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From Peril to Protection: an evaluation of regulations impacting eScooter injuries

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ABSTRACT

Background The use of standing electric motorized scooters (eScooters) has skyrocketed since its first release in 2016. This quickly popularized form of transportation has been associated with significant injury and even death. These eScooter-related traumatic injuries led to local advocacy efforts, resulting in safety restrictions including speed limit geofencing, sidewalk restrictions, and limiting the number of eScooter providers in high-density population areas. We hypothesized that these local safety restrictions decreased the number of eScooter-related injuries presenting to our trauma center.

Methods This is a retrospective cohort study of eScooter-crash patients presenting to our Level 1 trauma center from July 2018 to June 2023. Variables included patient demographics, injury severity score (ISS), and mortality. The primary outcome was the rate of eScooter patients presenting over time in relation to the implementation of local-regional safety regulations.

Results A total of 381 patients presented after eScooter crashes. Males were 73.8% of patients. The average age was 38.6 years; 45+ years was the most common age group at 33%, followed by ages 25–34 (31%). The mean ISS was 9±6, with ISS 0–9 (65.1%), 10–15 (24.4%), 16–24 (8.4%), and >25 (20.1%). There were three (0.8%) deaths. The median number of eScooter patients per month with prespeed limits was nine and post five (p=0.005), showing a 44.4% decrease in injured patients. After February 2022 restrictions, the rate precipitously declined with a median of two (p=0.033), reflecting an additional 60% decrease in injured patients.

Conclusion Local advocacy resulting in increased safety regulations was associated with a significant reduction in injured patients secondary to eScooter use. This demonstrates the importance of advocacy efforts in response to changes in injury patterns and mechanisms of injury. We believe that our work can serve as a model for other urban centers seeking to reduce eScooter-related injuries and implement effective safety measures.

Level of evidence IV, prognostic/epidemiologic.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Many previous studies have shown a rise in eScooter use and associated injuries, but not much has been published on how to reduce the number of injured patients.

WHAT THIS STUDY ADDS

⇒ This study demonstrates that our region saw a reduction in eScooter-related injuries that were associated with the implementation of local safety regulations, including no-use zones and speed limits enforced by satellite geofencing.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ We believe that our work can serve as a model for other urban centers seeking to reduce eScooter-related injuries and implement effective safety measures through local-regional regulations.

BACKGROUND

Scooters have been a part of transportation dating back for over 200 years; however, in 2017, multiple rideshare companies started distributing motorized stand-up scooters (eScooters) on our streets, creating a public health concern. eScooters were left on sidewalks and the side of the street for people to rent and use for local transportation and were advertised as an ecologically friendly alternative mode of transportation. Many urban environments became saturated with rental eScooters with minimal rules and regulations for their use at the outset. These eScooters were able to travel up to 35 mph on streets and sidewalks; helmets were not required and were rarely used.[1] In addition, it was common for multiple riders to get on an eScooter that is intended for a single person.

The insertion of this new mode of transportation into our communities was accompanied by a significant number of injured patients seen at trauma centers.[1–5] We previously reported on injuries occurring during the first year after eScooters were made available in our area, demonstrating a significant increase in the overall number of eScooter-related admissions starting in late 2018.[1] Of note, only 2% of patients were reported as having a helmet, and the majority of patients were intoxicated. In addition, a large proportion of these patients sustained significant injuries, with 42% of patients having an injury severity score (ISS) ≥9, and about one-third required surgical intervention.[1]

As part of our trauma center's injury prevention efforts, we collaborated with our university's School of Public Health and also reached out to local media to help inform the public[6] of the risks of eScooter-related injuries. Additionally, we collaborated with one of the major eScooter companies to serve as public health liaisons to help guide their safety policies. We hypothesized that these injury prevention efforts would have a positive impact on our community by decreasing eScooter-related injuries. Here, we aimed to characterize the evolution

of eScooter use in our region and how changes in the rules and regulations have decreased eScooter injuries.

METHODS

This study was approved by our institutional review board. This is a descriptive retrospective cohort study from the trauma registry of our Level 1 trauma center. We queried the registry and included all patients who presented with eScooter injuries between July 1, 2018 and June 30, 2023, based on the International Classification of Diseases, 10th Revision (ICD-10) E-codes for eScooter injuries. ICD-10 codes (V00.141A, V00.831A, V00.832A, V00.841A, V00.842A, V03.031A, V03.038A, V03.12XA, V03.131A, V04.931A, V13.4XXA, V23.4XXA, V27.4XXA, V28.4XXA, V87.7XXA, V87.8XXA, V87.9XXA, and Y33.XXXA) were used to identify charts to include. Injuries related to motorized wheelchairs or mobility devices, electric bikes, dirt bikes, and mopeds were excluded. Variables examined included age, gender, race, ethnicity, helmet use, alcohol intoxication, urine drug screen, injuries, injury severity score (ISS), need for the operating room, hospital length of stay (LOS), intensive care unit (ICU) admission, ICU LOS, ventilator days, and mortality.

The primary outcome was the rate of injured patients presenting due to eScooter crashes over time, in relation to the implementation of local-regional regulations for eScooters riders and companies. These regulations include speed limitations, road rules, geofencing, and limiting the number of companies allowed in the county. It is important to note that, though there are other trauma centers in our region, the county's trauma system is set up with strict catchment areas, and this institution receives all patients injured in the downtown corridor with rare exceptions. Though the regulations implemented were county-wide, the speed limits enforced by satellite geofencing on rental eScooters and no-ride zones are primarily in the downtown corridor, which is covered by this center's catchment.

Changes in the rate of patients injured over time were analyzed by month and set time periods defined by the dates of regulation implementation. July 2018–January 2020 represents the pre-regulation period. February 2020 was the initiation of speed limits and geofencing; therefore, we defined February 2020–January 2022 as post-regulation period 1. Multiple additional regulations were initiated in February 2020, including single passenger, no sidewalk use, parking restrictions, and limiting the companies to four. The start of these regulations was used to define post-regulation period 2 as February 2022–June 2023. The dates of March 2020–August 2020 represent the time period of lockdown due to the COVID pandemic. The difference in eScooter patient rates between time periods was analyzed by comparing the difference in medians using the Kruskal-Wallis test. We then performed a binomial regression to analyze the impact of each regulation on the number of injured patients over time, controlling for seasonality based on the month of the year and the months of lockdown due to the pandemic. The difference in median ISS and median AIS between time periods was also analyzed using the Kruskal-Wallis test.

Data analysis was performed using Microsoft Excel V.16.5 (Microsoft Corp, Redmond, Washington, USA) and SPSS Statistics V.28.0 (IBM Corp, Armonk, New York, USA). Descriptive statistics included percentages and frequencies. Continuous variables were described using mean±SD if normally distributed and median with IQR if not. The Strengthening the Reporting of Observational Studies in Epidemiology guideline was used to ensure proper reporting of methods, results, and discussion (online supplemental file 1). The authors have no conflicts of interest to disclose.

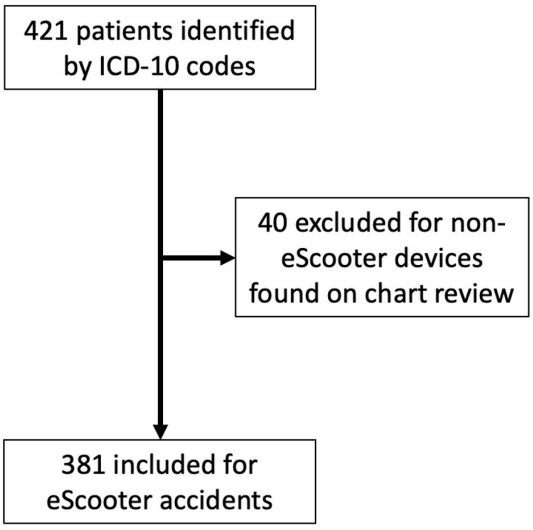

Figure 1 Consort diagram of patient selection. ICD-10, International Classification of Diseases, 10th revision.

RESULTS

A total of 381 patients were evaluated after eScooter crashes during the study period (figure 1). Men made up 73.8% of the patients. The majority of patients were non-Hispanic white (55.1%). The mean age was 38.6 years (SD ±12.5), with the majority (33%) being greater than 45 years. Ages 25–34 (30.9%) was the second largest age group (table 1).

Only seven patients (1.8%) were wearing a helmet at the time of their injury. At the time of admission, 94.8% of patients were tested for alcohol, of which 64.8% were positive. The median blood alcohol level in intoxicated patients was 210 mg/dL blood (IQR 140–250). Urine toxicology screening was performed in 75.6% of patients, of which 39.6% were positive. Of those patients undergoing urine toxicology, the most common substances identified were tetrahydrocannabinol at 20%, followed by methamphetamine and amphetamines at 8.9% (table 1).

The median ISS was 9 (IQR 5–12), and 34.9% of patients had at least moderate injuries with an ISS >9 (table 2). The most common injury regions with AIS ≥2 were the head (81.1%), face (32.5%), and extremity (17.8%) (table 2).

Intracranial hemorrhage (ICH) was identified in 87 patients (22.8%). The most common ICH pattern was subarachnoid hemorrhage (SAH) at 15%. ICU admission was required for 98 patients (25.7%), with 15 patients (3.9%) requiring intubation and mechanical ventilation. The median ICU LOS was 2 days (IQR 2–3), with intubated patients having a median of 2 (IQR 2–17) ventilator days. The median hospital LOS was 1 day (IQR 1–2); notably, the maximum was 115 days. Operative intervention was required in 85 patients (22.3%). There were three (0.8%) deaths in the study time period.

The median number of eScooter patients per month pre-regulations was 9 (IQR 7–14). In post-regulation period 1, the median number of eScooter patients per month was 5 (IQR 3–9); this was a significant decrease in the injury rate, with an overall decrease of 44.4% (p=0.005). Though there was a significant drop in injured patients during the 2020 pandemic lockdown, there was a compensatory high rate after the reopening and before additional city regulations were implemented (figure 2).

Table 1 Demographics and outcomes of patients involved in eScooter accidents

Total Study Population	n=381	%
Age		
>45 years	126	33%
35–44	92	24.1%
25–34	118	30.9%
20–24	37	9.9%
15–19	8	2.1%
Sex		
Male	281	73.8%
Female	100	26.2%
Race/ethnicity		
Non-Hispanic White	210	55.1%
Hispanic	83	21.7%
Asian	17	4.5%
Black	13	3.4%
Other race	57	14.9%
Not documented	1	0.3%
Helmet use	7	1.8%
Alcohol screen positive*	234	64.8%
Median blood alcohol level (IQR)	210 (140–250)	
Urine toxicology positive†	93	39.6%
Tetrahydrocannabinol	78	20%
Amphetamines	34	8.9%
Cocaine	19	5%
Required ICU admission	98	25.7%
Required surgery	85	22.3%
Median LOS (IQR)	1 (1-2)	
Median ICU LOS (IQR)	2 (2-3)	

*Total patients screened=361.
†Total patients screened=288.
ICU, intensive care unit; LOS, length of stay.

Post-regulation period 2, the rate of eScooter patients had another significant decline with a median of 2 (IQR 2–4) patients per month, representing an additional 60% decrease (p=0.033). The Kruskal-Wallis test resulted in a statistically significant decline in eScooter patients over time when comparing time periods after the implementation of new regulations (figure 3).

Table 2 Injury characteristics following motorized scooter accidents

Total Population	n=381	%
Median ISS	9 IQR 5–12	
Mild ISS 0–9	248	65.1%
Moderate ISS 10–15	93	24.4%
Severe ISS 16–24	32	8.4%
Critical ISS ≥25	8	2.1%
Abbreviated Injury Score ≥2		
Head	309	81.1%
Neck	7	1.8%
Face	124	32.5%
Chest	25	6.6%
Abdomen	9	2.4%
Extremity	68	17.8%
Skin	34	8.9%
Mortality	3	0.8%

ISS, injury severity score.

Additional analysis was performed using the Kruskal-Wallis test, excluding the COVID lockdown dates. The median number of eScooter patients per month pre-regulation was 9 (IQR 7–14); in post-regulation period 1, excluding the lockdown dates, the median rate was 5 (IQR 3–11), and in period 2, the median rate per month was 2 (IQR 2–4). With the lockdown dates excluded from the analysis, there was no longer a significant decrease in injuries during post-regulation period 1 (p=0.097). However, post-regulation period 2, from February 2022 to June 2023, did have significantly fewer eScooter patients per month compared with both of the preceding time periods (p=0.002 and p<0.001, respectively).

Binomial regressions to assess the impact of the two regulations in February 2020 and February 2022 over the entire study period were performed, adjusting for seasonality and the lockdown dates. After the first regulations, the relative risk (RR) of eScooter crash patients per month was 2.2 (p=0.282). Subsequently, after the second regulation, the RR was 0.4 (p=0.073).

Injury severity remained consistent over all time periods (pre-February 2020, February 2020–January 2022, post-February 2022) with a median ISS of 9 (IQR 5–12). The Kruskal-Wallis test did not show a statistically significant difference in median ISS over time (p=0.362). In comparing head AIS between time periods, pre-February 2020 had a median AIS head of 2 (IQR 2–2), February 2020–January 2022 had a median AIS head of 2 (IQR 2–3), and post-February 2022 had a median AIS head of 2 (IQR 1–2). The Kruskal-Wallis test did not result in a statistically significant difference in median head AIS over time (p=0.123).

DISCUSSION

eScooter injuries have been on the rise nationwide since they were made widely available for rental in many cities.[7] This study demonstrates that our region saw a reduction in eScooter-related injuries that were associated with the implementation of local safety regulations, including no-use zones and speed limits enforced by satellite geo-fencing, which controls the maximum device speed for all rented eScooters. Furthermore, after a second set of regulations went into effect that limited use to a single rider, prohibited sidewalk use, created designated eScooter parking areas, and limited distribution to only four eScooter companies, injuries further decreased.

The lockdown had a direct effect on eScooter activity, decreasing use overall and hence a decrease in the number of injuries. This lockdown effect was sharply followed by an immediate resurgence in eScooter use and resultant injuries. The uptick in eScooter injuries immediately following the end of the lockdown was likely multifactorial and could have been in part due to the excitement of the public to get back outside. Of note, the rates of eScooter patients quickly declined to pre-lockdown levels within 2 months of the re-opening and continued to decline thereafter. These variations due to the lockdown likely impacted the results of the binomial regression used to assess the change over time and are why the RR of eScooter patients is in relation to the two regulation periods despite the fact that the post-regulation period 2 had an RR reduction of 60%. Hence, we credit the long-term decrease in injuries to the effectiveness of implementing eScooter rules and regulations, supporting the need for ongoing advocacy with local government to address this public health issue.

Previous California state law required helmet use during eScooter use; however, an amendment was signed into law on September 19, 2018, which eliminated this requirement for drivers 18 years of age and older. Bloom *et al* demonstrated a

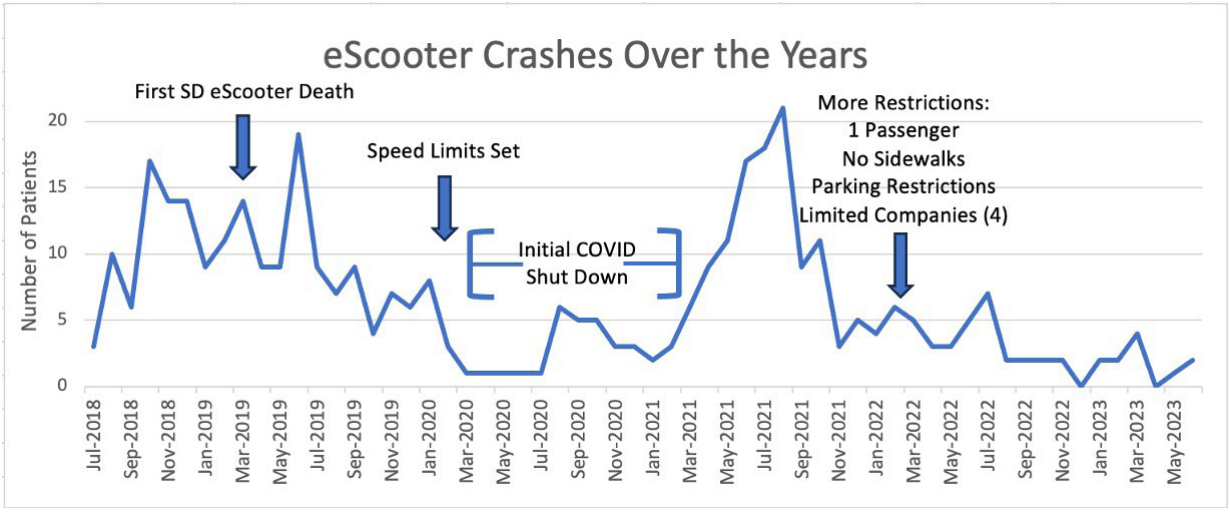

Figure 2 Pattern of eScooter crashes over time with a timeline of restrictions placed.

decrease in craniofacial injuries with helmet use.[8] Furthermore, another study reported that all patients presenting with traumatic brain injuries were unhelmeted riders.[9] Despite evidence of the benefit of helmet use and the recommendation provided by companies when signing up to rent an eScooter, many studies have shown that the majority of riders do not wear helmets.[2 8 9] This is supported by our study demonstrating less than 2% of patients wear a helmet, and this is similar to the rates reported by other studies in the USA.[2 8 10] The rate of head injuries was very high at 81%, which would account for many of the ICU admissions observed. AIS for head injuries did not change with regulation implementation, showing that although the overall injury rate decreased, the head injury rate did not. This leaves room for further research and regulations regarding helmet laws.

eScooter use is frequently associated with acute intoxication, further increasing the risk of injury. The increased use of eScooters during the late-night hours as transportation while intoxicated was demonstrated by a group in Oslo, Norway.[3] Similar to other studies, we demonstrated that people injured on eScooters were more likely to be under the influence of drugs or alcohol. Sher *et al* also demonstrated an association between increased injury severity and alcohol intoxication.[10] Additionally, Hamzani *et al* showed that patients were significantly more likely to be admitted to the hospital if intoxicated and injured while riding an eScooter.[11] Increased public awareness of the risks of driving eScooters while under the influence of alcohol or drugs is needed.

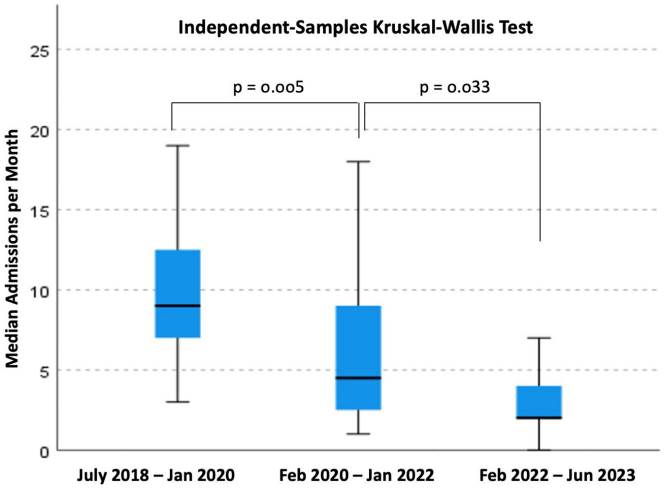

Figure 3 Median injury rates compared, showing a statistically significant decrease in eScooter injuries over time after primary and secondary restrictions were placed.

Limitations of this study include the retrospective descriptive nature, which precludes us from drawing conclusions on true causal relationships. While this study adds to prior descriptions of eScooter injuries, we remain limited by the small number of patients. The dates of regulation enactments were used as time points for change; these new laws were all announced and publicized prior to the date that police could enforce them. This could have had an effect on rider habits prior to the enforcement date and thus impacted these results, increasing the possibility that changes in rates of eScooter injuries were due to a natural fluctuation or restrictions. This study also spans the time of COVID lockdown within the city when people were largely staying home, creating variations that are difficult to account for fully. These variations and the small number of patients are why a true time series analysis was not performed. When restrictions were lifted, the resurgence in injuries was likely multifactorial. Additionally, with the subsequent multiple new regulations enacted in February 2022, it is difficult to determine which of these regulations individually had the most effect. There is also selection bias in the study towards more severely injured patients, as inclusion criteria required major trauma activation or a formal trauma service consultation. In addition, there are other trauma centers in our county that may have seen different trends. Patients could have been missed due to minor injuries that are either not treated at a hospital, treated in a delayed fashion, or discharged from the emergency department without trauma service consultation.

While eScooter use allows for more economical transportation and hypothetically reduces emissions by reducing car use, any of these benefits may not outweigh the potential risk for major injury and productive years lost. It has been shown that trauma patients are less likely to return to the workforce after discharge from the hospital despite the severity of the injury.[12] Many cities are starting to investigate their local rates of eScooter injury and how to improve injury rates and severity.

These data support implementing local-regional regulations to reduce eScooter injuries. The types of regulations used in our area can be replicated in other regions, including single-rider

regulations and geofencing boundaries, which enforced speed limits by area and deactivated devices in prohibited areas. Other regulations that helped law enforcement keep riders and pedestrians safer included no sidewalk use, the creation of designated parking areas, and limiting the number of eScooter companies allowed to four. Other potential interventions could be focused on mandating helmets to be worn whenever using eScooters and enforcing traffic laws against driving eScooters under the influence. Though additional research is needed to better conclude the association of these regulations with injury reduction, we believe that this provides a framework for further research. In addition, these results may serve as guidance for other urban centers seeking to reduce eScooter-related injuries and implement safety measures.

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