



Common Injury Patterns from Standing Motorized Scooter Crashes

Woon Cho Kim¹ · Andre R. Campbell¹

Accepted: 6 January 2021 / Published online: 9 March 2021

© The Author(s), under exclusive licence to Springer Science+Business Media, LLC part of Springer Nature 2021

Abstract

Purpose of Review With the rising popularity of standing motorized scooters in major cities in the United States, many hospitals are experiencing a surge of traumatic injuries associated with this new mode of transportation. The impact and characteristics of injuries associated with standing motorized scooters are evolving, and safety regulations for the riders are poorly defined. There is a need for a review for healthcare providers and policy makers on this topic.

Recent Findings Since its market introduction of rentable standing motorized scooters in late 2017, there has been an exponential rise in emergency department visits and hospitalization due to scooter-related trauma in urban hospitals. There have been a number of independent hospital-based and national-level studies describing demographics and trends of injury patterns in the last 2 years.

Summary Patients presenting to the hospital with injuries tend to be young male between 20 and 40 years of age, presenting at night. Head and extremity injuries are common, and patients often do not comply with helmets and other protective gears. Intoxication is a major risk factor for injuries requiring hospital admission and surgical interventions. These findings increase awareness for (1) healthcare providers to recognize and triage high-energy

injuries, and (2) policy makers to advocate universal helmet use, increase public safety education, and enforce road safety regulations to minimize the impact of these injuries.

Keywords Traumatic brain injury · Standing motorized scooter · Electric scooter · e-scooter · Micromobility · Injury prevention

Introduction

Standing motorized scooters have been rapidly adopted as a popular mode of transportation in the United States [1•]. A scooter consists of a narrow platform on two wheels and a battery-run accelerator, steered by a waist-high rod handlebar [2•]. Coupled with a smartphone app, these devices are marketed as “micromobility” technology that are easy to rent and use without formal registration or training. Since the first commercial launch in Santa Monica, California in late 2017 [2•], these rentable dockless electric kick scooters have gained explosive popularity. As of 2019, several companies were operating rental services in 109 cities across the United States [3].

Despite the growing market interest, there is no consensus on how to describe this new device in literature. Varying terminologies have been used including “electric self-balancing scooters,” “motorized kick scooters,” “dockless electric scooters,” “e-scooters,” or by their popular brand names (“Bird” or “Lime” scooters). The term “scooters” itself can be misleading, as it can sometimes imply moped-type motorcycles, pedal-operating scooters in pediatric population, or mobility scooters that are three- or four-wheeled for people who have difficulty ambulating.

This article is part of the Topical Collection on *Trauma Surgery*.

✉ Andre R. Campbell
Andre.Campbell@ucsf.edu

Woon Cho Kim
Wooncho.kim@ucsf.edu

¹ Division of Trauma and Critical Care, Department of Surgery, University of California San Francisco, Campus Box 0807, San Francisco, CA 94143-0807, USA

Public health implications of widespread use of standing motorized scooters are evolving. Despite increasing number of emergency department (ED) visits from scooter-associated injuries, there continues to be poor compliance or enforcement of local safety regulations. For instance, although most rental companies mandate riders to be a minimum age of 18 years and to strictly avoid sidewalks at all times, these rules are not always followed [2•]. Local city- and state-wide policies also vary widely, including helmet and driver's license requirements among riders [2•, 4]. Selected cities have trialed night-time curfews or partial or complete city-wide bans to regulate high-risk practices [1•, 5, 6].

Amid the COVID-19 pandemic, consumer demand for standing motorized scooters spiked as an alternative mode of transportation to avoid contact with others [7, 8]. How this will affect the burden of scooter-associated injuries in the upcoming years is unknown. We offer a review of traumatic injury patterns from standing motorized scooters in the United States.

Who Are on the Go?

According to a recent multi-city user survey, many scooter riders are young male under the age of 40. These scooters are typically used for short-distance travels for an average of one mile rides [3] for commuting or recreational purposes [9]. The average income of scooter users are typically higher than the local median income [3], although some cities experience increasing utilization of scooters in dense low-income neighborhoods with limited access to public transportation [9]. Helmet and driver's license requirements in riders may vary by state; most do not require either to rent these scooters [6, 10]. Most rentable scooters can speed up to 35–40 mph [11]. To counteract the risks of riders without protective gear, several major cities have restricted maximal speed to 15 mph [5, 10, 12], while its compliance is uncertain.

Who Gets Injured?

Several studies from high-volume trauma centers, along with national analysis of trends using the National Electronic Injury Surveillance System database, illustrate demographics and injury patterns of patients presenting to the ED after standing motorized scooter crash [1•, 2•, 4, 12–18•]. Not surprisingly, there has been a surge in number of ED visits, with an estimated number nationally increasing from 4881 visits in 2014 to 29,628 visits in 2019 [17]. Many patients presenting with injuries were adult men with a mean age of 33.6–37.1 years [1•, 2•,

4, 12–14]. Adults aged 20–40 years were the fastest growing patient cohort among all age groups [1•]. Interestingly, patients under 18 years of age, who represent demographics not permitted to rent commercially-available scooters, showed a steady increase in number over the last 2 years [2•, 15, 17, 18•].

Scooter-related injuries are an urban phenomenon where urban hospitals receive the majority of the patients (78%) compared to their rural counterparts (20%) [18•]. However, there exists regional variations even among urban trauma centers as demonstrated in a multi-institutional study of nine trauma hospitals in southern California [4]. The authors of this study suggest that socioeconomic differences in neighborhoods may explain this regional variation, as scooter users are associated with higher income status [4]. Unlike southern California, trauma centers in other parts of the country experienced fluctuation in volume with seasonal weather variations, where fewer patients presented with scooter-related injuries during cold weather months [12].

Patients presenting with standing motorized scooter injuries typically peak in the afternoon and evening hours. Although work commute is the most commonly reported reason for scooter rentals [9], nearly half of the ED visits related to scooter use occurred between 4 pm and midnight [2•, 4], suggesting high-risk behaviors on scooters are associated with non-work or recreational activities. In a level-1 trauma center in Atlanta, Georgia, 32% of the patients arrived during the temporary night-time ban hours of 9 pm and 4 am, with significantly more injuries occurring on weekends (Friday–Sunday) compared to other days of the week [12].

Head Injuries Are Common

Head injuries are the most common injuries in patients with scooter-related trauma. In all patients presenting to the ED with standing motorized scooter injuries, nearly 30% of them were diagnosed with head and neck trauma [15]. Such injuries include fractures of the skull, face, and neck; soft tissue injuries; dental injuries; concussion; and intracranial hemorrhage. While many sustained only minor injuries such as concussion, facial fractures, and soft tissue injury, it is important to note that 8–10% of all patients presenting to the ED were diagnosed with major head injuries, including skull fractures and intracranial hemorrhage [2•, 13]. Computed tomography (CT) of the head is the most commonly utilized radiologic exam during an ED visit [12], which is not surprising given the high intoxication rates in this patient population [1•, 2•, 4].

Head injuries are a major reason for hospital admissions as well. In a series in San Diego, California, 18% of the

scooter-related admissions were indicated for intracranial hemorrhage and 26% for facial fractures [1••]. A group in Dallas, Texas similarly described that 58% of admissions from scooter-related trauma were for head and neck injuries [19]. This study captures the heterogeneity of craniofacial injuries: while majority of the patients required non-operative management or simple laceration repair of the face, 12% did require significant surgical interventions including an emergent craniotomy and repairs of unstable Le Fort facial fractures in a number of patients [19].

These studies repeatedly call attention to the rarity of helmet use in patients presenting with head trauma. Across several patient series, the proportion of patients who report helmet use at the time of injury was well below 5% [1••, 2••, 19]. The local or state laws on helmet requirements are mixed, and rental companies largely rely on self-enforcement from the riders to wear appropriate protective gears [2]. The lack of helmet use may explain the paradoxically high proportion of concussion in patients riding standing motorized scooters compared to those riding other rentable micromobility devices such as motor-powered bicycles [16].

Promoting helmet use can save lives in these patients. The above findings around standing motorized scooters are concerning, because helmet use has been shown to decrease risk of traumatic brain injuries in bicycle [20] and motorcycle [21] crashes. Universal helmet law on a state-level has been linked to reduced healthcare cost, traumatic brain injury rates, and mortality in motorcyclists [22, 23]. Helmet use has been debated among bicycle users as well. Concerns that universal helmet use among bicyclists will deter people from cycling is weak; many agree on mandatory helmet requirements in high-risk riders, supplemented by improved bicycle infrastructure to promote road safety for all [24]. Although the benefits of helmet use in head injury prevention among scooter riders is not yet described in current literature, universal helmet use is strongly recommended, and therefore mandated, to standing motorized scooter riders as a key public health principle.

Extremity Injuries Are Problematic

Extremity injuries are common and comes to a close second in patients sustaining scooter-related trauma [13]. Similar to craniofacial trauma, extremity injury can vary widely in its severity and pattern, ranging from soft tissue injuries, fractures, and dislocations of the upper and lower extremities. Approximately 20–60% of patients with ED visits related to standing motorized scooter crashes have upper or lower extremity fractures or dislocations [4, 14, 15].

Many who sustain severe orthopedic injuries frequently require hospital admission and surgical procedures. Nearly half of the patients admitted from scooter-related trauma had extremity fractures as their primary diagnosis [1••]. Compared to craniofacial trauma, these patients were much more likely to undergo surgery during the same admission (odds ratio of 9.5 compared to 1.6) [1••]. It is evident from their injury patterns that some patients experience high-energy trauma; 12% of patients undergoing orthopedic procedures had open fractures and 9% had hip fractures [25]. In multiple series, severe orthopedic injuries were seen not only in adult riders but also underaged riders and pedestrians struck by scooters, identifying the need to improve regulations to protect the riders as well as the general public [25, 26].

Injuries Can Be Unpredictable

Given the high-energy mechanism, patients sustaining scooter-related trauma must be evaluated for torso trauma as well. Pelvic fracture, rib fracture, spinal injury, and solid organ injury can occur [2••, 4, 19], and polytrauma with ISS above 9 is common [1••, 14]. The rate of patients requiring major operations for thoracic or abdominal trauma is rare, but it is important to keep a high suspicion for pelvic, rib, spinal, and visceral injuries. Mortality was low [1••, 2••].

Intoxication Is a Risk Factor

Concurrent intoxication from alcohol and other illicit drug use was common in patients presenting to the ED from scooter-related injuries. In an early series by Trivedi et al. 5.2% of all riders presenting to the ED had confirmed alcohol intoxication [2••]. A multi-institutional study in southern California reported that 17.2% of the ED patients with scooter-related trauma had elevated blood alcohol level or a positive urine toxicology test [4]. Over 50% of patients requiring hospital admission from their injuries had elevated blood alcohol level or positive urine toxicology test on admission [1••], suggesting that intoxication is a risk factor for severe injuries among scooter riders.

The high rate of intoxication in this patient population is pertinent for two reasons. First, for the healthcare providers, it is important to expedite diagnostic tests and imaging to exclude devastating head injuries when neurologic exam is distorted due to concurrent alcohol or illicit substances. Second, this widespread observation is a plea for heightened regulation for safe riding practices, especially among recreational users of rentable scooters who

may often be at night, without a helmet, and under the influence.

Healthcare Burden Is Rising

Patients with injuries from standing motorized scooters impose a unique problem to the healthcare system, especially the emergency department in high-volume trauma hospitals. Many who present to the ED are discharged to home with a relatively short (< 4 h) stay in the ED [2•, 12]. Despite the short stay, patients presenting with scooter-related injuries require frequent radiologic imaging, including CT and X-rays [12], which can quickly overwhelm ED resources during busy overnight and weekend shifts.

Hospital admissions, along with ED visits, are on the rise [18•]. Data from 2019 to 2020 show that approximately 4–38% of the patients presenting to the ED with scooter-related injuries require floor admissions, while 1–25% require direct admission to the intensive care unit [1•, 2•, 14]. Approximately 5–30% of patients require urgent operations, suggesting that a subgroup of these patients sustain significant trauma from standing motorized scooter crashes [1•, 2•, 14]. A study in New Zealand showed that the economic burden of standing motorized scooter injuries to a regional healthcare system can be significant, leading to temporary ban of rental services in the area [27]. There is a need for more studies estimating cost of injuries within the domestic healthcare system.

Conclusion

With increasing popularity of rentable standing motorized scooters in the United States, the number of patients with injuries from standing motorized scooters are on the rise. While the majority of patients sustain minor trauma, early recognition of severe head and extremity injuries that require acute interventions is important. Although rare, one must also have a high suspicion for acute spinal, rib, and pelvic fractures and visceral injuries in patients sustaining high-energy insult. There also is an alarmingly high proportion of patients with concurrent intoxication presenting at night-time. Pedestrians and underaged riders are also affected, which all raise concerns for public safety. The local laws and regulations should be clear to the public, including universal helmet use among riders. Rental companies' reliance on self-enforced safety rules is unsafe, and further efforts on public safety education and rule enforcement should be made to minimize the impact of these injuries.

Funding No funding was received.

Compliance with Ethical Guidelines

Conflict of interest Woon Cho Kim and Andre Campbell declares that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Recently published papers of particular interest have been highlighted as:

- Of importance
- Of major importance

1. •• Kobayashi LM, Williams E, Brown CV, Emigh BJ, Bansal V, Badiie J, et al. The e-merging e-pidemic of e-scooters. *Trauma Surg Acute Care Open*. 2019;4(1):e000337. *Most institutional studies on injuries related to standing motorized rider describe patients presenting to the emergency department and therefore includes majority of those with minor injuries. Unlike these, this study looks at patients who require admissions and therefore describes a subpopulation with significant injuries from scooters.*
2. •• 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. *This is one of the pioneering studies describing injury patterns and demographics of patients presenting to the emergency department at a high-volume trauma center. This study also had a unique observational component of the standing motorized rider users in the community.*
3. National Association of City Transportation Officials (NACTO). Shared Micromobility in the U.S.: 2019 New York, NY: NACTO (2019). <https://nacto.org/shared-micromobility-2019/>.
4. Dhillon NK, Juillard C, Barmparas G, Lin TL, Kim DY, Turay D, et al. Electric scooter injury in Southern California Trauma Centers. *J Am Coll Surg*. 2020;231(1):133–8.
5. Lazo L. D.C. Council to weigh legislation further regulating scooter use in the city: Washington Post; Sep 12, 2020. https://www.washingtonpost.com/local/trafficandcommuting/dc-council-to-weigh-legislation-further-regulating-scooter-use-in-the-city/2020/09/12/89563dde-ec85-11ea-b4bc-3a2098fc73d4_story.html.
6. Schneider B. U.S. Scooter Ridership Surged in 2019. Now What? Washington DC: Bloomberg CityLab; August 27, 2020. <https://www.bloomberg.com/news/articles/2020-08-27/how-big-was-2019-s-scooter-boom-and-what-s-next>.
7. Demers J. City extends e-scooter pilot program as coronavirus cases rise among college students Tuscon, AZ: Tuscon.com; Sep 11, 2020 [Updated Sep 14, 2020. https://tucson.com/news/local/city-extends-e-scooter-pilot-program-as-coronavirus-cases-rise-among-college-students/article_69ae0084-2939-5f4d-bc2e-7956d87209f9.html].
8. Graf C. More scooters set to hit SF streets as city traffic starts to return San Francisco, CA: San Francisco Examiner; Sep 17, 2020. <https://www.sfoxaminer.com/news/more-scooters-set-to-hit-sf-streets-as-city-traffic-starts-to-return/>.

9. Caspi O, Smart MJ, Noland RB. Spatial associations of dockless shared e-scooter usage. *Transp Res D Transp Environ.* 2020;86:102396.
 10. Flora HC, Gloria P, Low TE. AB-2989 Motorized scooter: use of helmet: maximum speed. California Sep 19, 2018. https://leginfo.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB2989.
 11. Hollister S, Holland P, Serrels M, Little M. The electric scooter war continues. Here's how they work (FAQ): CNET.com; May 31, 2018. <https://www.cnet.com/news/electric-scooters-bikes-dockless-ride-share-bird-lime-jump-spin-scoot/>.
 12. Vernon N, Maddu K, Hanna TN, Chahine A, Leonard CE, Johnson JO. Emergency department visits resulting from electric scooter use in a major southeast metropolitan area. *Emerg Radiol.* 2020;27(5):469–75.
 13. 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.
 14. Bauer F, Riley JD, Lewandowski K, Najafi K, Markowski H, Kepros J. Traumatic injuries associated with standing motorized scooters. *JAMA Netw Open.* 2020;3(3):e201925.
 15. Aizpuru M, Farley KX, Rojas JC, Crawford RS, Moore TJ, 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.
 16. 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.* 2020;26(6):524–8.
 17. Farley KX, Aizpuru M, Wilson JM, Daly CA, Xerogeanes J, Gottschalk MB, et al. Estimated incidence of electric scooter injuries in the US from 2014 to 2019. *JAMA Netw Open.* 2020;3(8):e2014500.
 18. • Namiri NK, Lui H, Tangney T, Allen IE, Cohen AJ, Breyer BN. Electric scooter injuries and hospital admissions in the United States, 2014–2018. *JAMA Surg.* 2020;155(4):357–359. *This article shows an increasing trend in emergency department visits and hospital admissions related to standing motorized scooters in the United States using a national database.*
 19. 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.
 20. Sethi M, Heidenberg J, Wall SP, Ayoung-Chee P, Slaughter D, Levine DA, et al. Bicycle helmets are highly protective against traumatic brain injury within a dense urban setting. *Injury.* 2015;46(12):2483–90.
 21. Eltorai AE, Simon C, Choi A, Hsia K, Born CT, Daniels AH. Federally mandating motorcycle helmets in the United States. *BMC Public Health.* 2016;16:242.
 22. Carter PM, Buckley L, Flannagan CA, Cicchino JB, Hemmila M, Bowman PJ, et al. The impact of Michigan's partial repeal of the universal motorcycle helmet law on helmet use, fatalities, and head injuries. *Am J Public Health.* 2017;107(1):166–72.
 23. Centers for Disease Control and Prevention. COVID-19 in racial and ethnic minority groups June 25, 2020. <https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/racial-ethnic-minorities.html>.
 24. Hoye A. Recommend or mandate? A systematic review and meta-analysis of the effects of mandatory bicycle helmet legislation. *Accid Anal Prev.* 2018;120:239–49.
 25. 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 Jt Surg Am.* 2020;102(5):e18.
 26. Siow MY, Lavoie-Gagne O, Politzer CS, Mitchell BC, Harkin WE, Flores AR, et al. Electric scooter orthopaedic injury demographics at an urban level I trauma center. *J Orthop Trauma.* 2020;34(11):e424–9.
 27. Bekhit MNZ, Le Fevre J, Bergin CJ. Regional healthcare costs and burden of injury associated with electric scooters. *Injury.* 2020;51(2):271–7.
- Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.