SCHOOL OF
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University of Maryland Campus Multimodal Transportation Interaction and Conflict Study

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Executive Summary

In recent years, universities and colleges across the country have been dealing with the introduction of micromobility transportation on their campuses that supplement pre-existing modes of travel, such as walking, biking, transit, and driving. The most prevalent addition on many campuses has been e-scooters. The University of Maryland College Park campus has seen an increase in e-scooter usage throughout its campus. University of Maryland Department of Transportation Services (DOTS) has bike and e-scooter guidelines that provide examples of safe and unsafe riding practices as well as parking etiquette ("Electric Scooter Regulations | UMD DOTS" 2018). Even though these guidelines prevent the use of sidewalks by cyclists and e-scooters, many users continue to do so, at least partly due to the lack of adequate bike infrastructure on campus. These conditions leave all road and sidewalk users unsure how to correctly navigate shared spaces. This paper studies how roadway and sidewalk users interact on the University of Maryland campus, and offers specific recommendations for policies, infrastructure, pilot programs, educational programs, and information distribution to improve travel safety and reduce stress and intermodal conflicts.

A literature review was conducted to understand the types of interaction of pedestrians, e-scooters, and cyclists and search measures used in practice to prevent the conflicts among these modes effectively. This review found that intermodal conflict is a common concern among campus and municipal planners (Scott 2011; University of Maryland 2018; University of Minnesota 2019; and others) but that no consensus about how best to regulate the interaction between bikes, e-scooters, and pedestrians has emerged. In particular, pedestrians have reported a high degree of dissatisfaction with the presence of e-scooters on sidewalks (Badia and Jenelius 2021; James et al. 2019). Most attempts to reduce intermodal sidewalk conflict have centered on reducing conflict by removing scooters and bikes from sidewalks. Simple prohibitions were largely ineffective, with a high rate of ignorance among users (James et al. 2019). Researchers have found that, in general, introducing dedicated infrastructure for bikes and scooters is effective at drawing those riders off of sidewalks (Ciarlo et a. 2019), although results are sensitive to context (Choi et al. 2022; Goodno et al. 2013). Some municipalities have imposed speed governors on e-scooters using geofencing (Santacreu 2020, Ciarlo et a. 2019). Design elements such as centerline striping, educational signage, lighting, path curvature, and topography have also been explored as means of reducing conflict (Queensland Transport 2006). Finally, some municipalities, like Amsterdam, have experimented with a "shared spaces" approach, emphasizing the role of interpersonal negotiation in reducing conflict over rules and regulations (Knight 2019).

Motivated by the authors' personal experience with inter-modal conflicts and based in part on the findings of the literature review, a survey and video observations were conducted as a part of this study that sought to investigate:

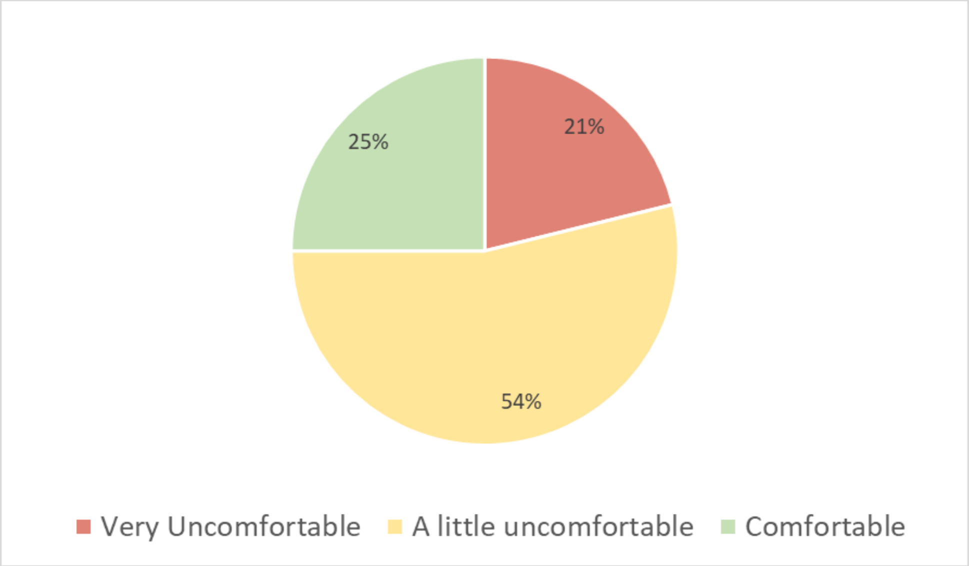
1) the perception of community members on campus about the interaction between e-scooters, bikes, and pedestrians on campus sidewalks and roadways;
2) knowledge of and preference about policies regarding where e-scooter and bicycle riding is permitted on campus;
3) the perception of e-scooter and bike riders about the safety and adequacy of existing infrastructure; and

4) opportunities for new infrastructure and policies that could minimize conflict between sidewalk and roadway users.

Section A (community member survey) examines UMD community members' perspectives of shared roadway and sidewalk spaces and their understanding of current rules for users through survey responses. This survey was open to anyone with a valid UMD email address. Eighty-seven participants responded. The questions were designed to better understand students' experiences with sidewalk and roadway conflicts, their primary transportation modes, factors that prevent them from biking or using an e-scooter on campus, and their perceived understanding of university policies regarding where multimodal modes should travel.

Seventy-five percent of respondents feel "a little uncomfortable" **or** "very uncomfortable" sharing the roadways with bicycles and/or scooters in current conditions (See Figure ES-1). Over 40% of bike or scooter-user respondents also feel unsafe riding on the roadway or the sidewalk. Surprisingly, the survey found the biggest deterrent to biking or scooting to be cost, not safety, as originally expected. Furthermore, we found that scooter riders were perceived as behaving most dangerously on sidewalks. Surprising low awareness of bicycle and scooter policies on campus was also identified, with a sizable portion of respondents being unaware that both are prohibited on sidewalks. Participants identified 13 roadways and 14 sidewalks locations where they encountered or observed the most conflicts between modes.

Figure ES-1: How Comfortable Respondents Feel Sharing Roadways with Bicycles/Scooters as a Percentage of Total Responses (N=52)



Section B (the field study of roadway and sidewalk users' interactions) describes the study's collection of real-time data on roadway and sidewalk users' interactions during class hours. Two high-traffic intersections were chosen for study based on previous reports of frequent conflicts (University of Maryland Bike Plan Implementation 2018). Finding an environment suitable to set up video equipment was also a consideration. Particular attention was paid to class-change time periods that generate the higher traffic volume. Camcorders were mounted on the top of an adjacent parking garage to obtain an unobstructed aerial view of the intersection, and two-hundred-thirty-eight minutes of footage was collected and analyzed. All near miss/close calls, full defiance or rolling at stop signs, failure to yield to other/vulnerable vehicles, long wait times, and instances of modes traveling in the wrong direction of traffic were recorded in an Excel spreadsheet and timestamped. Table ES-1 summarizes the type and quantity of incidents recorded. A two-minute compilation video including various clips of "near misses" from the Stadium Drive and Regents Drive intersection was created and can be found here.

Table ES-1: Type and Quantity of Recorded Incidents at Studied Intersections

Studied Intersections	**Stadium/Regents**	**Fieldhouse/Regents**
No Stop at stop sign	201	90
Rolling stops	185	105
Near miss/close call	10	47
No Yielding to other/vulnerable	26	15
Wrong direction of traffic	14	15
Long wait time	4	12

Skateboards, hoverboards, golf carts, and electric wheelchairs were all recorded using the studied intersections, in addition to bicycles, e-scooters, cars, trucks, pedestrians, buses, and trucks. "Rolling Stops" and "No Stop at Stop Sign" made up an overwhelmingly large share of the instances observed, mostly by cars. Many bicyclists and e-scooters did not come to a full stop at stop signs, especially when no other vehicles were present. Across both intersections, the research team recorded a roughly equal share of incidences (~5-6%) in which a vehicle did not yield to another vehicle or other road user. Long wait times, especially during class change time periods, led to high congestion and unintentional blockage of crosswalk areas.

This data was analyzed to provide DOTS with helpful information that is not currently available. Although DOTS has access to accident reports and mode counter data, e-scooters are not specified, and counters can be unreliable. Providing e-scooter behavior and "near miss" data will contribute to improving roadway and sidewalk protocols.

The findings from Section A (community member survey) and Section B (the field study of roadway and sidewalk users' interactions), combined with the literature review, all help inform the University of concerns regarding intermodal interactions.

This study provides a set of 10 recommendations for the University and DOTS to consider for implementation on the University of Maryland campus:

1. Prioritize road space for vulnerable users
2. Invest in bicycle infrastructure, such as well-connected, dedicated, and protected bike lanes
3. Install shared-use path on McKeldin Mall and other large pedestrian blocks

4. Traffic calming and road markings on Regents Drive
5. Curb cuts should have rumble strips for awareness of curb cut/grade change (for pedestrians & bike dismounting)
6. Move bicycle parking in-road or closer to the curb
7. Limit vehicular access during high-congested periods
8. Strengthen education and policy strategies
9. Implement effective enforcement strategies
10. Future studies

These recommendations are detailed in the report below with the goal of creating safer roadways and sidewalks on campus through sustainable efforts. We commend the University for recognizing these needs and taking steps such as creating guidelines for bikes and e-scooters, committing to a net carbon-neutral campus by 2025, as well as a fully-electric school vehicle fleet by 2035 ("Keeping Our Climate Pledge"). The continued attentiveness to these important issues by the University of Maryland's leadership team will be vital for further success. The below study and recommendations provide avenues for the University to continue upholding its commitment to a safer, more sustainable campus.

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Introduction

The University of Maryland does not currently have any dedicated bicycle lanes on campus yet permits a variety of modes of transportation on its campus, including bicycles, e-scooters, skateboards, mopeds, cars, shuttle buses, commercial trucks, and other forms of micromobility. This paper examines how roadway and sidewalk users interact on campus, and offers recommendations for policies, infrastructure, pilot programs, educational programs, and information distribution to improve travel safety and reduce stress and intermodal conflicts.

Following this brief introduction, each subsequent section describes a literature review, community member survey, and video-observation field study of two intersections on campus conducted to identify conflicts that involve cyclist and e-scooter users and possible recommendations. The literature review explores three topics: sidewalk conflicts; evaluation of factors and policies that can lessen conflict between sidewalk users; and a review of university and municipal policies. Two field studies were conducted for this paper: a community member survey and a video-observation field study. The methodology and results are shared in their respective sections. This paper concludes with a series of recommendations for providing a safe environment for all users on campus. This study and recommendations provide avenues for the University to continue upholding its commitment to a safer, more sustainable campus.

Literature Review

To inform the survey and video observations conducted in this report, the research team reviewed the experience of university campuses and municipalities that have attempted to regulate bicycles and e-scooters on shared travel paths. The literature review focused on three areas of research; first, the frequency and nature of conflict on sidewalks; second, the success of policies and design elements that can improve safety and comfort of pedestrians, cyclists, and e-scooter riders; and third, the current regulatory landscape concerning bicycles and e-scooters.

Sidewalk Conflicts

Although far less dangerous to pedestrians than cars, riders of bikes and electric scooters (e-scooters) pose a potential hazard and inconvenience to pedestrians and each other. Municipalities with high rates of cycling, such as Amsterdam, have begun to contend with high rates of intermodal conflict, exploring policies to reduce tension between sidewalk users without discouraging cycling or scooter riding altogether (Knight 2019).

University campuses, which experience large peaks of pedestrian and bicycle traffic between classes, are particularly susceptible to conflict between sidewalk users. Scott's (2011) study of bicycling behavior on the campus of Kansas State University found that fewer than half of pedestrians on campus "often" or "always" felt safe sharing sidewalks with bicyclists. Universities that have conducted bicycle plans (including the University of Minnesota (2019) and the University of Maryland (2018)) have emphasized the need to reduce conflict between cyclists and pedestrians as a core goal of their policymaking.

The introduction of e-scooters onto streets, sidewalks, and college campuses has intensified conflict among sidewalk users. In a recent review of e-scooter policies and behavior in the U.S. and Europe, Badia and Jenelius (2021) found that dissatisfaction with e-scooters was widespread. Although e-scooters were found to be involved in a few accidents that injure non-riders, their presence was reported to be inconvenient and unnerving. 70% of non-riders in Arlington, VA, say they feel unsafe when scooters are present. 60% of non-riders in Chicago said they had had negative experiences with scooters. 30% of pedestrians in Oslo said they found e-scooters annoying, considerably higher than bicycles or cars. Reports suggest pedestrian dissatisfaction with e-bike and e-scooter riders who speed, ride on sidewalks, run red lights, and go the wrong way on streets (Hu and Marcius 2021).

Evaluation of Factors and Policies that Can Lessen Conflict between Sidewalk Users

Universities and municipalities have experimented with various policies to promote cooperation among road and sidewalk users, with varying degrees of success. Many scholars and policymakers have focused on discouraging scooter and bike riding on sidewalks as the primary mechanism of reducing intermodal conflict on sidewalks. Several scholars found that policies simply banning scooters and bicycles on sidewalks had low rates of compliance. Scott reviewed the effectiveness of "dismount zones" on the campus of Kansas State University and found that cyclists obeyed posted notices to dismount only 17% of the time (Scott 2011, 40). Some non-compliance with sidewalk riding of scooters may be the result of ignorance on the part of riders. James et al.'s study of e-scooters in Arlington County found that over half of survey respondents believed erroneously that scooters were allowed on sidewalks. Contributing to the confusion may be the fact that Washington, DC, just across the river from Arlington, *does* permit sidewalk riding in some areas (James et al. 2019).

By contrast, many studies have demonstrated that constructing new infrastructure for micromobility devices like e-scooters and bikes is effective at reducing sidewalk riding, in part because cyclists and scooter-riders view road-riding as dangerous. In a comprehensive report about e-scooter use in the city, the Portland Bureau of Transportation (PBOT) noted that "anecdotal observations show that riders were up to twice as likely to ride on the sidewalk when no bike infrastructure was present" (Ciarlo et a. 2019, 41). Choi et al. (2022) found that the presence of bike lanes substantially reduced the presence of scooters and bikes on sidewalks, though the effect was most pronounced at locations without nearby rail stops. Near rail, sidewalk riding occurred at a similar frequency with and without bike lanes; sidewalk riding was more common along larger roads.

Goodno et al. (2013) concurred with other researchers that dedicated cycle infrastructure reduces sidewalk riding, but cautioned that such infrastructure could pose its own risks. Goodno et al. found that a majority of pedestrians along 15th St disagreed with the statement, "I feel safer crossing 15th Street now because of the cycle track," which may be due to the low rate of signal compliance by cyclists found in their study. In addition, although cyclists reported feeling safer using the new infrastructure, they found an increase in bicycle crashes, even after adjusting for increased volume, leading to a question about the overall impact of the lanes on cyclist safety. Goodo et al.'s study implies that reducing sidewalk conflict is more complex than just providing infrastructure.

The geolocation technology that enables e-scooter vendors to track dockless vehicles also allows for "geofencing" to regulate where scooters are parked, where they can ride, and at what speed. PBOT used geofencing as part of its project to discourage scooter riding along Portland's Waterfront Park. A review of the project found that the combination of the two-way cycle track on the adjacent Naito Parkway, educational signage, and geofencing was effective at reducing e-scooter traffic in the pedestrian zone. In the year after the project was completed, scooter rides in Waterfront Park dropped 45% (Ciarlo et al. 2019, 24). A report on safe micromobility produced by the International Transport Forum also endorses geofenced speed limits for e-scooters in pedestrian areas. Santa Monica, California, Lyon, France, and Paris, France have all implemented an 8 kph limit for e-scooters in pedestrian zones, but these policies are only applicable to motorized rental devices; unassisted or privately owned devices cannot be speed-limited via geofencing (Santacreu 2020).

Design factors can also help mitigate sidewalk conflict. A report by Queensland Transport (Queensland Transport 2006) emphasizes the need for careful study and observation of the area of interest to determine both existing use and latent demand and argues for careful, context-sensitive design strategies. The report recommends adequate lighting, centerline striping, signage, space for entering and exiting travel lanes and, in environments where traffic exceeds 300 users per hour, physical separation between lanes. Physical features such as elevation changes and corners can impede visibility and contribute to accidents and should be avoided when possible. The report also emphasizes avoiding embankments along travel paths to allow for emergency exits. Regular maintenance of signage and striping is necessary to ensure continued effectiveness.

In contrast to the construction of separate infrastructure and the use of regulations, some planners have emphasized the role of informal norms in creating coordination among users. Amsterdam has experimented with removing traffic lights at intersections with heavy bicycle traffic under the theory that "cyclists and pedestrians will tend to 'negotiate' at crossings using eye contact and gestures" (Knight 2019).

Review of University and Municipal Policies

Policies on bicycles and scooters on seven US university campuses were reviewed (see Appendix B). All but two (Harvard University and the University of Virginia) ban scooters from campus sidewalks. University policies on bikes on sidewalks were less readily available for review. In addition to Kansas State University, UCLA designates several areas of campus as "Dismount Zones," where bicycles, scooters, and other personal wheeled devices must be dismounted and walked. According to our partial review, campus policies give more latitude to cyclists than to scooters. For example, scooters are banned on most of the campus of Washington University, including on a shared-use sidewalk where bicycles are explicitly permitted. Three campuses (Harvard, UCLA, and UT Austin) require vendors to enable geofence parking requirements for e-scooters.

A review of national legislation on e-scooters shows that among US states, the most common approach to e-scooter regulation is to allow scooters on roadways and bike paths and prohibit them on sidewalks ("Electric Scooter Laws by State." n.d.). However, considerable regulatory variance exists: two states explicitly permit e-scooters on sidewalks; Rhode Island and Virginia. Washington and Indiana prohibit e-scooters in bike lanes. In Delaware, e-scooters are banned on sidewalks, roads, and bike paths, making their use largely illegal.

Based on the findings of the literature review, the survey and video observations conducted as a part of this study sought to investigate:

1. how people on campus perceive the interaction between e-scooters, bikes, and pedestrians on campus sidewalks and roadways;
2. knowledge of and preference about policies regarding where e-scooter and bicycle riding is permitted on campus;
3. the perception of e-scooter and bike riders about the safety and adequacy of existing infrastructure;
4. opportunities for new infrastructure and policies that could minimize conflict between sidewalk and roadway users;
5. compliance with road and sidewalk rules and regulations; and
6. behaviors of sidewalk and roadway users that contribute to safety and comfort.

A: Survey Design, Implementation & Analysis

Methodologies

American college campuses are often an anomaly of multimodal travel in an otherwise auto-dominated country. Their networks of sidewalks, paths, roads, and crosswalks are notoriously frantic environments at times of peak travel, as students dart across campus between classes. The University of Maryland's campus is a prime example, where cyclists, pedestrians, e-scooter riders, and other modes intermingle on sidewalks and roadways. To gauge individuals' opinions of intermodal conflicts across campus, a survey was administered to 87 members of the University of Maryland Community. Participants were questioned on their connection to the university, frequency of coming to campus, transportation habits, micromobility preferences, travel paths on campus, and frequent conflict points. The survey included multiple choice, ordinal rating, and open-ended questions. Links to the survey were posted on the UMD Reddit page (r/UMD) and distributed to students across campus. To encourage participation, respondents were entered into a raffle to win one of two $25 Visa gift cards when they were willing to provide contact information. Limitations of our survey include our small sample size and lack of respondents who were visitors. This could be improved by increased survey distribution, possibly during campus events or visits where we could collect more nonstudent and faculty responses.

Findings

Demographics and Travel Behaviors of Survey Respondents

The first section of the survey collected demographic data of respondents. First, we asked the respondent about their connection to the University, providing options: "student living on campus," "student living off campus," "employee," or "visitor." Each respondent was then asked how often they travel to campus each week. Figure 1 shows the composition of respondents' connections to the University. The majority of respondents (55%) were students living off campus, followed by 42% of students living on campus.

Only three respondents (3%) were employees. Figure 2 shows the breakdown of respondents' frequency of traveling to campus. Most respondents who did not live on campus traveled there four or more times a week. Eight percent of respondents traveled to campus two to three times a week. Very few respondents traveled to campus fewer than two times a week (3%).

Figure 1: Respondents' Connection to Campus (N=87)

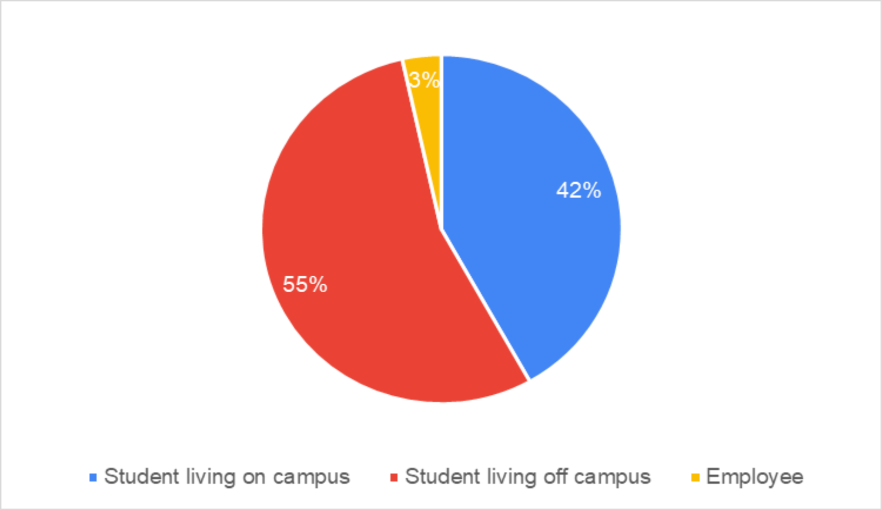
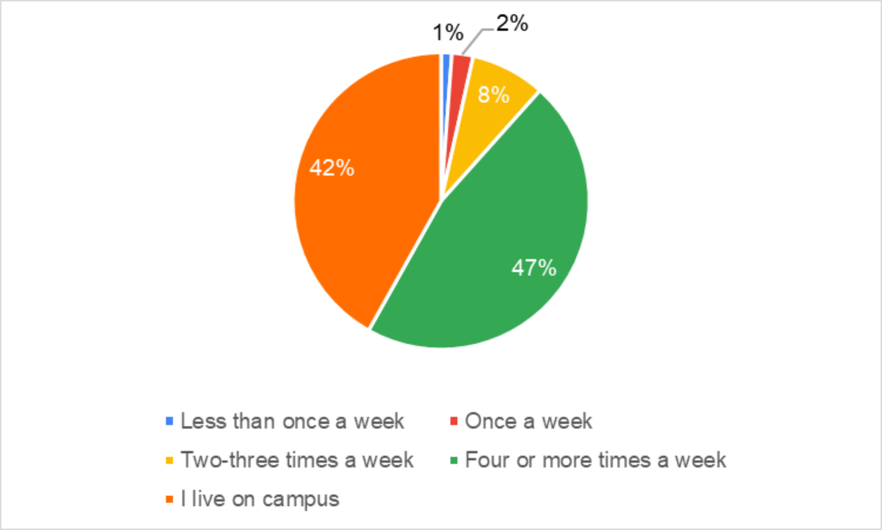
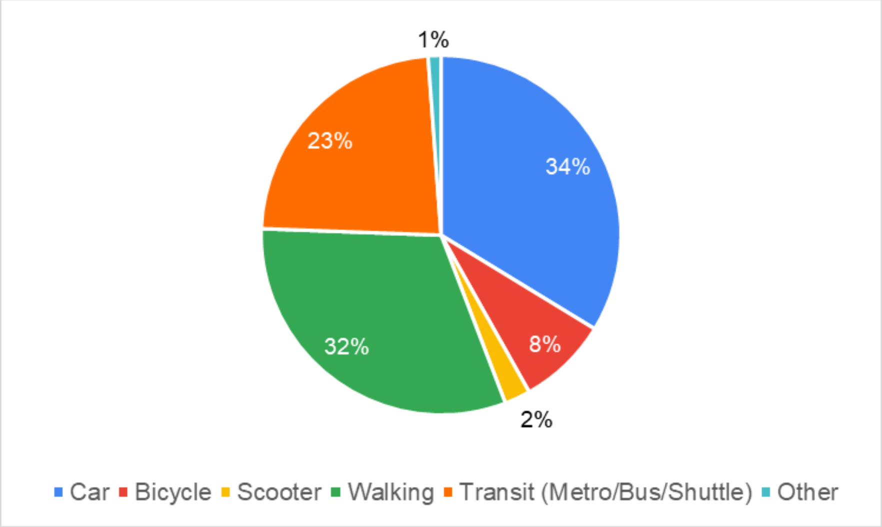


Figure 2: Respondents' Frequency of Traveling to Campus (N=87)



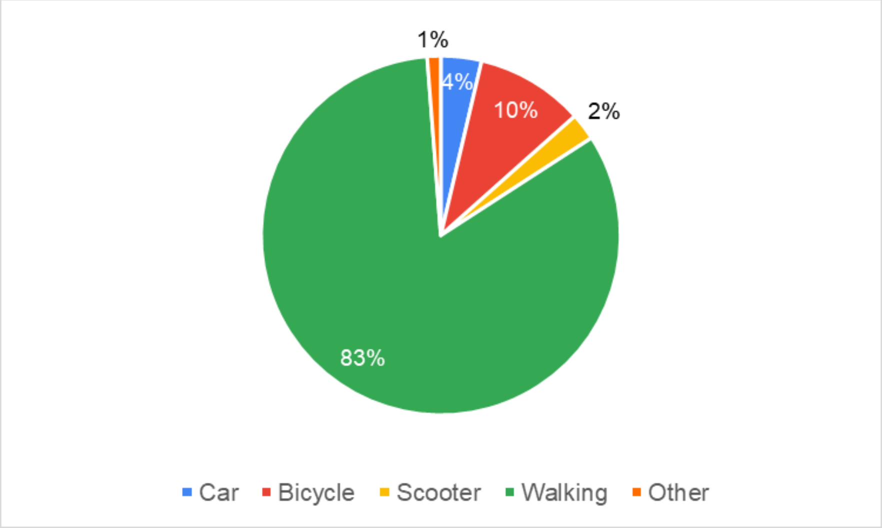
Next, we asked respondents what their primary mode of transportation was traveling both to and around the campus. Figure 3 shows those who travel <u>to and around campus</u> by automobile present the largest percentage among all modes, with 34 percent of all respondents. Walkers followed close behind, representing 32 percent of respondents. Transit also represented a sizable portion of responses, with 23 percent reporting that they utilize this mode. Eight percent of respondents indicated that they travel to and around campus primarily by bicycle, and even fewer (2%) reported using scooters to travel to campus. One respondent reported using a mode other than those provided when traveling to campus.

Figure 3: Respondents' Primary Mode of Transportation to and around Campus (N=86)



As illustrated in Figure 4, a mode used on campus was predictably skewed toward walking, making up 83 percent of respondents. Cyclists made up ten percent of respondents, and individuals using scooters again made up only two percent. Interestingly, three respondents reported using a car when on campus. This would seem inconvenient due to its sparse road network and restricted parking. Again, one respondent reported using a mode than those provided.

Figure 4: Respondents' Primary Mode of Transportation on Campus (N=82)

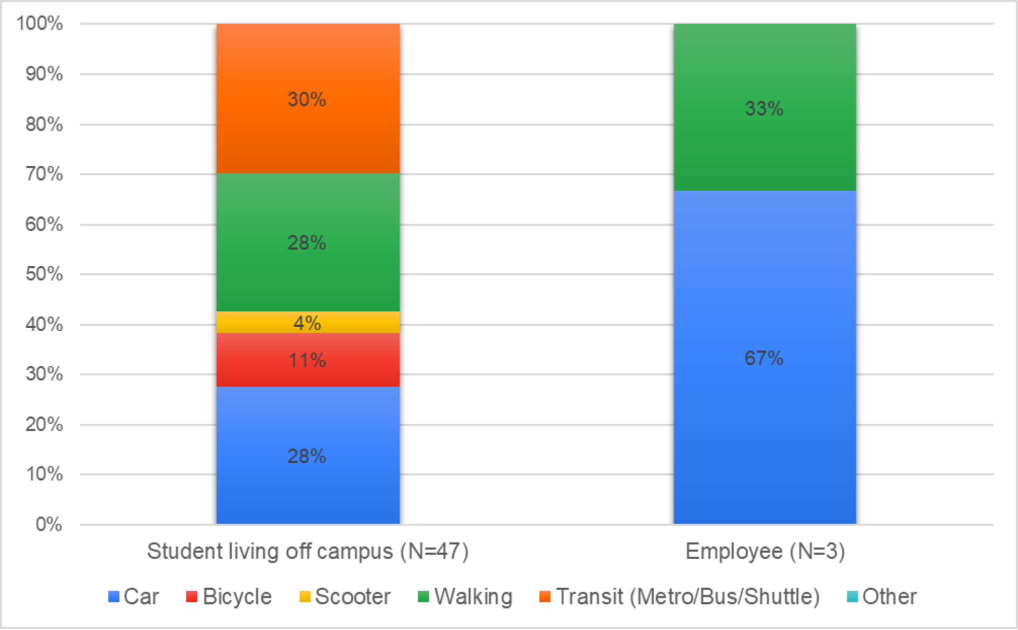


Although bicycles and e-scooters were a small portion of primary mode choices, more people selected these as additional modes. Figure 5 shows the total number of respondents who reported using a bicycle or scooter as either a primary or additional mode. The graph indicates that slightly more people utilize these modes when traveling on campus than traveling to campus from elsewhere.

Figure 5: Use of Bicycles/Scooters as Either Primary or Additional Mode of Travel

After collecting this data, we wanted to examine the relationship between respondents' primary mode choices and the demographic factors they reported. To do so, we constructed several graphs comparing the mode choice of respondents by their connection to the university and how often they came to campus. Figure 6 shows the percentage of primary transportation mode taken to campus by respondents' affiliation with the University. The largest percentage of these respondents used transit services to get to campus. This meets our expectations, given that several campus shuttles connect students to off campus housing sites at no cost. An equal percentage of students living off campus traveled to campus either by car or walking (28%). The smallest percentages of students either ride a bicycle or scooter to campus, comprising 11 and four percent of respondents, respectively. Most employees traveled to campus by car (67%), with the remaining respondents reporting that they walked to campus.

Figure 6: Primary Transportation Mode Taken to Campus by Affiliation with the University



As previously noted, walking dominates most people's transportation choices on campus. Figure 7 shows this was consistent across all three categories of respondents' affiliation with the university. Walking made up the largest percentage of modal choices among students living on campus (86%). The remaining 14 percent of these respondents traveled on campus via bicycle. Most students living on campus also walked primarily, with their remaining responses divided among biking, scootering, and driving. Cycling made up a slightly larger percentage than the other two categories at seven percent, compared to five percent for both scootering and driving. It was again intriguing to find that some students primarily drove around campus, although it is more understandable that most of them lived off campus, where more students own vehicles. The percentages of employees walking and driving on campus were reversed, with walking making up the majority of their primary travel modes.

Figure 7: Primary Transportation Mode Taken on Campus by Affiliation with The University

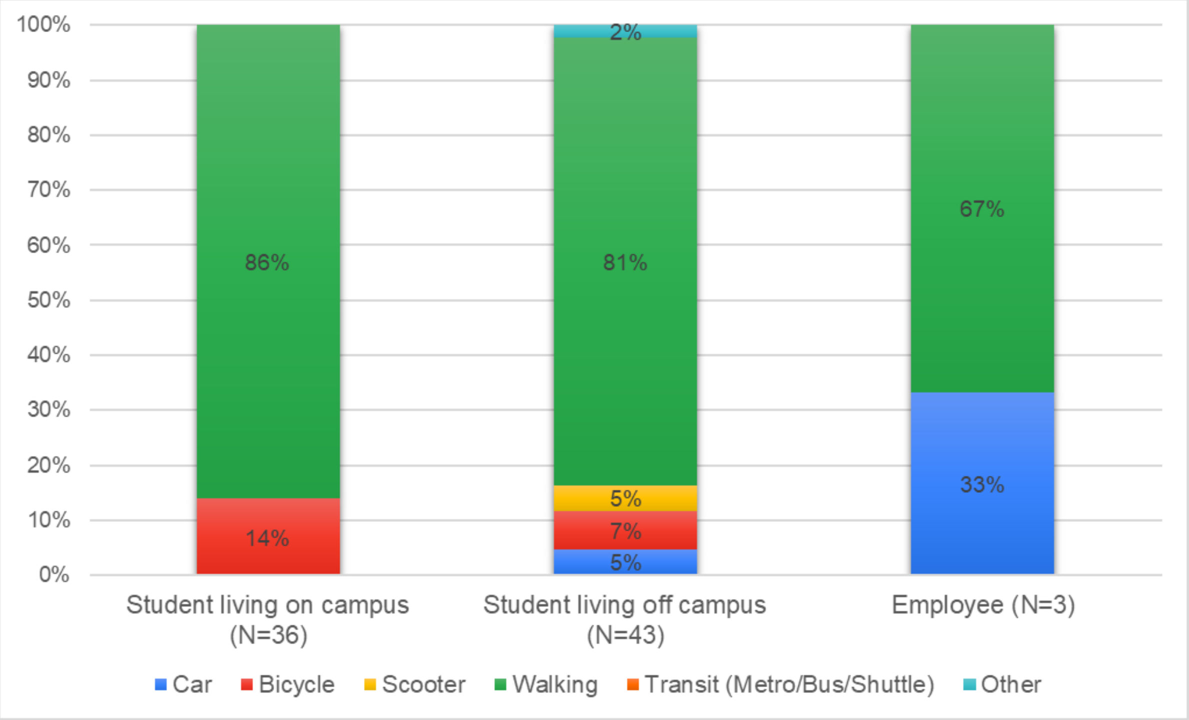


Figure 8 illustrates the modal choice of respondents when traveling to campus, categorized by the number of their weekly trips to campus. Respondents traveling to campus once a week were split evenly between cyclists and walkers. Those who traveled to campus two to three times a week did so primarily by car (57%). Twenty-nine percent of these respondents walked while the remaining 14 percent used transit. The share of drivers fell dramatically amongst those who travel to campus four or more times a week to 28 percent. Transit riders now made up the largest share of respondents in this category, with the share of walkers falling only slightly to 25 percent. Additionally, ten percent of these respondents primarily cycled to campus while the remaining five percent primarily rode an e-scooter.

Figure 8: Primary Transportation Mode Taken to Campus by Frequency Coming to Campus

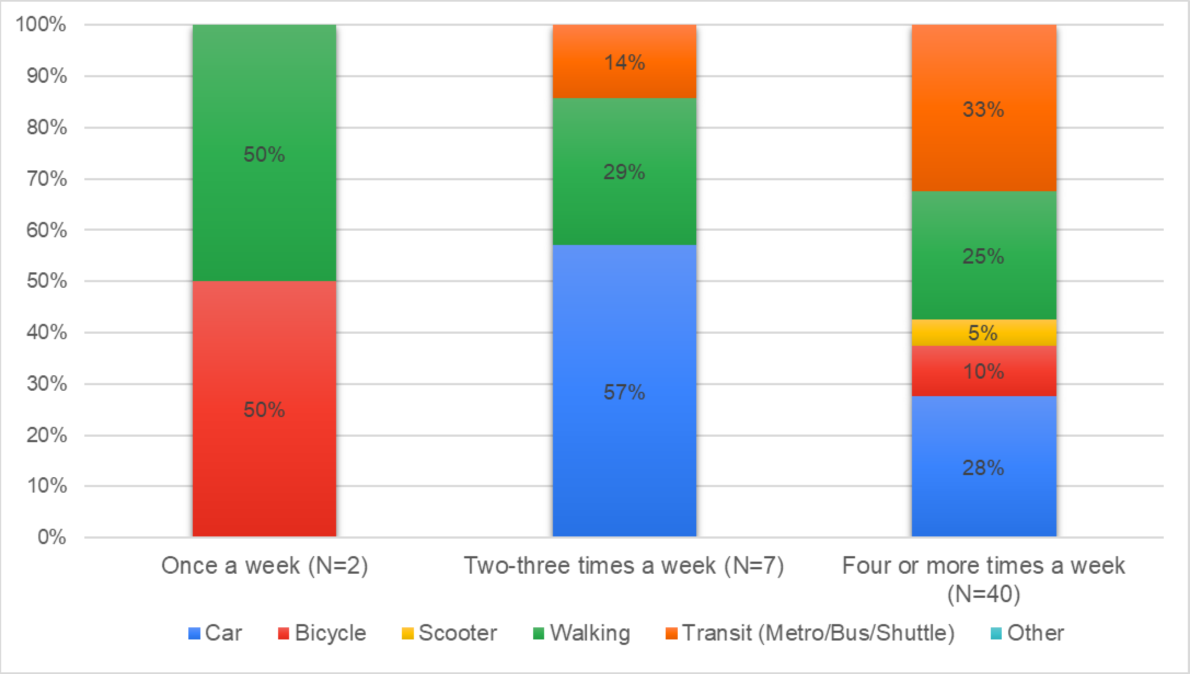
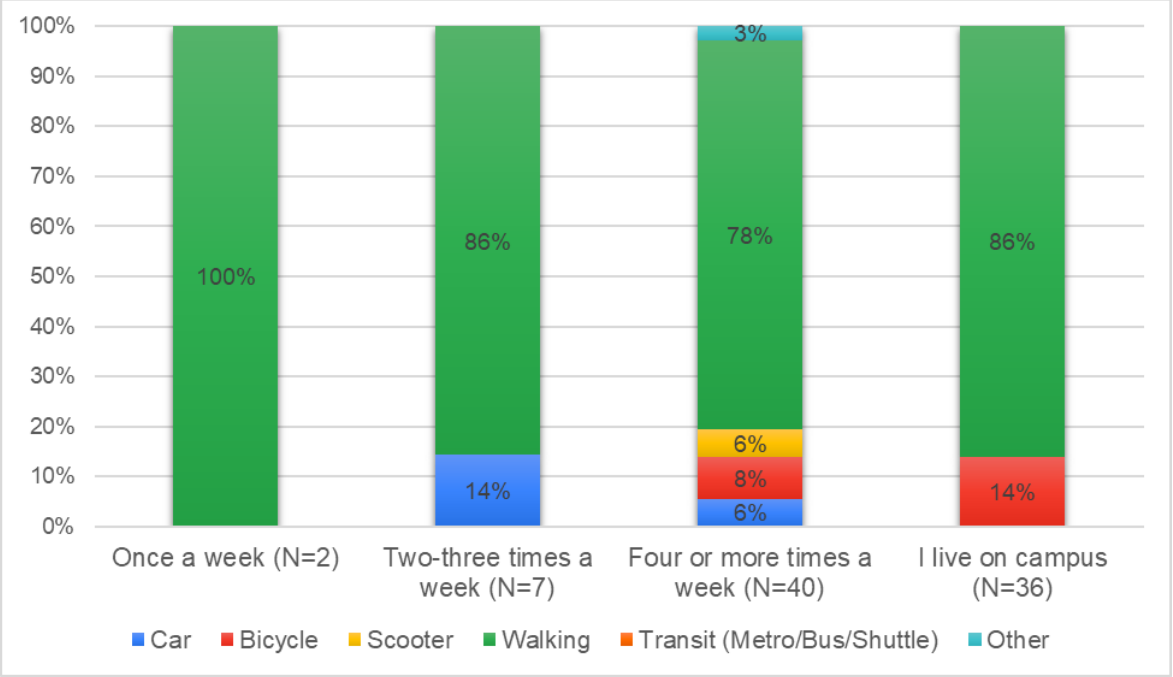


Figure 9 shows the modal choice of respondents when on campus, again categorized by the number of their weekly trips to campus. All respondents who travel to campus once a week reported walking primarily. The overwhelming majority of respondents who travel to campus two to three times a week also reported walking, while 14 percent drove on campus. This was the highest percentage of drivers among any of the four categories, indicating that those who come to campus less frequently will be more likely to drive around it. The share of walkers on campus again fell significantly among those who travel to campus four or more times a week to 78 percent. Six and eight percent of respondents either used a scooter or bicycle when on campus, respectively. The share of drivers in this category also fell to six percent, while two percent of respondents reported using other modes. The share of walkers returned to 86 percent among respondents who live on campus. The remaining 14 percent in this category cycle to school. Drivers among students who live on campus would presumably be rare due to the lower number of them who have access to a vehicle. Surprisingly, no students living on campus reported using a scooter or bicycle as their primary mode of transportation on campus.

Figure 9: Primary Transportation Mode Taken on Campus by Frequency Coming to Campus



Opinion of Intermodal Conflict

The primary purpose of our study is to gauge the satisfaction with the shared use of roadway and sidewalk facilities amongst the University of Maryland community. We, therefore, included several questions in which respondents would rate how well different modes share these facilities on campus. Each respondent was given a Likert Scale from one to five to rate, with one indicating users share the facility "very poorly" and five indicating it is shared "very well." To analyze these results, we recategorized the responses to the rating scale as either "well" or "poorly." Ratings of 4 or 5 were categorized as "well," and those of 1 or 2 were categorized as "poorly." We then created a differential index to measure the overall rating of facilities by taking the difference in the percentage of respondents rating the facility as being shared "well" or "poorly."

Table 1 shows the differential ratings for both roadways and sidewalks on campus, respectively. Roadways overall have a stronger negative perception than sidewalks, with 27% more respondents rating their shared use poorly than positively. This pattern is consistent when isolating responses by the primary mode used when traveling to campus. Roadways had the strongest negative perception among those who primarily used transit when traveling to campus. Respondents who walked primarily on campus rated roadways and sidewalks equally, at negative 26 percent each. This was also the lowest negative score among users of the sidewalk. Those who travel to campus by car had the lowest negative perception of both roadways and sidewalks, possibly due to the dominance of roadways and less frequent usage of sidewalks. Additionally, those who identified bicycle or scooter as either a primary or secondary mode of travel on campus rated roadway lower than sidewalks. Those who did not bike or scoot on campus perceived sidewalks even more poorly, with a negative rating of 28 percent. Perception of both facilities also differed by respondents' connection to campus. In general, students living off campus had a more negative perception of roadways and sidewalks than those residing on campus. This could indicate that students living on campus are more adjusted to roadway and sidewalk conditions. Again, roadway conditions were viewed more negatively than sidewalk conditions.

Table 1: How Well Users of Sidewalks and Roadways Share each Facility on Campus

	Roadways	Sidewalks
Total	-27%	-16%
Primary Mode of Travel To Campus		
Car	-17%	-3%
Walk	-26%	-26%
Bike	-29%	-14%
Transit	-45%	-20%
Scooter*	0%	100%
Ever bike or scoot	-25%	-17%
Do Not Bike or Scoot	-28%	-16%
Affiliation with University		
Students Living Off Campus	-40%	-26%
Students Living On Campus	-14%	-6%

Note: A negative percentage indicates more respondents are dissatisfied with the shared use of each facility than those who are satisfied.

Both questions in this section were followed by open-ended questions, where respondents were asked if there was anything else they would like to say about modal sharing on campus. Their responses were coded into the following seven categories: "conflicts between all modes," "conflicts between Bicycles/Scooters and pedestrians," "conflicts between scooters/bikes," "conflicts between cars and scooters/bikes," "conflicts between cars and pedestrians," "no issue," and "other."

The first opened-ended question addressed conflicts on campus roadways. The "Count" column in Table 2 identifies the number of responses that mentioned each type of conflict. Conflicts between all modes were most cited by respondents, followed by other issues which were not modal conflicts. Many of these other responses either cited construction disruptions or petitioned for the construction of bike lanes on campus. A total of 15 responses mention bike lanes as a potential solution to modal conflicts on roads, as shown in the column "Bike Lanes." Conflicts between cars and pedestrians were the third most cited, with conflicts between cars and scooters/bikes close behind.

Of the responses citing conflicts between all modes, most identified all road users behaving dangerously. The second most common responses were split between those who identified drivers behaving dangerously and those who identified both cycle/scooter riders and pedestrians behaving dangerously. The overwhelming majority (86%) of respondents who identified conflicts between bikes/scooters and pedestrians faulted cyclists for behaving dangerously toward pedestrians. Finally, most respondents identifying conflicts between cars and bikes/scooters cited drivers behaving dangerously toward cyclists. Generally, faster moving vehicles were blamed for conflicts specifically between two modes.

Table 2: Coding of Open-Ended Responses Concerning Mode Sharing on Roads

Conflict Type	**Code**	**Count**	**Percentage**
Conflicts between all modes	1	21	27%
Conflicts between Bicycles/Scooters and pedestrians	2	7	9%
Conflicts between scooters/bikes	3	0	0%
Conflicts between cars and scooters/bikes	4	11	14%
Conflicts between cars and pedestrians	5	12	16%
No issue	6	8	10%
Other	7	18	23%

Table 3 shows the coded results of the open-ended questions concerning mode sharing on campus sidewalks. Most respondents identified conflicts between bikes/scooters and pedestrians. Of these responses, most identified cyclists and scooter riders behaving dangerously toward pedestrians (57%). Significantly more respondents identified scooter riders behaving dangerously alone than cyclists behaving dangerously alone. Many specifically noted that cyclists were often more courteous and respectful when using sidewalks, while scooter riders would often ride recklessly without communicating with pedestrians. A larger percentage of respondents to this question did not identify an issue with mode sharing on sidewalks. This is consistent with their slightly less negative reception identified in Table 1. Bicycle lanes were again mentioned as a solution to divert bikes and scooters off of sidewalks and on to roadways. Additionally, two respondents complained of a lack of scooter storage which led to them being left haphazardly along sidewalks.

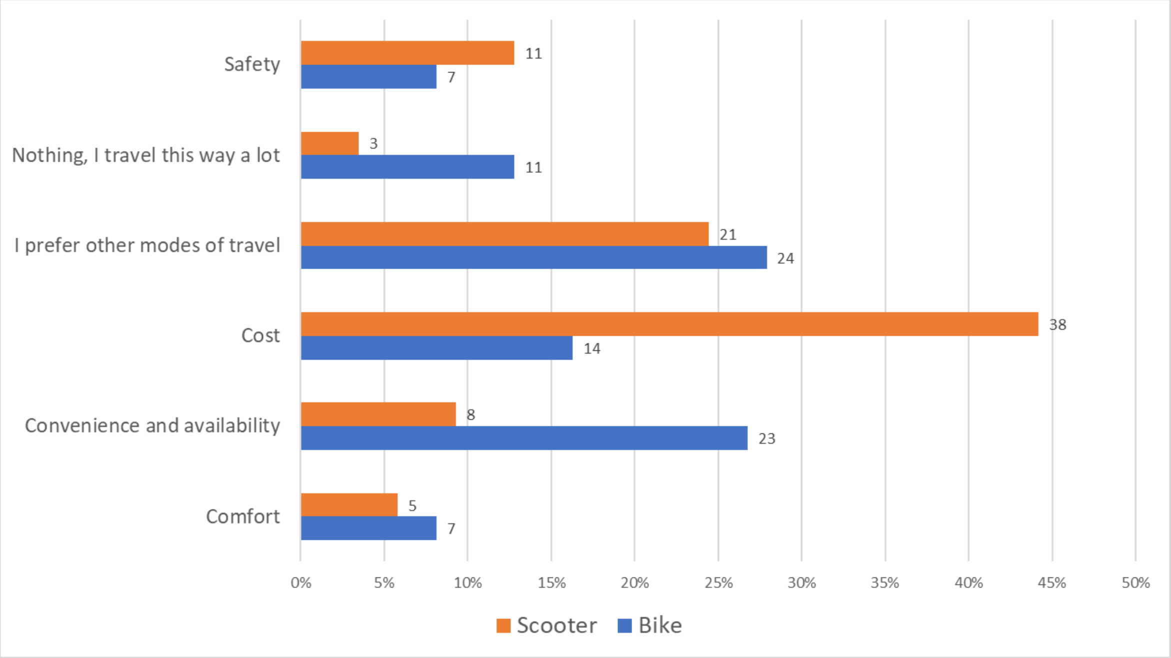
Table 3: Coding of Open-ended Responses Concerning Mode Sharing on Sidewalks

	Code	Count	Percentage
Conflicts between bikes/scooters and pedestrians	2	41	57%
Conflicts between scooters/bikes	3	0	0%
No issue	6	15	21%
Other	7	16	22%

Perception of Safety

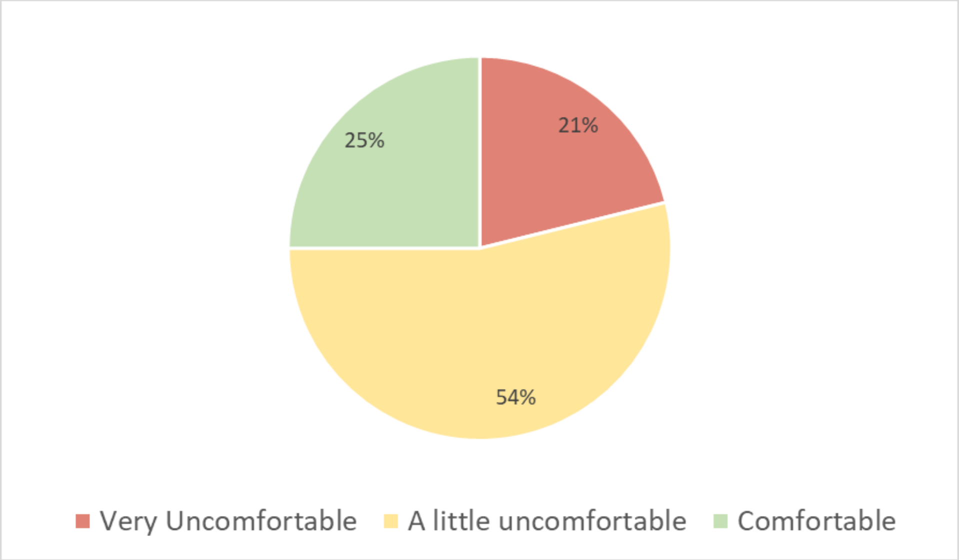
To assess perceived safety issues surrounding bikes and scooters, our respondents were questioned about their comfort level using and sharing facilities with either mode on campus. Figure 10 shows the factors preventing respondents from using either bikes or scooters on campus. The results show that safety is less important to respondents relative to other factors when considering using these modes of travel. Furthermore, safety is a much greater concern to potential scooter riders than cyclists.

Figure 10: Factors Preventing Respondents from Using Bikes and Scooters



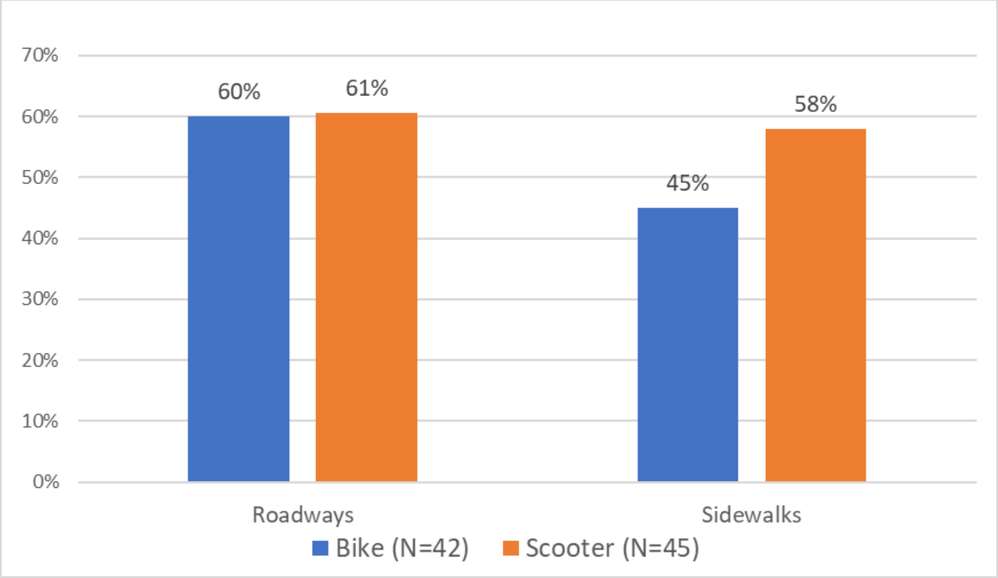
Next, we asked drivers to evaluate how comfortable they are sharing roadways with bicycles and scooters. Respondents rated their level of comfort from one to three or reported that they did not drive on campus. Figure 11 shows a count of ratings as a percentage of respondents who identified as drivers. Most drivers felt slightly uncomfortable sharing roadways with cyclists (54%). Only 25 percent of drivers reported being comfortable sharing roadways.

Figure 11: How Comfortable Respondents Feel Sharing Roadways with Bicycles and Scooters as a Percentage of Total Responses (N=52)



Finally, we wanted to know how comfortable cyclists and scooter riders felt using either sidewalks or roadways. Users of both modes were asked to rate how comfortable they were using each mode on a scale of one ("very unsafe") to four ("safe"). Figure 12 shows the percentage of each mode user who rated sidewalks as either "very unsafe" or "somewhat unsafe." Generally, users of both modes found it safer to ride on sidewalks. Overall, cyclists felt safer on both facilities than scooter users.

Figure 12: Percentage of Respondents Feeling Unsafe (by Mode and Facility)



Rule Awareness & Adherence

Our next section examined the awareness of rules concerning bicycles and e-scooters on campus. At the time of this study, neither are permitted on sidewalks or crosswalks. To gauge awareness of each rule among members of the University of Maryland community, we asked respondents where each mode is permitted to ride, where they should be allowed to ride, and where they currently use these modes on campus.

The graph in the left half of Figure 13 shows that 38 percent of respondents believe they are allowed to ride bicycles and scooters on sidewalks. Our results indicate a substantial lack of awareness of campus bicycle and scooter policies. Forty-seven percent of these respondents lived on campus, and 32 resided off campus. The right half of Figure 13 shows that a slightly lower percentage of total respondents (34%) believe bikes and scooters should be allowed on campus. Again, most of these respondents resided on campus.

After analyzing respondents' understanding of rules, we looked at where respondents actually ride bicycles and scooters on campus. Figure 14 shows the percentage of respondents who ride their bike or scooter on either sidewalks primarily, roadways primarily, or both equally. It indicates that most riders of both modes use roadways primarily. This discrepancy is much larger for cyclists, 69 percent of whom use roadways. A nearly even percentage of scooter users use roadways or both facilities equally (41% and 38%, respectively), and 11 percent more scooter riders use sidewalks whenever possible than cyclists

(21%). This could contribute to the greater number of respondent complaints concerning scooter riders behaving dangerously on sidewalks than cyclists doing so.

Figure 13: Where Respondents Think Bicycles and Scooters Are Allowed to Ride and Should Be Allowed to Ride as a Percentage of Total Responses

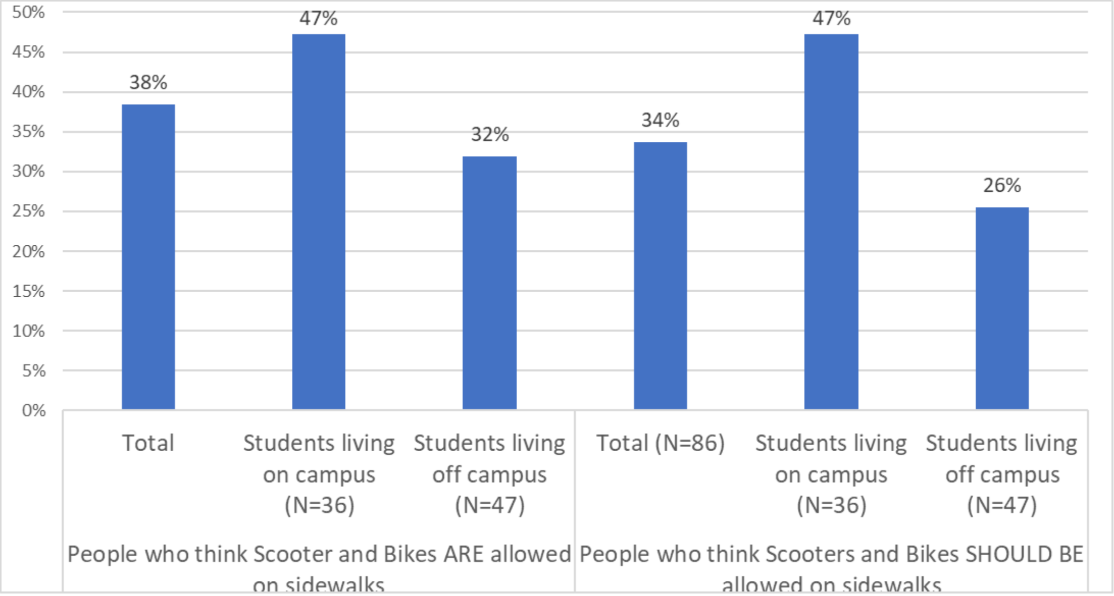
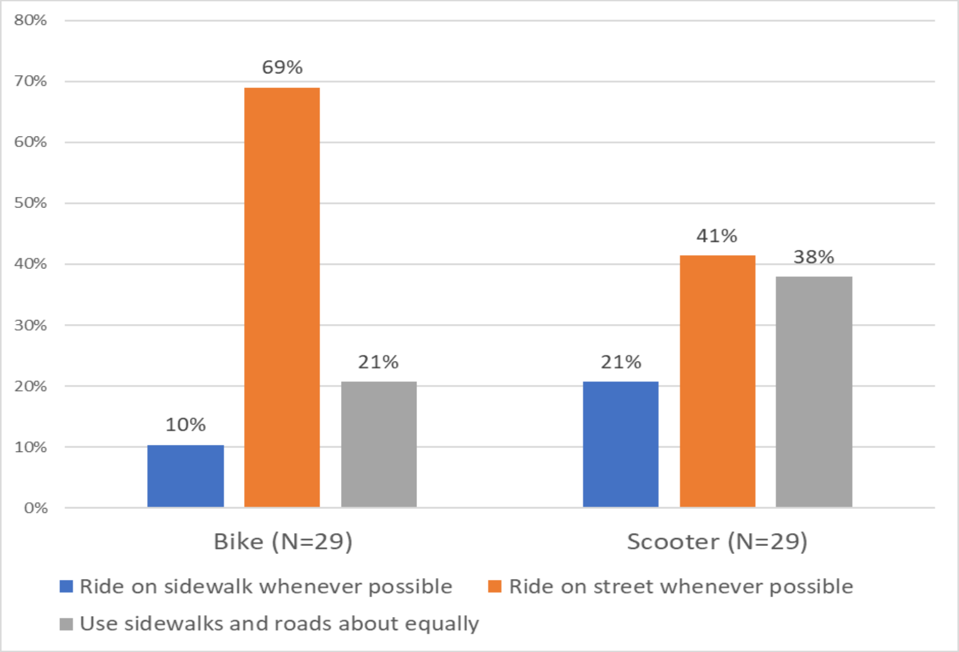


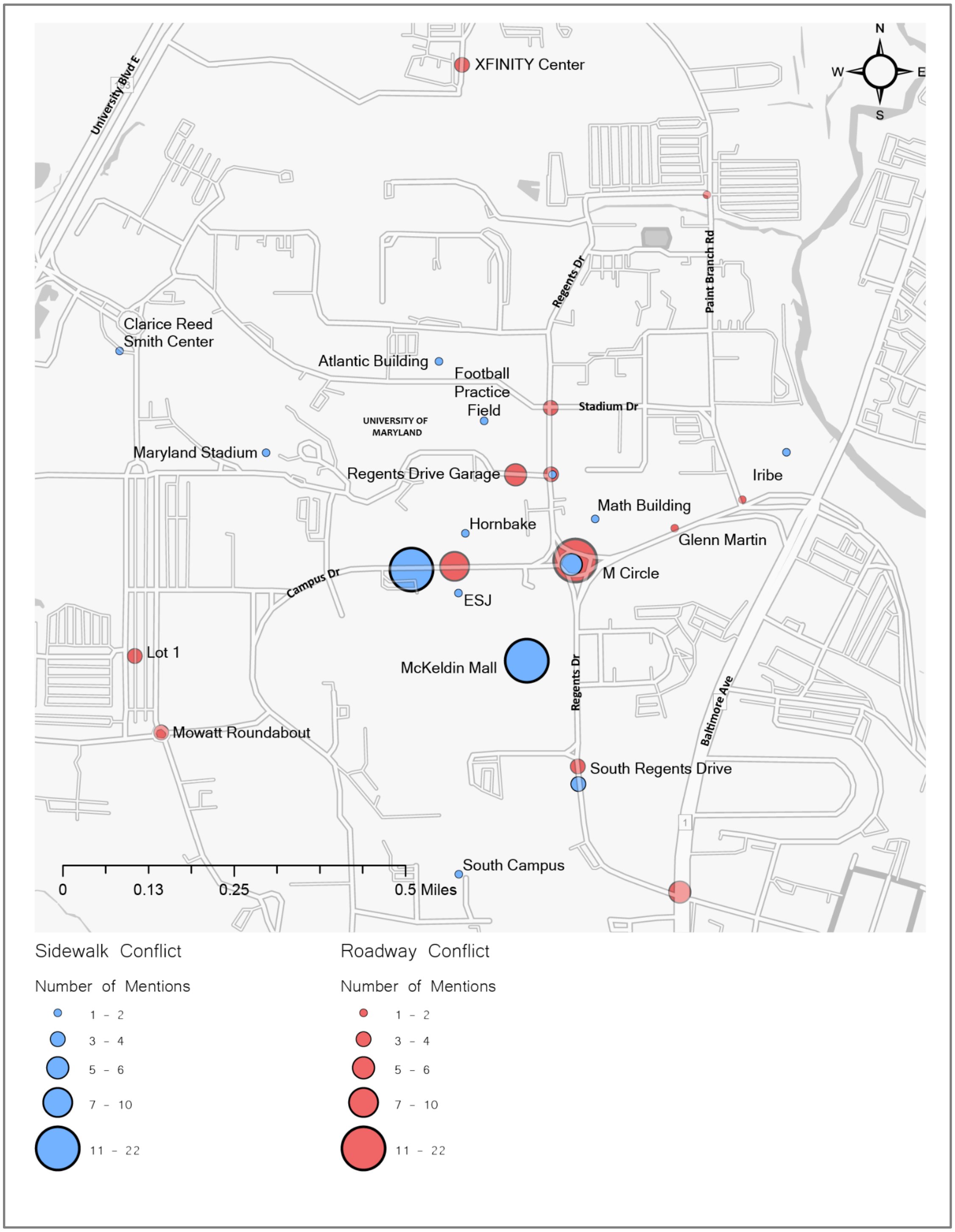
Figure 14: Where Respondents Ride Bikes and Scooters on Campus



Location of Conflicts

Finally, we asked participants where they encountered or observed the most conflicts between modes on campus sidewalks and roadways. Respondents identified 13 high-conflict locations for roadways and 14 for sidewalks. Figure 15 shows the locations where respondents identified the most conflicts on campus. The blue circles represent high conflict locations on sidewalks, while red circles represent these locations on roadways. The size of each marker increases with the number of responses noting its location as a high-conflict point.

Figure 15: High Modal Conflicts Locations on the University of Maryland Campus



The most commonly noted roadway conflict points were located along Campus Drive which connects to the main entry point from U.S. Route 1 (Baltimore Avenue) on the eastern side of campus. Additionally, it contains the future MTA Purple Line right-of-way, which is undergoing construction at the time of this study. The most frequently cited conflict point was the "M Circle," a traffic circle at the intersection of Campus Drive and Regents Drive. This intersection experiences some of the highest vehicular traffic on campus, and is currently undergoing reconfiguration as part of Purple Line construction. The second most commonly cited point of conflict was Campus Drive between the circle and the Adele H. Stamp Student Union. This stretch of roadway contains the busiest bus stops on campus, and is often clogged with a combination of vehicular traffic, cyclists, scooter riders, and pedestrians walking between classes and to the Student Union.

Two locations dominated reported conflict points on sidewalks. The first were sidewalks in the area of the Adele H. Stamp Student union, which was previously cited on roadways. The other were sidewalks in the area of McKeldin Hall, which is the university's main library. Sidewalks in this area are also notoriously congested between class times. This area is also noted as a common place where cyclists and e-scooter riders use sidewalks, as they offer the shortest route between most academic halls.

B: Video Observation and Location-Based Analysis

Methodologies

Video evidence of instances of risky travel behaviors was documented by stationing a camcorder device on the top level of Regents Garage (8056 Regents Drive Bldg. 202), College Park, MD 20742 to ensure an unobstructed, clear visual of the studied intersections.

Figure 16: Stadium Drive/Regents Drive Intersection View

Figure 17: Fieldhouse Drive/Regents Drive Intersection View

Two camcorders were used to collect the data. These intersections were chosen for this study due to knowledge of the high volume of multimodal usage and high traffic, especially during class-change times (University of Maryland Bike Plan Implementation 2018). This study was conducted on Wednesday April 27, 2022 between the hours of 7:08 AM-2:00 PM. Figure 18 breaks down the specific times the camcorders were recording during the study period. The conditions were conducive to an outdoor study, dry and sunny weather averaging about 70 degrees Fahrenheit with light winds. On the University of Maryland campus, class-changes for undergraduate students for Wednesday classes occur ten minutes before the hour between 8:00 AM through 2:00 PM. This allowed data collection of four class-change periods to be analyzed during the study.

Table 4: April 27, 2022 Video Recording Start and End Times

Video	Start Time	End Time	Total Duration	Class-changes observed
Video 1 - Fieldhouse/ Regents	10:25 AM	12:15 PM	100 minutes	2
Video 2 - Fieldhouse/ Regents	07:42 AM	07:52 AM	10 minutes	0
Video 3 - Stadium/ Regents	07:50 AM	08:08 AM	18 minutes	0
Video 4 - Stadium/ Regents	08:10 AM	08:46 AM	36 minutes	0
Video 5 - Stadium/ Regents	12:42 PM	02:00 PM	74 minutes	2

Video camcorders were placed on secure tripods, and the 2x speed setting was enabled to double the recording speed. The camcorders filmed until either the battery died or the memory card was filled. This was inconsistent and a reason for the various recorded times during the study period. For future studies, additional time should be allocated for testing the equipment.

After obtaining the video footage, each memory card was uploaded to Google Drive. Five videos totaling 238 minutes of traffic conditions were recorded. A shared Google Sheet was created to analyze the footage. Three members of the research team analyzed different videos, all following the same methodology. This included recording the video number, video clip number, incident timestamp, involved modes, observed incident, and notes regarding the near-miss incident. We then either took a screenshot or a short video clip of the incident and uploaded it to a shared folder using the template Clip(Clip #)_V(Video #).

The involved mode options included:

- Bicycle
- E-Scooter
- Cars
- Trucks
- Pedestrians
- Bus
- Truck
- Other micromobility (skateboard, hoverboard)
- Other larger vehicles (golf cart, lawn mower)

The observation incident options included:

- Near miss/close call
- No Stop at Stop Sign
- No Yielding to other/vulnerable vehicle
- Rolling stops
- Long wait time
- Wrong direction of traffic

If a transportation mode involved in a near-miss incident was not an option from the pre-identified list, we chose from one of the "other" options and noted the specific mode in the notes section. We were given the option of recording up to two observed incidents involving the same modes to provide further detail of multiple violations.

Early in the data analysis process, it was noted that cars involved in rolling stops were extremely high. One of the members, therefore, kept tallies of these incidents while others continued tracking them on the shared sheet with associated screenshots. These departures of data recording methods do not affect the findings or results.

Site Description and Features

The site of the video observation study focused on two intersections along the Regents Drive spine, which serves as a key corridor connecting residence halls, academic buildings, parking, bus stops, and other key campus destinations. Regents Drive Garage is a central transit hub and a converging point for traffic at the University of Maryland. The parking structure hosts DOTS offices and facilities and can hold up to 1,493 cars. Fourteen of the 19 shuttle routes stop at the Regents Drive Parking Garage shuttle stop ("Parking | UMD DOTS." n.d.).

The two intersections are one block apart on Fieldhouse Drive and Stadium Drive. Below we outline some stand-out elements about the existing built environment that is intended to guide travel through these sites. The observations from the study are discussed in the Findings and Recommendations section of this report and reflect location-based analysis.

Fieldhouse Drive/Regents Drive Intersection:

A. Three-way stop intersections and crossings
B. Bi-directional through lanes on all sides
C. Southbound turning lane on Regents Drive onto Fieldhouse Drive.
D. Sidewalk and curb on all corners of the intersection
E. Bollard & Chain on the east side of the sidewalk separating the sidewalk from the roadway except at crossings
F. Orange hazard barriers around the steam tunnel in front of the pedestrian crosswalk on Fieldhouse Drive
G. Downhill grade change, eastbound

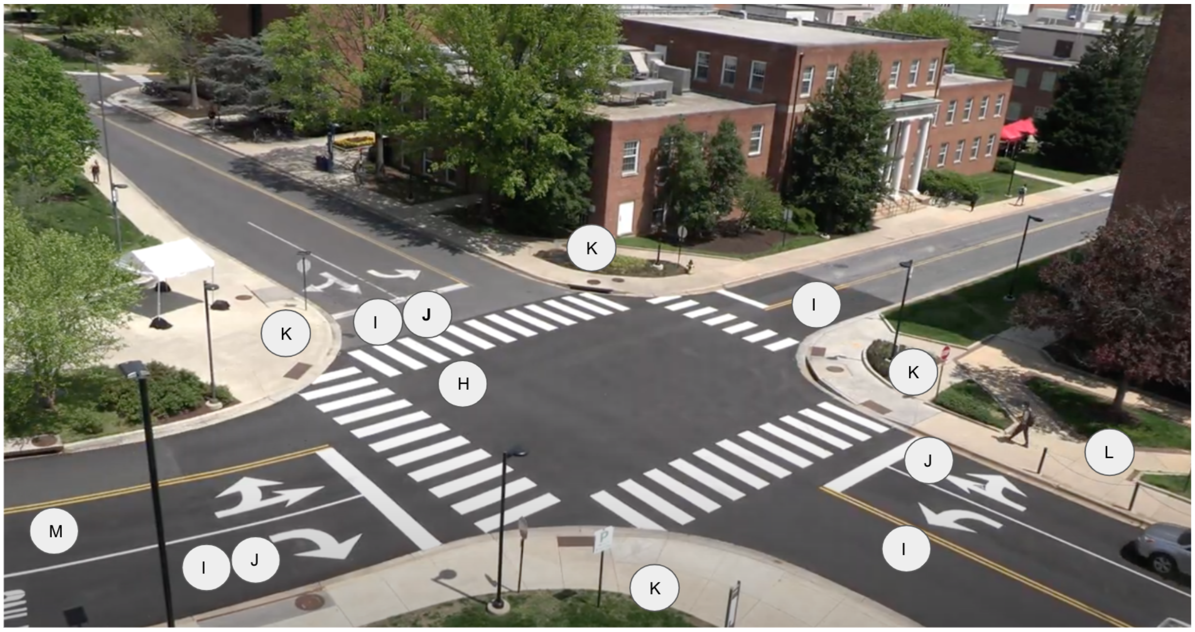
Figure 19: Fieldhouse Drive/Regents Drive Intersection

Stadium Drive/Regents Drive Intersection:

H. Four-way stop intersection and crossings
I. Bi-directional through lanes on all sides
J. Turning lanes on three legs of the intersection
K. Sidewalk and curb on all corners of the intersection

L. Bollard & Chain on the southeast side of the sidewalk separating the sidewalk from the roadway except at crossings
M. Downhill grade change

Figure 20: Stadium Drive/Regents Drive Intersection



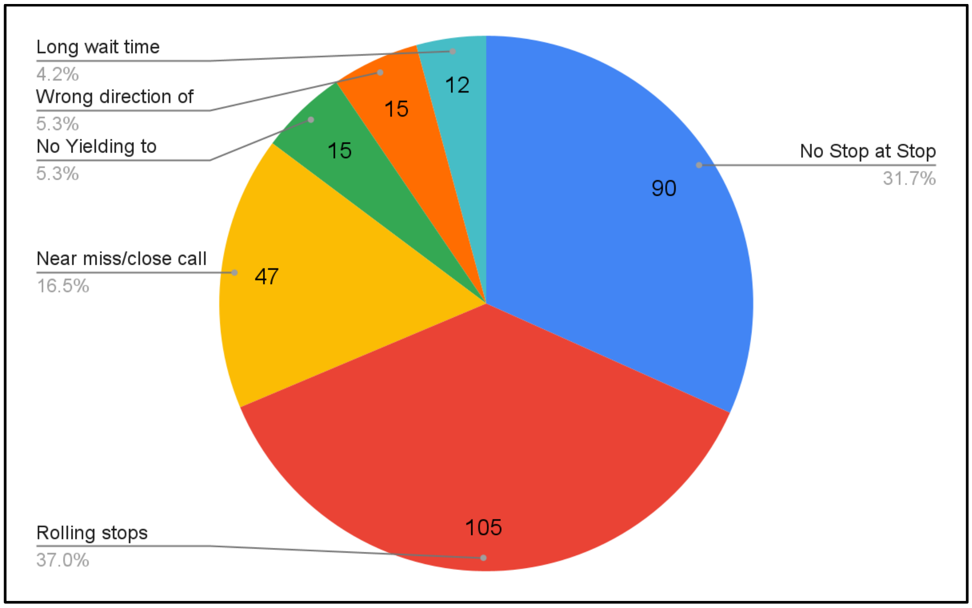
The results below reflect 110-120 min of mid-week video observations at each intersection between the hours 7:30 AM - 2 PM. At each site, we recorded two busy class change periods as well as times during class sessions.

Findings

Types of Incidents Observed

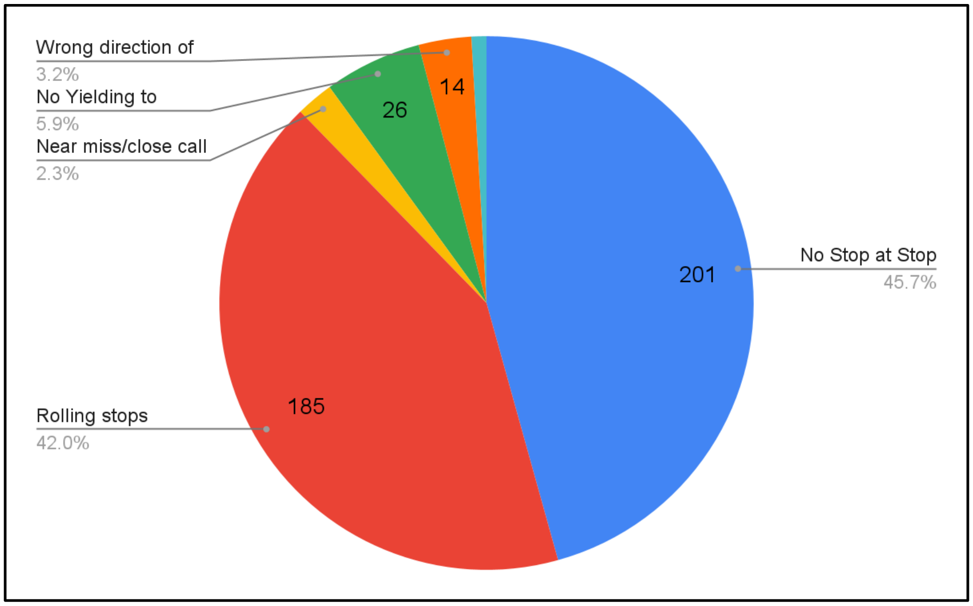
In Figures 21 and 22, illustrate the breakdown of each incident type at both the Fieldhouse and Stadium intersections of Regents Drive. Fortunately, no accidents or collisions occurred during the observation period. Figure 23 and 24 break the incident types down further by the mode involved. At both Fieldhouse Drive and Stadium Drive intersections of Regents Drive, “Rolling Stops” and “No Stop at Stop Sign” made up an overwhelmingly large share of the instances observed. Forty-five percent of the incidents at Stadium Dr. were “No Stop at Stop Signs” compared to 42% of rolling stops. At Fieldhouse Dr., which is a three-way intersection, “Rolling Stops” were more common, making up more than 37% of the incidents compared to the 31% “No Stop at Stop Signs.” More “Near miss/close call” incidents were identified at the Fieldhouse Drive (16.5%) site during the observation period than at the Stadium Dr. intersection (2.3%). Across both intersections, the research team recorded a roughly equal share of incidences (5-6%) in which a vehicle did not yield to another vehicle or a more vulnerable road user. In both intersections, 3-5 % percent of the incidents observed were vehicles traveling in the wrong direction (14 incidents at Stadium Dr. and 15 incidents at Fieldhouse Dr. incidents).

Figure 21: Incidents Observed at the Fieldhouse Drive/Regents Drive Intersection



Note: Percentage breakdown of incidents observed at the Fieldhouse Drive/Regents Drive intersection of 284 total observed instances.

Figure 22: Incidents Observed at the Stadium Drive/Regents Drive Intersection

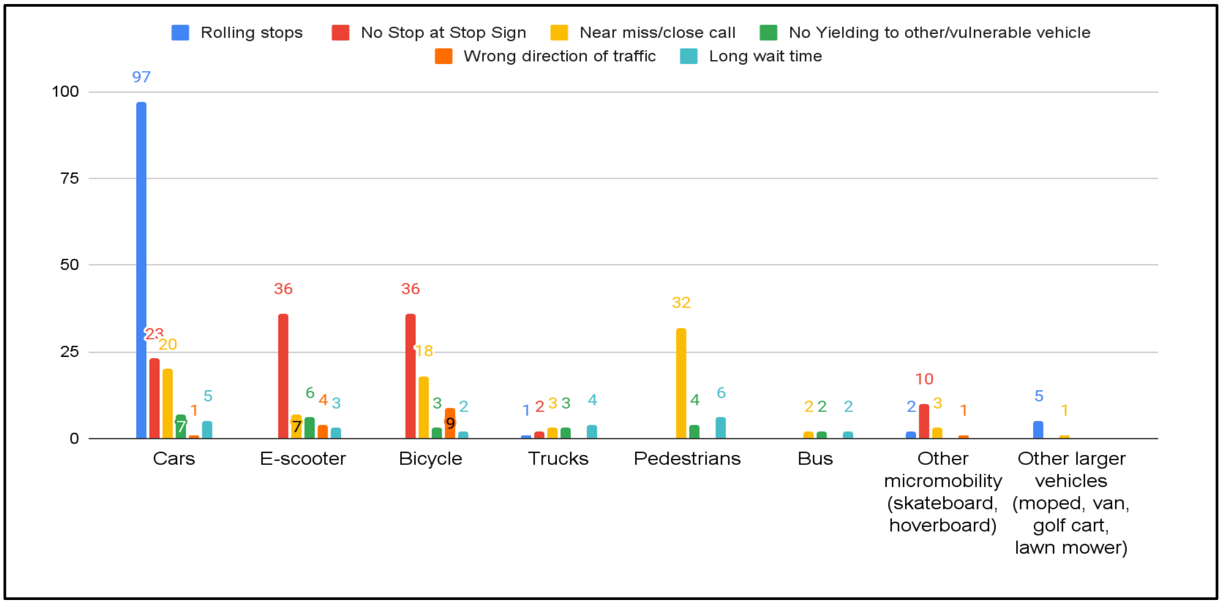


Note: Percentage breakdown of incidents observed at the Stadium Drive/Regents Drive intersection of 440 total observed instances. “Long wait time” accounts for 0.09% in teal.

Rolling Stops and No Stops at Stop Signs

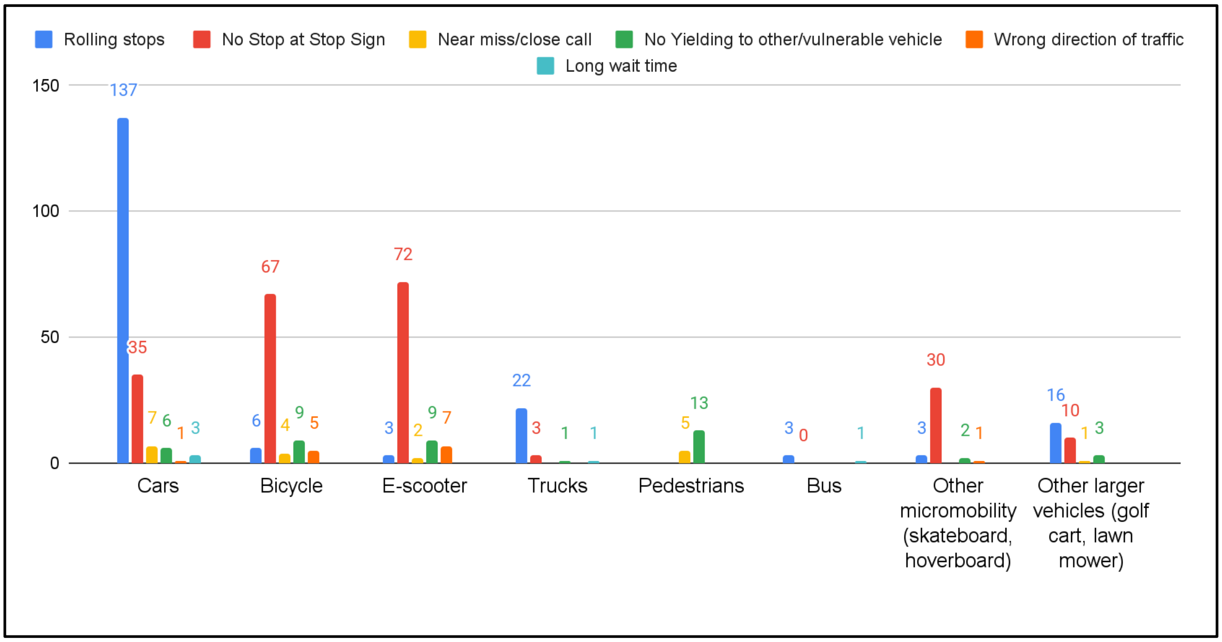
From Figures 23 and 24 above, the most common incident observed was vehicles rolling through or not stopping at stop signs at all. Cars dominated the stop sign roll incidents with 97 incidents observed at Fieldhouse Drive and 137 incidents observed at Stadium Drive. The modes most engaged in not stopping or slowing down at intersections were bicycle and e-scooters at roughly even shares (30-40% each) compared to other modes, though higher total instances were observed at the Stadium Drive intersection than at Fieldhouse Drive. Micromobility devices such as skateboards and hoverboards were also observed not stopping at stop signs approximately 30 times at Stadium Drive intersection and 10 times at Fieldhouse Drive intersection during the observation period.

Figure 23: Incidents Observed at Fieldhouse Drive and Regents Drive Intersection by Mode



Note: Bar graph detailing the number of incidents observed at Fieldhouse Dr. and Regents Dr. intersection by type and mode involved of 284 total instances observed.

Figure 24: Incidents Observed at Stadium Drive and Regents Drive Intersection by Mode



Note: Bar graph detailing the number of incidents observed at the Stadium Dr. and Regents Dr. intersection by type and mode involved of 440 total observed instances.

Though rolling stops are most prevalent especially among cars and heavier vehicles, the behavioral patterns of not stopping at stop signs at all are mainly by bicycles, e-scooters, and skateboarders, and contribute a deal of risk, especially in the presence of other modes. From observation notes, the researchers took note of the downhill when traveling east on both Stadium and Fieldhouse Drive, in which many bicyclists and e-scooter riders propelled down at fast speeds across the intersection.[1]

The members also noticed that heavier vehicles avoided complete stops when there was a low level of activity in the intersection but were more likely to completely stop and wait when there was a higher level of activity in the intersection. The same distinction was not inferred for bicycle, scooter, or skateboard riders. Speed, direction of travel, or proximity to other modes were not documented in this study. However, these combined variables as well as the control and awareness of the drivers, bicyclists, e-scooterists, or skateboarders factor into the overall risk and potential for collisions.

Near misses/Close Calls and No Yield to Other Vulnerable Vehicles

Of the 57 total near misses/close calls observed (47 at Fieldhouse Drive and 10 at Stadium Drive), 37 involved pedestrians at risk of an accident. Cars were involved 27 times, bicycles 22 times, and e-scooters 9 times. The team also recorded 41 instances of vehicles not yielding when supposed to. Bicyclists, e-scooter riders were recorded as the highest offenders of not yielding to other travelers with 13 and 12 instances, respectively. This is consistent with a low rate of compliance with regulations by bicyclists and e-scooter riders found in other studies. Cars followed closely with 8 recorded instances during the observation period. Pedestrians were overwhelmingly at the receiving end of not being yielded to.

Figure 25: Image of Stadium Drive/Regents Drive Conflict - Pedestrian and E-Scooter

Note: Example of an e-scooter rider not yielding to a pedestrian in the crosswalk. The pedestrian is looking down at a phone. Neither seems alarmed or reactive to the other.

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[1] For exactly this reason, Queensland Transport advises planners to avoid placing multi-use trails on steep inclines where possible (2016).

Figure 26: Image of Stadium Drive/Regents Drive Conflict - Truck and Pedestrians

Note: Example of a motorist not yielding to a pedestrian in the crosswalk after seemingly long wait time at the stop sign. Other vehicles at the intersection wait patiently for pedestrians to cross.

Long Wait Time and Wrong Direction of Travel

Long wait times can point to congestion and inefficiencies in the transportation network and undesirable experiences for road users. During the observation period, our team documented a few instances where long wait times, and related causes and effects such as backed up traffic, resulted in vehicles having a hard time crossing the intersection. During such congested periods, small vehicles, like bicyclists, e-scooter riders, mopeds, or skateboarders, often diverted from long waits, overtook motorists, and rode to their destination in other locations like the sidewalk, in between driving lanes, or in a different lane regardless of their direction of travel. The research team noted vehicles traveling in the wrong direction of traffic 29 times. These congested conditions were among some of the riskiest and most challenging times observed. Vehicular traffic was at a standstill due to the high overall pedestrian, bike, e-scooter volume, travelers were in more of a rush, and behaviors were less predictable.

While the literature review and survey results suggest that cyclists and e-scooter riders choose to ride on the sidewalk because of the perception that roadways are dangerous, the video observation reveals another possible explanation: riding on the sidewalk is sometimes faster, especially during periods of high roadway congestion.

A two-minute compilation video of these events can be found here. Table 4 identifies which segments of which video recording were used, the modes involved, and the timestamp. This is a sample of how videos were recorded and timestamped.

Table 4: Regents/Stadium Video Highlight Incidents

Timestamp	**Modes involved**	**Clip name**
0:00.00 - 0:05.9	Bicycle and pedestrian	Clip 269 & 270 - V5.mp4
0:06.00 - 0:13.70	Bicycle, e-scooter, and pedestrian	Clip 291, 292, 293 - V5.mp4
0:13.71 - 0:25.47	Bicycle, Other micromobility (skateboard, hoverboard), E-Scooter	Clip 295, 296, 297, 298 - V5.mp4
0:25:48 - 0:41.06	Cars, e-scooter	Clip 313 - V5.mp4
0:41.07 - 0:54.73	Other micromobility (skateboard, hoverboard), E-scooter, Other large vehicles (golf cart, lawn mower)	Clip 461, 462, 463, 464 - V5.mp4
0:54.74 - 1:10.26	Bicycle, Truck,E-scooter	Clip 483, 484, 485, 486 - V5.mp4
1:10.27 - 1:22.00	Bicycle, E-scooter	Clip 496, 497, 498, 499.mp4
1:22.01 - 1:27.86	Bicycle, Other micromobility (skateboard, hoverboard)	Clip 522, 523, 524, 525, 526 - V5.mp4
1:27.87 - 1:35.66	Bicycle	Clip 527 &528 - V5.mp4
1:35.67 - 1:47.43	Bicycle, other micromobility (Skateboard, hoverboard)	Clip 529 & 530 - V5.mp4
1:47.44 - 1:57.23	Bicycle, e-scooter	Clip 531, 532, 533, 534 - V5.mp4

Other observations

Regents Drive Garage is a campus transit hub and hosts a bus bay in the lane adjacent to the sidewalk. After boarding passengers, buses needing to depart often need to overtake cars in the right turn lane to reach the through lane in the direction of their destination.

Recommendations

Based on the findings in the literature review, survey, and video observations, this study provides the following recommendations for a better campus-built environment with minimum inter-modal conflict, improved safety, and well-maintained access in the coming years.

Recommendation 1: Prioritize Road Space for Vulnerable Users

One component of this study was to identify opportunities for new infrastructure and policies that could minimize conflict between sidewalk and roadway users. The existing footprint of buildings limits the amount of land physically available to link all buildings by all modes of travel. For example, the video observations of both the Stadium Drive/Regents Drive and Fieldhouse Drive/Regents Drive intersections show conflict between various modes of travel. There is limited road space available at each of these intersections. It is recommended the University prioritize accommodating the most vulnerable road users' safety. Pedestrians (inclusive of wheelchair users and other mobility-impaired individuals) are most vulnerable, followed by micromobility users (bicyclists, e-scooter-riders, skateboarders, and hoverboarders). Each user group needs a minimum amount of space to operate safely and comfortably. It is recommended the University prioritize vulnerable users, which may require limiting access by automobile in order to dedicate the needed road space for protected bicycle (and e-scooter) lanes and facilities such as bike racks. This will aid in removing bicycles and e-scooters from the sidewalk and reduce tension between pedestrians and cyclists/e-scooterists.

Recommendation 2: Invest in Bicycle Infrastructure, such as Well-connected, Dedicated, and Protected Bike Lanes

Investing in bicycle infrastructure such as well-connected, dedicated, and protected bike lanes throughout the campus would help move both bicycles and e-scooters off sidewalks. The video observations captured more than 12 bicyclists, eight e-scooters, and two skateboarders riding on the sidewalk at some point during the 238 observed minutes. Though surveyors did not count all modes crossing the site, these numbers are expected to decrease if adequate infrastructure is available based on PBOT's study that identified e-scooter riders "were up to twice as likely to ride on the sidewalk when no bike infrastructure was present" (Ciarlo et al. 2019).

Recommendation 3: Install a Shared-use Path on McKeldin Mall and Other Large Pedestrian Blocks

Minimizing conflicts on the road will encourage bicyclists and e-scooter users off sidewalks, but there are spaces on campus where roads are not available to install bike lanes. For example, the survey responses identified a number of conflicts with bicyclists and e-scooter riders on McKeldin Mall (Figure 15). There is no easy way identified in the campus map for a bicyclist or e-scooter user to cross McKeldin Mall without going completely around it on Regents Drive (east), Campus Drive (north), or cutting across on the sidewalks, which is not permitted. It would be beneficial for the University to provide north-south and east-west connections on McKeldin Mall with a shared-use path, such as the north-south connection behind Library Lane as depicted in the UMD Bike Infrastructure Implementation Plan (UMD Bike Study Implementation Plan 2019, 7). Since McKeldin Mall is an iconic point of interest at the heart of the campus with desirable pedestrian leisure and activity space, careful attention should be given to the signage, marking, and surface design so that the shared-use facility complements the character of the Mall.

Recommendation 4: Implement Traffic Calming and Road Markings on Regents Drive

From our video observation study at the two intersections of Regents Drive, rolling stops and vehicles skipping stop signs all together as the most common behavioral risk observed. Cars and automobiles pose the biggest risk to pedestrians as the weight, size, and speed of a car can be deadly. Reducing speed through speed tables and bumps on the roadway and at crosswalks will force vehicles, bicyclists, and e-scooter riders approaching the intersection to slow down and help maintain a safe environment for pedestrians and other vulnerable road users.

In addition, the videos captured a few instances where bicyclists, e-scooter riders, skateboarders, and cars crossed into the on-coming traffic's side of the intersection box. Extending center lines in dashed painting patterns to identify the directions of turning lanes can aid in keeping vehicles in their appropriate location and prevent collisions or near misses.

Recommendation 5: Apply Texture to Curb Cuts for Awareness of Curb Cuts and Grade Change for Pedestrians' Safety and Bicycle and Scooter Dismounting

It was observed in the videos that bicyclists, e-scooter riders, and skateboarders would utilize a curb cut to get onto the sidewalk to either park their bike or scooter or continue on their path. These instances can be dangerous to pedestrians as these modes are often traveling at higher speeds than pedestrians. Pedestrians may not expect a bicycle or e-scooter rider, unless the rider physically signal. It was also observed that pedestrians are often looking at their mobile phones and may not be as observant of their surroundings. Implementing a standard for all curb cuts to have a rumble strip or sidewalk bumps can physically signal pedestrians and other users that they are a) approaching a curb cut and intersection, b) signal to cyclists and e-scooter riders to dismount, and c) provide critical cues to visually impaired community members. The rumble strip and sidewalk bumps will also signal that there will be a grade change.

Recommendation 6: Move Bicycle Parking In-road or Closer to the Curb

The University rule is for bicyclists to dismount at the crosswalk and walk their bicycles while on the sidewalk ("Campus Bike Regulations & Safety." n.d.). As observed in the fieldwork, cyclists would bike on the sidewalk to get from the road to bicycle racks and park their bikes. This can be because riding a bike is quicker than walking. Though bike racks in the observed videos are nearby the crosswalk and curb cut, a number of bike racks on campus are rather away from the road, such as the ones by Preinkert Hall. It is recommended to install covered bike racks on the road or closer to the curb to reduce the amount of time bicycles are on the sidewalk.

Recommendation 7: Limit Vehicular Access during High-congested Periods

Transitioning Regents Drive to have limited car access during class times can further ensure pedestrian safety. It is recommended to conduct a pilot study to better understand how traffic and mobility will be impacted if Regents were to be closed off to car traffic. The duration of the restriction and the time of day can be examined carefully. It is also recommended to prioritize the time periods of class changes as these periods are the busiest traffic time on campus, as observed in the study. Since parking location is a main driver of the traffic congestion, a long-term recommendation for campus land-use and planning is to consolidate parking to the perimeter of campus and permit only pedestrians, shuttle buses, micromobility, and service vehicles within the campus interior.

Recommendation 8: Strengthen Education and Policy Strategies

Based on the survey results regarding rule awareness, it is evident that in addition to the lack of intuitive design or protected facilities, Figure 14 identified 38 percent of respondents believe they are allowed to ride bicycles and scooters on sidewalks, and 34 percent believe they should be able to ride on sidewalks. We recommend strengthening policies and education strategies so that ambiguity is reduced.

DOTS lists riding regulations on its website and conducts education campaigns about sharing the road via the *"Same Roads, Same Rules, Same Rights"* principles and a host of other bicycle and e-scooter safety events and voluntary courses at peak periods over the year. ("Electric Scooter Regulations | UMD DOTS" n.d.). These efforts can be scaled up to have more impact and reach across the campus community. Combined education and policy strategies, such as campus-wide mandatory mobility safety courses during orientation, can be adopted to strengthen mass awareness of the rules of the road. Additionally, improved signage at existing and future facilities and distributed maps displaying where bikes and e-scooters are to ride can strengthen the campus population's awareness.

Though directed at all road users, DOTS has received feedback from cyclists who feel that the *"Same Roads, Same Rules, Same Rights*" education campaign messaging does not adequately target drivers. In addition to voluntary and passive education efforts, embedding quizzes, or driver safety acknowledgment of speed and vulnerable road users in the parking registration process is an opportunity to reach the driving population more directly. Repeating the survey effort in future semesters will help monitor the improvements on these issues.

Recommendation 9: Implement Effective Enforcement Strategies

We expect piloting, measuring, and implementing the earlier recommendations would result in a reduction in inter-modal conflicts on campus and cases of speeding. However, if there is still a need for improvement, enforcement may be beneficial for efforts to curb or correct dangerous travel behaviors.

We recommend conducting a field survey to identify the primary location of speeding, which should be prioritized for deploying speed cameras. Identifying key locations, testing speed cameras, and analyzing how ticketed drivers act over a period of time will aid in understanding the impact the speed cameras have. The presence alone may deter drivers from speeding, while appropriate levels of fine should be examined over time.

Often enforcement of minor infractions, such as side-walk riding or failing to stop sign, are limited due to the desire to avoid aggressive penalties that can be harmful to someone's long-term record. A ticket diversion program can assist with diverting penalties away from traffic court procedures to a more localized practice of adjudication that has a higher likelihood to influence a behavior change. College campuses are well-suited for ticket diversion programs as the institution would have more involvement and influence on the response and education process of a violator within the campus community. Schools such as Boise State ("Ticket Diversion." n.d) and Stanford University ("Bike Safety and Bike Citation Diversion Classes." n.d) have utilized ticket diversion programs. It is recommended that a ticket diversion program be implemented in conjunction with the installation of speed cameras to ensure people can learn from their behavior.

Recommendation 10: Conduct Future Studies

Because this study was a pilot project in the limited time in one-semester course, a number of improvements can be made for each component. The literature review can be extended to include more formal studies on the subjects published in the future. It is recommended to repeat the survey in the coming years to track if e-scooter riding increases and how the perception of rules and traveling conditions changes over time.

Regarding the video observation component, although our study focused primarily on the observed incidents listed above, it is recommended to count all modes that cross the site for a more comprehensive understanding of the traffic makeup. In the observation study, the direction of travel can be documented more systematically to develop a more granular point of analysis. Using a radar gun or other technology to capture the velocity of modes would be beneficial as trends, level of risk, and interventions can be better identified. Adding symbols to the video summary would aid in identifying conflicts to laypeople; some segments have multiple conflicts occurring at once, and utilizing graphics to draw people's attention to them would be helpful in identifying important interactions.

Geofencing and speed limitations are active on UMD's campus for the Veo e-scooters. This study, however, did not analyze or test the current settings in place. Additionally, personal e-scooters are not enforced by the same mechanisms that Veo e-scooters are. A study of the presence and behaviors of personal e-scooters is recommended to better understand how they are operated on campus and how to prevent conflicts between them and pedestrians. One suggestion is designating or geofencing certain parts of campus as "slow zones' for high pedestrian activities, with regulating e-scooter operation at speeds between 7-10 miles per hour.

Lastly, if recommendations are adopted, future studies should be adjusted to measure and evaluate the effectiveness of the intervention, update conditions, and iterate toward a more harmonious mobility network for all. The continued attentiveness to these important issues by the University of Maryland's leadership team will be vital for further success and support the University's commitment to go carbon neutral by 2025 ("Keeping Our Climate Pledge").

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Appendix

Appendix A: Links

- **Survey:** https://docs.google.com/forms/d/1YgGGmi_u_v2Y7lDYOdl0_jUrlfm71G9V4IRYSTHaMWM/edit?usp=sharing
- Full video recordings:
    - 1_Fieldhouse/Regents.mp4: https://drive.google.com/file/d/1y78EU41qo6bz3AKiyyLEqLiL0LrIyWMJ/view?usp=sharing
    - 2_Fieldhouse/Regents.mp4: https://drive.google.com/file/d/1IY4L2FVAncxx3Bo9gfKUrQjfHsaDjskT/view?usp=sharing
    - 3_Stadium/Regents.mp4: https://drive.google.com/file/d/1QGQsltBlAf0nfG-4NHXDBaLgcp2eLUPv/view?usp=sharing
    - 4_Stadium/Regents.mp4: https://drive.google.com/file/d/1-o_AGeChCzCUEyE58h3kpCq4QkMAZSsq/view?usp=sharing
    - 5_Stadium/Regents.mp4: https://drive.google.com/file/d/15TsQShsbJE4TUkRB9CBH565QHA545_qP/view?usp=sharing
- **Observation Tracking log (raw data):** https://docs.google.com/spreadsheets/d/1YOcvffmtTTwrvf3f2znNZJBr_8vc7LetOZZB5U2pa3k/edit?usp=sharing
- **Two-minute video compilation:** https://drive.google.com/file/d/1mwUnQ6dBYeZHKiV8lX3XX_yFwJZHsmYA/view?usp=sharing

Appendix B: Review of Policies Concerning Bicycle and E-scooter Use on Campus at Selected American Universities

Review of Policies Concerning Bicycle and E-Scooter Use on Campus at Select American Universities

	Campus size acres (2)	Total student enrollment F/T + P/T most recent avail. (4)	Pop. Per acre	Type of campus (8)	Date of policy update	Bicycles and scooters banned from most of campus	Bicycle parking permit req'd. if personally owned	Scooter parking permit req'd. if personally owned	Scooter parking in designated areas only	Bicycle parking in designated areas only	Authority to prohibit riding on sidewalk	E-scooter sidewalk prohib.	Bicycle sidewalk prohib.	Scooters allowed on roads	Geofencing for e-scooter vendors	Notes
Wash U	169	15,539	92	Urban	2019	1	0	0	0	1	1	100%	0%	1	0	9
U Wisc	936	47,932	51	Urban	2019	0		1	1		1	0%		1	0	1
Harvard (5)	209	25,110	120	Urban	2018	0	1	0	1	0	1	100%	5%	1	0	4
UCLA	419	45,900	110	Urban	2018	0		0	1		1	100%		1	1	6,7
VA Tech	2600	34,656	13	Rural	2019	0		0	1		1	0%		1	1	
U VA	1682	27,115	16	Suburba	2019	0		0	1		1	100%		1	0	
UT Austin	431	51,991	121	Urban		0		0	1		1	100%		1	1	

General note: In multiple web searches and literature searches, we could not find a previously done survey of university and college campus e-scooter policies.
Criteria for selecting these Universities: either (1) E. of Miss. River LAB Gold Bike Friendly, or (2) interest expressed by team members with preference given to bordering states.

(1) Representative of UW Transportation office 10:53 am EDT 4/26/22, who said riding on sidewalk "not recommended," but had no knowledge of posted prohibitions and suggested calling UW Police Department.

(2) Campus size data found mostly Usews.com' sometimes from University data

street sign is OK, but never in the path of pedestrians or in a way that blocks handicap access. Bicycling on the sidewalk is not permitted in Harvard Square or in several other locations in Cambridge.

(4) Most campus enrollment taken from campus website. When available, "on campus" registration only is reported.

(5) Cambridge campus only. Reported 5,000 acres includes 3 campuses and "holdings" https://hr.harvard.edu/guide-campus which includes forests:
https://web.archive.org/web/20130523000940/http://www.provost.harvard.edu/institutional_research/harvard_fact_book_2012_physical_plant.pdf

and walked through the area. Signage has been posted. This policy is not meant to discourage bicyclists from commuting around campus, but rather to protect the safety of pedestrians and bicyclists.

(7) Type of campus is subjective. USNews reports their view of it for several campuses.

(8) Bicycles are permitted to ride on more paths than for scooters