Analyzing Rideshare Bicycles and Scooters

Abstract

Rideshare bicycles and scooters have risen in popularity in recent years. This project assisted the US Consumer Product Safety Commission in understanding rideshare safety risks, rider behavior, and how rideshare companies and local authorities manage these risks. We achieved this through reviewing literature on rideshare programs, observing riders, surveying the public, and interviewing local officials and company employees. We found that many devices on the street have observable maintenance problems that could pose risks. We also found that many riders engaged in high risk behaviors, such as failing to wear helmets and riding in restricted areas.

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December 11, 2018
Over a ten-year span from 2004 to 2014, the total number of bicycle sharing programs increased by about 700 worldwide (Meddin & DeMaio, 2015). These programs offer an eco-friendly alternative means of public transport, which allows riders to get closer to their desired location than conventional public transport. In recent years, ridesharing companies have introduced electric bicycles and scooters in large numbers. In America, companies such as Bird, Lime, and others, have placed such devices throughout cities for customers to use. However, this exciting innovation in emerging technology brings with it new problems to users and non-users alike.

Incidents involving these devices have led to lawsuits, injuries, and even deaths, although data on these incidents are only now emerging. In 2018, Bird had to pay over $300,000 to plaintiffs in three lawsuits involving injuries (Etehad, 2018). According to a 2013 study in Montreal, the most common rideshare accidents have involved collisions with automobiles, but many also result from collisions with pedestrians, other riders, and fixed objects (Fishman, 2013). Dockless rideshare programs do not require riders to drop off devices at specific locations. This has led to a clutter of scooters along sidewalks and other public spaces in cities like Washington, DC, as seen in Fig. 1.

The US Consumer Product Safety Commission (CPSC) has a responsibility to ensure the safety of consumers by recalling faulty products, enforcing consumer safety regulations, and educating the public about safety issues (Supplemental Materials Part B). The CPSC is concerned about the safety of rideshare programs, especially regarding electric scooters and bicycles, and wants a more thorough diagnosis of the rideshare programs. The District Department of Transportation (DDOT) established a dockless pilot project in September 2017 through December 2018 to gather data to evaluate the effectiveness of the programs and develop appropriate regulations.

Collaborating with the CPSC, the overall goal of our project was to analyze the impacts of rideshare programs, focusing on electric bicycles and scooters in the DC area. We achieved this goal by addressing the following four objectives:

1. Assess the range of risks and other social impacts associated with electric bike and scooter ridesharing services.
2. Assess the behaviors, knowledge, and attitudes of rideshare users, especially those using electric bikes and scooters.
3. Identify and evaluate the effectiveness of local laws and policies to regulate and control the risks and social impacts of electric bike and scooter rideshare services.
4. Evaluate how rideshare companies are managing the risks of electric bikes and scooters.

Over 14 weeks, our group reviewed expert literature and news stories, completed interviews with key officials and other stakeholders in the Washington DC area, conducted observational studies of riders and the condition of electric scooters, surveyed the general public, and mapped the movement of rideshare devices in DC. Based on our data and findings, we suggested actions the CPSC might pursue to alleviate risks of the rideshare programs. The following report presents our background research, our methods, final results, and recommendations.
History, policies, and impacts of rideshare programs

Ridesharing is an “innovative transportation strategy that enables users to gain short-term access to transportation modes on an as-needed basis” (Nicoll & Armstrong, 2016). With the introduction of ridesharing, people have access to an alternative means of transport, including bikes, e-bikes, and e-scooters. Here, we establish what ridesharing is, its origins and operation, the associated risks, and how some cities manage the ridesharing services.

History and growth of ridesharing

Ridesharing has been used in many cities as a public form of transportation. With the advancement in technology, specifically electric bicycles and scooters, ridesharing has become more popular.

The origins of bikeshare

Bike sharing schemes have evolved through several generations, with incremental improvements in security and operations. Witte Fietsen of White Bikes (Figure 3) started the first bicycle-share program in Europe in 1965 (Davis & Hodder, 2014), but the program collapsed within days due to vandalism and theft. La Rochelle, France had the first successful French bikesharing system in 1974, and this scheme continues to operate in the city today. The program’s nightly lock up ensured the bikes were not stolen and painted borders were implemented to identify where riders could and could not go with the bikes (Huré & Passalacqua, 2017). In 1993, a program called Green Bike was launched in Cambridge, Massachusetts with almost 300 bicycles. Unfortunately, like the White Bikes program, Green Bikes lacked security arrangements resulting in its failure (Shaheen, Guzman, & Zhang 2010). In 1995, the first large-scale, second generation bicycle-sharing program (Bycyklen, or City Bikes) began in Copenhagen, with many improvements over the first generation (DeMaio, 2009). City Bikes allowed users to pick up bicycles at select city locations by paying for rentals with a coin deposit before using. Like their predecessors, these bicycles were often stolen or vandalized due to user anonymity and a lack of security measures.

These problems prompted third generation companies to invest in security systems and consumer tracking practices. “[Third] generation … bike-sharing systems were smartened with a variety of technological improvements, including electronically-locking racks or bike locks, telecommunication systems, smartcards and fobs, mobile phone access, and on-board computers” (DeMaio, 2009, p. 42). The new tracking technology was introduced in a bikesharing program in 1996 at Portsmouth University in England (DeMaio, 2009). These new tracking technologies and security measures enabled ridesharing programs to become profitable and collect user data, such as ride lengths and locations, that could be used to improve operations and marketing. Even with the addition of new technology, however, these newer ridesharing programs were not an immediate success.

The latest generation of bicycle sharing programs (BSPs) began in 2004 but did not grow rapidly until the success of Velo in Lyon. Launched in 2007 with 1500 bicycles, it was the largest program at that time. In 2007, Velib took notice of Velo, leading them to start their own program in Paris with 7000 bicycles. Due to theft of the bikes and mismanagement of repairs, Velib closed in 2017 and was replaced by Velib Metropole. This company had a difficult start, failing to have all the bicycles ready for the public in a timely manner and has been deemed a failed program (O’Sullivan, 2018).

Outside of Europe, American cities were slow to adopt bikeshare programs until 2008. In 2008, Washington DC partnered with SmartBike DC to launch the first successful bikeshare program in a US city. Touting this program to reduce pollution and congestion, SmartBike made 120 bicycles available at ten city locations. Users
were required to buy a $40 annual membership card and could rent the bikes for three hours at a time. To protect the bicycles and ensure availability for others, users risked losing their membership if they repeatedly exceeded their allotted riding time. Additionally, riders would be charged $200 if they were last to use a bicycle that was later lost (Becker, 2008). SmartBike DC ceased operations in 2010 after the DC Department of Transportation chose to partner instead with Capital Bikeshare (Klein, 2015).

The US bikeshare fleet exploded to 19,900 bikes in 2013, and more than 42,000 bikes by 2016 (Figure 4), although this fleet is miniscule compared to China. Globally, the total number of ridesharing bicycles was tallied at 946,000 in 2014, with roughly 80% in China (Meddin & DeMaio, 2015). By 2017, there were over ten million bikeshare bicycles and 100 million registered users in China alone (Song, Pell, & VanAudenhove, n.d.). As a result, the production volume of shared bicycles was expected to reach 30 million by the end of 2017. The rapid growth of the bikesharing industry in China has caused a variety of problems, such as cluttered streets and traffic control issues, forcing the government to impose regulations.

**The emergence of electric bicycle and scooter ridesharing**

Recently, some bikesharing companies, such as Spin, diversified and began offering electric bikes, while new companies like Lime and Bird began to offer electric scooters. The e-scooter rideshare companies originally placed their scooters in Washington DC, Los Angeles, and San Francisco. Rather than seeking regulatory approval, the companies decided to place their fleet in the cities without permission or warning, forcing the cities to adapt and, in some cases, send cease and desist letters to the companies. Some cities have negotiated with companies to establish pilot projects to assess impacts and identify appropriate regulations (Zaleski & Newcomer, 2018).

Over the past year, electric bicycle and scooter ridesharing programs have seen intense growth in major cities across the US (Figure 5).
charged (Gottfried, 2018). Proper maintenance of scooters has been a major roadblock in the expansion process as some companies failed to screen and train maintenance workers effectively. For example, Bird makes potential mechanics watch a few how-to videos and answer questions about them before sending them a kit and allowing them to work on scooters (Campbell, 2018). Companies must also navigate the plethora of regulations that cities are beginning to put in place to better manage the growing rideshare fleets.

Electric scooters and bikes have potential to offer a cheaper means of travel over other modes of transportation. When using public transit, commuters in DC can spend $1.85 to $6 per ride, depending on trip length (Navigating Washington, DC, with Metro, 2018, July 18). Comparatively, electric rideshare scooters in DC have an initial $1 unlock fee and an additional fee of 15 cents per minute of use. In some cases, this flat rate makes scooters the cheaper option during rush hour for short distances. Capital Bikeshare offers memberships at an annual payment of $85 or $28 for thirty days. Riders can also buy passes for unlimited trips of under 30 minutes for three days, one day, or one trip for $17, $8, and $2, respectively, with a small additional fee for trips over thirty minutes (Table 1) (Motivate International, Inc., n.d., Usage Fees).

(NACTO, 2017). Several major scooter companies, most notably Lime and Bird, became central to the spread of ridesharing electric scooters through their heavy financial backing from investors. In 2018, Bird raised $100 million to become a nationwide service while Lime received $335 million from Alphabet and Uber (Figure 6). To further their influence, the two companies expanded globally by introducing their scooters in several European cities (Dickey, 2018).

This rapid growth in capital investment and operations may have led to a series of missteps, and cities have taken notice. One problem that companies face is finding a workforce to maintain and charge their devices. When companies rely solely on crowd services to charge these devices, they cannot ensure their device are being properly maintained and safely charged. The reasons for ridesharing growth may lie in its many benefits

Ridesharing systems provide several benefits for both riders and cities. Programs allow users to participate in a quick, cheap, and convenient form of transportation while being environmentally friendly. For cities, reduced carbon emissions and potential traffic decongestion are amongst the biggest benefits.

Table 1. Capital Bikeshare member usages fees.

<table>
<thead>
<tr>
<th>Member Usage Fees</th>
<th>Pass Holder Usage Fees</th>
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</thead>
<tbody>
<tr>
<td><strong>Ride Length</strong></td>
<td><strong>Usage Fee</strong></td>
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<tr>
<td>0-29 min</td>
<td>$0</td>
</tr>
<tr>
<td>30 – 59 min</td>
<td>$1.50</td>
</tr>
<tr>
<td>60 – 89 min</td>
<td>$3.00</td>
</tr>
<tr>
<td>90 + min</td>
<td>$6.00 per  additional 30 min</td>
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Electric scooter and bike rideshare companies label themselves as a solution to the “last mile” problem (LMP) some commuters face when using public transportation. The LMP is the distance from one’s stop on public transportation to their destination. Riding a scooter with a top speed of fifteen miles per hour is significantly faster than the average walking speed of 3.27 mph (Bohannon 1997; Zenati 2018).

While touted as a possible way to ease automotive traffic congestion, this is only true in certain cases. For example, a 2015 study conducted in Pittsburgh, by University of Pittsburgh and Carnegie Mellon, showed a 2% decrease in parking demand the month following launch of a seven-station program. While the percentage was small, the bikeshare trips were calculated to have replaced 69 car trips each day (Pelechrinis, Li & Qian, 2016). When not replacing car trips, bikeshare systems also have potential to ease public transit congestion as well. In a 2014 study of 4800 Capital Bikeshare members, 47% of respondents revealed that the program led them to use the DC Metro less (Martin & Shaheen, 2014).

Electric rideshare scooters and bicycles provide environmentally friendly alternatives to automobiles (Fishman, 2016; Handy, van Wee, & Kroesen, 2014). The lithium batteries used by e-rideshare devices eliminate harmful emissions, although this depends on how the electricity used to charge them is generated (Ji, Cherry, Han & Jordan, 2014). One study found that over 1000 miles, the CO₂ emissions of a car were almost a hundred times more than that of an electric bike (Rose, 2017). Also, lithium batteries are rechargeable, reducing waste from used batteries. When the batteries need to be discarded, if done correctly, they cause little environmental harm (Lim, 2017).

**How ridesharing companies operate**

Some companies, such as Capital Bikeshare, use docking stations across the city to lock up rentable bikes. After paying through a kiosk located at a docking station or via mobile application, a consumer receives a code, so they can unlock the bike from the docking station. From there, the rider may ride the device freely and return it to any docking station near their destination (Motivate International, Inc., n.d., How Metro DC’s Bikeshare System Works).

More recently, companies such as Bird, Lime, Skip, Lyft, and Jump, have used dockless systems for devices in major cities such as San Francisco, DC, Portland and New York. The dockless systems are similar to docked systems in some ways, although users have greater flexibility to pick up and drop off devices anywhere, without having to locate a docking station. Users download an application that shows where unoccupied devices have been left by previous users. Upon downloading the app, users are prompted to create a profile and attach a credit card. The app reminds riders to wear a helmet, stay off sidewalks, ride in bicycle lanes, obey traffic rules, and park the vehicle out of the way of pedestrians on curbs when finished. After completing this profile, the user sees a map displaying locations of each available vehicle close by. Once users find a device, they tap the on-screen “scan” button to scan the QR code on a vehicle (Figure 7). First time riders, are shown a quick tutorial on how to ride the device before it fully unlocks. Although prices can vary across companies, users typically pay a dollar unlock fee and an additional fifteen cents per minute of use as mentioned earlier. While ridesharing is geared for riders over eighteen with a valid driver’s license, most companies, other than Lyft and Bird, do not check for a valid identification card for riders who sign up.

![Figure 7. Steps used to check out and use a ridesharing scooter or bike.](image_url)
trips in the month before the survey, 21% made between three and five trips, and 19% made between six and ten trips” (LDA Consulting, 2017).

Fishman (2016), citing a report from Buck (2013), correlated Capital Bikeshare membership to rideshare use in DC. He stated, “43% of long-term members’ last trip was work related, whereas this drops to 2% for short-term users” (Fishman 2016).

Fishman also posits that, generally, warmer weather encourages rideshare use. Figure 9 shows the number of trips per day, per bike, in twelve cities over the course of a year, giving insight into the popularity of these programs. The popularity of these BSP companies is correlated with weather. For example, Boston, NYC, and Washington D.C having increased usage when the temperature is warmer (Fishman, 2016).

**Ridesharing demographics and usage patterns**

With the use of data tracking software and surveys, BSPs have been able to gather information on user preferences and habits. Capital Bikeshare conducted a survey of their rideshare members in Washington DC in 2016. The survey found that riders were younger than the average commuter and more likely to be male (Figure 8). Besides collecting demographic data on users, Capital Bikeshare’s 2016 survey identified common trends in user motivations and use. “Primary motivations [for using Capital Bikeshare] were greater ease of travel, enjoyment of biking, and one-way travel flexibility… and… 65% of respondents said their primary use was commuting to or from work.” The survey also measured frequency of use: “About 21% of respondents had made fewer than three bikeshare

![Figure 8. Capital Bikeshare users age. Adapted from (LDA Consulting, 2017).](image)

![Figure 9. Trips per day per bicycle across 12 different cities in 2013. Adapted from (Fishman, 2016).](image)
Another study conducted in 2018 by Xie and Wang on Capital Bikes highlights the relationship between season and usage as shown in Figure 10 for the DC area. The graph shows that summer has the highest usage while winter has the lowest usage which supports Fishman’s data (Xie & Wang, 2018).

**Risks associated with ridesharing**

The rise in popularity of rideshare programs has led to several problems, including accidents, battery fires, and abandonment in cities. These risks affect not only the riders themselves but also pedestrians and automobile drivers. These problems can even lead to injury and/or death. A 2013 study of Montreal bikesharing highlighted types of crashes riders were involved in (Figure 11). McGee, Lerer & Associates Law Firm (MLA) in Santa Monica also observed rideshare programs and classified them as “an accident waiting to happen” (McGee, n.d.). MLA outlined the potential hazards that Bird and Lime riders’ face, including lack of stability and maneuverability around potential dangers such as potholes and pedestrians. They highlighted the risk of automobile accidents since electric scooters are small and fast, making it easy for drivers to not see them.

To minimize the chances of head injuries, riders are advised to wear a helmet. However, many riders do not, and DC law does not require riders over 16 to do so (Metropolitan Police Department, n.d.). Previously discussed risks are compounded by not wearing a helmet, and serious injury can result (McGee, n.d.). This is shown by the recent death of a 20-year-old male

**Figure 10. Trip rates by season for DC Capital Bikeshare. Adapted from (Xie & Wang, 2018).**

**Figure 11. Percentage of bicycle accidents involving a ridesharing user. Adapted from (Fishman, 2013).**
who was hit and killed while riding an electric scooter in Dupont Circle, Washington DC (Moore, 2018). Figure 12 displays data from a 2014 study, showing that after the implementation of rideshare programs, North American cities had an increase of roughly 8% in bicycle-related head injuries. The rise in head injuries was attributed to the lack of helmets being worn by rideshare users (Graves, Pless, Moore, Nathens, Hunte & Rivera, 2014). In addition, in another observational study, US bikeshare riders were four times less likely to wear a helmet than private bike riders in the same cities (Fischer, Sanchez, Pittman, Milzman, Volz, Huang, 2012).

However, Graves only highlighted the increase in percentage of bicycle related head injuries following BSPs implementation. He ignored the overall injury total which decreased by 14.4% in BSP cities and only 3.9% in the control cities (Fishman, 2016) (Salomon, Kimbrough & Bershteyn, 2014). Additionally, non-head injuries decreased by 37.8%, compared to a 6.2% increase in the control cities, leading to additional criticism of his study (Salomon, Kimbrough & Bershteyn, 2014). This is shown in Figure 13 which shows all injuries in cities before and after BSP implementation.

Despite companies advising users to wear helmets and abide by local traffic laws, many do not adequately enforce this. Bird offers free helmets if the consumer pays for shipping but does not require helmet purchase before riding. Despite these promotional tools, riding without a helmet remains a common practice. However, some studies show that long-term users are more likely to wear helmets. Buck conducted a study showing “94% of short-term subscribers did not wear a helmet, compared to 63% for long-term subscribers” (Fishman 2016, p. 99).

Another issue that exacerbates the risks of ridesharing is the lack of designated riding and parking areas. With many riders using sidewalks and streets as riding routes, pedestrians are at risk for injury. Despite rideshare companies informing their riders of proper handling and use practices, many complain that users blatantly disobey the rules. Some San Francisco rideshare users have ridden on restricted sidewalks and improperly abandoned scooters on sidewalks, posing a walking hazard to pedestrians (Pacheco, 2018). Issues of this kind prompted San Francisco city attorney Dennis Herrera to investigate potential legal actions to protect sidewalk pedestrians (Pacheco, 2018).

Also, batteries in e-bikes and scooters pose their own risks. Electric bicycles and scooters rely on lithium ion batteries as a power source. This technology has wide applications due to its high-energy capacity and in its fast and long-lasting charging capabilities (Larsson, Andersson & Mellander, 2016). However, due to the volatile nature of the lithium electrolyte, the battery may go into thermal runaway, a process in which rapid temperature change alters the conditions so a further increase in temperature occurs, often leading to an explosion of the battery.
A report published by The Electrochemical Society details the danger from the rapid increase of the lithium temperature without proper distribution of the heat throughout the battery. When the temperature of the battery reaches above 355 °F, the lithium ignites. This temperature can easily be achieved since recorded thermal runaways have reached as high as 1,110 °F (Bandhauer, 2011). Figure 14 shows a battery cell in thermal runaway and exploding in a controlled testing environment.

Reports of rental scooters catching fire have begun to appear in the news across the globe. In St. Paul, Minnesota, a woman had a secondary job of charging Lime scooters, and her garage caught fire when all eight of the scooters’ batteries ignited, resulting in over $20,000 in damages. The flashpoint was deemed to be the garage’s poor electrical system. The company, Lime, pays people to charge their scooters overnight without verifying or setting standards for their charging (Gottfried, 2018). Because of the lack of safety standards for people charging the batteries, the practice of hiring people to charge the scooters in their own home has been called into question. Also, in Singapore, a fire broke out after a man removed an electric scooter plug from the charging socket. The cause of the fire remains under investigation, but the Singapore Civil Defense Force (SCDF) cautioned people about overcharging the batteries as it can cause structural failure (Loi, 2018).

Battery ignition is an issue also for electric bicycles. For example, in the Netherlands, the warehouse of an electric bicycle company called Stella, contained 6000 lithium batteries that burst into flames. Around 300 people living nearby had to be evacuated due to toxic smoke emitted from the burning batteries (Schaik, 2018). A fire safety engineer and battery safety expert, Rob Overdijkink, stated that lithium ion batteries are “rather unreliable, rather explosive” (Oortwijn, 2018). He advised people in the electric bicycle business to use suitable battery storage containers with automatic extinguishing systems. While the public can take precautionary measures, such as keeping batteries in dry, safe conditions and not overcharging them, Overdijkink believes the public needs better, safer batteries (Oortwijn, 2018).

**Ridesharing safety regulations and policies**

With the introduction of ridesharing companies and devices, many cities and countries have implemented policies and laws aimed to improve the safety of BSP users, pedestrians, and motorists. These include setting age requirements, requiring licensing of companies, limiting the number of devices per license, establishing where users are permitted to ride, and regulating standard features such as steering, lights, and capping top speed. We contrast and highlight some of these measures by discussing several examples below.

**Washington DC**

Washington, DC stands as an example of a city negotiating with dockless rideshare companies to establish regulations and ensure public safety. Washington’s pilot program for

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**Figure 14. Lithium battery cell before (image 1) and after (image 2) explosion from thermal runaway.** Adapted from (Finegan, 2015).
dockless bikes and scooters began in September 2017 (Pascale, 2018). Through this program, dockless rideshare companies such as Lyft, Bird, Lime, Skip, and Jump were allowed to operate within the city under a permit as long as they covered all fees and provided the District Department of Transportation (DDOT) with access to usage, maintenance, and rider survey data. The city desired to use this data to develop a plan for program expansion while ensuring the safety of riders, pedestrians, and motorists and minimizing other potential adverse impacts on the city (Smith, 2018). During the pilot, the DDOT limited the number of ridesharing bicycles and scooters to 400 per licensed company. Despite the cap, the DDOT reported that users took 625,000 bicycle and scooter trips between September 2017 and June 2018 (Lazo, 2018). The DDOT categorized these devices as personal mobility devices, or PMDs. The DDOT created and published PMD regulations in 2013, stating that these devices can be driven without being registered as motor vehicles. These devices, however, cannot be driven by riders under the age of 16. The speed limit was listed at 15 mph for scooters and normal traffic speed laws for bikes. They also require only one rider per scooter or bike. The DDOT states that PMDs are not allowed on the sidewalks in the Central Business District, but they are allowed on the sidewalks in the rest of the DC area (Montgomery, 2018).

On October 26th, the DDOT came out with a proposal for new rules which would go in effect as of January 1st, 2019. These new rules are discussed in the results. Additionally, the DDOT imposed a tax on these companies during the pilot, and the 2019 budget indicated that taxes on ridesharing will increase from 1% to 6% (Siddiqui, 2018). These changes in policy have sparked conflict between city officials and rideshare companies. Most notably, two companies, Ofo and Mobike, removed their products from DC due to the regulatory measures conflicting with their business model (Lazo, 2018; Ryan, 2018).

**San Francisco**

San Francisco has had a more combative past with electric scooter and bicycle rideshare companies than Washington DC. Rideshare companies were quick to appear across San Francisco as startup campaigns. To avoid the clutter of dockless devices shown in Figure 15, the San Francisco Municipal Transportation Agency (SFMTA) continues to try to craft an effective measure to regulate dockless electric devices to get ahead of the expansion of companies. Bird and Lime have pledged to collect their devices for charging each night (although this does not prevent cluttering sidewalks and other areas by day), and share data collected with organizations like the SFMTA for transparency. Electric ridesharing in San Francisco is increasingly popular and has garnered both positive and negative press attention for the city and the companies.

![Abandoned Bird scooters in San Francisco create unnecessary risk to pedestrians, bicyclists. Adapted from (KPIX, 2018).](image-url)
(Fitzgerald, 2018a).

The growing popularity and misuse of electric scooters pushed San Francisco to take legal action against rideshare companies (Tyler, 2018). In late May of 2018, San Francisco issued a law temporarily banning all rideshare scooters until regulations and a permit program were established. San Francisco required that Bird, Lime, and Spin remove their scooters from the city on June 4, 2018 and apply for permits to participate in a 12-month pilot program (Tyler, 2018; Fitzgerald, 2018b). The SFMTA approved only two scooter permits (Brinklow 2018). Brinklow also reported that each company can have up to 625 scooters on the streets at one time during the first six months of the pilot but could double that in the final half year of the trial. The penalty for noncompliance was the impounding all scooters left on sidewalks and a $100 fine to riders abandoning scooters (Fitzgerald, 2018b).

Massachusetts

Hubway was the first bikesharing program in Massachusetts. The program is owned by the cities Boston, Somerville, Brookline, and Cambridge and was established in 2011. The program was hugely successful, with the company logging its five millionth ride in the fall of 2016. In spring of 2018, Hubway became sponsored by Blue Cross Blue Shield of Massachusetts and changed its name to Blue Bikes (Motivate International, n.d., About).

With the success of the Blue Bikes, Bird introduced their dockless electric scooter fleet to Cambridge and Somerville in 2018. In July 2018, the Massachusetts Department of Transportation (MDOT) issued a comprehensive review that WBUR said would “determine whether Bird’s scooters violate a state law requiring motorized scooters to be outfitted with brake lights and turn signals” (Borchers, 2018a). As a result, Cambridge and Somerville asked Bird to temporarily hold off on services, and as of this writing, this issue has not been resolved (Borchers, 2018b).

China

As of 2015, China was the world’s largest market for shared bicycle programs with more bicycles and docking stations than the rest of the world combined. The Chinese government subsidized the development of public bikeshare systems to encourage the population to switch to a non-motorized transportation (Lohry & Yiu, 2015). Despite the initial success of these programs, the rapid growth of the market exceeded the demand for rideshare bicycles. An internet research analyst for IDC China predicts less than ten of sixty ridesharing startups will survive into 2018. Some analysts have expressed concerns that there are too many bicycles on the streets and too little demand. Some companies have even declared bankruptcies. When companies go under, the bicycles go to bicycle graveyards such as that in Xiamen (Haas, 2017). In order to survive, some companies have merged. Two of the biggest companies, Ofo and Mobike, are valued at over a billion dollars each and have significant funding from the tech giants Alibaba and Tencent. Ofo and Mobike control over 90% of the Chinese market (Toh, 2017). The large number of bikes led to piles of underused bicycles that littered sidewalks and blocked pedestrian traffic in some cities, which forced the government to begin to limit the number of bicycles (Toh, 2017).

Ridesharing Summary

In summary, electric ridesharing services have had a large impact across major cities. Benefits include convenience, eco-friendliness, and cost efficiency, but these devices also pose risks to the public’s safety, especially when companies implement programs without conferring with cities. Understanding what ridesharing is, how the industry has evolved over time, and how cities react to implementation of these services is essential to minimize the new risks of these electric ridesharing devices. To meet our goal of analyzing the impacts of ridesharing electric bicycles and electric scooters, we collected observational data, interviewed officials and surveyed the public in Washington DC, which we explain in the next section.
Methods and Results

The overall goal of this project was to analyze impacts of electric bicycles and electric scooters in ridesharing programs. We accomplished this goal through a range of methods: reviewing existing data and literature on ridesharing programs, observing riders and the condition of rideshare scooters in the DC area, mapping vehicle locations, interviewing rideshare companies and officials, surveying riders and non-riders about their experiences with these devices, and analyzing company applications. Figure 16 outlines our four project objectives and the methods we used for each.

Objective 1: Assess risks and social impacts

Our first objective was to assess the range of risks and social impacts associated with electric bicycles and scooters used in ridesharing programs. We did so by reviewing the literature on these programs, most of which we discussed in the previous section. We reviewed published reports on the number and types of accidents, injuries, fatalities, and on other impacts associated with rideshare programs. In addition, we collected prominent news stories about these issues. We intended to draw on the CPSC’s National Electronic Injury Surveillance System (NEISS) database, which collects hospital data on US consumer product-related injuries. Although the NEISS data had details on more than 50 bicycle and scooter accidents in the past 10 years across the United States, only nine cases identified the device as a rideshare device. We assumed that a number of the other reported accidents entailed rideshare devices, but since ridesharing was not recorded systematically, we did not further analyze the data.

Using rideshare apps to locate parked scooters in Washington DC, we also conducted observations of the devices to document obvious maintenance problems. For a table of the total maintenance observations, see Supplemental Materials, Part C. Specifically, we noted problems that might pose safety risks, including bell malfunction, damaged or missing charging port covers, broken handles, broken lights, and loose throttle triggers. Additionally, we recorded brake function by performing a low speed test, pushing each parked scooter and engaging the brake to test tension levels. We separated brake line tension into three categories: high, medium, and low.

Once finished with our maintenance observations, we further tested three scooters, one we classified as having low brake line tension, one with medium tension, and one with high tension. We rode each scooter in a designated area, reaching 9 mph and applied the brakes when the front wheel reached a designated line. We measured the number of feet we traveled from that point to where the scooter came to a complete stop. We took the average from three trials for all three scooters. When going 9 mph

Figure 16. Project methods and objectives.
we classified high tension brakes as having a stopping distance less than 12 ft, medium brakes having a slightly longer stopping distance of 18 ft, while low brakes stopped the vehicle over 18 ft or more.

Figure 17 shows substantial variation in observed brake conditions across and even within companies. We found that Lyft scooters had higher brake tension than most others, with 18 of the 30 we tested having high brake tension. High brake tension means shorter stopping distances, but this may surprise riders if they switch from a company with brakes that are typically slacker. Over-braking could cause these riders to stop short and lose balance. Over the course of our project, Bird introduced a new model of scooters with electric brakes; however, the scooters we tested had non-electric brakes.

We observed 30 scooters spread out amongst the DC area from each of DC’s four most popular rideshare electric scooter companies: Lime, Skip, Bird, and Lyft. Of the 120 observed scooters, 57 (47.5%) of them had at least one of the problems noted above (Figure 18). The most prevalent scooter issue was missing pieces such as a bell or a kickstand at 29.9%. The second most common issue was the brake tension. We found the brake tension was low on 17 scooters. Lyft had the fewest number of problems, with only five scooters with a single problem, and none with multiple problems. Lime and Skip each had 20 (66%) scooters with at least one observed problem.

Readers should note that we noted only observable problems, and on a relatively small number of scooters from each company, so the results are more illustrative than conclusive. More extensive testing of a larger sample of scooters might reveal different patterns.

**Objective 2: Assess the behaviors, knowledge, and attitudes of rideshare users**

To assess the behaviors and opinions of rideshare bicycle and scooter users, we used three methods. First, we documented rider behavior, observing 1400 riders at eight locations across the city where large numbers of rideshare devices were located. Over a four-week period, we conducted 24 observation sessions at different

![Figure 17. Brake line tension for four different companies.](image1)

![Figure 18. Total maintenance problems for all devices.](image2)
times of the day on different days of the week to capture a variety of riders (commuters, tourists, students). For a summary of the locations, dates, and number of observations see the table in Supplemental Materials, Part D. We recorded the following (Supplemental Materials, Part D for observation sheet):

- Rider demographics (gender, approximate age)
- Company and device type (scooter or bike)
- Electric or non-electric device
- Safety practices (e.g., helmet and cellphone use)
- Traffic infractions (e.g., illegal street crossing, riding on restricted sidewalks, running lights)

Second, to gather opinions of and experience with ridesharing, we conducted an intercept survey of 100 adults (54 riders and 46 non-riders) at the eight locations. The survey provided information on the following (Supplemental Materials, Part E for survey):

- Demographics (gender; age; role: commuter, tourist, or student)
- Personal ridesharing experience and habits (riders only)
- Accidents witnessed or experienced
- Knowledge of rideshare programs and local policies
- General opinion about ridesharing

Third, using screenshots of an application called Transit, we tracked rider usage patterns to assess their movement. The screenshots were taken every hour from 6:00 am to 9:00 pm for two days, providing a visual time-lapse of scooter and bike locations throughout the day to determine rider usage patterns.

**Daily density of rideshare devices**

In a study conducted by Xie and Wang of the traveling patterns of the Washington DC bikeshare network, they found the demand-supply ratio (D-S) of each docking station. They also included docking stations along the metro lines to Rockville and to Fairfax. In their findings, they noted that some stations are under supplying bicycles to people based on the time of day. In the morning, the docking stations that were most commonly under supplying users were those in residential areas while the business district of DC could keep up with the demand for bicycles. During the evening, the business district had a majority of the docking stations fail to keep pace with demand while the residential docking stations had enough bikes to satisfy demand (Xie & Wang, 2018). When we mapped device movement through the Transit app, we observed scooters and bicycles conglomerate in the business district of Washington DC during the morning commute as well (Supplemental Materials, Part E).

**Observed demographics and behaviors**

Of the 1,400 riders we observed in the Washington DC area, 914 (65.3%) were using rideshare devices and 486 (34.7%) were riding personal scooters and bikes. Of the ridesharing devices, 531 were scooters while 383 were bicycles. Figure 19 shows that ridesharing users tend to be younger than those riding their own bikes or scooters. In our visual estimation of the rider’s age, 61% percent (558/914) of rideshare users were between 18 and 30 years, while only 40.7% (198/486) of personal users were in that same age range. Approximately 76.3% of all

![Figure 19. Estimated age of ridesharing users versus age of personal device users.](image-url)
riders we observed were male but there was no statistical difference between the ratio of male to female riders for rideshare bicycles and scooters. This is substantially different than the even gender split in the intercept survey of bikeshare riders conducted by Buck (2013) and the annual survey conducted by Capital Bikeshare. With riders under 18 years of age totaling only 12 individuals, we cannot accurately draw any conclusions about their rideshare usage from our observations.

Our observation data shows that the percentage of helmet use amongst rideshare users was significantly lower relative to helmet use by personal users. Of the observed population, rideshare helmet usage was at 8.75% compared to 60.7% for personal users. For personal users, each age group had a helmet usage rate above 50% while the highest rate of helmet use in any rideshare age group was only 11.3% (Figure 20).

Interestingly, helmet use among Capital Bikeshare was much higher at 16.7% of riders, compared with 3.9% among users of dockless devices (Figure 21). We ran a paired t-test for each age group between rideshare and personal riders to see if this difference was significant. The largest P value calculated was 0.0047, confirming a significant difference in helmet use of rideshare versus personal riders. However, when we conducted a t-test on helmet usage amongst rideshare users based on the age groupings, there was no statistical difference. The rate of helmet use for Capital Bikeshare users is comparative to what Fischer et al. (2012) found in their observational study of Boston and DC. After observing 3000 bike riders, they found 19.2% of bikeshare users were wearing helmets. Although, in our observations, we found the majority of riders, regardless of rideshare or

Figure 20. Percentage of helmet use by age.

Figure 21. Observed helmet use of riders on Capital Bikeshare and dockless devices.
personal devices, were riding legally, traffic violations were common (Figure 22). The most common traffic violation was illegal sidewalk use at 39.6%. In the DC business district, it is illegal for bicycle and scooter users to ride on sidewalks. Of the observed personal bicycle riders, only one-third committed a violation with 22.4% being illegal sidewalk use.

Fewer than 10% of rideshare users committed a traffic violation, excluding riding illegally on the sidewalk. Figure 23 shows that riders aged 31-50 are the most law-abiding group of riders. Also, there was no significant difference in the rate of traffic violators between Capital Bikeshare users and other rideshare users.

There appeared to be little difference in male and female riders’ rate and type of traffic violations they committed (Figure 24).

To assess the rider capability of rideshare users compared to non-rideshare users, we rated each rider’s ability to maintain control of their bike or scooter as good or poor (poor meaning they seemed to lose their balance, sway, etc.). Most users were in control of their devices at the time we observed them. A small percent of rideshare users displayed poor control.
over their devices (6.0%), and even fewer personal riders (1.6%) did so (Figure 25).

Since handheld devices and headphones can pose a risk to a rider’s ability to control their vehicle and listen to their environment respectively, we observed and recorded whether riders wore headphones or operated their devices while holding other personal items. The data shows a larger percent of ridesharing users wearing headphones than personal users (Figure 26). Similarly, the percent of rideshare users holding other personal items including phones or shopping bags was slightly larger than the percentage of riders doing so on personal devices (Figure 27).

Knowledge, attitudes, and experiences

We drew on the limited responses of our intercept survey to shed light on the reasons behind using ridesharing, the risky behaviors observed, and to gauge what laws and regulations the riders were aware of. For clarification, survey respondents weren’t the same people as the riders we observed. 92% of respondents to our intercept survey had heard of ridesharing bicycle and scooter programs. Of the 54 people who had used ridesharing devices, over half used rideshare less than four times in the past month (October 2018) and 31.5% used them more than eight times. The survey revealed that riders in DC use ridesharing devices for a variety of reasons (Figure 28).
The most common reason reported was for errands, while tourism, commuting to work or school, and leisure were reasons reported at roughly equivalent rates. Our results are like those of the 2016 Capital Bikeshare member survey, in which members’ top reasons for using the bicycles were social uses, personal appointments, and shopping/errands. However, Capital Bikeshare had 65% of respondents say they use it for commuting to work (LDA Consulting, 2017).

Our survey data also suggests that scooter rideshare users are less likely to wear helmets than bikeshare users. Figure 29 shows that 93.7% of respondents who reported using scooter devices also report having never previously worn a helmet compared to 57.5% of bikeshare users. We also used the survey to ask the respondent the reasons for not using a helmet if applicable. Figure 30 shows the variety of reasons they indicated, ranging from “unnecessary” or “inconvenient” to “do not own one”. These answers correspond to the concept of opportunistic transportation. This
means that riders do not always plan to use these devices, as they are not in set locations, and use them when presented the opportunity. If this is the case, then it would make sense most riders do not have a helmet, as that would suggest they carry around a helmet without necessarily planning to use it.

Riders and non-riders were both asked about their knowledge of local traffic laws for rideshare devices. As shown in Figure 31, many had no knowledge of any laws, although riders tended to know a bit more. In addition, respondents were categorized as having “knowledge” if they reported any correct laws, although many knew very little. For example, some mentioned sidewalk restrictions but did not specify which areas were restricted.

Respondents were prompted to state if they had been involved in any negative incidents involving rideshare devices, and if so what type. 26 respondents reported that they had been involved in incidents, but the number rises to 49 when asked about if they had witnessed an incident. One question solicited respondents’ overall opinion of the rideshare programs as shown in Figure 32. Most respondents reported that they were somewhat positive or neutral about the program, but some respondents also reported negative outlooks because they had some concerns.

**Objective 3: Identify and evaluate the effectiveness of local laws and policies**

To identify and evaluate local laws and policies regarding electric bike and scooter rideshare services, we further researched legal documents and news reports pertaining to the DC pilot program. We obtained current and proposed rules from the DDOT and feedback forms from both the BAC (Bike Advisory Council) and the PAC (Pedestrian Advisory Council) on these rules.

The DDOT released terms and conditions for

![Figure 31. Survey respondents’ knowledge of traffic laws.](image1)

![Figure 32. Riders and non-riders opinions on rideshare programs.](image2)
Under the new conditions, companies can expand their fleet to 600 devices but are required to distribute at least 100 total throughout each ward to make the devices available to a wider demographic.

The BAC addressed was concern on the maximum number of devices per permit. The BAC believed there should be no limitation on these devices.

The PAC generally supported the DDOT’s proposal but provided several comments. The PAC believed that the lock-to requirement would be beneficial and stated that companies also should mark designated scooter parking areas in places with high pedestrian traffic. The PAC also believed that the companies should equip all scooters with lights and reflectors to enhance scooter visibility, make scooters emit warning sounds to alert pedestrians of their presence, and to also develop a method of limiting sidewalk speed to 10 mph. The last major point the PAC addressed was injury prevention. They recommended that the DDOT work with the Department of Health and district hospitals to develop methods for tracking injuries related to ridesharing electric scooters and bicycles.

Using our research and the feedback from the two councils, we interviewed members of the DDOT and the DC Council to further analyze the pilot program and its rules. The questions asked and the notes of the full interview can be found in Supplemental Materials, Part F.

The DDOT was the lead agency involved in the DC pilot program. The agency collected non-personal usage data during the pilot on trip level data, route information, and system level information such as crashes and equipment failure. Representatives from the DDOT expressed issues with receiving compliance from companies on data sharing as some requested data was not fully presented. However, the DDOT understands this process was new to the companies and took time to adjust to. The agency also oversees rideshare device permits, giving the ability to pull permits if companies fail to follow the rules. One problem is that the agency must either fully take a permit away or do nothing; this either/or policy tends to discourage enforcement. As stated earlier, the agency published proposed rules for 2019 and were at the time of this writing, soliciting feedback and making final revisions.

The DC council also played a key role in the pilot as the council oversees the DDOT. The DC council can formally be involved through passing relevant legislation. The DC council can also be involved by managing the budget of the DDOT. The last way the DC council can get involved is informally; the council can offer advice to the DDOT based on public comments. The DDOT and the DC council both described several benefits these rideshare devices offer to the city. One benefit is the reduced number of automotive trips for the city. The DDOT and the DC council believe the rideshare devices are substitutes for short automotive trips in the DC area, which can decrease traffic congestion as well as create an eco-friendlier city. The DC area also benefits from the rideshare programs as the devices can reach places Capital Bikeshare cannot.
The DDOT said they have requests to put Capital Bike in locations which they have not been able to, but the rideshare devices fill this demand. The DDOT and the DC council also acknowledged the economic benefit for riders.

The DDOT cautioned against unregulated expansion of these programs in the DC area. The agency explained that there are benefits, but the programs must expand in a way which is closely monitored. The agency expressed concern about the maintenance of the rideshare devices, as well as some difficulty working with these companies. The agency wants to make sure the programs expand while the risks involved do not.

Objective 4: Evaluate how rideshare companies manage risk

To evaluate how rideshare companies manage risk, we collected information on these companies from public records and published articles, and we reviewed company policies and rider guidelines stated on the apps. We created a matrix of the information given on each company app under the following categories:

- Provide general safety instructions
- Provide how to ride information
- Provide local laws
- Require end ride photo
- Require driver’s license for proof of age
- Ability to report device issue(s)

Our analysis (see Table 2) shows that that all four companies provide basic information on how to operate the scooter as well as on general safety rules for riding such as telling users to ride in the bike lanes and in the street, not on sidewalks. Even though each company does have general safety instructions, not many surveyed rideshare users could identify a regulation about operating scooters or bicycles in the DC area. The applications also tell users to park responsibly and to either use a bike rack or park by the curb at all times. Each of the four companies tell users to wear helmets as well. Under Bird’s “how to ride” section on their application, they do have a local rules section, detailing the local laws in the user’s area such as no riding in public parking structures in the DC area. The Lime app requires users to click through multiple drop-down menus before finding such information, however. This information tends to be quite general.

Bird and Lyft are the only companies that require users to verify their age is over 18 before allowing use of their scooters. All companies require the users to take pictures of their parked devices at the end of the ride, to encourage responsible parking and help monitor damage. Each company has an option on the application to report on problems they observe, including parking location and maintenance problems.

<table>
<thead>
<tr>
<th>Table 2. Company applications matrix.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide how to ride instructions</td>
</tr>
<tr>
<td>Tells user where to ride</td>
</tr>
<tr>
<td>Tells user to obey traffic laws</td>
</tr>
<tr>
<td>Reminds users to wear helmets</td>
</tr>
<tr>
<td>Asks user to park responsibly</td>
</tr>
<tr>
<td>Map shows restricted areas</td>
</tr>
<tr>
<td>Provides local law information</td>
</tr>
<tr>
<td>Requires photo of scooter to end ride</td>
</tr>
<tr>
<td>Ask for proof of age in the form of a license</td>
</tr>
<tr>
<td>User can report an issue</td>
</tr>
</tbody>
</table>

Shown for all rides
Does not have
We attempted direct interviews with company representatives to get opinions on the pilot in place in DC and information on trends and usage patterns with their devices. Their press departments did not respond to our emails, so we tried to interview company members at events hosted in the DC area.

We interviewed pick-up crew members and employees at events on an ad hoc basis since they were more readily available than company managers. We talked to two Skip employees as well as a Capital Bike maintenance worker. The maintenance process of Capital Bikes starts with the rider simply pressing a button on the docking station where the bike is docked to notify the company of a problem. Maintenance workers are then alerted to check the bike. If the problem can be fixed on the spot, they will fix it; if not the bike is noted, and a van comes and picks up the bike where it is brought to a facility where it can be worked on. Capital Bikes also moves bikes from near full docking stations to stations that are less full, since they can be fined by the city if a station is full for more than an hour.

This maintenance practice is different for dockless companies such as Bird, where the anyone can become a maintenance mechanic. To become a mechanic for Bird, a person must review some online how-to videos and answer questions based on those videos. Then Bird sends the person a maintenance starter kit with basic tools and replacement scooter parts. To be notified that a scooter has an issue that needs addressing, users must report an issue with the scooter.

To begin the maintenance process for Skip, the consumer must flag a scooter in need of repair via the app. Once this is done, a “ranger” picks up the scooter to deliver it to engineers at a Skip facility. Once the scooter is in the hands of a Skip engineer, it undergoes a multipoint inspection and will receive repairs if needed. The warehouse where the engineers work can also house the scooters for charging as well. We learned from a Skip employee that as of November 27, Skip is beta testing a new locking mechanism that comes out of the stem of the scooter (Figure 33). This lock was designed to allow scooters to be locked to a fixed object, such as a bike rack, to help limit the clutter of scooters blocking sidewalk accessibility.

For additional graphs of our results, see Supplemental Materials, Part G.

Figure 33. Skip’s new locking mechanism.
Conclusions & Recommendations

After completing our analysis of our maintenance observations, rider observations, intercept questionnaire, and literature review, we drew conclusions on the impacts of rideshare bicycles and scooters. Based on these conclusions we have created recommendations for the CPSC.

1. Rider behavior

Rider observations and survey data showed that many riders do not practice safe riding. We found the lack of helmet use to be the most common risk behavior. Although there were minor differences in the safety practices between genders, we found those who most frequently did not use helmets and/or violated traffic laws were in the 18 to 30-year-old age group.

Overall, riders and non-riders were unaware of bicycle and scooter traffic regulations, including prohibited riding on sidewalks in downtown DC. Riding on restricted sidewalks stood out as the most common infraction among rideshare users. During the pilot, the DDOT and DC city council did not require the companies to inform riders of local traffic regulations, however, in 2019, rideshare companies will be required to inform riders of district laws and regulations, such as speed limits and parking, under the 2019 permit terms and conditions.

Riders would benefit from the CPSC creating a program or campaign, which will highlight the importance of helmets and reinforce rider’s knowledge of local laws and policies. We feel that the CPSC should target the 18 to 30 age group, the group that exhibited the riskiest behavior in our study. One suggestion will be to create a social media campaign to capture the age group’s attention. With a social media campaign, the CPSC can educate riders on the risks of head injury, dangers of committing traffic violations, and the importance of helmet use and general safety. Like previously used methods for their pool safety campaign, the CPSC might also use influencers with a big following of this age group to promote safety practices.

2. Condition and maintenance of ridesharing Scooters

Through our observations, we found many scooters with visible maintenance problems that could pose risks to riders, particularly to those that are riding recklessly. Missing pieces, loose brakes, and exposed battery charging ports can cause serious injury to not only the person riding the scooter, but the person maintaining the scooter as well. We believe the CPSC should promote safety standards for scooters on a national scale and utilize the knowledge of city transportation departments, such as the DDOT, to help do so. Currently, it is up to cities to issue permits but DC has no requirements for regular maintenance. By creating a national standard, the rideshare companies will need all devices up to the same safety code, improving the overall safety of these devices.

3. Laws and policies

In order to promote safer riding habits, cities can use police officers to enforce bicycle and scooter laws. Also, due to the newness of scooter ridesharing, cities should have regulations in place regarding systematic data acquisition regarding scooter usage and maintenance. The cities should also require more specific hospital records to include the ridesharing company. Like DC, other cities should consider policies and regulations for ridesharing and promotion of safety.

Summary

From our interviews with officials in different departments about the pilot system in DC, we believe these devices offer many benefits to cities and are a viable means of transportation. The DDOT and DC Council said the devices could decongest traffic, resulting in fewer automotive trips and reducing CO₂ emissions. Due to the seriousness of these devices, we believe that the CPSC should treat these devices similarly to the ATV department of their research facility. This means of transportation appears to have a place in the future of transportation and needs both regulatory standards and testing as new versions of this technology emerge.

Supplemental Materials for this project may be found at https://digitalcommons.wpi.edu/studentprojectsandalresearch/ by entering this report's title in the search bar. When the window appears, click on the appropriate project title and scroll down to "additional files".
References


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