program began in November 2018 in Brisbane, AUS (the results are from the first two months following the introduction).</p> <ul style="list-style-type: none"> • The incidence of e-scooter presentations during the two-month period was ~23/10,000 emergency presentations (n= 54). • In the first month of the e-scooter program, 29 e-scooter related presentations were identified (compared to 1 presentation during the same period in 2017). <ul style="list-style-type: none"> • The presence of a helmet reduced the odds of suffering a head injury (OR 0.18, 95% CI 0.04 to 0.83). Twenty percent (n= 11) of the patients were reported not wearing a helmet at the time of the incident and 46% (n= 25) were wearing a helmet. The presence of a helmet was not documented in 33% of cases (n= 18). • The most common types of injuries were contusions/abrasions and fractures/ dislocations. • Most common locations of injuries were upper limb and head injuries. • Six patients required surgery and 15 patients needed outpatient follow-up. 	Alcohol was involved in 27% of cases. Helmets were worn in 46% of the cases presented to hospital.

Author	Jurisdiction, Data Source, Study Design	Injury Type	Findings/Burden	Mechanism of Injury
			<ul style="list-style-type: none"> • There were no deaths. • Average patient cost per presentation was \$542 (ranged from \$285 - \$1345). • The report of alcohol use did not increase the odds of admission (OR 1.25, 95% CI 0.17 to 9.01) or operative management (OR 2.14, 95% CI 0.34 to 13.42). 	
Siman-Tov (2017) ¹⁹	Israel Israel National Trauma Registry (Retrospective study)	Injuries to the head, face, neck, spine, back, torso, or extremities, traumatic brain injuries	<ul style="list-style-type: none"> • Note: This study analysed e-bike and e-scooter riders together. • During the study period (January 1, 2013 to December 31, 2015) there were 27,733 hospitalized patients due to road traffic collisions. Among them, 795 (2.9%) patients were hospitalized due to involvement with an e-scooter (n=68, 8.6%), or both e-scooters and e-bikes (n=3, 0.3%). • There were no e-scooter deaths. 	Not reported.

Public Health Ontario
480 University Avenue, Suite 300
Toronto, Ontario
M5G 1V2
647.260.7100
communications@oahpp.ca
publichealthontario.ca

