Riding an e-scooter at nighttime is more dangerous than at daytime

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1 INTRODUCTION

With rapidly increasing e-scooter usage in the United States [1], a growing number of studies aim to understand the safety aspect of these emerging modes. The existing literature has a limited understanding of time-of-day and seasonal patterns of e-scooter crashes. While many e-scooter safety policies are based on the number of crashes [2, 3], accounting for exposure provides a measure of risk to inform effective preventive strategies [4].

This study focuses on motor-vehicle involved crashes since they constitute the most severe and fatal injuries. We compared daytime and nighttime motor-vehicle involved e-scooter crashes and combined them with micromobility trip data to generate exposure variables and estimate crash risk. The key research question of this paper is as follows:

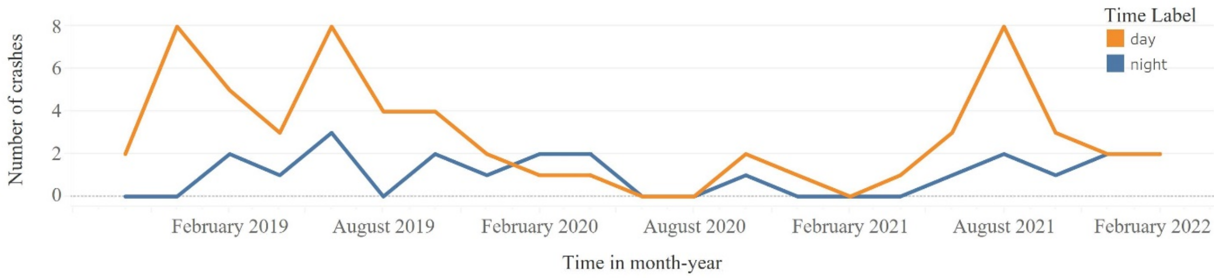
1. Are crashes or crash rates disproportionately higher at night than in the day?

2 METHODS

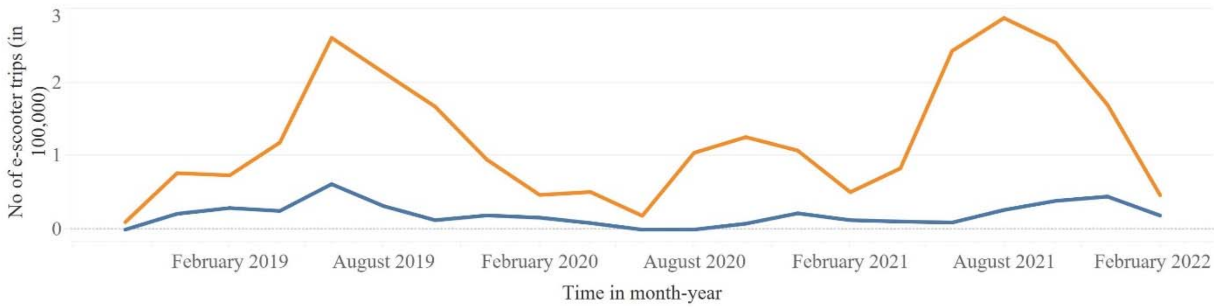
We combined crash records and e-scooter usage data in Nashville, Tennessee, from September 2018 to January 2022, using the following two datasets: 1) Tennessee Integrated Traffic Analysis Network (TITAN) police crash database to identify 82 motor-vehicle involved e-scooter crashes. We acquired the crash database for September 2018 to February 2020 from the research data of Shah et al. [5] and followed the same data collection processes to complete the dataset for the remaining study period. 2) Shared Urban Mobility Device (SUMD) dataset for e-scooter exposure for September 2018 to February 2020 acquired from the City of Nashville through a data request. We obtained e-scooter trip data for the remaining study duration from Populus Technologies, Inc, which currently curates e-scooter data for the City of Nashville. We also used Astral API to extract dawn and dusk time for a given day to identify the proportion of trips completed and crashes occurring during the daylight and nighttime hours [6].

We received hourly aggregated data from Populus Technologies, Inc with basic data cleaning (a total of 1,758,327 trips for March 2020 to January 2022). We cleaned the SUMD trip dataset from September 2018 to February 2020 following similar criteria as Populus Technologies, Inc. We first removed the duplicate trip records from the SUMD trip summary dataset resulting in 1,703,964 unique trips, and excluded 3% of the records following the cleaning criteria of Populus as follows: 1) trips with less than two or more than 5000 GPS coordinates (less than 1% of records), and 2) trip duration more than 7 hours (3% of records). In addition to these criteria, we also removed 16% of records with trip distances less than 200 feet as they are not likely e-scooter trips. We used 3,162,728 trip records throughout the study period for the analysis.

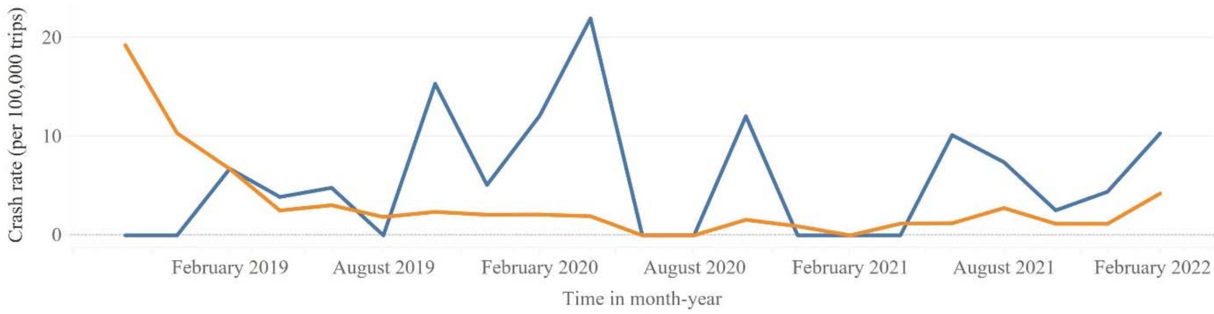
Figure 1 summarizes the bi-monthly number of crashes, e-scooter trips, and the number of crashes per e-scooter trip (crash rate) segmented by day and night throughout the study period. We used the bi-monthly level of aggregation because some months did not have any daytime or nighttime e-scooter crashes. The number of daytime crashes was generally higher than the number of nighttime crashes, as illustrated in Figure 1 a. The number of daytime trips was also higher than the number of nighttime trips, as illustrated in Figure 1 b. However, nighttime crash rates were generally higher than daytime, as indicated in Figure 1 c.



a) number of crashes



b) number of trips



c) crash rates

Figure 1 Bi-monthly number of e-scooter crashes, trips, and crash rates segmented by day and night

We used negative binomial regression in Stata to evaluate the statistical difference in the daytime and nighttime crash rates, with the number of trips segmented by time as the exposure. It is worth mentioning that Poisson regression is not suitable for this case because the mean and variance of the bi-monthly crash are not equal (1.9 vs. 4.4). The dependent variable is the number of bi-monthly crashes, and the independent variable is a dummy variable indicating nighttime crashes. We added a dummy variable for crashes observed between March 2020 to December 2020 as a control for COVID-19, as travel behavior was disrupted due to pandemic lockdown. We also used dummy variables for bi-monthly observations to control seasonal variation in e-scooter usage.

3 FINDINGS

Out of 82 motor-vehicle involved crashes, 60 (73% of all crashes) occur during the daytime, while 22 (27% of all crashes) occur during the nighttime. On average, we observed 2.6 crashes per 100,000 trips. When segmented by daytime and nighttime, the crash rate during the night was higher than during the daytime (4.8 vs. 2.2 crashes per 100,000 trips).

Table 1 summarizes the negative binomial regression model results of bi-monthly daytime and nighttime e-scooter crash rates. The model is statistically significant, indicated by the probability of LR test statistics (0.053). The pseudo-R-squared value is low (0.096) but expected as the model doesn't have many explanatory variables. The dummy variable for nighttime crashes is significant, indicating that the likelihood of nighttime crashes is 2.010 times greater than daytime crashes, holding the other variables constant in the model and controlling for exposure. The COVID-19 control is also significant, suggesting that the number of crashes decreased by a factor of 0.451 during the pandemic when accounting for exposure.

Table 1 Results of the negative binomial regression of e-scooter crash rates aggregated bi-monthly

Dependent variable: number of crashes	Incidence Rate Ratio (IRR)	Standard Error	p-value
Nighttime crashes (dummy variable)	2.010	0.538	0.009
COVID-19 control (dummy variable)	0.451	0.185	0.053
Constant	4.145	1.274	0.000
Alpha	0.047	0.111	
Model statistics			
Time control	Bi-monthly		
Number of observations	42		
Pseudo R-squared	0.096		
Log-likelihood	13.87		
Probability of LR test	0.053		

Possible reasons that e-scooter rides are riskier at night, at least compared to daytime, could be a) low conspicuity as e-scooters are small and are not equipped with powerful lights, including signaling lights, b) low visibility due to poor lighting of streets that makes it difficult for motor vehicle drivers and e-scooter riders to be aware of their environment. We did not see strong evidence of alcohol impairment in the police crash reports from drivers or scooter riders for the same crash dataset of Shah et al. [5]. Although single-vehicle e-scooter crashes might increase at nighttime (e.g., falls, colliding with objects), such crashes are not as severe as motor-vehicle involved crashes that are responsible for 80% of scooter rider fatalities [3]. The policy implication of the nighttime crash rate being higher than daytime is that additional interventions are required to improve the safety of e-scooter riders at night.

4 CONCLUSIONS

E-scooter crashes, with cars at least, are more likely to occur during the nighttime, as indicated by crash rates estimated from trip count as exposure variables. Over the summer, we are expanding this analysis to explore the built environment, transportation network, and behavioral factors contributing to e-scooter crashes.

Future research can evaluate exposure with rider demographics (gender and age group) and riders' experience (first time vs. regular riders). It is possible, but unknown, if tourists, students, or first-time riders are more prone to crashes with cars. Researchers can also explore crash severity during the day or night as well as compare the crash rates over time.

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