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Head and Neck Injuries and Electronic Scooter Use in the United States

Aditi Kappagantu, BS ; Kathleen Yaremchuk, MD, MSA ; Samantha Tam, MD, MPH

Objective: To quantify electric scooter injuries encountered in United States emergency departments, focusing on the head and neck, to understand the safety impact of these scooters to improve safe usage.

Study Design: Retrospective cross-sectional study from January 2009 to December 2019 of patients presenting to United States emergency departments with electric scooter injuries collected from a national database. About 2,823 cases of injuries were related to electric scooter use from January 2009 to December 2019. Stratified weighted counts and incidence rates were estimated for injury characteristics. Piecewise linear regression quantified the yearly change in incidence of injuries before and after introduction of rideshare programs.

Results: The estimated national total of electric scooter cases from 2009 to 2019 was 103,943 (95% CI: 79,650–128,237). Incidence grew in 2019 to 8.63 cases per 100,000 person-years from 4.46 in 2018 to 2.42 in 2017. Head and neck injuries represented 28.5% of total injuries (weighted estimate = 29,610). The most common age group of head and neck injuries before 2018 was ≤17 years, but injuries in 18- to 44-year-olds grew significantly to become the most injured group in 2018 to 2019 ($P < .001$). From 2009 to 2017, incidence of head and neck injuries fell by 0.02 cases per 100,000 person-years, but cases grew by 1.22 cases per 100,000 person-years post-2017 ($P < .001$).

Conclusion: Injuries following the launch of rideshare electric scooter programs increased significantly, especially in patients 18 to 44 years of age. Head and neck injuries represent many of these injuries. User safety education must be addressed to prevent injury as programs become more pervasive in the United States.

Key Words: Head and neck, statistics-clinical research, epidemiological studies-facial plastics/reconstructive surgery.

Level of Evidence: Level 2

Laryngoscope, 00:1–6, 2021

INTRODUCTION

Electric scooters have existed for decades, but rideshare electric scooters are a newer phenomenon. Since Bird's launch in September 2017, shared electric scooter companies have expanded services to over 100 cities and Americans took 38.5 million trips on them.¹ Lyft and Uber introduced their own electric scooter sharing services in 2018.² By 2030, the global scooter market is expected to be valued between \$300 and \$500 billion.³ Attractive features include having low operational costs and being user friendly: simply sign up on an app, locate, and unlock the scooter with the app, and they have full access to the scooter. Riders do not have to contend with parking and can "hop on, hop off."

Although rideshare electric scooters are easily accessible and cheap to use, there are potential public health risks. As the number of riders increases, the expected

number of associated injuries will increase as well. Many serious injuries and deaths resulting from these scooters have been reported in the news.⁴ The United Kingdom and Singapore have banned scooters, as have several cities in the United States. Legislation surrounding these scooters has been inconsistent and varies from city to city.⁵ Rideshare electric scooter companies have shown conflicting attitudes toward users riding their vehicles safely.⁶ Consequently, it can be difficult and confusing for riders to determine the safety of these scooters.

There have been a few studies analyzing electric scooter-related injuries. Many of these studies focused on data gathered from one emergency department (ED) making it difficult to generalize due to the variability of electric scooter policies between cities.^{7,8} Because rideshare electric scooters are relatively new, many of the current studies only analyze a few months' worth of data. The Consumer Product Sales Commission operates a national, multi-institutional injury surveillance and follow-back system known as the National Electronic Injury Surveillance System (NEISS). Its purpose is to collect data on consumer product-related injuries occurring in the United States. Using this database, hospital admissions from 2014 to 2018 in the United States due to electric scooter use was described in a short communication by Namiri et al.⁹ However, as rideshare scooters were only becoming available in 2017 and data were only available until 2018, trends were unable to be completely explored. Additionally, while head and neck injuries were one of the most common types of

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injury, details about these injuries were not reported. Therefore, this study aims to describe injuries due to electric scooter use from 2009 to 2019 with a focus on describing head and neck injuries in detail.

MATERIALS AND METHODS

NEISS Database

Patient data were collected from January 2009 to December 2019 using the NEISS database. NEISS collects data regarding consumer product-associated injuries encountered in a probability sample of approximately 100 EDs across the United States.¹⁰ Data collection is standardized among participating institutions then stratified by department size and ordered by geographic location, allowing for national weighted estimates to be calculated. All data were de-identified and publicly available, and therefore, exempt from institutional review board approval.

Case Identification

Cases were retrieved using product code 5042 (scooter/skateboards, powered) to identify injuries due to use of an electric scooter. Because the code is not specific for electric scooters, two reviewers (A.K. and S.T.) manually and independently went through each case narrative to ensure they fit the criteria of an injury resulting from electric scooter use. Cases were excluded if narratives included 1) “hoverboard,” “moped,” “self-powered,” “skate-,” “bike,” “cycle,” and “gas-powered,” 2) did not explicitly mention scooters, or 3) involved injuries that were not directly related to using a scooter (e.g., injuries resulting from seizures while riding an electric scooter).

Date of encounter, age, sex, injured body part, diagnosis, disposition, and location of the accident were available for each case. Patients were categorized as having an injury to the head and neck if the injury’s location was classified as being in the ear, eyeball, face, head, mouth, or neck. Age was categorized into five categories: 1) ≤17 years, 2) 18 to 44 years, 3) 45 to 64 years, 4) 65 to 84 years, and 5) ≥85 years.

Statistical Analysis

Stratified, weighted, nested national estimates were calculated. Descriptive statistics including median and proportions were calculated according to age, race, gender, patient disposition, and year of injury. Subgroup analyses were then completed for patients having a head and neck injury. Logistic regression was used to compare patients with and without head and neck injuries. Incidence per 100,000 persons was calculated based on United States populations from the U.S. Census Bureau for each year.¹¹ Piecewise linear regression was completed to investigate the total number of injuries and head and neck injuries before (2009–2017) and after (2018–2019) the introduction of rideshare programs. Regression coefficients were compared using linear combinations. All tests were two-tailed and a $P < .05$ was considered significant. Analyses were completed in Stata/IC (version 14.2; StataCorp LLC, College Station, TX, U.S.A.).

RESULTS

Total Injuries

Out of an initial 6,438 records pulled from the NEISS database, 2,823 fit the inclusion criteria of being an electric scooter-related injury. This results in an

estimated weighted total of 103,943 injuries (95% CI 79,650–128,237) that presented to EDs in the United States from 2009 to 2019 due to electric scooter use. Table I displays baseline characteristics of all included patients. Patients were more likely to be male (weighted estimate = 64,678, 62.2%) and White (weighted estimate = 54,791, 52.7%). The median age of injury was 29.2 years (95% CI 26.9–32.9 years). The largest proportions of injuries were in those between the ages of 18 to 44 (weighted estimate = 39,942, 38.4%) and those ≤17 years (weighted estimate = 38,859, 37.4%). Most patients were treated and discharged or examined and left without treatment (weighted estimate = 92,353, 88.8%). There were two fatalities due to injuries from electric scooter use: one patient expiring after hitting a tree and another expiring after being hit by a truck. Additional fields indicating alcohol and drug use at the time of the injury were added in 2019. In 2019, approximately 8.3% of cases (weighted estimate = 2340, 95% CI 332–4347) were reported to have involved alcohol and 1.2% of cases (weighted estimate = 332, 95% CI undefined) were reported to have drug involvement.

Head and Neck Injuries

The head and neck region was the second most commonly reported site of injury. An estimated total of 29,610 head and neck injuries (95% CI 21,450–37,772) occurred between 2009 and 2019 (Table II). Those who are ≤17 years old comprised 38.6% of the cases (weighted estimate = 9,114) while those between 18 and 44 years old comprised 35.9% of the cases (weighted estimate = 4,717). Head injuries were the most abundant with 15,742 cases reported (95% CI 12,140–19,344). The most common types of injuries were internal organ injuries, lacerations, and contusions/abrasions. The mean age of patients with a head and neck injury was 29.1 years (95% CI 26.1–31.1). In 2019, a weighted estimate of 1,417 patients (95% CI 181–2,653) suffered injuries while under the influence of alcohol and 108 (95% CI 0–283) under the influence of drugs.

Females were significantly less likely to have a head and neck injury compared to a non-head and neck injury (odds ratio 0.72, 95% CI 0.55–0.93). Patients having head and neck injuries had 6.60 times higher odds of requiring transfer to another hospital (95% CI 2.24–19.46) compared to non-head and neck injuries.

Change in Injuries Over Time

While there were small fluctuations in the total number of injuries between 2009 and 2017, there was a sharp increase in the incidence of scooter injuries from 2017 (weighted estimate = 2.42 new cases per 100,000 persons) to 2019 (8.63 new cases per 100,000 persons) (Fig. 1). During the period prior to the introduction of rideshare electric scooters, the number of injuries for patients ≤17 years old stayed relatively constant (Fig. 2A). However, a large increase in injuries in 2018 and 2019 was demonstrated in patients 18 to 44 years of age, and the proportion of injuries in this age group was

TABLE I.
Raw and Weighted Estimates for Number of Total and Head and Neck Injuries.

Characteristic	Total Injuries		Head and Neck Injuries	
	Raw Data	Estimated Number of Injuries (95% CI)	Raw Data	Estimated Number of Injuries (95% CI)
Age				
≤17	1,182	38,859 (30,459–47,258)	381	11,432 (9,114–13,749)
18–44	1,026	39,942 (21,847–58,037)	306	10,627 (4,717–16,540)
45–64	413	17,158*	117	5,288*
65–84	172	6,712 (4,998–8,425)	49	1,775 (1,148–2,402)
≥85	29	1,254*	10	489*
Unknown	1	18*		
Sex				
Male	1,766	64,678 (47,030–82,326)	579	20,054 (14,297–25,810)
Female	1,057	39,266 (30,643–47,889)	284	9,557 (6,388–12,726)
Disposition				
Discharged	2,433	92,353 (71,675–113,032)	722	25,562 (18,327–32,797)
Treated and admitted for hospitalization	284	7,809 (5,259–10,360)	91	2,283 (1,428–3,138)
Left against medical advice	41	1,492*	13	400*
Treated and transferred to another hospital	22	1,262 (902–1,622)	15	903 (684–1,123)
Held for observation	41	923*	22	461 (0–996)
Fatality	2	105*	0	0
Body part				
Upper extremity	648	23,537 (18,048–29,026)		
Lower extremity	844	32,757 (24,829–40,685)		
Torso	429	16,904 (12,492–21,316)		
All parts of the body (>50%)	14	348 (220–477)		
Not recorded	25	786*		
Head and neck	863	29,610 (21,450–37,772)		

*Weighted counts are based on a very small number of observations, so no confidence intervals were able to be computed.

statistically significantly greater compared to 2009 to 2017 ($P < .001$). Linear regression demonstrated that electric scooter injuries decreased an estimated 0.08 cases per 100,000 cases per year (95% CI -0.21–0.05) from 2009 to 2017. From 2018 to 2019, cases were observed to increase by 4.17 cases per 100,000 persons per year (95% CI 2.87–5.56). This difference was statistically significant ($P < .001$). No significant changes in type of injury was observed over time (Figure S1A).

Head and neck injury-specific data demonstrated a similar rise in injuries, from 0.55 cases per 100,000 persons in 2017 to 2.66 cases per 100,000 persons in 2019. Similar to the trends in the total number of injuries, cases in patients ≤17 years old remained relatively stable from 2009 to 2019 (Figure 2B). Cases in patients 18 to 44 years old demonstrated a steep rise from a weighted estimate of 443 cases in 2017 to 1645 in 2019. This increase in proportion of injuries in 2009 to 2017 compared to 2018 to 2019 was statistically significant ($P < .001$). Linear regression estimated that head and neck injuries due to electric scooter use was decreasing by 0.02 cases per 100,000 per year (95% CI -0.06–0.02) from 2009 to 2017. After the introduction of rideshare programs, however, there was a significant increase in the number of head and neck injuries with an estimated increase of 1.22 cases per 100,000 persons per year (95%

CI 0.78–1.66) from 2018 to 2019 ($P < .001$). No significant changes in type of injury was observed over time (Figure S1B).

DISCUSSION

Rideshare electric scooters are becoming an increasingly popular way to travel within select urban centers in the United States. Nevertheless, controversy remains about their place in society. On one hand, these scooters provide a fun, cheap, and convenient alternative to other modes of transportation. As well, they are environmentally friendly in comparison to other modes of transportation and encourage physical activity. They function as a middle-of-the-road option of travel that is perfect for going places that are too far to walk but too close to drive or take public transportation. On the other hand, many cities and public officials have attempted to ban or heavily restrict the use of these scooters in their jurisdictions.¹² Arguments against scooters focus on the safety of those riding along with being a nuisance to pedestrians who are affected by the improper storage of the scooters.

This study's findings demonstrate that electric scooter-related injuries in the United States have risen sharply since the introduction of rideshare scooters in 2017. While injuries were slowly decreasing prior to 2017,

TABLE II.
Raw and Weighted Estimates for Head and Neck Injuries by
Location and Type.

Characteristic	Raw Data	Estimated Number of Injuries (95% CI)
Location of head and neck injury		
Head	471	15,742 (12,140–19,344)
Face*	284	11,023 (6,546–15,500)
Mouth	67	1,493 (1,003–1,983)
Neck	33	1,070 [†]
Eyeball	4	179 [†]
Ear	4	104 [†]
Diagnosis of head and neck injury		
Internal organ injury	281	9,611 (7,143–12,080)
Laceration	199	7,364 (4,287–10,440)
Contusions/abrasions	124	4,625 (3,035–6,214)
Concussion	104	3,281 (2,586–3,976)
Fracture	59	2,315 (1,063–3,567)
Other/not stated	18	641 (7–1,275)
Strain/sprain	22	559 (250–868)
Dental injury	33	446 [†]
Hematoma	18	445 (75–815)
Foreign body	3	228 [†]
Avulsion	1	16 [†]

*Including eyelid, eye area, and nose.

[†]Weighted counts are based on a very small number of observations, so no confidence intervals were able to be computed.

there is an alarming rise in total and head and neck injuries from 2018 to 2019. By analyzing over a decade's worth of data, these results have shown that injuries have clinically meaningfully increased in the 18 to 44 age

range despite injuries in those 17 or younger having made up the largest proportion of injuries prior to 2017.

These findings support previous studies that have demonstrated an increase in injury incidence following the launch of rideshare programs. Badeau et al.⁷ demonstrated a substantial increase in the number of electric scooter-related injuries from 2017 to 2018 following the introduction of a rideshare program in Utah in 2018. Namiri et al.⁹ and Farley et al.¹³ also used the NEISS database from 2014 to 2018 and 2014 to 2019, respectively. They demonstrated a similar significant increase in scooter-related injuries in 2018. These findings are not unique to the United States. In an analysis of electric scooter injuries in Copenhagen, a significant increase in injuries was observed within months following scooter introduction in 2019.¹⁴ In New Zealand, Beck et al.¹⁵ found that prior to rideshare programs being introduced, no electric scooter injuries were identified, whereas 55 cases were identified in the year after their introduction. Given the alarming increase in electric scooter injuries after the introduction of rideshare programs in both our study and multiple previous studies, electric scooter rideshare programs have been demonstrated to be a rising public health concern.

To further establish the public health concern of electric scooter use, the current study demonstrated a clinically meaningful increase in injuries in patients between 18 and 44 years old after 2017. Prior to 2017, electric scooter injuries were most common in those less than 18 years of age. However, rideshare programs restrict the use of their scooters to those under 18 years old potentially explaining the shift in the demographic distribution after 2017. The increased incidence of injuries in this age group after the introduction of rideshare programs are echoed in other studies in the United States^{7–9} and New Zealand.¹⁵ Nevertheless, the number

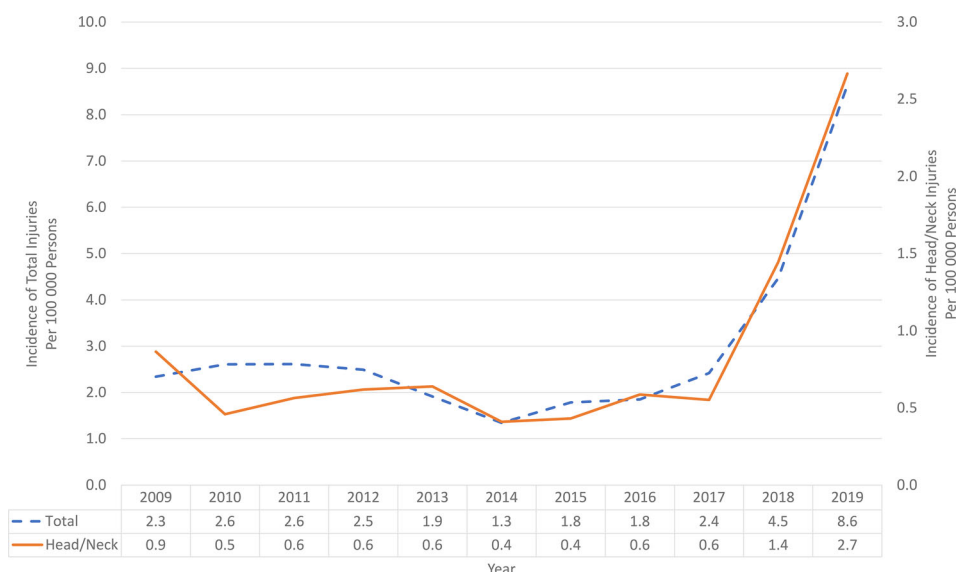


Fig. 1. Line graph and table demonstrating incidence per 100,000 persons of total and head and neck injuries related to electric scooter use from 2009 to 2019. Injury incidence increased sharply after 2017. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

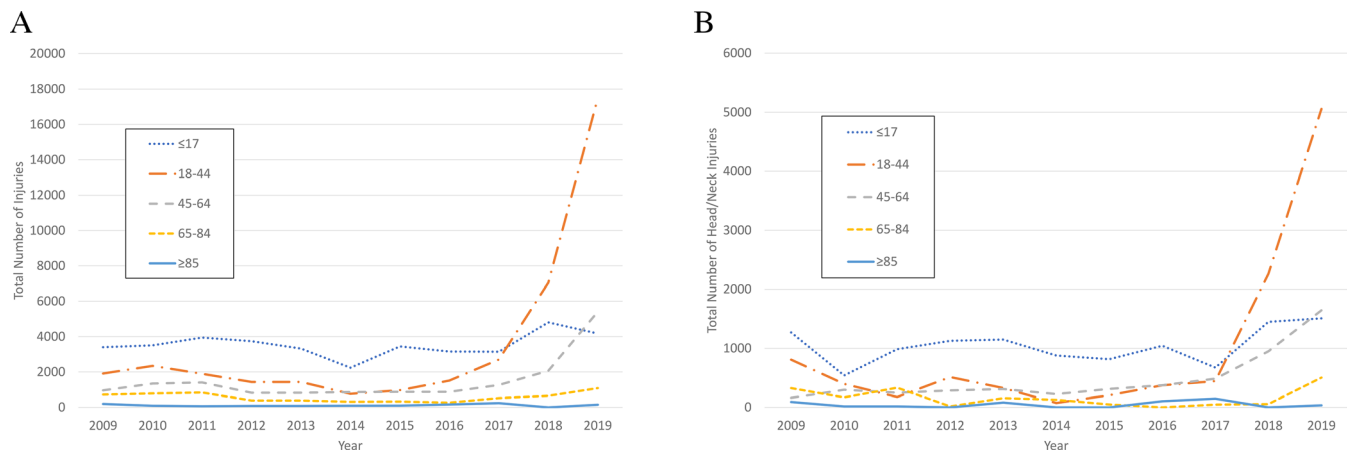


Fig. 2. Line graph demonstrating number of (A) total and (B) head and neck injuries by age group from 2009 to 2019. Eighteen- to 44-year-olds became the most injured group after 2017. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

of injuries in individuals younger than 18 years old is nonzero, and these patients continue to be at risk of injury due to scooter use.

Head and neck injuries were the second most common location of injury in the current study. This is similar to the findings in Namiri et al.'s⁹ findings using the same database from 2014 to 2018. To our best knowledge, this is the most in-depth study that focuses on head and neck injuries associated with electric scooters at a national level. Trivedi et al.¹⁶ investigated craniofacial injuries in a retrospective cohort study based on a single ED in Dallas, Texas demonstrating that a majority of patients (58%) presented with craniofacial trauma. From 2009 to 2018, the NEISS database did not include a field for a second injured body part. Therefore, while head and neck injuries were less common in our study than reported by Trivedi et al., its incidence might be underestimated given the limitations of the database.

In the current study, the most common location of head and neck injury was in the head or face, and internal organ injuries were the most common type. Although a majority of injuries were minor and allowed patients to be discharged with or without treatment, some injuries were severe enough to require more medical attention. Many of these injuries may have been avoided using a helmet. The NEISS database collects data on consumer products, and therefore, does not include a field for helmet use. Additionally, narratives were unreliable in mentioning helmet use, thus it was impossible to determine whether lack of mention of helmet use meant no helmet was used. While the current study was unable to account for helmet use, Trivedi et al. observed that no scooter riders admitted to the ED reported the use of protective headgear.¹⁶ Helmet use during electric scooter use is advocated for on all rideshare platforms. However, it is never enforced and rarely emphasized (Figure 3). Bird provides free helmets for riders if requested but this is shipped to their homes, limiting the convenience of this service. Rideshare programs emphasize convenience, yet no protective headgear is available at the point of access for any of these programs in the United States. As these

scooters become more widely used, it may become feasible to have nearby stations to pick up and drop off helmets at the same convenience as the scooters. Social media is fraught with photos of people using their scooters without helmets.⁶ Riders must be educated on the importance of protecting their head, but companies also need to be held more accountable for the safety of their consumers by promoting the use of protective gear. At minimum, e-scooter companies can demonstrate its commitment to safety by



Fig. 3. Scooter instructions indicate the rider should be at least 18 years of age, use a helmet, and park responsibly. These rules encourage safe riding but are not always followed. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

including images of riders following their rules, like wearing helmets, on their social media.

Limitations

This study's findings need to be considered in light of the limitations. The data source used was a national, deidentified sample. Thus, granularity of data was limited to protect patient identification. Therefore, our study relied on narratives to determine if an injury was related to an electric scooter. While this is standard in other studies using the NEISS database, no standardized process to ensure optimal case identification exists.^{17,18} For example, several cases involving individuals using mobility scooters may have been reported as electric scooters. However, by sorting through each narrative individually instead of relying solely on keywords in inclusion and exclusion criteria, this bias is believed to be kept to a minimum in this study, which is not the case for past studies where this was not taken into consideration.¹³ As well, electric scooters may have been in use outside of a rideshare program. This database also was unable to collect product-specific data, such as helmet use, which would be pertinent in understanding how to mitigate electric scooter injuries in the future. Multi-institutional prospective collection about these details would be useful in the future as other retrospective studies relying on chart review also suffered from this limitation.^{14,19,20} Alcohol and drug use were newly added fields in the 2019 database. While alcohol and drug use are prohibited by rideshare companies when using electric scooters, based on prior studies, 5% to 35% of patients reported scooter use while intoxicated.^{14,15} Additionally, the current database does not include any geocoded data. As cities have different regulations for rideshare use, variation by urban center would provide insight into variations in injury patterns due to local safety precautions.

Despite these limitations, this study demonstrates the alarming rising public health concern that rideshare electric scooters present, especially for users between 18 and 44 years of age. Head and neck injuries are very common in this population and many injuries may be mitigated with the use of helmets. Further quantification of helmet use is required using prospective, multi-institutional data collection. Future efforts should concentrate on designing practical and effective interventions to improve the safety of rideshare electric scooters, especially as more urban centers adopt programs.

CONCLUSION

Rideshare electric scooters are the latest trend in transportation. However, an alarming increase in the incidence of injuries has been observed in the United States since their introduction in 2017, which indicates they are a rising public health concern. Injuries among patients between 18 and 44 years of age, the age demographic most likely to use rideshare electric scooters, saw a particular increase in numbers. Head and neck injuries represent the second most common location of an injury and represent a category of injury that may be preventable with helmet use. Future efforts directed toward

improving the safety of rideshare electric scooter use are required to prevent further increases in the incidence of electric scooter injuries as their availability becomes more prevalent.

DATA ACCESS

S.T. and A.K. had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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