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Executive Summary

Dockless e-scooters, e-bikes, and pedal bikes, also known as shared mobility devices (SMDs), have recently emerged as another mobility option available for rental in many major cities across the US. Our study surveyed 182 Rosslyn residents, workers, and visitors about their experience with and attitudes towards dockless e-bikes and e-scooters. In addition, we counted over 600 parked e-scooters in three neighborhoods in Arlington County to evaluate how many were parked correctly.

Our study resulted in the following findings:

- E-scooter users are younger, more racially/ethnically diverse, and financially less well-off than non-users. User and non-user gender distributions are similar.
- Respondents choose e-scooters as the fastest option to make practical trips such as errands and work.
- Respondents would use e-scooters more frequently if they had safer places to ride, if prices were lower, and if accessing e-scooters were more convenient.
- E-scooters are more likely to replace car (mainly TNC and taxi) trips than public transit trips.
- Perceptions of e-scooter safety and parking impacts to sidewalks vary sharply between users and non-users—with more negative opinions for non-users.
- The most frequent causes of improper parking are that scooters were not upright, blocked the pedestrian right of way, or were on private property.
- Many respondents are unfamiliar with SMD rules in Arlington County.

As a result of our findings, we have provided the following recommendations:

- Arlington County should facilitate and promote increased usage of e-scooters, especially for first and last mile trips by creating safer places to ride non-automotive forms of transportation.
- Arlington County should coordinate with regional partners to encourage SMD operators to design more substantial kickstands or a “lock to” requirement on scooters.
- Arlington County, neighboring jurisdictions, and SMD operators should educate users on SMD rules and inform them on how those rules change across borders.
- Arlington County should reach out to non-users to inform them about e-scooter rules and safety.

Introduction

Since 2017, private companies have been operating fleets of free-floating pedal bicycles, electric bicycles, and electric scooters for short-term rental in localities across the United States. Collectively, these bikes and scooters are called shared mobility devices (SMDs). SMDs are commonly available for short-term rental via a smartphone app. Unlike other bike rental systems such as Capital Bikeshare or Citibike, SMDs do not need to be docked at specific stations but can instead be left anywhere within the operating area. In September 2018, Arlington County
began a 9-month pilot program that allows private companies to operate SMDs within the County and in Rosslyn in particular.

This report is the result of a semester-long studio class where graduate students from Virginia Tech explored ways to evaluate Arlington County’s SMD pilot program with the goal to provide initial results and recommendations for Arlington County’s SMD feedback form to be deployed in summer 2019. Specifically, students focused on three aspects of the pilot:

- Analysis of demographic, socio-economic, and trip purpose information for SMD users
- Assessment of parked SMDs and impacts on sidewalks and streets
- Evaluation of safety perception of SMDs for both users and non-users

To address these research questions our studio class conducted a survey of people who live, work, or visit Rosslyn and an observational study of SMD parking in Rosslyn, Courthouse, and Crystal City aimed at answering the following research questions:

- Who uses SMDs?
- Why do people use SMDs?
- What is the frequency and duration of SMD use?
- How are SMDs being parked?
- What factors determine SMD parking?
- What impact do improperly parked SMDs have on accessibility?
- How safe do pedestrians and drivers feel around SMDs?

**Methods**

**Online Survey**

Our studio class conducted an online survey using the Qualtrics survey tool. The survey was open for responses from April 4 through April 24, 2019. Based on a literature review and background research, we identified the Portland Bureau of Transportation (PBOT) e-scooter evaluation study as a model for our survey. Many of our questions were modeled after PBOT’s survey to improve comparability. Additionally, Arlington County, Mobility Lab, and Metrobike reviewed and commented on the survey.

The survey was distributed through several online channels, including the social media accounts of the Virginia Tech (VT) Master of Urban and Regional Planning (MURP) program, VT School of Public and International Affairs (SPIA), and VT National Capital Region (NCR) campus. The Rosslyn Business Improvement District (BID) also assisted with online survey

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1 On April 1, 2019, the Virginia Tech Human Research Protection Program (HRPP) approved the survey as exempt from IRB review
2 https://www.portlandoregon.gov/transportation/article/700914
distribution through their official twitter account and a weekly email distribution reaching over 10,000 Rosslyn employees and residents. As an incentive to complete the survey, participants were given the option to enter an email address for a chance to win one of four $50 Visa gift cards.

The survey’s target population was limited to SMD users and non-users in the Rosslyn area of Arlington County, Virginia (see map below). SMDs include e-bikes and e-scooters, but regular pedal dockless bikes were excluded as part of the survey as they currently are no vendors currently operating in Arlington County.

Survey respondents were first asked whether they had used dockless e-scooters in Rosslyn; if not, they were skipped to the second part of the survey, where they were asked if they had used dockless e-bikes in Rosslyn. Those who had used either type of SMD in Rosslyn received the same questions for each mode, covering a range of topics, including:

- Frequency of use
- Trip purpose
- Helmet use
- Trip Motivations
- Mode Replacement
- Shifts in travel behavior
- User behavior and preferences

For all survey participants, including those who had neither used e-bikes nor e-scooters in Rosslyn, the survey covered questions on safety perception, including:
- Perception of safety while walking around users of SMDs, docked bikeshare bikes, and non-shared bikes while walking in Rosslyn
- Comfort level while driving around people using SMDs, bikeshare, and non-shared bikes
- Frequency and impact of blocked sidewalks due to SMDs
- Knowledge of e-bike and e-scooter laws in Arlington County, and sources of that knowledge
- Whether certain changes would encourage the participant to use SMDs in Rosslyn or use them more often

The final module of the survey covered demographics, including home and work/school locations (ZIP codes), gender, age group, education, income category, employment status, race/ethnicity, housing type, and disability status.

**Observational Study**

The observational study aimed to collect data illustrating scooter parking practices and how they may differ across locations within Arlington, by time of day, and based on attributes of the built environment.

The class identified three study areas, one in Crystal City, one in Rosslyn, and one in Courthouse. We selected these study areas based on our review of a heatmap of e-scooter usage (Figure 2) provided by MetroBike, which identified the Ballston-Rosslyn corridor and Crystal City/Pentagon City area as hubs of scooter activity.

*Figure 2. Heatmap of 180,900 E-Scooter and E-Bike Trips During October-December 2018 (courtesy MetroBike)*

Each study area constituted one linear mile of sidewalk— in Crystal, we established a ½-mile route and made observations on both sides of the street. In Courthouse and Rosslyn, we
established a 1-mile circuit and made observations on only one side of the street. Study routes are illustrated below:

Figure 3. Crystal City Study Route for Observational Study
Figure 4. Rosslyn Study Route for Parking Observations

Figure 5. Court House Study Route for Parking Observations
We conducted 25 observation sessions. Table 1 summarizes when we observed each study location. We conducted weekday observations after the morning and evening commute to be able to observe user parking behavior (instead of scooters parked by company employees (i.e., chargers)).

<table>
<thead>
<tr>
<th></th>
<th>Weekday</th>
<th>Weekend</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Early Observation Time</strong></td>
<td>9:30-11:00 AM</td>
<td>11:30 AM-12:30 PM</td>
</tr>
<tr>
<td><strong>Late Observation Time</strong></td>
<td>6:30-8:00 PM</td>
<td>6:30-8:00 PM</td>
</tr>
</tbody>
</table>

To collect data, we designed an observational questionnaire using the smartphone mobile application, Epicollect 5. The questionnaire captured data on time of day, weather conditions, scooter location, attributes of the built environment, scooter parking condition, and, for improperly parked scooters, a photo.

**Built Environment**

We recorded three elements of the built environment:
- Street-side attributes (i.e., identifying the use of the road immediately adjacent to the sidewalk)
- Sidewalk attributes (i.e., identifying infrastructure or amenities on the sidewalk)
- Non-street-side attribute (i.e., identifying building and other uses immediately adjacent to the sidewalk)

Table 2 provides more detail on specific characteristics of the built environment we observed.

<table>
<thead>
<tr>
<th>Built Environment Element</th>
<th>Attributes of Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Street-Side Attributes</td>
<td>● Bike lane&lt;br&gt;● Parking lane&lt;br&gt;● Travel lane</td>
</tr>
<tr>
<td>Sidewalk Attributes</td>
<td>● Bike parking&lt;br&gt;● Planter, tree, grass strip, traffic and other light posts&lt;br&gt;● Street furniture&lt;br&gt;● Fire hydrant/valve&lt;br&gt;● Bus stop&lt;br&gt;● Bikeshare station</td>
</tr>
<tr>
<td>Non-Street-Site Attributes</td>
<td>● Restaurant&lt;br&gt;● Offices&lt;br&gt;● Retail&lt;br&gt;● Off-street parking&lt;br&gt;● Residential</td>
</tr>
</tbody>
</table>

We determined street-side attributes by drawing an imaginary line through the parked scooter perpendicular to the closest street.
We identified attributes that narrow the pedestrian right of way (e.g., planters) and attributes whose use could be impaired by improperly parked scooters (e.g., sidewalk furniture, like benches). To determine the presence or absence of a sidewalk attribute, we measured approximately two feet in either direction from the object, creating a “band” across the sidewalk perpendicular to the street; if a scooter was parked inside this band, we coded the feature as ‘present’ for that observation. Figure 6 shows an example of how we coded the presence or absence of a planter. The built environment for scooters parked in the area indicated by the orange diagonal stripe pattern was coded as planter.

![Figure 6. Illustration of Methodology for Determining Presence or Absence of Sidewalk Attributes](image)

We determined non-street-side attributes by drawing an imaginary line through the scooter perpendicular to the closest street. For mixed use developments (e.g., offices with street-level retail), we coded based on the street-level use.
Scooter Condition

We established and recorded a set of conditions, any of which on its own would constitute improper scooter parking. These criteria originated from the Memorandum of Agreement between scooter operator companies and Arlington County, which establishes appropriate parking. Table 3 provides more detail on each improper scooter parking condition we observed.

<table>
<thead>
<tr>
<th>Scooter Condition Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blocking pedestrian right of way</td>
<td>Scooter is impeding pedestrian access or crosswalks. This includes any scooter that obstructs the Americans with Disabilities Act (ADA)-established five-foot clearance zone. See Figure 7 for more detail.</td>
</tr>
<tr>
<td>Blocking vehicle right of way</td>
<td>Scooter is (even partially) in the street.</td>
</tr>
<tr>
<td>On private property</td>
<td>Scooter is (even partially), for example, in a driveway, in a residential yard, on a stoop, in a restaurant outdoor seating area, or in a building nook.</td>
</tr>
<tr>
<td>Damaging property (i.e., plants or trees)</td>
<td>Scooter is leaning against or on top of vegetation or otherwise in a planter.</td>
</tr>
<tr>
<td>Not upright</td>
<td>Scooter is laying on its side or leaning against another object.</td>
</tr>
<tr>
<td>Obstructing access to fire hydrant or valves</td>
<td>Scooter is within a two-foot radius of a fire hydrant or valve.</td>
</tr>
<tr>
<td>Obstructing access to street furniture</td>
<td>Scooter is within two feet of the side of a piece of furniture a furniture user must access (e.g., for a bench with a back and armrests, the obstructing side would be only the front of the bench).</td>
</tr>
<tr>
<td>Obstructing access to bus stop</td>
<td>Scooter is between the bus stop and the street or within two feet of either side of the bus stop.</td>
</tr>
<tr>
<td>Obstructing access to bikeshare station</td>
<td>Scooter is within two feet of the side of a bikeshare station a bikeshare user must access to (un)dock a bike.</td>
</tr>
</tbody>
</table>

In Figure 7, blue lines represent properly parked scooters that do not obstruct the pedestrian right of way on four example sidewalks with and without furniture and frontage zones. The frontage zone is on the non-street-side and includes such things as restaurant seating or signs for businesses. The furniture zone is on the street-side and may contain bus stops, benches, planters, etc. When a sidewalk includes both a furniture and frontage zone, scooters should only be parked in those zones. When a sidewalk contains only a frontage or furniture zone, scooters should be parked in that zone, but may also be appropriately parked along the edge of the right of way parallel to the flow of pedestrian traffic. When a sidewalk has only a right of way zone, scooters must be parked along either edge, parallel to the flow of pedestrian traffic.

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Results

Online Survey

This section provides the main findings from the online survey. Due to a small number of e-bike users ($n=20$), the results specific to e-bike use are presented in the appendix only.

Dockless E-Scooter Usage

The majority of survey respondents (59%) are non-users who have never used dockless e-scooters in Rosslyn. 74 respondents (41%) have used dockless e-scooters in Rosslyn (Figure 8).
Dockless E-Scooter User Demographics

Our survey depicts various demographic patterns amongst dockless e-scooter users and non-users in Rosslyn. Survey questions focused on the distinction between users and non-users in terms of gender, age, racial and ethnic background, as well as annual household income. The following provides demographic charts of dockless e-scooter users and non-users in Rosslyn, where the majority of survey respondents were found to be predominantly white, female and earned a substantial income, in addition to users being younger than the average respondent.
As shown above, the majority of overall survey respondents were female (approximately 57%) and approximately 58% of users were female as well.
While the majority of non-users providing their age are at least 35 years old, 84% of users are under the age of 34. As shown above, the majority of dockless e-scooter users and the plurality of non-users in Rosslyn were between 25 to 34 years of age (approximately 65% of users and 34% of non-users).
Figure 11. Dockless E-Scooter Users and Non-Users by Race/Ethnicity in Rosslyn

- Over 30% of users identified as Middle Eastern or North African; Hispanic, Latino, or Spanish; Black or African-American; and/or Asian, compared to only 15% of non-users who identified as non-white.
The majority of survey respondents earned a gross annual household income of at least $50,000. Respondent median income for users was $75,000-100,000 while respondent median income for non-users was $100,000-125,000.

Dockless E-Scooter Use Frequency

Of our responding dockless e-scooters riders in Rosslyn, the majority (52%) typically ride the devices less than once per week, while one-third ride at least once per week. 15% of users have only used dockless e-scooters in Rosslyn once. This is indicative of the majority of respondents using e-scooters for occasional one-time trips, rather than regular use for daily commuting trips.
Figure 13. Frequency of Dockless E-Scooter Usage in Rosslyn

Dockless E-Scooter Trip Purpose

Responding dockless e-scooters riders in Rosslyn were able to select up to three of the most common trip purposes for their e-scooter trips. Figure 14 shows that the top three trip purposes of dockless e-scooters in the survey were for shopping or errands (58%), to or from work (56%), and social/entertainment trips (52%). About 26% of respondents used dockless e-scooters to and from public transit (e.g. bus or Metrorail).
Dockless E-Scooter Trip Purposes

Figure 14 shows the top three trip purposes for which you use dockless e-scooters in Rosslyn? (N=66)

- 58% Shopping or errands
- 58% To or from work
- 52% Social/entertainment
- 47% To or from a restaurant
- 41% For fun/recreation
- 21% To or from work-related meeting/appointment
- 20% To or from Metrorail
- 15% To or from bus
- 10% To get exercise
- 3% To or from school

Note: Multiple responses allowed for this question

Dockless E-Scooter Trip Motivations

Figure 15 shows the top two motivating factors for users to choose e-scooters are because it was the fastest option (61%) and least expensive (39%). 34% of respondents also chose e-scooters for their most recent trip because car parking was difficult at that time or destination or because it was fun. For clarity, Figure 15 only shows trip motivations with at least 20% of respondents (9 answers did not meet this threshold).
Dockless E-Scooter Mode Replacement & Traveler Behavior Change

One of the more controversial elements of dockless e-scooters is whether they complement or compete with other modes such as public transit or walking. The most common (39%) mode that respondents would have taken if no dockless e-scooter had been available was a taxi, Uber, Lyft, and Via trip (Figure 16). However, 33% of respondents used e-scooters to replace walking for their last trip. There was minimal direct trip replacement for public transit (7%). Respondents reported how their use of various modes had changed since first using dockless e-scooters. Highlights from travel behavior changes include:

- 52% of respondents use taxis, Uber, Lyft, and Via less often since first using dockless e-scooters.
- 63% of respondents walk about the same, while 28% walk less often since first using dockless e-scooters.
- 35% of respondents drove a personal car less often and 61% about the same since first using dockless e-scooters
- Most public transit users continue to use bus and Metrorail about the same since first using dockless e-scooters. 70% of respondents use Metrorail about the same and 22% less often. 68% of respondents take the bus about the same, compared to 25% who use the bus less often.
Figure 16. Dockless E-Scooter Trip Replacement

If a dockless e-scooter had not been available for your last trip in Rosslyn, how would you have made that trip? (N=67)

- Would not have made this trip: 3%
- Taken a bus: 7%
- Ridden a shared dockless e-bike: 2%
- Walked: 33%
- Taken a taxi/Uber/Lyft/Via: 39%
- Ridden a personal bike or e-bike: 4%
- Ridden a Capital Bikeshare bike: 6%
- Driven a personal vehicle, carshare vehicle, or other motor vehicle: 4%
- Other: 2%

Figure 17. E-Scooter Trip Behavior Change

Since first using dockless e-scooters in Rosslyn, how has your use of the following options changed?

- Took a taxi, Uber/Lyft/Via (N=65): 43% more often, 52% less often, 5% the same
- Capital Bikeshare Bike (N=35): 63% less often, 44% the same, 3% more often
- Drove a personal car (N=46): 61% the same, 35% less often, 4% more often
- Drove a carsharing car (e.g., ZipCar, Car2Go) (N=13): 57% the same, 33% less often
- Walked (N=65): 63% more often, 26% less often, 9% the same
- Bus (N=44): 68% more often, 25% less often, 7% the same
- Dockless e-bike (N=17): 71% more often, 24% less often, 6% the same
- Metrorail (N=60): 70% the same, 23% less often, 8% more often
- Personal bike (N=27): 78% more often, 19% less often, 4% the same
**Dockless E-Scooter Preferences**

Given the opportunity to rank on a 1–5 scale in what type of facility they would prefer to ride dockless e-scooters, respondents indicated a strong preference for riding in protected bike lanes, giving them an average rating of 4.4. Unprotected bike lanes came in second with an average rating of 3.3, with off-street trails and sidewalks (both currently illegal for scooters in Arlington County) virtually tied at 2.9 and 2.8. Shared travel lanes with automobiles were by far the least preferred option, coming in last at 1.6.

![Figure 18. Dockless E-Scooter User Preferences](image)

**Dockless E-Scooter Rider Behavior**

While protected bike lanes are preferred, 69% of respondents always or often ride e-scooters in bike lanes in the street, compared to 54% always or often riding in protected bike lanes. It should be noted that protected bike lanes are somewhat limited in Rosslyn, so many users may not have this as an option. However, protected bike lanes were installed in 2018 along Wilson Boulevard in Rosslyn.

Mirroring the preferences of users, 29% of respondents always or often ride in shared travel lanes (same lane used by cars), compared to 40% always or often riding on the sidewalk and 31% always or often on a trail or path.
Table 4. E-Scooter Rider Behavior

Regardless of where you would prefer to ride, where do you actually ride dockless e-scooter in Rosslyn?

<table>
<thead>
<tr>
<th>Location</th>
<th>Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sidewalk (N=65)</td>
<td>17%</td>
<td>23%</td>
<td>26%</td>
<td>28%</td>
<td>6%</td>
</tr>
<tr>
<td>Bike lane in the street (N=65)</td>
<td>30%</td>
<td>39%</td>
<td>18%</td>
<td>5%</td>
<td>8%</td>
</tr>
<tr>
<td>Trail/path (e.g. Mt. Vernon Trail) (N=65)</td>
<td>14%</td>
<td>17%</td>
<td>15%</td>
<td>20%</td>
<td>34%</td>
</tr>
<tr>
<td>Shared travel lane (same lane used by cars) (N=66)</td>
<td>9%</td>
<td>20%</td>
<td>33%</td>
<td>21%</td>
<td>17%</td>
</tr>
<tr>
<td>Protected bike lane (e.g. Wilson Blvd.) (N=66)</td>
<td>24%</td>
<td>30%</td>
<td>30%</td>
<td>5%</td>
<td>11%</td>
</tr>
</tbody>
</table>

Dockless E-Scooter Helmet Usage

Overall, users reported very low helmet usage. The vast majority (94%) of users reported never or rarely using a helmet, compared to only 3% always or often wearing a helmet. Arlington County code requires all riders 14 years of age or younger to wear a helmet, but all survey respondents were required to be at least 18 years of age.

Figure 19. Helmet Usage for Dockless E-Scooters

How often do you wear a helmet when riding a dockless e-scooter in Rosslyn? (N=66)
Safety Perceptions

For all survey participants, including those who had not used either e-bikes or e-scooters in Rosslyn, the next section of the survey included questions about how people felt around other people using the devices while walking and driving, how often they encountered devices blocking their walkway, and what would encourage them to use the devices, or use them more often if they already do.

Perception of safety around users of SMDs and bikes while walking in Rosslyn

In general, respondents feel safe while walking around riders of Capital Bikeshare (62% "safe" or "very safe") or personal bikes (68% "safe" or "very safe"), but significantly less comfortable around riders of dockless e-bikes (41% "safe" or "very safe"). However, most respondents (56%) feel unsafe around users of dockless e-scooters.

![Figure 20. Perception of Safety Around Users of SMDs and Bikes While Walking in Rosslyn](image)

There was an important difference between e-scooter users and non-users (Figure 21). Respondents who had used dockless e-scooters in Rosslyn themselves were much more likely to feel safe around other riders of the devices. While 75% of the 95 respondents who had never used one feel ‘unsafe’ or ‘very unsafe’ around e-scooter riders, 50% of the 58 people who had used one at least once feel ‘safe’ or ‘very safe’ and less than 25% feel ‘unsafe’ or ‘very unsafe’. (One person, who had not used a dockless e-scooter in Rosslyn, answered ‘neutral’ for the other three device types but did not give an answer regarding dockless e-scooters.)
Respondents were also asked about their comfort level while driving around users of SMDs and bicycles. 31 (20%) answered ‘not applicable’ to all four device types, suggesting that they do not drive or do not drive in Rosslyn; the remainder indicated they are generally comfortable driving around users of Capital Bikeshare (50.4% "comfortable" or "very comfortable") and personal bikes (57.8% "comfortable" or "very comfortable"), somewhat less comfortable driving around users of dockless e-bikes (36.3% "comfortable" or "very comfortable"), and profoundly uncomfortable driving around users of dockless e-scooters (67% "uncomfortable" or "very uncomfortable").
Once again, familiarity with the device has a strong effect on the respondent’s comfort level around other users of the device (Figure 23). Nearly half (49%) of respondents who had not used a dockless e-scooter said they were ‘very uncomfortable’ driving around scooter users, while about one in eight (12%) were ‘comfortable’ or ‘very comfortable’; those who had used a dockless e-scooter at least once were three times as likely (36%) to be ‘comfortable’ or very comfortable’ driving around other scooter users.
Frequency and impact of blocked sidewalks due to SMDs

Many respondents indicated that they encounter sidewalks blocked by improperly-parked dockless e-scooters frequently (54.9% "always" or "often"), much more so than by the various bike types (17.6% "always" or "often" are blocked by improperly-parked dockless e-bikes, while less than 2% have similarly-frequent problems with Capital Bikeshare or non-shared bikes). We did not ask how often walking trips are impacted by improperly-parked automobiles and delivery vehicles, though this might be worth incorporating into future research.
Once again, there is a significant disparity between responses of those who have not used the devices and those who have: Those who have used a dockless e-scooter are substantially less likely to encounter sidewalks blocked by the devices (Figure 25). It is not possible to say from this data what accounts for this difference.
Knowledge of laws in Arlington County and sources of that knowledge

Riders and non-riders gave fairly consistent responses to questions about Arlington County laws regarding SMDs, though non-riders were more likely to admit they did not know what the laws are.
Figure 26. Laws Relating to SMD Use in Arlington County.

Note: Users could choose multiple responses. Two answer choices with responses less than 10% omitted.

Notably, several options that are not actually the law in Arlington received positive responses—for example, 35% of respondents, including nearly 60% of riders, said all SMD users are
required to wear helmets. In fact, in Arlington County, only those under age 14 are required to wear helmets⁴, while the County’s MOA with SMD operators restricts use to those over age 16.⁵

Arlington County code §14.2-64.1.B prohibits “any motorized vehicle powered by an … electrical motor, or other electrical device” from bike paths.⁶ Virginia code §46.2-903 permits riding “electric power-assisted bicycles” on sidewalks, but not powered scooters.⁷

When asked how they learned about these laws, several respondents who had said they did not know what the laws were gave source answers and vice versa. (In both cases, respondents could give multiple answers.) Notably, Arlington’s MOA with SMD operators requires that they “must notify SMD users of Arlington County and state regulations applicable to operating SMDs in Arlington County,”⁸ but only 41% of respondents who had used scooters in Rosslyn said that they had learned of device regulations through their device’s app; 22% of scooter users had learned of regulations on the device itself (9% of scooter users gave both answers).

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⁷ Code of Virginia, § 46.2-903. Riding or driving vehicles other than bicycles, electric power-assisted bicycles, or electric personal assistive mobility devices on sidewalks, https://law.lis.virginia.gov/vacode/title46.2/chapter8/section46.2-903.
Note: Users could choose multiple responses. Five answer choices with responses less than 10% omitted.

Changes which would encourage (more) SMD use

Finally, participants were asked what changes would encourage them to use SMDs, or to use them more often if they already do use them. “Safer places to ride” was the clear winner, with 72% of 57 scooter riders selecting it; 46% of the 96 non-users selected it, putting it in a tie for first among this group with “None of these changes would encourage me to use dockless e-bikes or dockless e-scooters more often”. Other popular choices among those who already use SMDs were “Lower cost” (34%), “More SMDs available in Rosslyn” (34%) and “in surrounding jurisdictions” (29%), and “Longer battery life” (29%). The only choice selected by more than 15% of non-users was “Lower cost” (19%), though 16% selected “other”.

Among the additional options entered by non-users were suggestions both for higher speed limits for scooters (and lower for cars) and lower speed limits for scooters; suggestions to clarify regulations for where SMDs can and can’t be used and parked and whether helmets are
required; suggestions to provide helmets for users; and suggestions for safety training and opportunities to test-ride the devices—one person wrote, “I am mostly just unfamiliar with using them”.

Additional suggestions entered by those who have used dockless e-scooters included requests for better power for hill-climbing and better tires for shock absorption; another request for helmets; and requests to be able to go faster or use them legally on the sidewalk—“They’re too slow to ride in the street right now”, one person wrote.

A couple people in both groups encouraged having more consistent places to find SMDs, with one person (non-user) specifically referencing the convenience for planning of knowing where to go to find a Capital Bikeshare bike.

Figure 28. Changes Needed to Encourage More SMD Use
Observational Study

The overall rate of parking noncompliance was 16% (97 of 606 e-scooters) (Figure 29). However, only 6% of e-scooters were found to be blocking the pedestrian right of way.

Figure 29. Share of Scooters Parked Properly and Improperly

Figure 30 shows the distribution of improper parking by scooter condition. The most frequent causes of improper parking were that scooters were not upright, blocking the pedestrian right of way, or on private property. The numbers in this figure add to more than the total number of improperly parked scooters (97), because in many cases a scooter was improperly parked for more than one reason (e.g., a scooter was both not upright and blocking the pedestrian right of way).
Figure 30. Types of Improper Parking (Counts)
In terms of sidewalk attributes, e-scooters were most likely to be improperly parked near fire hydrants/valves, bus stops, bike parking, street furniture, likely due to obstructing access to facilities/amenities. In terms of land use, scooters were most likely to be improperly parked near offices, likely due to being parked on private property.
Scooters were most likely to be parked blocking the pedestrian right of way near residential buildings or offices, near fire hydrants/valves, or when the sidewalk was adjacent to a travel lane.

Survey Lessons Learned

Our survey was structured in four sections: two parallel sections, the first addressing e-scooters and the second addressing e-bikes, then a section on safety, and finally a section covering demographics. Respondents only were presented with the e-scooter questions if they answered that they had ridden an e-scooter at least once; a similar requirement was in place for the e-bike section. We observed a lower response rate (approximately 60%) for the e-bike section of the survey compared to the e-scooter section (approximately 85%). When breaking down the response rate for the e-bike section of the survey among respondents who had previously
answered the e-scooter questions and those who had not, the low response rate for the e-bike section was driven by respondents who had already answered the e-scooter questions.

- **Recommendation**: Organize the survey by topic area (e.g., safety), and within each topic area, pose each question for both e-scooters and e-bikes. Alternately, design two surveys (one for e-scooters and one for e-bikes) that can be randomly assigned to respondents.

We observed a lower response rate (about 10 percentage points lower than average) for the question “Regardless of where you actually ride, rank where you would prefer to ride” in both the e-scooter and e-bike sections of the survey. This question required respondents to rank five choices. In the related question asking “Regardless of where you prefer to ride, where do you actually ride,” which had about average response rates, respondents were required to select the frequency with which they used an SMD in five types of facilities. We attribute the lower response rate to respondents finding the ranking question more challenging to answer.

- **Recommendation**: Avoid ranking questions; if using a ranking question, provide no more than three choices.

In our survey, we did not quantify or otherwise define answer selections including often, sometimes, and rarely in the question about e-scooter impacts on pedestrians. This left room for subjectivity in respondents’ answers (e.g., a respondent may deem encountering one e-scooter per week blocking the sidewalk “often” while another might encounter e-scooters blocking the sidewalk daily and indicate “sometimes”).

- **Recommendation**: Provide representative time intervals for frequency questions.

In the question on mode substitution, we asked about trips “in Rosslyn.” We were a bit surprised that no respondents indicated that they have used SMDs instead of Metrorail. This result may be an artifact of the wording of the question because respondents may have interpreted the question to be asking about trips occurring entirely within Rosslyn instead of trips beginning or ending in Rosslyn.

- **Recommendation**: Clarify in questions regarding specific trips whether respondents should consider trips entirely within a geography or trips beginning/ending in the location of interest.

Our survey did not ask respondents about their knowledge of SMD parking requirements, instead focusing on safety concerns like where riding is allowed and whether riders must wear helmets.

- **Recommendation**: Given the perception of improper parking exceeding the actual occurrence of improper parking, and the variable perception of improper parking between users and non-users, we recommend gauging Arlington County residents’ understanding of parking requirements.
Discussion

Who uses SMDs?

E-scooter users are younger, more racially/ethnically diverse, and less financially well-off than non-users. User and non-user gender distribution is similar. While the majority of non-users providing their age are at least 35 years old, 84% of users are under the age of 34. Over 30% of users (compared to approximately 15% of non-users) identified as Middle Eastern or North African; Hispanic, Latino, or Spanish; Black or African-American; and/or Asian. Respondent median income for users was $75-100k while respondent median income for non-users was $100-125k.

Why do people use SMDs?

Respondents choose e-scooters as the fastest option to make practical trips. Our study found that, survey respondents who have used dockless e-scooters used them for utilitarian purposes. The top three reported trip purposes in Rosslyn were shopping, work, and social activities. Respondents overwhelming reported that the reason they chose an e-scooter for their last trip in Rosslyn was because it was the fastest option. This indicates that respondents are using e-scooters as a transportation option and are choosing to use scooters in Rosslyn not because of the novelty, but because they are genuinely useful. This conclusion should be tempered, however, by the fact that over half of surveyed e-scooter users reported using them less than once per week.

Respondents would use e-scooters more frequently if they had safer places to ride, if prices were lower, and if accessing e-scooters were simpler. Over half of respondents, including nearly three-quarters of those who already use scooters, indicated safer e-scooter facilities would encourage them to ride e-scooters more often. About a quarter of respondents indicated that lower cost would encourage more SMD use. Some respondents indicated a barrier to SMD use was the number of companies in the market resulting in several apps--users want a more streamlined experience.

- **Recommendation**: The County should prioritize complete streets to create safer places to ride non-automotive forms of transportation. Arlington should engage in education and outreach about tiered pricing schemes and how low-income residents can access these benefits. Arlington should coordinate with regional partners to encourage SMD operators to collaborate on developing an integrated platform for SMDs.

E-scooters are more likely to replace car trips than public transit trips. One concern with SMDs is that SMD trips replace walking, biking, and transit trips and so do not remove cars off the road. Our study found that, in Rosslyn, this is partially the case, but there are hopeful signs as well. While one third of respondents said that if an e-scooter had not been available for their last trip in Rosslyn they would have instead walked, the plurality of users, almost 40%, reported that their last trip would have been by TNC or taxi. Only 19% of respondents said they would
have taken bus or bike instead. When asked how the introduction of dockless e-scooters has affected use of other forms of transportation, automobile use seems to be reduced: respondents indicated they used TNCs and taxis less (52% of respondents), drove personal cars less (35% of respondents), and used carsharing less (33% of respondents). Most respondents’ use of public transportation did not decrease (22% of respondents for Metrorail and 25% of respondents for bus).

- **Recommendation**: Facilitate use of e-scooter for first or last mile purposes. Encourage or require SMD operators to deploy SMDs near metrorail stations and bus stops.

### User and Non-User Perceptions

**Perceptions of e-scooter safety and parking impacts to sidewalks vary sharply between users and non-users.** Our study revealed interesting differentials between the attitudes of users and non-users of e-scooters. 76% of non-users reported feeling “unsafe” or “very unsafe” around SMDs in Rosslyn as a pedestrian, while only 24% of scooter users reported feeling unsafe or very unsafe. There are similar results for comfort while driving around SMDs in Rosslyn. Fully 80% of non-users reported feeling “uncomfortable” or “very uncomfortable” while only 47% of users reported feeling uncomfortable or very uncomfortable. In fact, the percentage of non-users who felt “very uncomfortable” (49%) was higher than the combined percentage of users who reported feeling “uncomfortable” and “very uncomfortable.” These differences in perception carry over to parked SMDs as well. One third of non-users report “always” encountering SMDs blocking sidewalks in Rosslyn while only 7% of users reported “always” encountering them. Compare these perceptions to our observational data which found that only 5.8% of e-scooters were blocking the pedestrian right of way. Arlington County could reach out to non-users to inform them about e-scooter rules and safety.

While these differences could indicate that greater familiarity with SMDs in Rosslyn leads people to be less bothered by them, causation is hard to determine. It could also be the case that people who do not like SMDs and feel uncomfortable around them choose not to use them. An intervening variable could also be age. SMD users in our survey were on average much younger than non-users. SMDs might pose a greater challenge to older people who may not be able to move them out of their way as easily. We did not define what a “blocked sidewalk” was so respondents likely have different ideas about what constitutes a blocked sidewalk.

### The Built Environment & Parking

**The most frequent causes of improper parking were that scooters were not upright, blocking the pedestrian right of way, or on private property.** However, the highest rates of improper parking (greater than 30%) appeared near fire hydrants/valves and bus stops.

- **Recommendation**: Arlington should coordinate with regional partners to encourage SMD operators to design next generation e-scooters with more substantial kick-stands, or implement a “lock to” requirement, as is done in San Francisco, to address the
problem of scooters not being parked upright. Arlington should conduct further user education regarding appropriate parking to help users understand how to avoid parking on private property, in spaces blocking the pedestrian right-of-way, and in other ways that obstruct access to public facilities/utilities. For example, in Atlanta, the city has established a requirement that parked scooters allow at least five feet of space for pedestrians to move. Arlington should partner with business improvement districts to address improper parking when it occurs.

Safety

Many respondents were unfamiliar with SMD rules, which suggests that greater education efforts are needed. Over half of all respondents said they “don’t know” what the rules are and over 40% of users reported being unfamiliar with the rules. Even among respondents who reported knowing the law, there was still confusion. Although 36% of non-users and 57% of users correctly stated that e-scooters were not allowed on the sidewalk, 50% of users and 29% of non-users incorrectly stated that e-bikes were not allowed on the sidewalk and 59% of users incorrectly stated that all users were required to wear helmets. Interestingly, only a fraction of users actually reported wearing a helmet while riding an e-scooter in Rosslyn.

- Recommendation: This confusion suggests a need for increased education and outreach efforts to current and potential e-scooter users in Arlington. The County and SMD operators both have a role to play in informing people what the rules for scooters are and how they change between jurisdictions and type of SMD. For example, DC allows scooters to be ridden on the sidewalk outside of the central business district but right across the river in Arlington, they are not allowed on the sidewalk at all.
Appendix A

Due to a low-number of responses, dockless e-bike survey results are presented below in Appendix A.

Dockless E-Bike Survey Results

![Figure 33. Dockless E-Bike usage in Rosslyn](image)

![Figure 34. Dockless E-Bike Usage Frequency in Rosslyn](image)
What are the top three trip purposes for which you use dockless e-bikes in Rosslyn? (N=13)

- To or from work-related meeting/appointment: 45%
- Social/entertainment: 40%
- For fun/recreation: 35%
- To or from a restaurant: 30%
- Shopping or errands: 25%
- To or from work: 20%
- To or from Metrorail: 15%
- To or from school: 10%
- To get exercise: 5%

Figure 35. Dockless E-Bike Trip Purposes

How often do you wear a helmet when riding a dockless e-bike in Rosslyn? (N=14)

- Never, 71%
- Rarely, 14%
- Sometimes, 7%
- Always, 7%

Figure 36. Dockless E-Bike Helmet Usage
Figure 37. Dockless E-Bike Trip Motivations
Figure 38. Dockless E-Bike Trip Replacement

Table 5. Dockless E-Bike Rider Behavior

Regardless of where you would prefer to ride, where do you actually ride dockless e-bikes in Rosslyn?

<table>
<thead>
<tr>
<th></th>
<th>Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sidewalk (N=14)</td>
<td>14%</td>
<td>0%</td>
<td>36%</td>
<td>21%</td>
<td>29%</td>
</tr>
<tr>
<td>Bike lane in the street (N=15)</td>
<td>0%</td>
<td>53%</td>
<td>27%</td>
<td>0%</td>
<td>20%</td>
</tr>
<tr>
<td>Trail/path (e.g. Mt. Vernon Trail) (N=14)</td>
<td>14%</td>
<td>14%</td>
<td>29%</td>
<td>14%</td>
<td>29%</td>
</tr>
<tr>
<td>Shared travel lane (same lane used by cars) (N=15)</td>
<td>7%</td>
<td>33%</td>
<td>27%</td>
<td>13%</td>
<td>20%</td>
</tr>
<tr>
<td>Protected bike lane (e.g. Wilson Blvd.) (N=14)</td>
<td>7%</td>
<td>29%</td>
<td>21%</td>
<td>14%</td>
<td>29%</td>
</tr>
</tbody>
</table>
Figure 39. Dockless E-Bike Travel Behavior Changes

Figure 40. Dockless E-Bike Rider Preferences