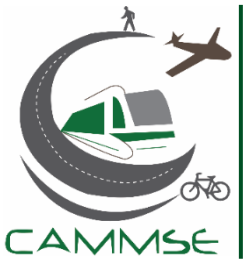

Center for Advanced Multimodal Mobility Solutions and Education

Project ID: 2021 Project 01

IMPACTS OF SPEED ON DOCKLESS ELECTRIC SCOOTER CRASHES

Interim Report

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September 2022

ACKNOWLEDGEMENTS

This project was funded by the Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE @ UNC Charlotte), one of the Tier I University Transportation Centers that were selected in this nationwide competition, by the Office of the Assistant Secretary for Research and Technology (OST-R), U.S. Department of Transportation (US DOT), under the FAST Act. The authors are also very grateful for all of the time and effort spent by DOT and industry professionals to provide project information that was critical for the successful completion of this study.

DISCLAIMER

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EXECUTIVE SUMMARY

E-scooters have been praised for being an answer to some classical mobility problems, like the last-mile problem, but have not been well-studied in terms of their risks and dangers. Dockless scooters entered the micro-mobility scene in the United States around 2017 and by 2018 had already appeared in at least 100 cities across the country. In addition to helping bridge the gap for the last-mile travel, they have also been viewed positively because of their potential to shift trips away from private vehicles, reduce one's carbon footprint, and opening the door for more travel options for underserved communities. Still, e-scooter safety issues like their speed capabilities, have not been studied well.

Transportation safety analysts have recognized the relationship between speed and fatality crashes, but speed limits for scooters have not been formally established. E-scooters can reach up to 17 mph in some cases with that number only increasing when traveling downhill. Some cities and other entities have recognized the issues with these high speeds and low-level of protection that e-scooters offer and have tried to implement safety countermeasures through geofencing. Geofencing essentially functions as a digital governor that limits scooter operations, like parking ability, speed, or even hours of operation, within a defined geographical area. The geofencing solution has been implemented in places where scooters are highly used, like universities or tourist areas. However, few studies have conducted before and after analyses of these measures and it is hard to know whether or not they truly are effective at preventing serious injuries and crashes.

This report provides and overview of the typical ways geo-fencing can improve user safety, statewide rules regarding the implementation of geofencing for e-scooters, and an overview of cities that have implemented geofencing and any issues that they faced. The objective of this report is to provide an inventory of places that have implemented geofencing to improve safety. This inventory will form a basis for further study and in-depth review. Most places that implemented geofences did so in 2019 and only provide a short window of *after* observations after being interrupted by the pandemic, which poses a significant challenge for conducting an analysis. Future planned work includes leveraging this inventory to conduct a comparative analysis of crash frequency and server for e-scooter crashes before and after the implementation of geofencing to control speeds.

Chapter 1. Introduction

1.1 Background

Dockless electric scooters, or e-scooters, were released onto the public around July 2017 (Cross, 2020). Available for rental through phone apps, the e-scooters spread like wildfire and quickly popped up all over the country. By late 2018, over 100 cities across the country saw over 85,000 e-scooters in use. In 2018 alone, riders took 38.5 million trips on e-scooters, in addition to 36.5 million trips taken in station-based bike share systems (Transportation, 2020). Marketed benefits of using an e-scooter include shifting trips away from private vehicles, completing last mile-trips, reduce one's carbon footprint, and opening the door for more travel options for underserved communities. Yet in 2020, e-scooters appeared to disappear from the roadways, as most cities enacted stay-at-home orders to slow the spread of the COVID-19 virus. Studies found that although total shared e-scooter trips decreased during the pandemic, partially owing to vendors pulling out of the market, the average trip length increased, and temporal patterns of this mode did not meaningfully change (Dean & Zuniga-Garcia, 2022). Now in 2022, e-scooters ridership levels have rebounded to pre-pandemic levels (Brasuell, 2022). The decrease in e-scooter trip use during the height of the pandemic causes a challenge in terms of understanding their impact on safety because there is less data available.

Now, as the popularity of e-scooters has continued in an upward trajectory, there has been little to no research done on the safety impacts of e-scooters. Most e-scooter vendors allow users to reach up to 15-17 mph (The Zebra, n.d.), which is a high speed for someone with little to no protection. Safety research has shown that the likelihood of injury in any crash increases with increasing speed or increasing speed differential between the bodies that intersect paths.

One solution that cities and private vendors have come up with is geofencing. Geofencing is an invisible, geographical fence that lowers the speed of an e-scooter once it crosses the fence boundaries. The e-scooter rider is tracked by GPS technology and enforced speed reductions can either slow down or completely stop the rider. Therefore, less speed means less momentum to be dissipated if a scooter collides with another body. Less speed also allows the e-scooter rider more time to react to anything crossing their path. Safety studies frequently compute the AASHTO stopping sight distance consisting of two components that are both directly proportional to speed. These components are the distance traveled when reacting, and the distance traveled when braking. Thus, speed reduction should reduce both components of the stopping sight distance.

1.2 Problem Statement

The research question to be examined in this study is whether the mandatory speed reduction, or implemented geofencing method, has had any impact on the number of scooters involved crashes and their severity. Due to the lack of collected trip data during the pandemic on UT campus, the research team is shifting their research toward another location. The location will be chosen based on the consistency and availability of their dockless scooter trip and hospital data before and after the implementation of a speed limit geofence.

1.3 Objectives

Due to the lack of collected trip data during the pandemic on UT campus, the research team is shifting their research toward another location. The location will be chosen based on the consistency and availability of their dockless scooter trip and hospital data before and after the implementation of a speed limit geofence. Once the location is chosen, the before-after analysis will be able to characterize the impact of mandatory speed reduction on e-scooter crash frequency and injury severity. The proposed work will address at least two CAMMSE research thrusts:

- Generate innovations in multi-modal planning and modeling for high growth regions;
- Innovations to improve multi-modal connections, system integration and security.

1.4 Expected Contributions

This report will provide the different types of dockless scooter safety measures that are available to the public, which will aid research efforts examining safety impacts of these measures.

1.5 Report Overview

The following sections include a basic overview of the geofence speed limit method, and a time-of-day as well as season restraint. From there, the report will review the cities that have utilized these methods, why they implemented these measures, what resulted from these safety countermeasures. Next, the report will go over the availability of data from the researched cities. Lastly, from the collected knowledge of the research cities and their data availability, this report will then reveal important knowledge gaps that stem from e-scooter geofencing. The conclusion section will provide the cities that are the highest contenders for the before-after analysis.

Chapter 2. Safety Countermeasures Available

Cities have tried to combat e-scooter safety concerns by requesting the implementation of geofencing through the scooter vendor. This section will provide a brief description of geofencing and the types of geofences that can be implemented.

2.1 Geofencing

Geofencing is an invisible, geographical fence that changes the capabilities of the scooter once it crosses the fence boundaries. Vendors track e-scooters using GPS technology and they can enforce speed reductions can by either slowing down or completely stopping the rider.

3.1.1. Speed Reduction

Geofences aim to reduce the crash rates of e-scooter by slowing down the user therefore allowing the user more time to react and avoid danger. Dangerous collisions can occur with either vehicles or pedestrians. To avoid such collisions, geofences are typically placed along areas with high-pedestrian or vehicle volumes, examples of these areas include university campuses, tourist areas, parks, and highways. Figure 1 shows the pink overlay of the University of Texas at Austin campus area where e-scooter speeds are electronically limited to 8 mph. The area includes most of the central campus from E. Dean Keeton Street on the north to MLK Blvd on the south to Guadalupe Street in the west.

Figure 1 Campus area with e-scooter speeds limited to 8 mph shown in pink overlay

3.1.2. Time Limits

Geofences do not have to remain static, and can work dynamically by only being active for specific times of day. Some examples include geofences being activated during the nighttime,

holidays or festivals. Activating the geofence during nighttime hours along areas such as downtown could greatly reduce intoxicated individuals from using e-scooters, or activation during holidays where pedestrian activity increases can reduce pedestrian and e-scooter related collisions. The Portland Bureau of Transportation used this feature after a violent clash between right and left political groups on August 22nd, 2021. To avoid further violence during this time of politically scrutiny, the city stated that "e-scooters will not be available to ride in downtown Portland or Waterfront Park" from noon Aug. 22 to 6:01 am on Aug. 23 (Smith, 2021). This alert was released to users who opened the Lime Scooter app in that area.

2.2 Summary

Geofencing is an invisible, geographical fence that lowers the speed of an e-scooter once it crosses the fence boundaries. This mechanism is used to increase safety for e-scooter users. The two forms of geofencing include: speed reduction, and/or time limits.

Chapter 3. Statewide Rules and Implementation Process

Some states throughout the U.S have enforced statewide restrictions on e-scooters riding along streets and sidewalks, yet the majority (38 states) remain in allowing street and sidewalk usage. To combat the lack of legal regulation, city officials may request geofencing technology along areas with high pedestrian or vehicular volumes. This section will provide further details on the states that have enforced e-scooter restrictions. Following this section, will be a brief discussion of the process of acquiring a geofence, and the struggle between navigating the relationship between the e-scooter vendors and city officials.

3.1 Street and Sidewalk Legal

Street Legal is the allowing of e-scooters to ride on the street alongside with vehicles and cyclists. E-scooters are street legal in 38 US states, while another ten states have deemed them not to be street legal. While electric scooters are street legal in most of the states, some states have applied different laws to where and how scooters can be operated while on public roadways (Hayes, 2022). Four of the states; California, Colorado, Massachusetts, and New York, do not allow scooters on highways, expressways, or limited-access roads due to most scooters not being able to reach safe enough speeds to keep up with the traffic. Massachusetts, Connecticut, Indiana, Maine, and Virginia have added the stipulation that while scooters are street legal, they must stay to the right side of the road while being ridden.

Electric scooters can legally be ridden on sidewalks in only five states: Arizona, Iowa, Louisiana, Rhode Island, and Virginia (Hayes, 2022). Most of the states expressly state that scooters are not allowed on sidewalks. However, the laws in 19 states fail to mention sidewalk use at all.

3.2 Implementation

The implementation of geofences typically begins with a request by the city to private companies such as Lime, Bird, and Bolt. Once the company has agreed to the request, they then are in-charge of creating the geofence. Yet once the fence is created, it is up to the city to check that the geofences are operating accordingly. City governments also do not regulate companies' service areas. Companies create their own service area boundaries and can change them at any time without approval from local officials. This can lead to confusion among riders when different companies' e-scooters stop functioning at different geographical borders. This issue appeared in Portland, Oregon, when two companies, without warning to city officials, significantly reduced their service areas during winter which made traveling outside downtown via e-scooter difficult for people who relied on the e-scooters for their year round, first choice, mode of transportation (Transportation, 2020).

3.3 Case Studies

There has been some research over geofences. A paper written by Moran in 2021, analyzed the geofences in San Francisco from 2017-2019 via manual digitization of all geofences. It was found that each e-scooter vendor's geofence expanded with time, starting in the northeast quadrant of the city, yet with little to no expansion into western neighborhoods (Moran, 2021). Moran also reviewed permit guidelines and applications submitted to e-scooter vendors

which indicated San Francisco's regulations for geofences have been limited and inconsistent, which may have contributed to the concentration of services in one section of the city, as well as disconnected geofence "islands" (Moran, 2021).

Another study by Liazos, Iliopoulou, et al., in 2022, created a methodological tool for decision-making in regulating e-scooter usage in urban areas. In other words, this paper aimed to maximize the extent of extent of geofences in an urban area for the sake of maximizing road safety, while considering travel time impacts for users (Liazos, Iliopoulou, Kepaptsoglou, & Bakogiannis, 2022). Utilizing a Non-Dominated Sorting Genetic Algorithm, NSGA-II, researchers were able to conduct a case study in downtown Athens, Greece (488 edges). Researchers used cost (travel time) and safety (geofence length) as their measurements of effectiveness. The length of a geofence was used as a measure of safety, it was assumed that the greater the length, the greater the safety impacts. Results found that the cost-wise best solution features 46.3 vehicle hours, at a geofenced length value of 10,700 m. On the other hand, safety-wise, the best solution is achieved when the geofence covers 14,100 m, yet at a high cost of 68 vehicle-hours. Evidently, there are notable differences between the two solutions, which differ by almost 40% in terms of total geofenced length and 30% in terms of user cost (Liazos et al., 2022).

Overall, research regarding geofences is limited, and from that comes an even greater lack of research regarding a review of geofences effectiveness toward safety. The research conducted by Moran in 2020 brought to light the policy issues that come with implemented geofences, while Liazos, Iliopoulou, et al., in 2022, simply used the geofence length as the assumed increase in safety. There has been no research that has conducted a before-after analysis of the injury rates after the creation of a geofence.

3.4 Summary

There are some states that clearly state that e-scooters are not street or sidewalk legal, but the majority of states lack the clear and legal condemnation of this act. Luckily cities can geofencing to hopefully lower the collision rates of e-scooters with other modes of travel.

Even this solution proves to have its own shortcomings. Ambiguity remains in the where and when geofences are place and even removed. Largely managed by the private e-scooter companies, government officials are essentially subject to the whim of the e-scooter companies on how they operate and manage the geofences. Also, there is a clear lack of research regarding the safety impacts of geofences. The following section will reveal the cities that have implemented either one or both listed safety measures.

Chapter 4. Cities with Implemented Safety Measures

There are discrepancies in U.S statewide regulations on where e-scooter users can ride. This leaves the cites without statewide regulations with very little power over e-scooter operations. City officials are allowed to request e-scooter companies to enforce geofences throughout certain locations to improve safe interactions between other modes of travel. This section serves as a brief review of the some of the cities that installed geofencing or other e-scooter safety measures. Major details such as where the geofence was placed, and what ensued after the installment of the geofences, i.e., was there a successful reduction in e-scooter related crashes will also be provided.

4.1 San Diego, CA

3.1.3. Safety Measure Details

September 2018 is when the City of San Diego created geofence boundaries as well as designated parking locations along the beach boardwalk and downtown. Their stated purpose of the geofence and parking spaces was to prevent access of e-scooters to certain areas, prevent vehicles form being locked, and limit the number and locations of vehicles parked together in downtown. The geofence reduces speeds form 15 mph to 8 mph or even 3 mph, depending on the user's location (Cutter, 2020).

The city of San Diego is one of the few cities that utilizes location data from user's cellphones to track the progress of the geofences (Cutter, 2020).Unfortunately, this trip data is not available to the public.

3.1.4. Issues

Overall, the City of San Diego claims that the geofenced boundaries generally work as expected and consistently across all vendors. Yet they did note some challenges their agency has experienced related to the limitations of GPS and to cellphone issues. Cellphones present challenges when riders switch their phones to Airplane Mode to prevent being detected in geofenced areas (Cutter, 2020). This allows the users to continue to reach up to 20 mph along the boardwalk (Nieto-Gregorio & Coronado, 2019).

4.2 Los Angeles, CA

3.1.5. Safety Measure Details

Around August 2019, the Los Angeles Department of Transportation (LADOT) began their geofence program. This program includes basic speed reductions and designates/prohibited parking areas. The geofence locations include local roadways, trails, or paths. Once the user reaches the geofence they are either subjected a maximum speed of 15 mph, or 0 mph, depending on the area (Garcetti, 2021). E-scooter users can rider on surface streets and are encouraged to ride in bike lanes if available (Cutter, 2020). Also, the LADOT requires a cap on how many e-scooter users a company can operate within city boundaries. The company must also have liability coverage, and provide community outreach/education programs, and share all trip data with the city (Cutter, 2020).

Like San Diego, LADOT also utilizes location data from user's cellphones. This data is not available to the public.

3.1.6. Issues

Los Angeles Department of Transportation claimed that the geofence boundaries typically work across all vendors, yet there has been claims of GPS location "ping-rate", and tracking errors. The GPS "ping-rate" is the automatic release of location information to vendor servers. Once the location is captured and notified that that the user is within a geofenced area, the servers then send a signal back to the scooter which then lowers its speed. The issue is that these location signals differ depending on the vendor/company that operates that scooter (Cutter, 2020). This could cause some scooters to take longer to decelerate.

There have also been issues with GPS location inaccuracies. For example, the app claims that scooter is within a geofenced area when in reality they are traveling alongside or near a geofenced area (Cutter, 2020). The latter circumstance results in an unnecessary change in vehicle speed.

4.3 Denver, CO

3.1.7. Safety Measure Details

The Denver Public Works geofence program began in August 2019. Geofenced facilities include pedestrian malls and plazas, as well as other locations with a high-volume of pedestrians. The stated goal of the geofences is to prevent access to specific areas and designated/prohibit parking areas (Cutter, 2020). The geofence can creates dead zones (0 mph), but also has reduced the speed limit to maximum of 15 mph along 16th Street transit/pedestrian mall. Based on the results from the initial geofencing pilot program, the city council voted on a new ordinance that states that e-scooter can only be used on streets or in designated bike lanes (Curley, 2019).

3.1.8. Issues

The Denver Public Works reported that geofenced boundaries generally work as expected and consistently across all vendors. In 2020, the agency even noted that geofencing has been especially effective on the city's 16th Street transit/pedestrian mall (Cutter, 2020). But in 2022 the community was singing a different tune, claiming that the 15-mph cap is not enough to deter the ever-bombarding e-scooter users (Rubino, 2022). People who live in the area claim that e-scooter users are still consistently using the sidewalk due to lack of enforcement by police officers, resulting unsafe interactions between pedestrians and e-scooter users (Rubino, 2022).

The Denver Public Works and City of San Diego respondents reported that geofenced boundaries generally work as expected and consistently across all vendors. However, respondents from Los Angeles Department of Transportation, City of Fort Collins and Portland Bureau of Transportation reported varying performance.

4.4 Tallahassee, FL

3.1.9. Safety Measure Details

Beginning in July 2019, the Tallahassee City Commission implemented a 3-month program until October 2019 to see if e-scooters are a good fit for the city (Chapter, 2019). Scooters can be ridden at various locations around the city, with one caveat. The scooters may not be used on campus, whether that of Florida State University, Florida A&M University, or Tallahassee Community College. To enforce this, the companies are required to implement geofencing to stop scooters from operating on campus. If a scooter were to enter the university, the scooter's speed would be gradually slowed to a stop.

3.1.10. Issues

As soon 5 days after the e-scooters were allowed to operate within the city, issues with the geofencing immediately arose. College and city officials claimed it to be overall ineffective, with no evidence of a speed reduction occurring on campuses (Casey, 2019). Each vendor, including Lime, was required to remove all scooters from the streets until the geofences were operating (WTXL Tallahassee, 2019). After retesting the boundaries, the e-scooter vendors redeployed the scooters in late July (Ogles, 2019). There haven't been no other complaints of the geofences malfunctioning.

4.5 Portland, OR

3.1.11. Safety Measure Details

Portland Bureau of Transportation (PBOT) initially released a 120-day pilot program in July 2018, which was then followed by a second one-year pilot program in April 2019. This second program was to gather additional data about e-scooter operations and test management strategies to address the issues identified during the first pilot (Transportation, 2020). The results from the second pilot-programs resulted in the creation of geofences that slow e-scooters from 15 mph to 12 mph, 3mph, or even 0 mph. The speed cap is dependent on the location. Most of the geofences are located along trails, paths, parks, and other non-roadways (Cutter, 2020; Transportation, 2020).

The areas with the 12-mph cap include Waterfront Park, the Eastbank Esplanade, and the Springwater Corridor. North and South Park Blocks is where e-scooters lower to 3 mph in the, and the 0 mph geofence includes natural areas like Forest Park, parks with playgrounds, and other areas of concern (Transportation, 2020). The goal of the geofences is to prevent access to specific areas, limit device speed, and designate/prohibit scooter parking areas.

Another caveat to relationship between PBOT and the e-scooter vendors is that PBOT is authorized to provide geofence shapefiles for the vendors to employ and update. This effort is to standardize geofencing boundaries across all e-scooter companies (Cutter, 2020).

3.1.12. Issues

PBOT noted that the geofencing technology functions inconsistently across e-scooter vendors. Not only that, but these inconsistencies even appear within a single e-scooter company.

These inconsistencies may be related to the ability to draw geofence boundaries given relatively low or variable geographic information system (GIS) accuracy (Cutter, 2020).

4.6 Atlanta, GA

3.1.13. Safety Measure Details

July 2019 city officials created geofences around the Eastside trail of the Beltline between Monroe Drive and Dekalb Avenue (Scott, 2019). These geofences lower riders to a cap of 8 mph. Unfortunately, the speed cap was not enough. Four e-scooter users died from getting hit by a vehicle. These fatalities occurred in Metro Atlanta during the nighttime and early morning (Bazemore, 2019). City officials responded by banning e-scooter use during the nighttime, between the hours of 9 pm to 4 am. Some cities in the metro area of Atlanta have an outright ban on e-scooters including Alpharetta, Marietta and Lilburn (Bazemore, 2019).

3.1.14. Issues

There were no stated issues with the geofences, themselves. The type of geofencing that was implemented was simply determined to not be a good fit for the city of Atlanta.

4.7 Summary

Each city implemented different safety countermeasures. These measures differ mostly between the chosen geofence speed limit. Most of the reviewed cities found some issue with the geofences, whether its inaccurate tracking measures, inconsistency across vendors, or simply not working.

Chapter 5. Data Availability

This section will provide cities that have implemented geofences, the type of geofencing, when the geofence was activated, location of the geofence, data availability for scooter trips and hospital data, and finally any other noteworthy information. From this inventory a city will serve as the case study for the geofence safety study

Table 1 Summary of Data Availability for Safety Case Studies

City	Date Activated	Safety countermeasure type	Location of Countermeasure	Available Scooter Trip Data?	Hospital/Crash Data?	Purpose for Geofence
Corpus Christi, Tx	February 2022	-Geofence (reduces to 10 mph or 20 mph depending on the area) -Designated Parking Zones	-Downtown Area -SEA District -Beach Seawall	NA	Texas Department of Transportation Crash Report and Records	Geofencing used to: • Remedy parking, safety, and oversaturation problems.
Santa Monica, CA	September 2018	-Geofence (reduces to 0mph) -Designated Parking Zones	Beach Area	Ride Report	California Health and Human Services Open Data Portal	Geofencing used to: • Remedy parking, safety, and oversaturation problems.
San Diego, CA	July 2019	-Geofence (reduce speeds from 15 mph to 8 mph or 3 mph at specified locations) -Designated Parking Zones	Beach Area	NA	California Health and Human Services Open Data Portal	Geofencing used to/for: • Prevent access to specific areas. • Pilot program delineation. • Limit device speed. • Prevent vehicle from being locked, parked, or ending a ride at specific locations. • Designate parking zones; limit number and location of vehicles parked together downtown. People are still reaching up to 20 mph

San Jose, CA	February 2019	-Geofence (reduces speeds to 12 mph) -Operations are not allowed during major US holidays	-Downtown Area –Sidewalks and transit stops	NA	California Health and Human Services Open Data Portal	Only Operators that comply with the sidewalk riding prevention requirement in the Designated Area will be allowed to continue operating in this area
Los Angeles, CA	August 2019	-Geofence (reduces speeds to 15 mph or 0 mph, location dependent) - Designated/prohibited parking zones -Los Angeles City Council requires a cap on how many vehicles a company can operate inside city boundaries; liability coverage; community outreach and education; and data sharing.	-Local roadways, trails, or paths.	NA	California Health and Human Services Open Data Portal	Geofencing used to: • Prevent access to specific areas. • Pilot program delineation. • Limit device speed. • Designate/prohibit parking areas.
Denver, CO	August 2019	-Geofence (reduces speeds to 15 mph or 0 mph, location dependent) - Designated/prohibited parking zones	-Pedestrian mall, and other specific locations	Ride Report	Denver Crash Data Dashboard	Geofencing used to: • Prevent access to specific areas. •Designate/prohibit parking areas.
Fort Collins, CO	October 2019	-Time limit: Scooters will operate daily, except between 1 a.m. and 3 a.m. -Geofence (reduces speeds to 0 mph) Scooters programmed to stop within a quarter mile of the cities and university's designated no-ride zones.	-Trails or paths, sidewalks. -University Campus's	Ride Report	Colorado Crash Data Dashboard	Geofencing used to: • Prevent access to specific areas. • Limit device speed. • Reduce sidewalk use. • Designate/prohibit parking areas.

Portland, OR	November 2018	-Geofence (reduces speeds to 12 mph or 0 mph, location dependent) - Designated/prohibited parking zones	-Trails or paths, parks (non-roadways).	Ride Report	Oregon Public Health Division Injury Data	Geofencing used to: • Prevent access to specific areas. • Limit device speed. • Designate/prohibit parking areas. • Administrative rule authorizes the agency to produce geofence shapefiles for vendors to employ and update, an effort to standardize geofencing boundaries across companies.
Tallahassee, FL	May 2019	-Geofence (reduces speeds to 15 mph or 0 mph)	-University Campus's	NA	Florida Injury Surveillance System	Geofencing used to: • Eliminate Scooter related fatalities
Gainesville, FL	June 2021	-Geofence (reduces speeds to 15 mph or 0 mph, location dependent) -Time Lime: Scooters will operate daily, except between 10 pm – 6 am. - Designated/prohibited parking zones	-University Campus's	NA	Florida Injury Surveillance System	Geofencing used to: • Eliminate Scooter related fatalities
Newark, NJ	August 2021	-Geofence (reduces speeds to 15 mph)	-Plaza in front of Subway Station -Sports Arena	Ride Report	New Jersey State Health Assessment Data	Geofencing used to: • Remedy parking, safety, and oversaturation problems.
Atlanta, GA	July 2019	-Geofence (reduces speeds to 8 mph) -Time Lime: Scooters will operate daily, except between 9 pm – 4 am.	-Trails or paths, parks (non-roadways) -Downtown Area .	Ride Report	Georgia Discharge Data System	Geofencing used to: • Eliminate Scooter related fatalities

Louisville, KY	August 2019	- Geofence (reduces speeds to 15 mph or 0 mph, location dependent) -Time Lime: Scooters will operate daily, except between 9 pm – 6 am.	-Trails or paths, parks (non-roadways) -School for the blind -Skatepark -Main bridge -Expo Center	Ride Report	Louisville Public Health Data & Reports	Geofencing used to: • Eliminate Scooter related violence and fatalities • Limit some locations access to scooters
Milwaukee, WI	June 2022	- Geofence (reduces speeds to 15 mph or 0 mph, location dependent) -Operators must release data monthly to Department of Public Works, including complaints and crash information	-Trails or paths, parks (non-roadways) -Skatepark -Main bridge –Sidewalks and transit stop -University Campus's	Ride Report	Milwaukee County Medical Examiner Public Access	Geofencing used to: • Remedy parking, safety, and oversaturation problems.

Chapter 6. Conclusions and Next Steps

E-scooters have become increasingly popular in the United Sates, but there has been very little research done on the safety impacts of e-scooters and associated safety countermeasures. Scooters can reach speeds shy of 20 mph, exposing users to crashes and injuries. Safety research has shown that the likelihood of injury in any crash increases with increasing speed or increasing speed differential between the bodies that intersect paths. Speeds of intersecting bodies can change depending on the context, such as whether the scooter is riding in the roadway or on a sidewalk. There are some states that clearly state that e-scooters are not street or sidewalk legal, but the majority of states lack clarity on the issue. Therefore, scooters can easily mix with both motor vehicles and pedestrians in many places.

One solution to the speed issue that cities and private vendors have come up with is geofencing. Geofencing has been implemented in major cities in places like dense urban areas, universities, or tourist locations. Geofences can work in different ways, for example, in terms of their active hours or how they achieve speed reductions. Geofences can active all the time or during specific hours like nighttime hours or special events. They can also reduce speeds in a stepwise manner or bring riders to an abrupt stop. A challenge with these geofences though is that the privately-owned vendors are the ones in charge of setting them up, and can make changes to them without cities or other officials requesting the change.

This study 1) identified cities that have described their use of geofences and associated issues, and 2) created an inventory of cities that open scooter data available and injury or emergency room data. Cities that have significant experience with geofencing include San Diego, Los Angeles, Denver, Tallahassee, Portland, and Atlanta. These cities identified several concerns with their experience in using geofences. Notable problems include: airplane mode on a phone rendering a geofence useless; GPS location inaccuracies; speed limits reductions that are not sufficient; or geofence malfunctions.

6.1 Directions for Future Research

Future research will include leveraging the inventory that was developed and provided in this report to conduct safety analysis of geofencing. The inventory will also be updated, if necessary, for the final report of this study to provide the research community the most up-to-date e-scooter geofence information for the cities identified.

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