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Financial impact of electric scooters: a review of injuries over 27 months at an urban level 1 trauma center (cost of e-scooter injuries at an urban level 1 trauma center)

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ABSTRACT

Background Electric scooters (e-scooters) have become a widespread method of transportation due to convenience and affordability. However, the financial impact of medical care for sustained injuries is currently unknown. The purpose of this study is to characterize total billing charges associated with medical care of e-scooter injuries.

Methods A retrospective review of patients with e-scooter injuries presenting to the trauma bay, emergency department or outpatient clinics at an urban level 1 trauma center was conducted from November 2017 to March 2020. Demographic and clinical data were collected. Primary outcomes of interest were total billing charges and billing to insurance (hospital and professional). Multivariable models were used to identify preventable risk factors associated with higher total billing charges.

Results A total of 63 patients were identified consisting of 42 (66.7%) males, average age 40.19 (SD 13.29) years and 3.2% rate of helmet use. Patients sustained orthopedic (29%, n=18), facial (48%, n=30) and cranial (23%, n=15) injuries. The average total billing charges for e-scooter clinical encounters was $95 710 (SD $138 215). Average billing to insurance was $86 376 (SD $125 438) for hospital charges and $9 334 (SD $14 711) for professional charges. There were no significant differences in charges between injury categories. On multivariable regression, modifiable risk factors independently associated with higher total billing charges included any intoxication prior to injury ($231 377 increase, p=0.02), intracranial bleeds ($75 528, p=0.04) and TBI ($360 898, p=0.006).

Discussion Many patients sustain high-energy injuries during e-scooter accidents with significant medical and financial consequences. Further studies may continue expanding the financial impact of e-scooter injuries on both patients and the healthcare system.

Level of evidence III

INTRODUCTION

There has been a recent surge in use of the 'first and last mile' business model with electric scooter (e-scooter) companies exponentially growing both financially and geographically.[1–5] In roughly 100 major American cities, there are now 85 000 e-scooters available for use with the National Association of City Transportation Officials reporting 84 million shared micromobility trips in 2018, more than double the 38.5 million trips in 2017.[6] The appeal of e-scooters as a convenient, efficient and affordable commute option has been a major driving factor behind the growth of the business.[7–9] Despite extensive contracts between scooter companies and cities, there are still questions regarding the legal, operational and financial implications as these scooters are incorporated into cities' commute options.[10–12]

As more commuters opt for e-scooter transport, visits to medical professionals for related injuries have increased. Recently, a handful of studies have reported on e-scooter related injuries in the emergency department setting with a focus on the low helmet use—reported at <5%—and the broad spectrum of injuries patients have been experiencing from minor soft tissue injuries to traumatic brain injuries.[13–17] In addition to rising rates of scooter riders experiencing injuries, injury rates of pedestrians sharing the sidewalk with scooter riders have also increased. This has led to a dilemma of where scooter riders should be as they have the potential to seriously injure pedestrians in collisions, but on the road riders are relatively unprotected as compared with vehicle passengers.[13 18] This continues to be a challenging issue to address, especially when considering results of a recent study reporting e-scooter riders are more likely to engage in more risky behaviors than pedestrians and cyclists.[19]

While previous studies have focused on demographics of those sustaining e-scooter related injuries, there has been a paucity of data on the financial consequences associated with these injuries. The purpose of this review is to: (1) broadly characterize the epidemiology and morbidity of e-scooter injuries, (2) investigate total billing charges of clinical encounters for the average e-scooter injury and (3) identify modifiable risk factors associated with higher charges. This may provide initial guidance for public health safety measures with the goal of decreasing cost in today's value-based healthcare environment.

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METHODS

Patient identification and data extraction

This investigation was conducted in accordance to Strengthening the Reporting of Observational Studies in Epidemiology guidelines for cross-sectional studies. Following Institutional Review Board approval, the institutional medical record database was queried from 1 November 2017 to 31 March 2020 for all encounters in the emergency department or trauma bay with an associated diagnosis code pertaining to e-scooter injuries and trauma protocol activation. This time period was chosen as it corresponds to the institution of e-scooters as a transportation option in the city of study and the statewide stay-at-home order due to the coronavirus pandemic. Of note, the institution at which this study was conducted is organized with the trauma bay separate from the Emergency Department (ED). The following International Classification of Diseases, 10th Revision (ICD-10) codes were used for identification of e-scooter related injuries: V00.141A (*fall from scoter, initial*), V00.141D (*fall from scooter, subsequent*), V00.141S (*fcooter accident, sequelae*), V00.142A (*scooter colliding with stationary object*), V00.148A (*other scooter accident, initial*) and V00.148D (*other scooter accident, subsequent*). Following removal ob duplicates, records of clinical encounters with an associated e-scooter related injury diagnosis code were screened for the presence of any objective injury. Medical record review confirmed that all patients sustained one or more injury. Data of interest were explicitly defined prior to abstraction in a standardized guide (please see online supplemental materials). Full medical records were manually reviewed for demographic characteristics (gender, age and primary residence), context of injury (intoxication, mechanisms of injury and helmet use), clinical course (time of first medical evaluation, trauma protocol activation, admission, surgery requirement and radioimaging), transport method (ie, transported by paramedics vs self-presentation), injury diagnoses, laboratory results, subspecialty consultation, total billing charges, total hospital charges billed to insurance and total professional charges billed to insurance.

Patients were grouped into the following categories based on the body region with the highest Abbreviated Injury Scale score: orthopedic, facial, cranial or chest/abdominal injuries. Since there were <5 patients with primarily chest/abdominal injuries, this injury category was excluded from subsequent analyses and reporting to maintain patient anonymity. The primary outcome of interest was total billing charges after e-scooter injury clinical encounters. Secondary outcomes of interest included total billing to insurance for hospital or professional charges.

Analysis

Descriptive analysis of data was summarized as counts and percentages. Healthcare costs were summarized as means with SD to capture overall financial burden as well as medians with IQRs to capture individual patient financial burden. Bivariate analysis for categorical variables was conducted using Pearson's χ^2 test. Continuous variables were compared using analysis of variance or Kruskal-Wallis tests where appropriate. Multivariable linear regression was conducted for total billing charges to account for confounding effects and identify modifiable risk factors independently associated with higher financial impact. Independent variables included in regression consisted of all patient characteristics that were present prior to clinical presentation. These included gender, age, primary injury category, Injury Severity Score (ISS), substance use, loss of consciousness or concussion, transport to the institution via ambulance (BIBA), motor vehicle involvement, helmet use (as reported by patients, bystanders or medical transportation personnel) and time of day during which the patient presented to the institution after e-scooter injury. Due to the exploratory nature of this study, adjustments for multiple comparisons were not appropriate, and thus, alpha was set at 0.05 for all statistical tests.[20 21] Analyses were performed using RStudio software V.1.0.143 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Patient characteristics and clinical course

A total of 442 patients were identified, of which 63 patients met inclusion criteria. Eighteen patients (29%) had orthopedic injuries, 30 (48%) had facial injuries and 15 (23%) had cranial injuries. A majority of patients were male (66.7%, n=42), while a minority (3.2%, n=2) reported helmet use prior to injury. Motor vehicles were involved in 16 (25.4%) of e-scooter injuries, while 37 (58.7%) of patients were intoxicated with any substance prior to injury (table 1).

A total of 50 (79.4%) patients were transported to the institution via ambulance. Eighteen (28.6%) patients required surgical intervention with two patients requiring emergent surgery. All patients were admitted for treatment of injuries with average length of stay of 3.90 (range 1–60) days (table 1).

Injuries sustained and subspecialty consultation

Overall, the morbidity of injuries was relatively high with average ISS 8.79 (range 1–30). Patients sustaining orthopedic injuries had the lowest morbidity ((average ISS 7.67 (range 1–17)), whereas facial and cranial injuries were associated with higher morbidity (Average ISS 8.67 (range 1–14) and ISS 10.20 (range 5–30), respectively). The majority of patients received either radiograph (60.3%) or non-contrast CT (96.8%) imaging.

Subspecialty consultation of trauma surgery (74.6%, n=47) was most common, followed by otolaryngology (33.3%, n=21) or ophthalmology (28.6%, n=18) consultation. Patients received an average of 1–2 consultations (table 2). One patient deceased from injuries despite intensive care. This patient had experienced a diastatic occipital fracture with scattered subarachnoid and pontine hemorrhage followed by diffuse cerebral edema and cerebral herniation.

Total billing and insurance charges

Average total billing charges for e-scooter encounters was \$95 710 [median (IQR) \$50 432 (\$42 194–\$83 046)]. Charges to insurance were an average \$86 376 [median (IQR) \$46 212 (\$39 658–\$77 686)] for hospital billing and average \$9334 [median (IQR) \$4303 (\$2528–\$8252)] for professional charges. There was a trend of higher billing charges for orthopedic and cranial injuries but no statistical difference between injury categories (table 3).

Characteristics associated with increased total billing charges included >2 consultations with \$152 540 higher charges (p=0.03), ISS 10–14 with \$43 219 higher charges as compared with ISS<10 (p=0.05), ISS>14 with \$331 154 higher charges as compared with ISS<15 (p=0.03), intracranial bleeds with \$19 448 higher charges (p=0.04) and traumatic brain injury (TBI) with \$429 805 higher charges (p=0.03). However, ISS 0–5 was associated with \$54 701 fewer charges as compared with ISS>5 (p=0.01). Involvement of motor vehicles in e-scooter crashes had a trend toward increased charges (\$26 848), but this did not reach statistical significance (table 4).

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Table 1 Patientcharacteristics and clinical course

	All injuries (n=63)	Orthopedic injury (n=18)	Facial injury (n=30)	Cranial injury (n=15)	P values
Patient demographics					
Age (years)	40.19±13.29	41.83±15.52	40.73±12.56	37.13±12.21	0.69
Male, n (%)	42 (66.7)	12 (66.7)	23 (76.7)	7 (46.7)	0.14
Out-of-town visitor, n (%)	2 (3.2)	0 (0.0)	1 (3.3)	1 (6.7)	0.56
Injury context					
Motor vehicle involvement, n (%)	16 (25.4)	7 (38.9)	4 (13.3)	5 (33.3)	0.11
Helmet use, n (%)	2 (3.2)	2 (11.1)	0 (0.0)	0 (0.0)	0.08
Any intoxication, n (%)*	37 (58.7)	6 (33.3)	23 (76.7)	8 (53.3)	**0.01**
Positive BAL, n (%)†	34 (54.0)	5 (27.8)	21 (70.0)	8 (53.3)	**0.02**
Positive urine toxicology, n (%)	11 (17.5)	2 (11.1)	9 (30.0)	0 (0.0)	**0.03**
Clinical course					
BIBA, n (%)‡	50 (79.4)	14 (77.8)	24 (80.0)	12 (80.0)	0.98
Surgery, n (%)	18 (28.6)	5 (27.8)	11 (36.7)	2 (13.3)	0.20
Length of stay (days)	3.90±8.72	6.61±14.56	2.27±2.69	3.93±7.03	0.18

P-values <0.05 bolded.
*Intoxication defined as defined by clinical evaluation, positive BAL or urine toxicology.
†BAL >11 mmol/L.
‡Patient brought in by ambulance (BIBA).
BAL, blood alcohol level.

Table 2 Injuries, radioimaging and subspecialty consultations

	All injuries (n=63)	Orthopedic (n=18)	Facial (n=30)	Cranial (n=15)	P values
Injuries					
ISS	8.79±4.63	7.67±4.06	8.77±3.40	10.20±6.86	0.40
Concussion, n (%)	7 (11.1)	0 (0.0)	1 (3.3)	6 (40.0)	**<0.001**
Intracranial bleed, n (%)*	7 (11.1)	0 (0.0)	0 (0.0)	7 (46.7)	**<0.001**
TBI, n (%)	2 (3.2)	0 (0.0)	0 (0.0)	2 (13.3)	**0.04**
Any fracture, n (%)	38 (60.3)	12 (66.7)	23 (76.7)	3 (20.0)	**0.001**
Lower extremity fracture	6 (9.5)	6 (33.3)	0 (0.0)	0 (0.0)	**<0.001**
Upper extremity fracture	4 (6.3)	3 (16.7)	1 (3.3)	0 (0.0)	0.10
Facial fracture	27 (42.9)	1 (5.6)	23 (76.7)	3 (20.0)	**<0.001**
Spine or rib fracture	2 (3.2)	2 (11.1)	0 (0.0)	0 (0.0)	0.08
Radioimaging					
Any X-ray	38 (6.3)	16 (88.9)	15 (50.0)	7 (46.7)	**0.01**
Any non-contrast CT	61 (96.8)	18 (100.0)	30 (100.0)	13 (86.7)	**0.04**
Any contrast CT	10 (15.9)	2 (11.1)	3 (10.0)	5 (33.3)	0.12
Any MRI	2 (3.2)	1 (5.6)	0 (0.0)	1 (6.7)	0.39
Subspecialty consultation					
Total number of consults	1.63±0.97	1.67±1.19	1.57±0.82	1.73±1.03	0.90
Trauma, n (%)	47 (74.6)	13 (72.2)	22 (73.3)	12 (80.0)	0.86
Orthopedic trauma, n (%)	8 (12.7)	8 (44.4)	0 (0.0)	0 (0.0)	**<0.001**
Otolaryngology, n (%)	21 (33.3)	1 (5.6)	15 (50.0)	5 (33.3)	**0.007**
Ophthalmology, n (%)	18 (28.6)	2 (11.1)	14 (46.7)	2 (13.3)	**0.01**
Neurosurgery, n (%)	14 (22.2)	1 (5.6)	4 (13.3)	9 (60.0)	**<0.001**
Orthopedic hand, n (%)	7 (11.1)	6 (33.3)	1 (3.3)	0 (0.0)	**0.002**
Plastics, n (%)	10 (15.9)	2 (11.1)	7 (23.3)	1 (6.7)	0.29
Orthopedic spine, n (%)	2 (3.2)	1 (5.6)	1 (3.3)	0 (0.0)	0.67

*Intracranial head bleeds including subarachnoid hemorrhage, intraparenchymal hemorrhage, subdural hematoma, epidural hematoma, and intraventricular hemorrhage.
ISS, Injury Severity Score; TBI, traumatic brain injury.

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Table 3 Healthcare encounter cost					
	All injuries	Orthopedic	Facial	Cranial	P values
Total hospital charges to insurance	\$86 376±\$125 438	\$97 562±\$138 163	\$65 408±\$50 818	\$122 136±\$211 574	0.39
Total professional charges to insurance	\$9334±\$14 711	\$13 691±\$21 773	\$5784±\$4015	\$12 103±\$18 577	0.17
Total billing for encounter	\$95 710±\$138 215	\$111 253±\$158 031	\$71 192±\$54 027	\$134 239±\$228 501	0.37

Multivariable regression of total billing charges revealed several modifiable risk factors to be independently associated with higher charges. These included intoxication during e-scooter crash (\$231 377 increase, p=0.02), intracranial bleeds (\$75 528 increase, p=0.04), TBI (\$360 898 increase, p=0.006) and >2 subspecialty consultations (\$200 339 increase, p=0.01). Helmet use, ISS, and type of injury were not associated with statistically significant differences in total billing charges (table 5).

DISCUSSION

Electric scooters have continued to rise significantly in prevalence and so too has the need for an effective approach to mitigate the medical and financial consequences of related injuries in today's value-based healthcare environment. In this series, we investigate the epidemiology and morbidity of e-scooter injuries, characterize billing charges for e-scooter injury clinical encounters, and identify modifiable risk factors associated with higher billing charges. We report a high prevalence of substance use (58.7%) and low use of helmets (3.2%) in those sustaining any injury while riding e-scooters. Risk factors associated with

Table 4 Total billing associated with specific patient characteristics			
	Without variable	With variable	P value
Patient demographics			
Male	\$83 932±\$76 184	\$101 146±\$159 561	0.52
Age (years)			
<40	\$74 472±\$57 566	\$116 215±\$184 729	1.00
40–64	\$110 436±\$176 614	\$76 861±\$60 208	0.67
>64	\$97 996±\$141 640	\$54 566±\$23 888	0.34
Out-of-town visitor*	\$97 644±\$140 365	\$42 538±\$486	0.27
Motor vehicle involvement	\$90 058±\$123 940	\$116 906±\$187 586	0.09
Helmet use	\$97126±\$140 459	\$56 760±\$35 898	0.59
Any intoxication†	\$69 558±\$47 148	\$110 965±\$169 250	0.97
Positive BAL‡	\$92 917±\$128 932	\$97 741±\$146 536	0.83
Positive urine toxicology	\$92 724±\$127 266	\$108 198±\$184 068	0.58
BIBA§	\$116 214±\$232 187	\$88 304±\$103 760	0.20
Clinical course			
Number of consultations			
0–2	\$224 165±\$306 098	\$71 625±\$55 326	**0.03**
>2	\$71 625±\$55 326	\$224 165±\$306 098	**0.03**
Injuries			
ISS			
0–5	\$110 105±\$157 562	\$55 404±\$36 708	**0.01**
6–9	\$111 547±\$177 735	\$76 828±\$64 825	0.78
10–14	\$85 095±\$106 651	\$128 314±\$209 823	**0.05**
>14	\$84 091±\$116 853	\$415 245±\$347 573	**0.03**
Concussion	\$70 494±\$48 323	\$116 859±\$180 833	0.34
Intracranial bleed¶	\$84 652±\$44 214	\$104 100±\$15 626	**0.04**
TBI	\$80 629±\$94 358	\$510 434±\$482 190	**0.03**
Extremity fracture	\$118 547±\$213 981	\$87 020±\$113 898	0.72
Face fracture	\$121 666±\$182 678	\$64 763±\$30 240	0.90

Results in text reported as difference between value in 'With variable' column as compared to 'Without variable' column. For example, male patients had an average total billing of \$101 146 as compared to female patients with an average total billing of \$83 932, amounting to an increased cost of \$17 214 for male patients as compared to female patients.
*As reported by patient or clinical plan for follow-up visits.
†Intoxication defined as defined by clinical evaluation, positive BAL or urine toxicology.
‡BAL >11 mmol/L.
§Patient brought in by ambulance (BIBA).
¶Intracranial head bleeds including subarachnoid hemorrhage, intraparenchymal hemorrhage, subdural hematoma, epidural hematoma and intraventricular hemorrhage.
BAL, blood alcohol level; ISS, Injury Severity Score; TBI, traumatic brain injury.

Table 5 Multivariable regression of total billing cost			
	Estimate	95% CI	P value
Patient demographics			
Male	−\$79 578	−\$199 772–\$40 615	0.18
Age (years)			
<40	Ref.		
40–64	−\$5385	−\$89 424–\$78 655	0.90
>64	\$39 818	−\$138 111–\$217 747	0.65
Out-of-town visitor	−\$50 191	−\$306 275–\$205 893	0.69
Injury context			
Motor vehicle involvement	\$17 812	−\$124 103–\$159 728	0.80
Helmet use	−\$159 708	−\$413 329–\$93 913	0.21
Any intoxication*	\$231 377	\$32 501–\$430 254	**0.02**
Clinical course			
BIBA†	−\$10 475	−\$111 059–\$90 110	0.83
Number of consultations			
0–1	Ref.		
>2	\$200 339	\$47 452–\$353 226	**0.01**
Injuries			
ISS			
<6	Ref.		
6–9	\$2930	−\$168 469–\$174 329	0.97
10–14	\$6862	−\$202 951–\$216 676	0.95
>14	\$25 815	−\$258 010–\$309 640	0.85
Primary Injury			
Orthopedic	Ref.		
Facial	−\$67 604	−\$239 177–\$103 969	0.42
Cranial	\$57 648	−\$161 254–\$276 550	0.59
Intracranial bleed‡	\$ 75 528	\$ 63 169 to \$87 887	**0.04**
TBI	\$360 898	\$116 228–\$605 568	**0.006**
Extremity fracture	−\$60 896	−\$225 661–\$103 870	0.45
Face fracture	\$102 330	−\$103 647–\$308 308	0.31

*Intoxication defined as defined by clinical evaluation, positive BAL or urine toxicology.
†Patient brought in by ambulance (BIBA).
‡Intracranial head bleeds including subarachnoid hemorrhage, intraparenchymal hemorrhage, subdural hematoma, epidural hematoma and intraventricular hemorrhage.
ISS, Injury Severity Score; TBI, traumatic brain injury.

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independent increases in total billing charges included intoxication during e-scooter crash ($231 377 increase), intracranial bleeds ($75 528 increase) and TBI ($360 898 increase).

There has been a dramatic increase in e-scooter injuries with morbidity ranging from benign superficial abrasions to devastating severe traumatic brain injuries or death.[12–15 17 22] The incidence of e-scooter injuries increased from 1.6 per 100 000 in 2014 to 2.6 per 100 000 in 2017 with a 77% rise specifically within the millennial cohort (aged 22–39 years).[16]

In addition, the introduction of e-scooters into major cities has caused some cities to resort to temporary e-scooter bans in order to develop the infrastructure to support e-scooter use.[23 24] Solutions proposed to minimize scooter-related injuries have included increasing helmet use by mandating e-scooter companies to provide appropriate head protection,[12 25] as well as minimizing pedestrian bystander injuries and scooter injuries from motor vehicle crashes by designating scooter-specific lanes similar to bike lanes.[11 26] Ultimately, the solution to decreasing injuries will likely consist of a multifaceted approach incorporating new infrastructure, public education and formal legislation measures.

To date, no study has reported on the financial implications electric scooter injuries have on either the healthcare system or individual patients. The presently reported average $95 710 total billing charges for e-scooter injury clinical encounters are in stark contrast to the commonly advertised $1 activation fee for use of e-scooters.[27] This total billing charge is indicative of the payment the non-profit medical system would need to receive to avoid accruing debt in relation to the clinical encounter. It is challenging to identify which party absorbs the majority of the financial burden for clinical encounters after e-scooter injuries. However, this burden is significant in all scenarios: patients may experience significant financial stress, medical insurances may respond by increasing cost of baseline plans and premium or the medical system may increase charges for other services. Regardless, the fact remains that one party ultimately absorbs the majority of the financial burden for an e-scooter injury encounter that may have been prevented with improved public health safety measures in place.

Risk factors associated with higher total billing charges included any substance use prior to e-scooter crash, ISS >10, intracranial bleeds, TBI and >2 subspecialty consultations. These were identified in the context of a 58.7% rate of any substance intoxication and 3.2% self-reported rate of helmet use during e-scooter crashes. Enforcing use of helmets while riding e-scooters may decrease both overall morbidity of sustained injuries as well as decrease rates of TBI.[28 29] Unfortunately, it is unreasonable to expect e-scooter companies to have claim responsibility for helmet use, especially after riders choose to sign the waiver of responsibility on the mobile app prior to having access to e-scooters. It is thus not surprising to observe that social media promotion of e-scooters portrays riders wearing protective gear in a mere 6.79% of content with completely absent written content regarding protective gear.[30 31] Investigations of e-scooter crashes, similar to those in non-motorized bicycle crashes, may serve as further evidence for publish health advocacy of improved regulations measures.[12 25 32]

Disincentivizing substance use while riding e-scooters is another concrete, and likely highly impactful, risk factor to target for mitigation of medical and financial consequences of e-scooter injuries. While there are clear legal mandates against operation of motor vehicles and bicycles while intoxicated, e-scooters are not defined in motor vehicle codes and thus are not explicitly covered in local operational law.[33] Recent state-specific legislation proposals by e-scooter companies to legalize e-scooter use have incorporated clauses preempting local city authorities from regulating shared micromobility services in exchange for introduction of e-scooters into metropolitan areas.[6] The mounting global literature reporting increasingly morbid e-scooter injuries is clear evidence of the need for improved public safety regulations.[14 15 17 32 34–40] The issue at hand is complex with corporate social responsibility, medical ethics, public health ethics and government stewardship at play.[41–44]

Limitations

This study has several strengths and limitations. First, this paper addresses costs associated with admitted patients as this cohort of patients had the most reliable documentation of mechanism of injury due to the multiple independent documentation from specialty consultations. However, there were many more patients presenting to the ED and subsequently discharged that incurred costs associated with e-scooter related injuries. Use of ICD-10 diagnosis codes for identification of our patient population may have incorporated a selection bias towards more severe injuries. While this method successfully included most patients evaluated for scooter-related injuries, it relies on accurate assignment of diagnosis codes by providers. Providers may not be aware of the available ICD-10 code specification for e-scooter injuries or may not code injuries according to mechanism of injury. Additionally, patients with very minor injuries may not have disclosed to their provider the association of e-scooters with their injury. Thus, our patient population may be skewed towards more severe injuries that warranted patient interview and documentation by multiple providers. Second, abstraction of helmet use prior to injury relied on medical provider query of helmet use and subsequent medical record documentation. This may have led to under-representation of helmet use within the present cohort. However, incorporation of patient's self-reported helmet use portends the risk of over-representation. Overall, the risk of over-representation or under-representation of helmet use was likely minimized, as the currently reported rates are similar to prior observational studies,[14] the majority of patients had medical record documentation from more than one provider (increasing the likelihood of more inclusive documentation within the medical record), and the majority of patients had explicit documentation of answering negatively to the question of 'were you wearing a helmet when you were injured'. Finally, use of total billing charges from a single institution limits the generalizability of results to patients evaluated at other institutions. However, this was minimized by focusing the investigations of financial burden towards relative differences in cost rather than absolute values. In the context of these strengths and limitations, this study provides useful insight into the financial burden of e-scooter injuries and therefore possible actionable changes that can be made on a policy level.

CONCLUSIONS

While electric scooters continue to be a convenient and attractive commute option, the financial burden of clinical encounters for injuries, averaging $86 376 for each clinical encounter, is much higher than the advertised activation fee of $1. Modifiable risk factors independently associated with higher charges included any substance use prior to injury, intracranial bleeds and TBI in the context of high substance and low helmet use in those sustaining e-scooter injuries. Further studies will be needed to evaluate the payment distribution of hospital charges between insurance and individual patients as well as the total amount that

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is ultimately unaccounted for and absorbed by the healthcare system.

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Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information. Data contains personal health information (PHI) and so has been presented in anonymized format in the manuscript as per the accepted institutional review board (IRB) protocol.

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