Identifying Best Practices for Management

of Electric Scooters

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SMRT COLUMBUS

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Executive Summary

In 2018, rentable electric scooter (eScooter) companies flooded urban markets across the globe. In the summer of this year, eScooters appeared almost overnight in the City of Columbus, Ohio. The city was not prepared for such a disruptive industry to appear and did not have any policy or regulations to deal with the eScooters. Cities across the United States have attempted to manage this new mode of transportation by passing different policies to regulate the eScooters.

The goal of our research was to identify management best practices for eScooters for the City of Columbus by researching reason for use, safety concerns, and potential policy solutions.

Through our research, we found there are safety concerns within the City of Columbus that are correlated with areas of high usage of eScooters. We identified safety implications in the City of Columbus through the use of eScooter ride data from the Lime Scooter Sharing Company and crash statistics from the Ohio Department of Transportation. We conducted a statistical analysis and a geographic information systems (GIS) analysis to analyze usage trends and accident trends within the Columbus MSA. By comparing the time of day and day of week trends between eScooters and crash data, we are able to further identify patterns to make safety recommendations. After analyzing our findings, we researched eScooter policies across cities in the United States. This benchmarking allowed us to make informed recommendations to the City of Columbus for eScooter regulations.

The main findings that emerged from our research are:

1. There are correlations between when eScooters are used and when accidents happen.

2. There are four main regions in Columbus where eScooters are used: the University District, the Short North Arts District, the Downtown District, and along High Street.

3. There are hotspots of safety concern in the University District and in the Downtown District.

4. There are policies in place in other cities that could be used to help the City form regulations for eScooter usage.

Based on these research findings, we identified the following recommendations for the City of Columbus to better manage the eScooters:

1. Provide a definition of eScooters under the Ohio Revised Code

2. Require eScooter collision reports from eScooter companies

3. Require licensing of eScooters

4. Require removal of defective eScooters in a timely fashion

5. Establish parking parameters and enforcement for eScooters

6. Provide infrastructural improvements for safety implications

7. Require congestion pricing during peak hours of safety concern

With these recommendations, the City of Columbus will be better positioned to manage the eScooters to improve safety and aid in SMART Columbus' goal of providing alternative transportation options to the citizens of Columbus.

Introduction

Electric Scooter (eScooter) sharing companies inundated cities worldwide during 2018 and into 2019. There is potential to improve mobility in urban centers through the use of eScooters. However, eScooters pose a risk to safety and traffic congestion. Cities scrambled to establish policy in reaction to protect riders, pedestrians, and motor vehicle operators. Policies focus on where eScooters could be used and parked, as well as limitations on fleet sizes, how many companies can operate, and where they must have fleets within the city.

We seek to answer the question of how Columbus, Ohio can manage eScooters so that they contribute to the SMART Columbus goal of creating a "robust set of transit and alternative transportation options" (SMART Columbus, 2018). The City of Columbus won the inaugural smart city challenge in 2016. As the winner of this nationwide was provided with a $40 million grant from the United States Department of Transportation matched by a $10 million from the Paul G. Allen Family Foundation to establish a Smart City Initiative that establishes an agenda to improve standard of living through the use of smart technology (SMART Columbus, 2018).

Our research identifies trends in eScooter usage in Columbus, Ohio, potential safety hazards associated with usage, and provides an analysis of policy being implemented across America to answer this question. We use our research to generate recommendations for policy and infrastructural implementations to be submitted to SMART Columbus in partnership with Vulcan Projects.

Research Goals

1. Identify "hot spots" of safety concern by generating a heat map.

2. Investigate trends in crash and start/stop data through statistical analysis.

3.   Hypothesize use-value of eScooters through statistical analysis.

4.   Provide policy or infrastructural recommendations based on benchmarking analysis paired with findings from heat maps and data analysis.

Study area

The City of Columbus, Ohio is a ten-county Metropolitan Statistical Area (MSA) with an estimated population of 880,000 people as of 2017. It is the 14th most populous city in the United States. The 2010 Census identifies that 22.7% of the population is under 18 years old. The proportion of high school (or equivalent) graduates is 89.1% and the proportion of

Figure 1: City of Columbus 1950 Boundary retrieved from the City of Columbus

residents with a bachelor's degree or higher is 35.1% (U.S. Census Bureau, V2018). The area of research is restricted to the city limits of Columbus, this does not include bordering cities that are within the MSA.
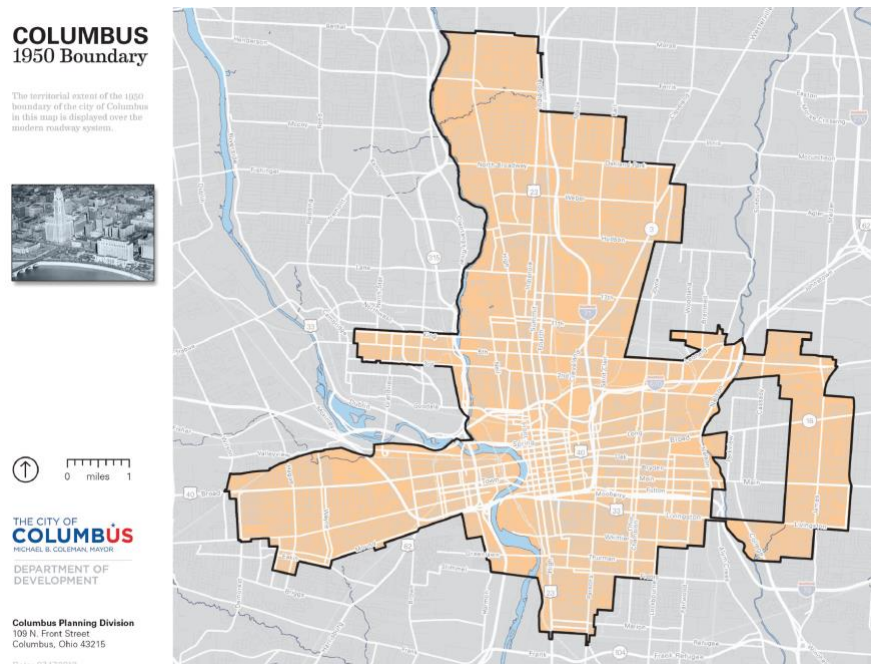
Data

Data for our research were collected from the Lime Scooter Sharing company and retrieved from Smart Columbus. This data includes the start and stop longitudes, latitudes, times of day, and

days of the week of eScooter rides. The issue with this dataset is that it does not include route information of eScooter rides. The data for crashes in Columbus, Ohio were retrieved via public records request through the Ohio Department of Transportation (ODOT). Variables that were relevant to our area of research included times, dates, locations, and types of vehicles involved in crashes. Other variables that could contribute to further safety management research are road condition, severity of the crash, and potential impairment of involved parties. A key limitation of the data from ODOT is that there are no provisions to define eScooters under the Ohio Revised Code. Results from these data cannot be interpreted in terms of eScooters specifically because the selection of vehicle type analyzed is based on similar safety risks of vehicles. Nonetheless, the results are beneficial in identifying relevant trends in similar crashes as a baseline on which to formulate recommendations specific to eScooters.

Data Analysis Methods

We used geographic information systems (GIS) analysis and statistical analysis to analyze the datasets collected. To conduct the GIS analysis, we used QGIS to generate maps to visualize the density of eScooter usage and potential hotspots of safety concern within the City of Columbus. Due to limitations with the dataset, we could not analyze the flow patterns of eScooter use. Instead, we produced a heatmap using the start latitudes and longitudes to show high start use areas. GIS analysis was also used to determine hotspots of safety concern using crash data in Columbus. A grid of ¼ mile by ¼ mile was created to count the number of accidents within each block. As explained above, the dataset involving crashes did not include accidents specific to eScooters, so we used data for bicycles, mopeds, and pedestrians because they behave similarly to eScooters.

To analyze trends in eScooter usage, we used the Lime start/stop data to identify the times of day and days of the week that eScooters are most popular using STATA 15. From these data, combined with the GIS heatmap, we could hypothesize on the reason for use. Using the ODOT dataset and STATA, we looked to identify the same trends in the crash statistics as we did with the Lime data. We created histograms for the time of day and day of the week that crashes involving bicyclists, mopeds, pedestrians, and skaters. By comparing trends between eScooters and crash data we are able to further identify patterns to make safety recommendations.

Research Results

Statistical Analysis

Descriptive trend analysis reveals that the average Descriptive trend analysis reveals that the average
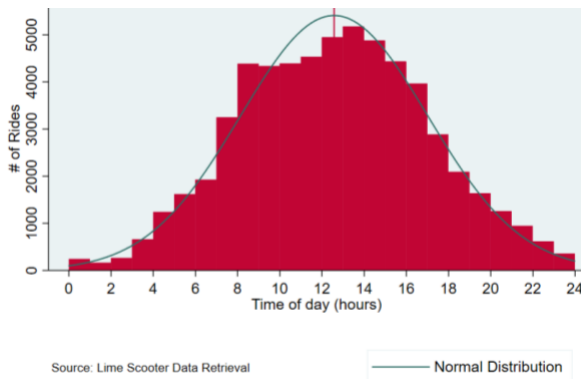

Figure 2: eScooter Ride Frequency Based on Ttime of Day
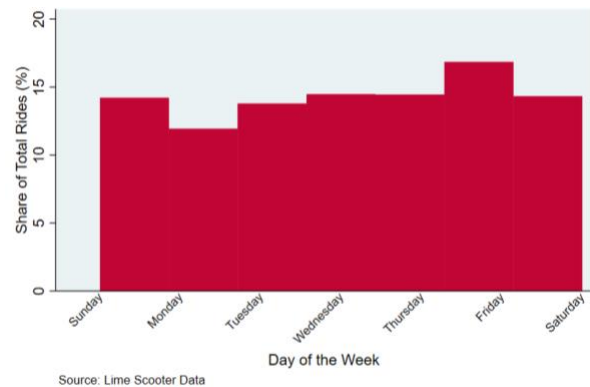

Figure 3: Share of eScooter Usage by Day of the Week

time of day that scooters are being activated is just after 12:30 PM (**Figure 2**) and largest percent of rides happen on Fridays at 16.85% (**Figure 3**). The blue bell curve in **Figure 2** demonstrates that the data for start time has normal distribution. This shows that 68% of the observations fall within a standard deviations of the mean start time of 12:30 PM. With a standard deviation of 4.43 hours, 68% of eScooters are

started between 8:00 AM and 5:00 PM, which is the span of a typical work day. Usage share on

Saturday and Sunday (**Figure 3**) are not significantly more or less than the week days; Monday

has the lowest usage rate. This pattern implies that there is no significance to the correlation in

working hours. An alternative hypothesis is that the density of usage between 8:00 AM and 5:00

PM is related to availability of daylight.

Trend analysis of crash frequencies indicates that the average time of an accident is 1:52 PM

(**Figure 4**), however the median crash time

is 2:52 PM. The one hour difference

between combined with the visual

interpretation allows us to conclude that the

data is positively skewed. Looking at the

histogram it appears the highest frequency
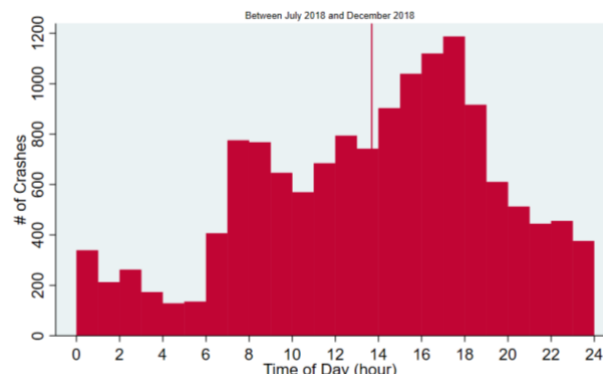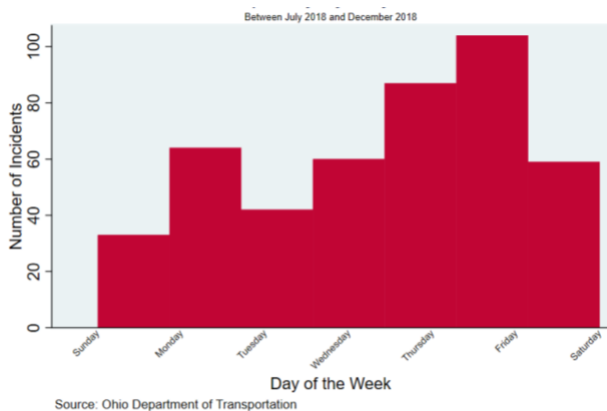
of crashes are happening between 3:00 PM

Figure 4: Frequency of Crashes by Time of Day

and 6:00 PM. This time frame combined with the spike in accidents around 8:00 AM leads to an

intuitive interpretation of the data: most accidents are happening during times of day that people

are commuting to and from work or their educational institutions. The greatest frequency of

accidents is on Fridays (**Figure 5**). Increased crash frequencies on Fridays during 'rush-hour'

suggests a behavioral explanation: as people are

leaving work or school and going to participate in

non-work associated activities, there is a spike in

the frequency of crashes.

When the trends from crash data and eScooter data

are jointly analyzed, there is a common time frame

Figure 5: Crash Frequency by Day of the Week

between the two data sets: most crashes are happening during work commute times as roadways and walkways become more populated and a majority of eScooter usage occurs during working hours. This finding is also supported by the trend in Friday being the most common day of the week for crashes and for eScooter usage.

Geographic Information Systems Analysis

To better understand the eScooter usage, we developed a heatmap (**Figure 6**) using the start/stop data from the Lime Electric Scooter Company's data.
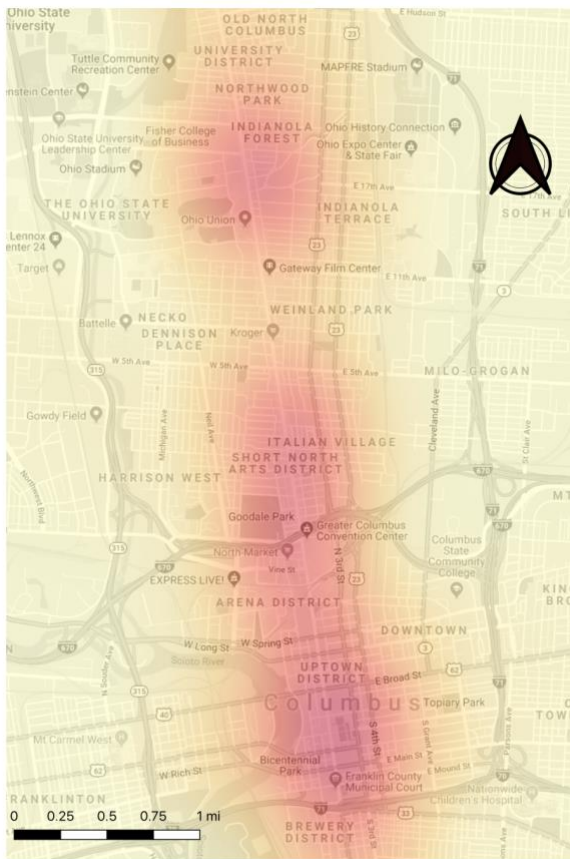

Lime eScooter data retrieved from the City of Columbus. Data collected is from July-August 2018

Figure 6: Heatmap of eScooter usage within the city of Columbus

The spatial analysis reveals that eScooter usage is heavily located in four areas in the study area. These areas are:

1.   Along High Street

2.   Within the University District

3.   Within the Short North District

4.   Within the Downtown Area

These four areas are heavy traffic regions within the Columbus city limits. High street is the main street within Columbus that cuts the city in half that runs north and south and is often the street of choice for transportation between the neighborhoods of the city.

Similarly, the University District is heavily trafficked. Due to the Ohio State University residing within the University District, the majority of the people living within this area are college students. The high usage within this area and the time of day usage determined in **Figure 4** in the statistical analysis may suggest that students are using eScooters to travel between class and home.

The third area with heavy concentrated use is the Short North area. This neighborhood is a destination location within the City of Columbus. With hundreds of restaurants, retail stores, bars, and galleries, the Short North District is a popular area for recreation and draws citizens from many different neighborhoods in. The high usage on Saturday and Sunday shown in **Figure 5** along with the high usage in the University District and Short North area may suggest that the eScooters are often used for recreational purposes.

Finally, the last area with high usage is the Downtown district. The usage of the eScooters in this area may be correlated to workers traveling between work and home or to lunch during the workday.

The usage of eScooters as an alternative mode of transportation to help attain the SMART Columbus goal of providing multi-modal transportation options may also pose safety concerns. We identified areas of safety concern in **Figure 7** using the data on accidents from the Ohio Department of Transportation. From **Figure 7**, it is clear that safety concern is clustered in the

University area and in the Downtown area. This is correlated with two of the highest usage areas for eScooter rides.

Source: Ohio Department of Transportation safety data collected from July to December 2018 for bicycle, pedestrian and moped accidents

Figure 7: Hotspots of safety concern within the city of Columbus

In the University District, the worst intersection for accidents in this study is on the corner of Lane Avenue and High Street. There were 3 accidents within this block over a 6 month period between July and December 2018 related to bicyclists, pedestrians, or mopeds. Similarly, there were a relatively high amount of accidents along High Street compared to other streets, with three of the six blocks in the University district having 2 or more accidents.

The other area of concern for safety is downtown. However, downtown has more accidents along Third Street and Fourth Street. Due to the high level of motor vehicle traffic here during business hours, this could explain the high count of accidents in the area. As noted earlier, most traffic accidents happened during the afternoon rush hour, as shown in **Figure 4**. Therefore, high counts of safety incidents in this area may be due to more vehicles on the road in these areas.

Ground Truthing

To gain a better understanding of the high accident areas in Columbus, we used ground truthing to provide a first-hand look at the surroundings. The goal of this phase of the analysis was to better understand why these accidents may occur. Based on our statistical analysis of the start/stop data for Lime scooters and where most accidents between automobiles and bikes/pedestrians occur, we found that the areas around Broad St. and Cleveland Ave, High St. around the OSU campus, and Summit St. in general, were all good candidates for ground truthing. Based on our statistical analysis of the start/stop data for Lime scooters, we found that the ideal time frame to study scooter activities would be around lunchtime. To observe the most potential scooter activity, we ground truthed around noon, while taking notes and photographs of our findings.

We paid particular attention to certain factors when ground truthing. These included: existing street signage for pedestrian/bicycles, existing bicycle lanes, crosswalk presence and visibility, scooter rider behavior, including riding on sidewalks versus the street, scooters breaking road laws, and poor parking parameters (**Image 1**).

Image 1: eScooters parked illegally on Ohio State's campus

Lane Ave. near OSU campus:

There is a lack of crosswalk presence and visibility. We also witnessed many instances in which pedestrians were just walking blindly into the crosswalk, trusting that the cars coming have seen them and are stopping. With this being a major area of congestion during the day when class is in

session, much more could be done to adequately mark crosswalks to make them more visible (**Image 2**).

Image 2: Crosswalk near Lane Avenue

Summit St.:

This area provides a test bed for assessing the impacts of different road layouts and signage because there are features that aren't seen anywhere else in Columbus. It's no coincidence that Summit St. is where we found the largest number of

accidents occur. We noticed a higher amount of signage than typically seen on such a high-speed street. This makes it pointless to utilize when no one has time to read them without slowing down. The street has a unique layout in which there is a row of street parking on the right hand side of the one way road in addition

Image 3: Bike lane on Summit Street

to a large bike lane (**Image 3**). We found this to be an issue, with drivers having to pull out into the bike lane to see past the parked cars, in order to turn from side streets onto Summit (**Image 4**). There were also instances where we noticed cars driving down the large bike lane in order to access a driveway more easily.

Image 4: Car obstructing the bike lane

Accidents are likely higher due to the fact that the street parking between the road traffic and the bike lane causes a major blind spot for drivers crossing the bike lane to enter driveways and side streets (**Image 5**). A traffic feature that was seen while ground truthing that appears to be well

done, was bike lane traffic signals (**Image 6**). These traffic signals indicates who has the active right-of-way among motor vehicles, pedestrians, and bicyclists.

The ground truthing exercise revealed several key patterns that are suggestive of the underlying causes of the frequency of crashes in these areas. We initially hypothesized that there would be a clear pattern of factors that would explain the frequency of accidents in these areas. However, after completing the ground

Image 5: Blind spots on Summit Street

truthing exercise, we realized this was not the case. Each area was unique, with some having an
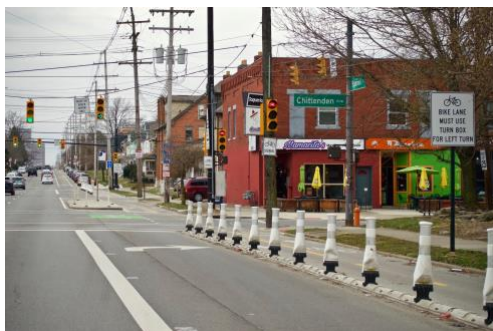

obvious lack of signage and crosswalk visibility, while others had adequate signage but were confusing with the road/bike lane layout. The ground truth findings added useful insights into the safety practices that seem to work and not work and has been helpful in forming our recommendations.

Image 6: Proper bike lane signage

Benchmarking

Mayor of Columbus, Andrew Ginther, established preliminary rules for eScooter use. The rules did not include restrictions on the eScooter fleet companies but focused on the user and prioritized safety risk mitigation (Bench, 2018). Examples of these rules include but are not limited to:

- Age requirement for use of scooters and requires users under 18 years of age to wear safety helmets.

- Restrictions on where it is appropriate to ride eScooters.

- Limits use to one rider per unit.

- Units in use at night are required to have a "white headlamp and red rear reflectors".

The purpose of benchmarking is to research similar cities that have implemented policies in response to the introduction of eScooters and compare the effectiveness of these policies to Columbus' preliminary rules to make policy and infrastructural recommendations. Comparison cities were determined based on the following criteria: demographic similarities, relatively equal initial fleet sizes, and areas with a university area. We conducted the benchmarking through consulting online information on eScooter policies from the different cities. Connecting our research results to the benchmarking is accomplished by narrowing our recommended policy criteria. The criteria for policy we analyzed focuses on distribution, licensing, infrastructure, and recovery of defective scooters.

Austin, Texas: (Director Rules for Deployment and Operation)

- Limits the number of eScooters licensed to a maximum of five hundred (500) units per initial license with possibility of adding additional units

- Defines designated parking areas as the hard surface (concrete asphalt) within the landscape/furniture zone of a sidewalk with a 3 foot pedestrian clearance as well as at a public bike rack

- Requires eScooters to be equipped with on-board GPS unit or equivalent that can report location of a unit at any time for the purpose of use, recovery, repair, data collection, and incident investigation

- More information on Austin, TX regulations can be found at

  https://austintexas.gov/sites/default/files/files/Transportation/Dockless_Final_Accepted_

  Searchable.pdf

Los Angeles California: (LADOT Dockless On-Demand Personal Mobility Permit)

- Limits the number of eScooters to a maximum of 3,000 units per company with a

  minimum of 500 units

- Requires application process and conditional permit fees

- Defines designated parking zones in the landscape/furniture zone of the sidewalk and any

  bicycle racks in the public right of way

- More information on Los Angeles, CA regulations can be found at

  http://basic.cityofla.acsitefactory.com/sites/g/files/wph266/f/Final%20One-

  Year%20Dockless%20Permit.pdf

Portland, Oregon: (Portland 2018 E-Scooter Findings Report)

- Limits the number of eScooters to 683 units per company

- Requires permit for eScooter companies to operate

- Defines parking guidelines on the sidewalk, close to the curb, and in a manner that

  doesn't interfere with pedestrian access or travel

- Requires comprehensive data sharing from the eScooter companies

- More information on Portland, OR regulations can be found at

  https://www.portlandoregon.gov/transportation/article/709719

Washington DC: (District DOT Dockless Terms and Conditions Scooters)

- Limits the number of eScooters in the district to a maximum of four hundred (400) units

  per company

- Requires Public Right of Way Occupancy Permit

- Requires permit holder to provide monthly report which includes: number of rides for the previous month, number of eScooters in service for the previous month, origin, destination, trip duration, repair information, safety reports

- Defined parking parameters to maintain unimpeded access to entrances to private property or driveways, to maintain a pedestrian travel space to a width of at least 5 feet, outside of any protected tree planting or landscaped area

- More information on Washington D.C. regulations can be found at https://ddot.dc.gov/sites/default/files/dc/sites/ddot/page_content/attachments/Dockless%20Terms%20and%20Conditions%20-%202019%20-%20Scooters%20-%2011.02.18.pdf

Recommendations

Upon completion of our multiple phases of research, we formulated multiple recommendations for the City of Columbus:

<u>Design provisions to define eScooters under the Ohio Revised Code.</u> There are no clear definitions of eScooters in the Ohio Revised Code. If eScooters were defined, it would make classification much clearer when collecting data and analyzing statistics. Cities like Washington, D.C.; Los Angeles, CA; and Austin, TX provide excellent examples for defining eScooters for their cities.

<u>Require scooter companies to report eScooter collision, unit, and user data to law enforcement</u>. As data collection was the most significant challenge during this research project, it is critical that these data be collected and available to law enforcement and the city for their reference. It was identified through benchmarking that Austin, Texas and Washington, D.C. already have

policies in place which require that this data be shared.

Unit data (i.e. start/stop data locations and times) were valuable to analyze the best management practices for eScooters. However, our analysis was limited due to the limited data. Additional data from eScooter companies would have been valuable in our analysis. This data would include crash statistics related to eScooters, the costs of maintenance of eScooters, route data from rides, and the price paid by consumers.

Implement application fee per eScooter - to be paid by eScooter company. Implementation of safety infrastructure and management of eScooters will cost the city considerable money. To finance this, the City of Columbus should implement an application fee per eScooter. An example of this recommendation in action can be seen in Los Angeles, noted within the benchmarking portion of our analysis. This application fee should be billed to the eScooter company to encourage appropriate management of eScooter quantities.

Enforce responsibility of eScooter companies to remove unsafe or non-functional eScooters within specified time period. The City of Columbus should require eScooter companies to remove eScooters that need repaired or replaced. Los Angeles is a great example of a city that has implemented this type of regulation (LADOT Dockless On-Demand Personal Mobility Permit). Not only does the perception of eScooters diminish as more eScooter fleets are implemented around town, but these littered eScooters pose a safety concern to pedestrians, bicyclists, other eScooter riders, and in some cases, motor vehicles in the roadway. **Image 1** provides a visual example of how littered eScooters diminish the safety and aesthetic value of an area.

Define eScooter parking parameters to include fines for unsafe parking locations. As outlined in the ground truthing section of this research report, eScooter parking is generally unregulated and

is a cause for concern in Columbus. It is evident in **Image 1** that there is room for improvement with eScooter parking. The City of Columbus should define safe and organized parking parameters. The benchmarking section of this research report provides details specific to what other cities have done to manage parking parameters.

If the established parking parameters are not followed, the eScooters should be fined or impounded. The fees associated with these penalties should be billed to the eScooter companies. If the eScooter companies wish to pass these expenses to the user, that is their prerogative. This has been done in Austin, Texas and appears to be a successful program.

We recommend that the eScooter companies add a step to ending a user session. This additional step could require the user to photograph how and where the eScooter is parked. If the photo does not accurately display that the eScooter was secured against a fixed structure, at a bike rack zone, etc., then it would be appropriate to pass fine expenses to the user. This step would add a layer of validation for both the eScooter company and user.

Update signage and road layout to improve traffic flow and safety for all modes of transportation. We recommend that the city use the spatial analysis provided in this research report to further study the safety hotspots and recommend specific infrastructure improvements. As outlined in the benchmarking section of this research report, eScooters are required to be used on the road with other vehicles. When ground truthing, we noticed that a significant portion riders ignore the law by riding on the sidewalk and in other pedestrian areas. We also noticed that the areas of high congestion and frequent accidents occurrences needed crosswalk improvements for the safety of all. Striped walkways across the road, highlighted crossing signed, and "active crossing" lighting appeared to be most effective method of keeping pedestrians, bikers, eScooter riders and drivers safe and alert.

There were locations (specifically, Summit Street) in which it appears there was an attempt at improving the safety and flow of traffic in the roadway, but the success of these improvements is unclear. Traffic signals (**Image 6**) indicate the active right-of-way among motor vehicles, pedestrians, and bicyclists. Road signage and other indicators should be clear. This feature should be incorporated throughout the city to improve safety of those using all modes of transportation.

Consider congestion pricing structure to manage safety during peak traffic. An additional method to improve safety and traffic flow is congestion pricing. When completing the benchmarking analysis, congestion pricing was not identified as a method that other cities have implemented. However, it has been implemented for other ride sharing platforms such as Uber and Lyft. The City of Columbus may be able to better manage congestion if a surge price for eScooter use in congested areas, or during common times of congestion (i.e. rush hour), is implemented. An example of surge pricing can be seen with ride sharing programs, like Uber (Uber, n.d.). The analysis of **Figure 2** identifies times that surge pricing may be beneficial.

Conclusion

Based on descriptive trends and spatial data analysis, we find that there are clear correlations between when the eScooters are being used and the when accidents are occuring. In addition, our analysis revealed hotspot locations between density scooter use and crashes involving pedestrians, motorcycles, mopeds, or skaters. Ground truthing provided qualitative support of the conclusions drawn from spatial analysis. Benchmarking allowed us to compare the effectiveness of other reactionary policies. Drawing on each of our methodologies we were able to formulate a set of recommendations based on evidence and best practices of other cities.

It is also important to note that the recommendations provided in this report may not be the most effective management practices of eScooters because there is an insufficient amount of time since their arrival to fully assess the impacts. However, it is apparent that there is a necessity for a definition of eScooters in the Ohio Revised Code and policy and infrastructure implementations to mitigate safety risks inherent to eScooters. We encourage further research as more quantity and quality of data become available.

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Appendix 1

Dataset #1: City_Lime_eScooter.xsl

Received from: SMART Columbus; Data provided to SMART Columbus from the Lime Electric Scooter Company

Description: This data set provided from the City of Columbus includes data from Lime electric scooters for the months of June and July in 2018. The dataset included: trip id, date, time of start, start latitude, start longitude, distance of ride, end time, end latitude, and end longitude. The dataset originally included 176755 rides, however some were cleaned out due to a ride distance of zero. This dataset was used in the statistical analysis for Figure 1, Figure 2, and Figure 5.

Dataset #2: CrashStatistics.csv

Retrieved from: Ohio Department of Transportation (ODOT)

Description: This dataset provided to us by ODOT includes accident data for July to December 2018 in Columbus, Ohio. The dataset includes general information on accidents. Each accident has an ID field that is linked to two other datasets: dataset 3 and dataset 4. There are 17651 entries in this dataset. This was used in Figure 3, Figure 4, and Figure 6.

Dataset #3: UnitStatistics.csv

Retrieved from: Ohio Department of Transportation (ODOT)

Description: This dataset provided to us by ODOT includes accident data for July to December 2018 in Columbus, Ohio. This portion of the dataset includes information on the type of vehicle such as bicycle, moped, pedestrian, motor vehicle, etc., involved in the accident. The ID matches up with the ID in dataset 2 and dataset 4. This was used in Figure 3, Figure 4, and Figure 6.

Dataset #4: PersonStatistics.csv

Retrieved from: Ohio Department of Transportation (ODOT)

Description: This dataset provided to us by ODOT includes accident data for July to December 2018 in Columbus, Ohio. This dataset includes statistics on the person that was involved in the accidents such as gender, age, etc. The ID matches up with the ID in dataset 2 and dataset 4. This was used to inform the statistical and geographic analysis in Figure 3, Figure 4, and Figure 6.