MICRO-MOBILITY ON THE UC DAVIS CAMPUS: ADDRESSING THE RESEARCH GAP IN E-BIKE AND E-SCOOTER SAFETY AND TRENDS

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Abstract

This report examines trends in the rising use of e-mobility, specifically studying its implications on safety. Using data from the UC Davis Campus Travel Survey, differences in usage rates, safety and other statistics are pulled out. Additionally, data on crash locations was used to create a map of incident hotspots. Finally, some recommendations are provided.

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Executive Summary

Motivation and Goals

Micro-mobility, including e-scooters and e-bikes, is transforming urban and campus transportation by providing a sustainable alternative to cars. At UC Davis, a strong cycling culture and bike-friendly infrastructure support this shift, aligning with the university's environmental goals. However, the rapid rise of e-mobility has also raised safety concerns, highlighted by a tragic e-scooter fatality of a UC Davis student in Sacramento (*"She Was a Phenomenal Doctor,"* 2024).

This study examines e-mobility trends and safety at UC Davis by: (1) analyzing user demographics to guide policy and infrastructure decisions, (2) identifying safety risks to improve transportation coexistence, and (3) mapping crash hotspots to target infrastructure improvements. The findings offer insights to enhance micro-mobility safety and sustainability on campus and beyond.

Methods

This study utilizes data from the UC Davis Campus Travel Survey (CTS), an annual effort by UC Davis Transportation Services and the National Center for Sustainable Transportation. The 2024-2025 survey gathered responses from 4,526 individuals on their commuting habits, including mode choice, trip characteristics, and accident history. The dataset was weighted by gender and campus role to ensure representativeness.

We conducted exploratory data analysis to examine usage trends and crash statistics across different transportation modes. This analysis provided insights into modal shares, accident frequencies, and demographic patterns related to micro-mobility use.

To identify high-risk areas, we performed a hotspot analysis using DBSCAN, a density-based clustering algorithm, which pinpointed locations with frequent e-mobility crashes. Each hotspot's severity was assessed using injury cost estimates based on the Value of a Statistical Life, allowing for prioritization of safety interventions. A sensitivity analysis confirmed the robustness of the severity weighting system. The results were visualized on an interactive map, highlighting critical locations for infrastructure improvements to enhance micro-mobility safety on campus.

Results

Literature Review

The growth of micro-mobility, especially shared micro-mobility, is a worldwide trend. By 2030, the shared micro-mobility market is expected to grow to $50 billion to $90 billion, representing a 40% annual increase from 2019 to 2030. By then, shared micro-mobility could account for approximately 10% of the total shared-mobility market. The global e-scooter market, including both personal and shared vehicles, is valued at $2.3-3.6 billion. The US e-bike market itself is valued at $2 billion, with an expected CAGR of 15.6% till 2030. Personal e-scooters range from $200 to $2500 in price, with the average being around $350. We estimated that sales of personal e-scooters in the US in 2025 will be around 300,000 units.

Regarding safety, according to the US Consumer Product Safety Commission, emergency department visits related to micro-mobility devices surged from 34,000 in 2017 to 57,800 in 2020, primarily due to a substantial rise in e-scooter injuries, which more than tripled from 7,700 in 2017 to 25,400 in 2020. Helmet use rates remain stubbornly low, and the effectiveness of mandates has been mixed. Finally, there is a lack of research on infrastructure requirements to support e-mobility, but the current recommendation is to have paths 12-14 ft in width.

Exploratory Data Analysis

Across the six transit modes identified in the CTS (Walk/Wheelchair, E-bike, Bike, E-scooter, E-skateboard, Skates/Conventional Skateboard/Kick Scooter), most (80%) respondents reported fewer than 2 accidents over the course of a year. Among all modes, most crashes reported were attributed to a “slip or swerve resulting in a fall” or a “collision with a bicyclist”. Collisions with e-scooters comprise a larger percentage (7%) of all collisions for pedestrians than for any user of micro-mobility, for which collisions with bicyclists comprise between 2% and 4% of all collisions. We speculatively attribute this to e-scooter riders using the same space as pedestrians i.e. sidewalks. Among all modes, most crashes are classified as resulting in either “no apparent injury” or “minor or possible injury”. Users of e-scooters report a larger share (19%) of all crashes resulting in “severe injury” than users of any other mode (*UC Davis Campus Travel Survey*, n.d.).

Hotspot Analysis

The hotspot analysis identified **23** high-risk locations for bike and e-scooter crashes, categorized as roundabouts (10), roadway intersections (5), bikeway intersections (7), and one "other" (TLC Parking Lot). While roundabouts were expected to dominate, crashes were more evenly distributed across different intersection types. Roadway intersections, particularly those on Russell Blvd (La Rue & Sycamore), warrant closer attention due to the interaction of micro-mobility with motor vehicles.

The ARC Parking Lot at Orchard Road emerged as the most severe hotspot, with four severe crashes concentrated near Sprocket by Segundo and the ARC Peet's roundabout, likely due to high-speed merging and unpredictable rider behavior. Other notable hotspots include the Sprocket & Soccer bikeway intersection, where complex traffic flows and left-turn conflicts contribute to crashes, and the Katherine Esau Science Hall bikeway, which sees high-speed, head-on collisions due to poor visibility and abrupt turns into bike parking. The California at Hutchison roundabout, despite no severe crashes, remains a priority due to interactions with buses. Site inspections and further analysis of crash metadata are recommended to determine precise causes and inform safety improvements.

Recommendations

Improvements to the Campus Travel Survey (CTS)

- Inclusion of questions about receptivity to micro-mobility.
- Including a question on academic majors.
- Add option for 'moderate injury' and provide an example of each severity.
- Assess helmet use rates and risk perceptions.

Shared mobility systems (SPIN)

- Holding periodic safety workshops and expanding helmet access programs.
- Improving lighting and visibility in high-risk areas.
- Addressing community concerns through analysis of 311 complaints.
- Introduction of a student safety ambassador program.

Infrastructure improvements

- Performing a root cause analysis at identified hotspots, prioritized by severity weights.
- Widening selected paths to 12-14 ft.
- Improving data collection methods at the Student Health and Wellness Center

Regulations

- Disallowing vehicles that are either too fast or too heavy (based on SAE classifications of micro-mobility).

- Not mandating helmets due to concerns over discriminatory enforcement but continuing to encourage use.

Student projects

- Conduct an annual student project to count micro-mobility devices.
- Use student projects to analyze hotspots for potential intersection redesigns.

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Motivation

The Rise of Micro-mobility in Urban and Campus Transportation

The growing popularity of micro-mobility has fueled a dramatic revolution in urban and campus transportation during the last several decades. This trend has evolved as a feasible alternative to personal passenger vehicles in densely populated urban areas. Micro-mobility refers to a range of lightweight, short-distance transportation options, such as bicycles, electric scooters (e-scooters), electric bikes (e-bikes), and other personal-sized vehicles. One of the main elements of micro-mobility is electric mobility (e-mobility), the electrification of personal vehicles. E-mobility is considered an important puzzle piece to meet the rising demand for effective and environmentally friendly transportation options. As highlighted by the International Finance Corporation, it is especially well-suited for "last mile" delivery because it offers significant advantages in urban areas with heavy traffic, short distances, and frequent stops, such as reduced emissions, lower operating costs due to minimal fuel consumption, and increased maneuverability with smaller electric vehicles (Jesus,Pruna,Madalina,Pulido,Daniel, n.d.). The implementation of e-mobility on college campuses, such as the University of California Davis (UC Davis), not only improves mobility but also aligns with broader environmental and sustainability objectives.

E-Mobility as a Key Component of Sustainable Transportation

According to the International Transport Forum, universities are in a unique position to promote the use of low-carbon and zero-emission vehicles (Hilary, 2020). The global push for decarbonization of the transportation sector has brought attention to mode shifts and universities are considered strong case studies for implementing pedestrianized transportation infrastructure and policies. UC Davis maintains a strong commitment to sustainability, and, through encouragement of public transit and e-mobility adoption, the university hopes to reduce its carbon footprint and create a more sustainable campus environment (*University of California, Davis | Scorecard | Institutions | STARS Reports*, n.d.). This modal shift not only helps to meet environmental goals, but it also improves the overall quality of life for students and faculty by providing convenient and environmentally friendly transportation options.

Safety Concerns and Challenges of E-Mobility on College Campuses

Despite the numerous benefits of micro-mobility, safety is still a major concern. The rapid spread of e-scooters and e-bikes has resulted in an increase in accidents and injuries, particularly in densely populated areas such as college campuses. An Austin Public Health study conducted at the University of Texas at Austin found that e-scooter injuries have increased significantly, with many of these incidents taking place in areas with a high pedestrian traffic volume (*Dockless Electric Scooter-Related Injuries Study — Austin, Texas, September–November 2018*, 2019). The specific challenges of a campus environment, which frequently includes a mix of pedestrians, cyclists, and e-mobility users, may exacerbate these safety concerns. Ensuring the safe coexistence of various modes of transportation is critical to the long-term success and widespread adoption of e-mobility.

UC Davis and the City of Davis have a long-standing tradition of being bicycle-friendly, with an existing culture and infrastructure that supports micro-mobility. The city is renowned for its extensive network of bike lanes, bike-friendly policies, and a community that actively promotes cycling as a primary mode of transportation (*Davis Bike and Pedestrian Infrastructure | City of Davis, CA*, n.d.). This established culture of micro-mobility has laid a strong foundation for the integration of e-mobility options. However, the introduction of e-scooters and e-bikes has introduced new safety challenges. Tragically, the campus experienced an unfortunate incident where a student was fatally injured while riding a bicycle ("UC Davis Student on Bicycle Dies after Being Struck by Garbage Truck on Campus," n.d.). Two years later, a UC Davis resident physician was killed in an accident while riding an e-scooter (*"She Was a Phenomenal Doctor,"* 2024). These incidents spotlight the urgent need for a comprehensive understanding of the safety implications of micro-mobility in such environments. This incident underscores the importance of addressing safety concerns through knowledge acquisition, robust campus policy, infrastructure improvements, and user education.

Research Objectives: Understanding Safety, Trends, and Infrastructure Needs

This study aims to explore the safety and trends of e-mobility on the UC Davis campus, focusing on three major areas: (1) Understanding the user demographics of e-mobility to tailor policies and infrastructure to the needs of the campus community. (2) Identifying and addressing safety concerns to ensure the safe coexistence of different modes of transportation. (3) Analyzing the current infrastructure and identifying hotspots for improvements to enhance the overall e-mobility experience.

Culminated in this report are insights that can inform policy and practice to enhance the safety and sustainability of micro-mobility on UC Davis campus and in other similar settings. By addressing these critical issues, we can ensure that the benefits of e-mobility are realized without compromising the safety and well-being of the campus community.

Literature Review

The rapid adoption of micro-mobility technologies, particularly e-scooters and e-bikes, has prompted extensive research on their effects on urban and campus environments. This literature review will synthesize previous studies to provide a comprehensive understanding of the important themes and findings connected to micro-mobility, with a particular emphasis on safety and user demographics under the context of U.S. and global trends. Examining the existing literature will help us spot knowledge gaps and guide our investigation into e-mobility trends and safety on the UC Davis campus.

Market and Usage Trends

Global

The term “e-scooter” can refer to several different vehicle sub-types depending on the country of use. The broad range of “e-scooter” can refer to stand-up personal scooters, step-through scooters, mopeds, or electrified “tuk-tuks”. As a result, many pieces of literature with regards to academic research and business market analytics vary in their term usage and insights relating to usage and safety. Below is a table summary of common vehicle types and descriptors (Baumgartner & Helmers, 2024).

Vehicle type No	Vehicle types	Vehicle subtypes	
0	electrified boards or skates without a handlebar	0a	powered skates (two, separated)
		0b	hover-board, e-board, unicycles (1–2 wheels)
		0c	skateboard (4 or more wheels)
1	electrified vehicles with a handlebar and without a seat	1a	stand-up scooter (e.g., a Segway HT/PT from 2001)
		1b	**kick scooter (here: “e-scooter”)**
2	bicycle similar vehicles that can be operated alternatively without the electric engine	2a	e-bike
		2b	bike-like three- and four-wheelers
3	electrified larger two- and three-wheelers	step-through scooters, mopeds, motorcycles, and larger three-wheelers (e.g., electrified Tuk Tuks). – under micro-mobility definition with a top speed ≤ 30 mph (48 km/h) and a curb weight ≤ 500 lb (227 kg)	
4–6	light four-wheelers, passenger cars, Light commercial vehicles, heavy-duty trucks (for more details, see [5])		

Table 1 *Summary of common vehicle types and descriptors*

Kick-scooters are particularly relevant to this study. Thus, the following definition will be used: electric scooters (E-scooters) are small electric-powered vehicles designed for short-distance transportation, with two wheels, a standing platform, handlebars, and a rechargeable battery. This modern e-scooter rose to prominence with the introduction of the Go-Ped in 1989 by Steve Patmont (*U.S. Patent for Motor Scooter Having a Foldable Handle and Friction Drive Patent (Patent # 4,821,832 Issued April 18, 1989) - Justia Patents Search*, n.d.). Early versions of the modern e-scooters in the 1990s targeted niche markets.

However, the industry transformed with the introduction of shared micro-mobility services such as Bird and Lime in American cities in 2017. As one component of micro-mobility service, modern e-scooters allow urban commuters a mode of affordable and environmentally friendly transportation.

Ownership Types

E-scooter use is typically broken down by their ownership type: private owned, retail rentals, and shared systems (as fleet operators), with the most popular ownership models being private ownership and shared fleet systems. Individuals can purchase their own e-scooters for daily commuting or leisure. This option provides reliability, cost savings over time, and longer scooter lifespan compared to shared models. Brands like Unagi, Segway-Ninebot, and Xiaomi cater to this market with foldable, high-performance scooters *(*New Website + Micro-mobility Landscape Tops 1,000 Companies*, n.d.)*. Shared fleet services emphasize last-mile transportation, reducing reliance on automobiles and public transportation for short urban trips. Shared fleets operate under agreements with local governments and frequently include sustainability initiatives such as swappable batteries and geofencing to manage parking and speed limits. The three largest companies in the shared e-scooter space are Bird, Lime and Spin. Additionally, some companies, such as Voi and Unagi, provide monthly subscription plans to help bridge the gap between ownership and short-term rentals. These services appeal to frequent riders who do not want to deal with maintenance because they provide personal scooters for a set price without the need for an upfront purchase.

Market Trends

Several prominent business journals and consultants have estimated the current and projected market size of e-scooters. According to a McKinsey report on shared mobility, the rapid growth of the micro-mobility market in recent years was fueled by increased consumer interest during the COVID-19 pandemic, specifically highlighting hygiene concerns, sustainability preferences, and increased travel flexibility are key factors driving this trend forward. Notably, over 90 cities have implemented policies to promote micro-mobility through increased cycling infrastructure.

Advances in technology are expected to improve consumer experience by allowing for longer travel distances and better integration with urban transportation systems. By 2030, the shared micro-mobility market is expected to grow to $50 billion to $90 billion, representing a 40% annual increase from 2019 to 2030, as shown in Figure 1 below. By then, shared micro-mobility could account for approximately 10% of the total shared-mobility market.

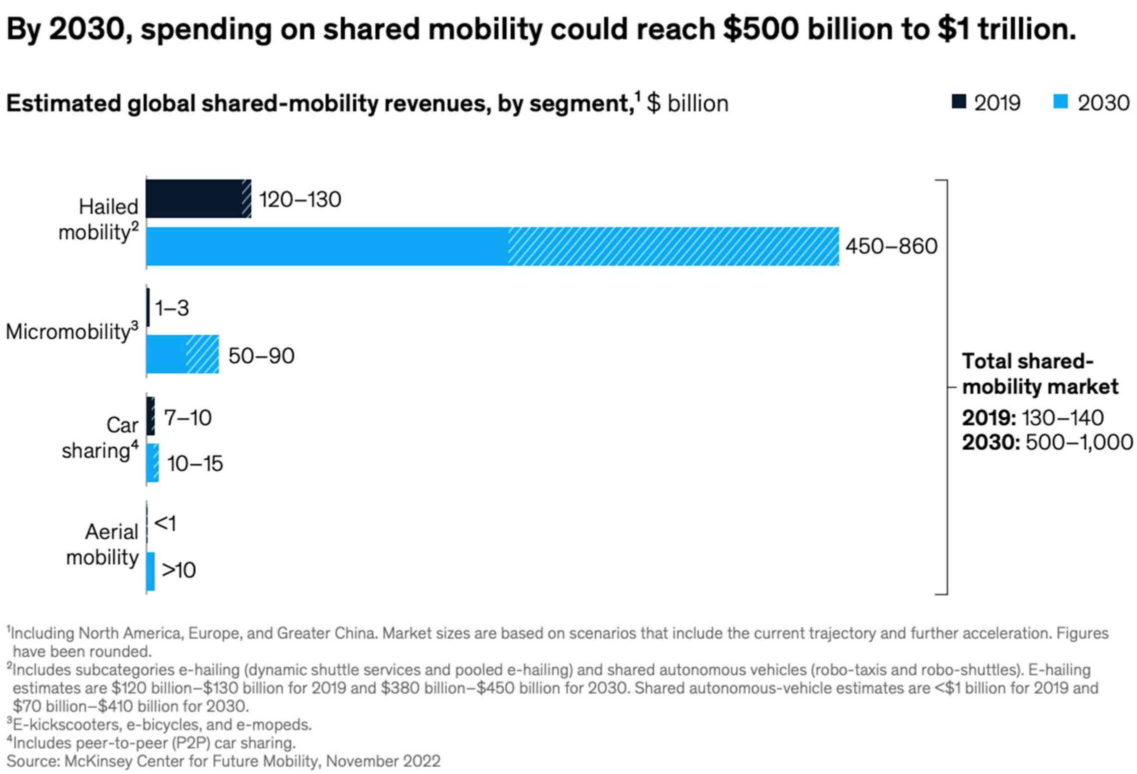

Fig. 1 *Estimated global shared-mobility revenues, by segment*

While McKinsey estimated the global micro-mobility sector at roughly $2 billion in 2019, more recent estimates provide market values for e-scooters alone at $2.3 Billion *(Research and Markets ltd, n.d.)* to $3.6 Billion *(SPHERICAL INSIGHTS LLP 9 min read, 2024)* in 2023. This market is driven by both personal ownership and ride-sharing models. For personal ownership, the average price of an e-scooter typically ranges between $300 and $600+, while ride-sharing services operate on a per-trip basis, charging an average of $1 per trip plus 15 cents per minute. Globally, the number of e-scooters in circulation varies depending on ownership and usage patterns. Ride-sharing accounts for approximately 40% of the market, with an estimated 1.5 million to 4.8 million units, while private ownership makes up 60%, with 2.3 million to 7.2 million units in use *(Nova One Advisor, n.d.)*.

Usage Trends

Globally, the number of e-scooters in circulation varies depending on ownership and usage patterns. Ride-sharing accounts for approximately 40% of the market, with an estimated 1.5 million to 4.8 million units, while private ownership makes up 60%, with 2.3 million to

7.2 million units in use. E-scooter usage rates demonstrate varying performance metrics. Bird's Life Cycle Assessment (LCA) assumptions suggest an average lifespan of 2 to 3 years, during which shared e-scooters travel between 3,055 and 4,295 kilometers, equating to an average daily usage of 4.18 km to 3.92 km (excluding weekly maintenance)(Bird, 2022). Another study estimates an average travel distance of 15 km per day over 360 days of operation, resulting in an annual range of 5,400 km, with a lifespan analyzed at 6, 12, and 24 months (Baumgartner & Helmers, 2024).

This highlights the reliance of shared e-scooter fleets on intensive use. Energy consumption further differentiates e-scooters from other modes of transport: e-scooters consume 1.3 kWh per 100 km, compared to 0.4 kWh for e-bikes and 20 kWh for electric cars, underscoring the energy efficiency of e-scooters relative to cars. E-bikes and electric kick scooters, however, still outperform Type 3 e-scooters (e.g mopeds) in energy savings, and have reduced energy consumption by over 90% compared to electric passenger cars (Weiss et al., 2020). In shared fleets, average usage per ride is approximately 8 minutes for 0.7 miles at an average speed of 5.23 miles per hour, as observed in specific markets like Seoul, South Korea (Baek et al., 2021).

United States

The market for e-scooters and e-bikes in the United States has experienced rapid growth over the past few years, driven by increasing demand for sustainable, cost-effective, and convenient transportation options. As cities face growing congestion and environmental concerns, e-scooters and e-bikes have emerged as viable alternatives to traditional modes of transport, particularly in urban areas. The rise of shared micro-mobility services, such as Lime, Bird, and Spin, has further accelerated the adoption of e-scooters, making them easily accessible to users for short-term rentals. Additionally, the surge in e-mobility sales can be attributed to an increasing focus on eco-friendly commuting and recreational activities. Many consumers are turning to e-mobility devices for their ability to cover longer distances while reducing the physical strain of traditional biking. A recent report by Grand View Research pegged the US e-bike market value at $2 billion, while projected a CAGR of 15.6% from 2023 to 2030 (*U.S. E-Bike Market Size, Share And Trends Report, 2030*, n.d.). According to Statista, the revenue for the E-Scooter sharing market is about $750 million in 2025. They also expect the number of users to increase to ~31 million by 2029 (Statista, n.d.).

The Bureau of Transportation Statistics published a data repository and analysis of bikeshare and e-scooter systems in the U.S., showing trends in commercial shared micro-mobility systems from 2015 to 2024. The following maps (fig 2) depict the different rideshare systems in the contiguous U.S. over time (2015, 2019, 2022 and 2024)(*Docked Bikeshare Ridership by System, Year, and Month | BTS Data Inventory*, n.d.).

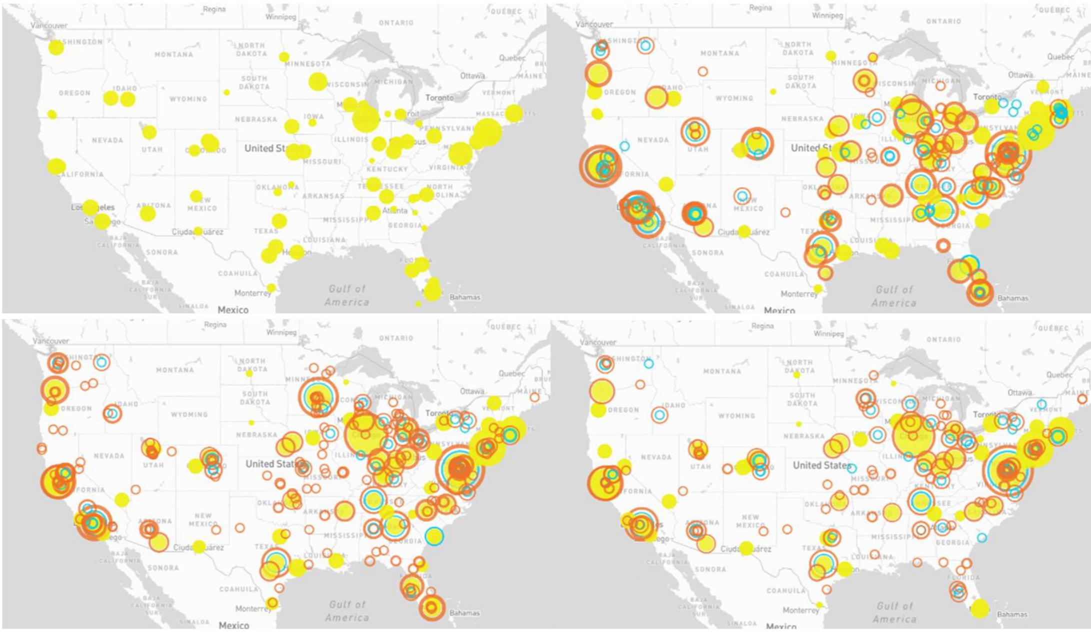

Fig. 2 *Micro-mobility sharing services over time. Yellow circles indicate docked bikeshare systems; blue circles indicate dockless bikeshare systems; orange circles indicate e-scooter fleets*

The COVID-19 pandemic further influenced e-mobility trends. A study in Chicago revealed that shared e-scooter usage increased during the pandemic, highlighting a shift toward micro-mobility solutions as people sought alternatives to crowded public transportation (Alisawi et al., 2024). However, a sharp closure in docked systems was seen in 2020, due to many docked systems being forced to cease operations due to the pandemic. Statistics from the BTS report show that the number of docked bikeshare systems nearly doubled from 2015 to 2019 (from 66 to 109) then declined from 109 in 2019 to 66 in 2020, and then to 54 in 2024 (Fig 4). In terms of number of trips, 2019 saw 46.5 million docked bikeshare trips, which fell to 38.3 million in 2020. This number has since increased to 56 million in 2023 (Fig 3). Data about undocked rides and e-scooters is not available, but Chahine et al. put the number of total trips by all shared micro-mobility modes at 35 million in 2017 (Chahine et al., 2024a).

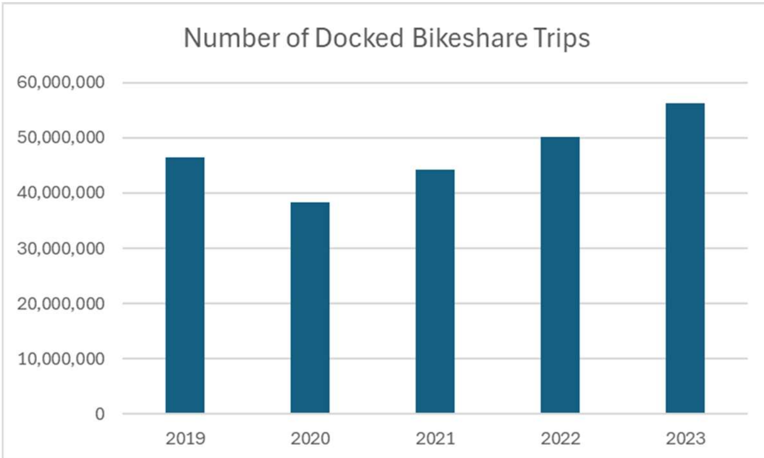

Fig. 3 *Number of Docked Bikeshare Trips in the United States (BTS)*

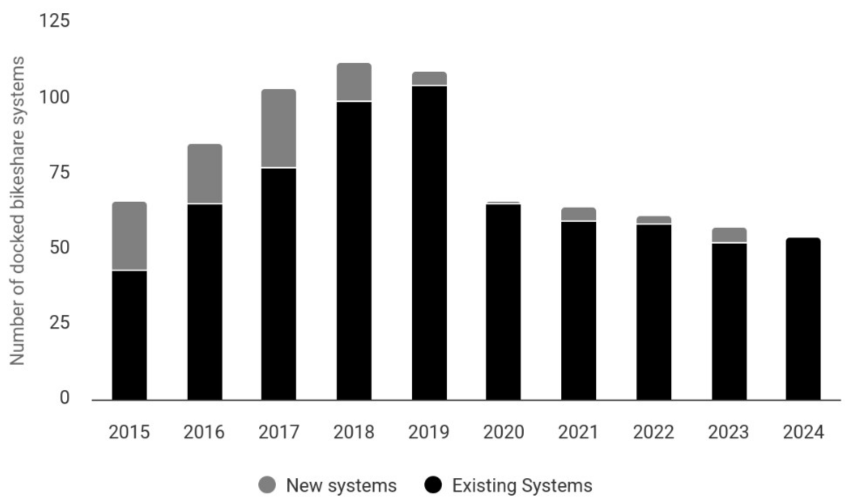

Fig. 4 *Number of Docked Bikeshare Systems in the United States (BTS)*

Meanwhile, e-scooter systems continued to grow till 2023, with only a marginal decline in 2020 (Fig. 4). In 2024, e-scooters served 130 cities down from the 2022 high of 179 cities. Consolidation and bankruptcy of e-scooter systems contributed to the decline.

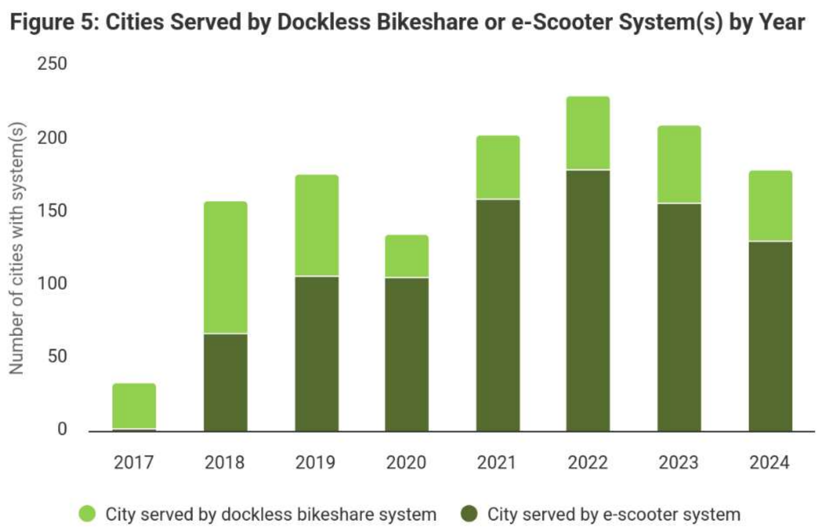

Fig. 5 *Cities Served by Dockless Bikeshare or e-Scooter System(s) by Year (BTS)*

Usage patterns of shared micro-mobility systems can be affected by local climate. We looked at monthly usage of docked bikeshare systems in select U.S. cities with different climates to identify differences. Specifically, we chose Austin, TX, which has hot summers and cool winters; Los Angeles, CA, which has a moderate climate throughout the year; and Boston, MA, which has cold winters (Figs. 6,7,8). For Austin, a 'double-peak' pattern is seen, with usage peaking in shoulder seasons between the hot summer and cold winter - this may also partially be attributed to decreased usage in the summer by UT Austin students. Los Angeles sees more consistent use throughout the year, with dips in the winter. Boston has the most pronounced pattern, with bikeshare trips falling sharply to a fifth of the annual maximum in the winter. Micro-mobility companies must thus plan for wildly varying revenues from month to month while maintaining service, favoring larger companies with greater cash reserves.

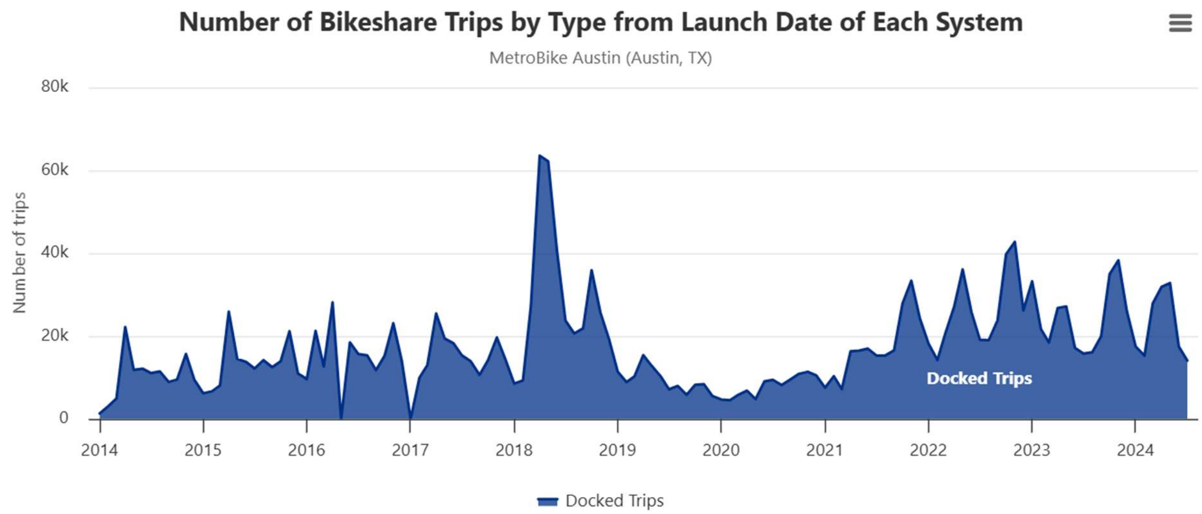

Fig. 6 *Number of Bikeshare Trips by Type from Launch Date of Each System (Austin, TX) (BTS)*

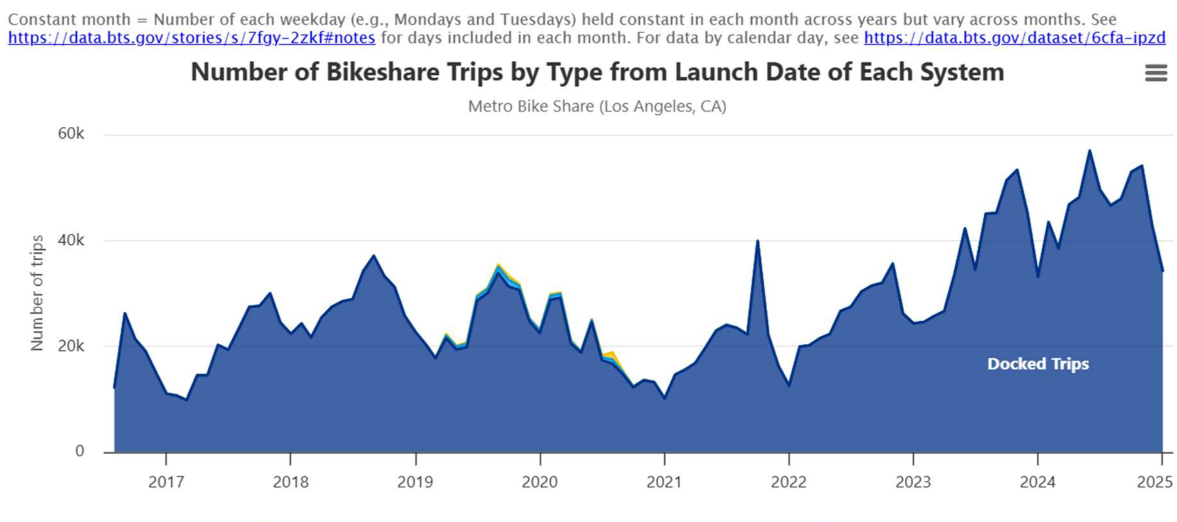

Fig. 7 *Number of Bikeshare Trips by Type from Launch Date of Each System (Los Angeles, CA) (BTS)*

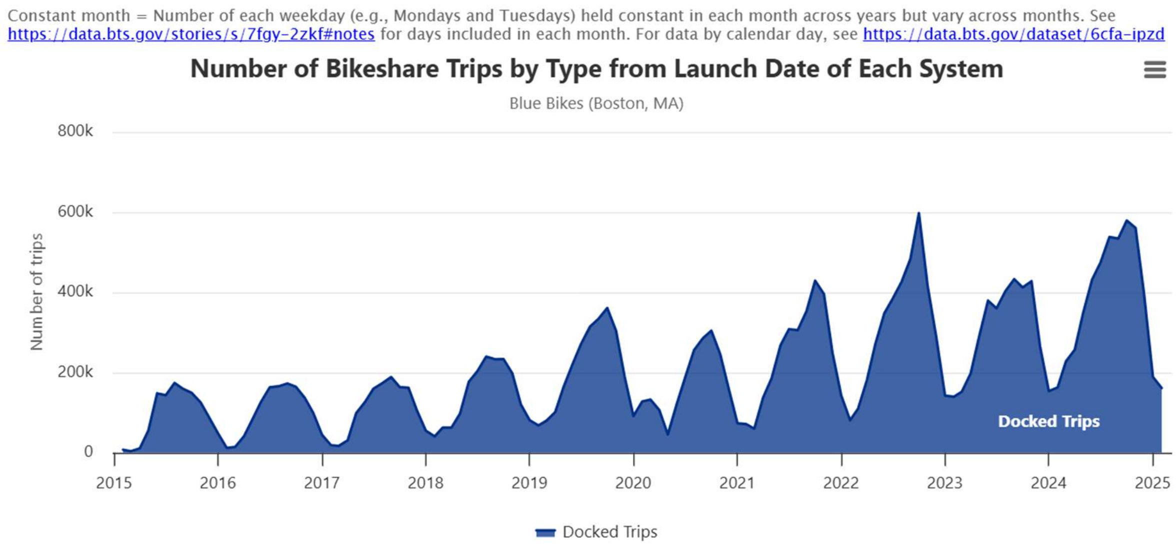

Fig. 8 *Number of Bikeshare Trips by Type from Launch Date of Each System (Boston, MA) (BTS)*

However, this rapid growth has also led to challenges. Cities like Santa Barbara have reported a significant rise in e-bike accidents, prompting discussions about safety regulations. Additionally, regulatory developments in Europe, such as Italy's new laws requiring helmets and insurance for e-scooter riders, have raised concerns about potential impacts on demand (Pridgen, 2025).

Personal E-Scooter Market

Personal e-scooters are fast growing to be as relevant as shared e-scooters with rapidly decreasing costs of ownership. The median price of an e-scooter is $300-400, ranging from basic $200 models to premium ones costing over $2500. To estimate the annual market size for personal e-scooters in the United States, sales data from various sources were considered. A review of best-selling e-scooters on Amazon suggests that approximately 15,000 units were sold in the past month alone. If these figures are accurate and representative of typical monthly sales, this would translate to an estimated 200,000 units sold annually through Amazon alone. However, Amazon is not the only sales channel for personal e-scooters. Consumers also purchase from other major online retailers such as Temu and brand-specific websites, as well as through brick-and-mortar stores. Taking these additional sales channels into account, a conservative estimate for total annual personal e-scooter sales in the U.S. is approximately 300,000 units. While this figure is an approximation, it provides a useful benchmark for understanding the scale of the personal e-scooter market. A study conducted in San Francisco in 2019 observing micro-mobility use found that of e-bike users, 74.7% were riding a shared vehicle and of e-scooter users, 34.6%. This indicates personal ownership of scooters is increasingly popular.

Universities

Literature studying micro-mobility use and perceptions on campus typically focus on non-motorized transportation modes. Explicit research into the use of e-bikes and e-scooters in a university setting is considered a research gap.

Literature has identified various demographic characteristics as predictors of both micro-mobility receptivity (one's predisposition to considering micro-mobility as an alternative to personal vehicle use and public transportation) and usage (one's observed behavior, including the frequency of micro-mobility trips taken).

The prevailing focus on receptivity, rather than usage, reflects the perception that potential users of micro-mobility represent the boundary of expanding micro-mobility uptake on university campuses. Thus, the majority of resources intended to increase micro-mobility use, considered a goal for campus administration, are directed towards (a.) identifying demographic groups at that boundary and (b.) providing recommendations for courting those groups, including infrastructure improvements, increasing the availability of sharing services, and information campaigns.

Demographic analysis from survey data into non-motorized micro-mobility indicates a gender gap in receptivity, with female respondents less receptive to active transport than male respondents (Davison et al., 2015; Hamad et al., 2024) However, surveys exploring receptivity of motorized micro-mobility indicate little-to-no statistical difference between genders. Instead, receptivity to motorized micro-mobility depends more on proximity to campus and a history of micro-mobility use (Chahine et al., 2024b; Eccarius et al., 2021a) A 2021 study of receptivity to shared electric micro-mobility on two university campuses in Australia identified three groups of respondents characterized not by shared demographic characteristics, but attitude. The most eager adopters are international students, who are more likely to associate shared micro-mobility with “community” and “environmental friendliness”. The group with the most skepticism toward shared micro-mobility, predominantly Australian-born students with an academic major in the STEM (science, technology, engineering, and math) field, are and describe it as “unnecessary”, or giving a “negative image”. The largest share of respondents view shared micro-mobility with positive attitudes, but are resistant to using it themselves and are more likely to view shared electric micro-mobility as incompatible with their lifestyles. Respondents in this group are likely to relate it to “travel uncertainties”, despite associating electric micro-mobility with environmental friendliness and convenience (Eccarius et al., 2021a).

On university campuses, micro-mobility is mostly considered a replacement for both walking and public transportation. One 2018 study of micro-mobility use at Arizona State University shows that in some cases, micro-mobility can serve as a substitute for personal vehicles, though this is atypical. There is some evidence that e-scooters can replace short distance commuting and are therefore well-suited to provide last-mile transit. This trend is increasing, with more students opting to use micro-mobility over personal vehicle use for commuting on university campuses (Sanders et al., 2020).

Safety

The rapid growth in the use of e-mobility has meant literature and data collection on safety has struggled to keep up. Significant safety concerns for both riders and pedestrians have been raised due to notable increases in crashes, fatalities and injuries. A literature review by the National Transportation Safety Board found that at least 119 fatalities related to e-bikes and e-scooters occurred between 2017 and 2021. According to the US Consumer Product Safety Commission (CPSC), emergency department visits related to micro-mobility devices surged from 34,000 in 2017 to 57,800 in 2020, primarily due to a substantial rise in e-scooter injuries, which more than tripled from 7,700 in 2017 to 25,400 in 2020 (CPSC 2021b). Additionally, the CPSC's preliminary analysis of 2021 data suggests an even larger potential increase in micro-mobility injuries, from 57,800 in 2020 to 77,200 in 2021, with e-scooter injuries continuing to be a major contributor (CPSC 2022). Similar increases in injuries were observed among e-bike riders in the United States during the same period. These trends are not limited to the United States. For example, a study in the Netherlands found that e-bike injuries were not only increasing but that Dutch e-bike riders were 1.6 times more likely to be injured than those riding conventional bicycles (Ricker 2022). Similar trends are seen in fatalities, in fact, a study conducted using data from 180 University of California, Los Angeles, outpatient clinics, found that e-bikes may have a higher rate of fatalities than motorcycles and cars (*Micro-mobility: Data Challenges Associated with Assessing the Prevalence and Risk of Electric Scooter and Electric Bicycle Fatalities and Injuries*, n.d.). A literature review by Kazemzadeh et al. found that the most common accident type for e-scooters was single collision (i.e. falling from the e-scooter) and head and face injuries were the most common damages (Kazemzadeh et al., 2023).

Helmet Use

A report published by the International Injury Research Unit at Johns Hopkins reviewed safety studies and regulations for e-mobility in various countries. A German study found that over 50% of emergency department patients involved in e-scooter crashes sustained head injuries, with none reporting helmet use despite company recommendations.

Similarly, studies in the U.S. have documented extremely low helmet usage among injured riders, with one study finding that 40% of reported injuries involved the head or neck—many of which could have been prevented or mitigated by helmet use. A study of micro-mobility users in San Francisco revealed significant differences in helmet usage between personal and shared vehicle riders. Among personal e-scooter riders, 56% reported wearing a helmet, compared to only 17% of shared e-scooter users. A similar trend was observed for e-bikes, where 86% of personal e-bike riders used helmets, while only 41% of shared e-bike users did (Frye et al., 2024).

The report also highlighted helmet regulations worldwide. In China, helmets are mandatory for e-bike riders, while Israel and Canada require helmet use for e-scooter riders under 18. Switzerland mandates helmets for high-speed pedal-assist e-bikes. Brisbane, Australia mandated helmet use for e-scooter riders and has seen consistent helmet use rates above 60%, indicating effectiveness of legal mandates (Haworth et al., 2019). Within the U.S., Connecticut has the strictest e-bike helmet laws, requiring all riders and passengers—regardless of e-bike class—to wear helmets. In a university setting, the University of Maryland Department of Transportation Services (DOTS), in collaboration with the town of University Park and the city of College Park, is piloting a one-year ride-share service that mandates helmet use.

The report emphasized the importance of safety awareness campaigns, improving data collection, and considering regulatory measures. A systematic review by Høye found that mandatory bicycle helmet laws reduced overall head injury rates by 20% and serious head injuries by 55% (Høye, 2018). However, the effectiveness of such laws remains debated. For example, Seattle recently repealed its mandatory helmet law due to concerns over disproportionate enforcement.

In 2023, a coalition of shared mobility providers, including Bird, Lime, Spin, and Superpedestrian, introduced guidance on best practices for e-mobility regulation. Regarding safety, they recommended a 15-mph speed cap, aligning e-scooter speeds with bicycles and e-bikes. A lower speed discourages riders from using roadways with fast-moving vehicles and encourages them to stay in bike lanes or on sidewalks. However, they cautioned against auto-throttling speeds on sidewalks, arguing that it could force riders onto unsafe roadways without significantly improving pedestrian safety.

The coalition also challenged the assumption that helmet laws improve rider safety. Citing multiple studies, they argued that there is no reliable correlation between helmet mandates and reduced injuries. One explanation is that helmets may create a false sense of security among both riders and drivers, leading to closer interactions and increased collision risks. Additionally, research suggests that "safety in numbers" plays a critical role—cities with higher concentrations of micro-mobility users tend to experience fewer accidents overall. Since helmet mandates can discourage e-scooter and e-bike use, they may inadvertently reduce this protective effect.

From an equity perspective, the coalition highlighted concerns that helmet laws disproportionately impact lower-income and minority riders. Studies by Wisniewski et al. and Sanders et al. found that such laws are more strictly enforced against minority riders. Furthermore, the cost and accessibility of helmets pose an additional burden for lower-income users, potentially limiting their access to micro-mobility options.

Infrastructure

The infrastructure requirements for supporting micro-mobility in a college campus context differ from those necessary for a city due to the absence of motor vehicles. Such a pedestrianized multi-modal environment is understudied in the literature, however, general guidelines for bike path widths and infrastructure still serve as a baseline to build from. The American Association of State Highway and Transportation Officials' (AASHTO) guidelines for multi-use trail widths are often used as a standard. They recommend paths be 12-14 ft in width if heavy use is expected, as is the case on the UC Davis campus. Concerning pavement conditions, e-scooters are highly susceptible to road surface imperfections and surface transitions. Poor pavement conditions like potholes, cracks and uneven surfaces have been identified as major causes of e-scooter crashes. Thus, paths should be regularly maintained and designed to have smooth transitions between surfaces. Clear right of way markings at intersections can help prevent crashes. Speed limits on multi-use trails are another way of managing behavior. The UC Davis campus has a 15-mph limit on riders. Yet, this is rarely, if ever, enforced. In fact, most riders are probably unaware that this speed limit exists as there aren't any signs for it. The Rails to Trails Conservancy recommends speeds be limited to those a regular bicycle could achieve - 15 to 20 mph. A similar example in a city is the Capital Crescent Trail in Washington, D.C., and Maryland, with approximately 1 million users each year. It has a legal speed limit of 15 mph to help in managing conflicts between road cyclists and slower users, but enforcement is essentially left to other trail users. Legal enforcement could potentially generate concern among groups that have experienced discriminatory enforcement practices, as was the case with the Seattle helmet law (*Micro-mobility Devices on Multiuse Trails*, n.d.).

Assessing Receptivity in Micro-Mobility Surveys

The most heavily emphasized aspect of micro-mobility research on university campuses is the use of survey questions to understand receptivity to micro-mobility. Various works in this subject have explored survey respondents' opinions on micro-mobility in addition to, and irrespective of, their usage of micro-mobility. For example, Eccarius et al. employed the use of an analytical model to calculate *Willingness to Adopt*, a metric used to compare respondents across demographics (Eccarius et al., 2021b).

Methodology

Exploratory Data Analysis

The UC Davis Campus Travel Survey is a collaborative effort between Transportation Services (TS) on campus and the National Center for Sustainable Transportation (NCST), which is part of the Institute of Transportation Studies (ITS) at UC Davis. Since 2007, the survey has been conducted annually in the fall by a graduate student at ITS. Its primary goal is to gather annual data on how members of the UC Davis community commute to campus, including details such as commuting methods, vehicle occupancy, distances traveled, and carbon emissions.

Over time, the survey results have been utilized to evaluate awareness and usage of campus transportation services, estimate the demand for new services aimed at promoting sustainable commuting, and offer researchers valuable insights into how people's opinions about different transportation options influence their choices for commuting. This year's survey, conducted for the 2024-2025 academic year and administered online in October and November 2024, marks the eighteenth time the campus travel survey has been administered. As part of the wider acknowledgment, this survey was conducted and completed by Justin Darr and Dillon Fitch-Polse. This paper expands on the work and dataset developed as part of the 2023-2024 and 2024-2025 UC Davis Campus Travel surveys (Darr, n.d.).

Similar to the 2023-24 survey, the 2024-2025 survey gathered information from 4,526 individuals associated with UC Davis about their travel to campus during a one-week period in October 2024. It utilized a stratified random sampling technique to ensure the collection of a representative sample of the campus population.

To ensure the statistics in this report accurately reflect the broader campus population, responses are weighted according to the respondents' roles and gender, aligning the sample composition with the actual demographic proportions of UC Davis. Unique to this survey, as compared to previous iterations, was the inclusion of safety data between modal shares surveyed as accidents experienced and the severity of the most recent accident of a respondent.

The CTS data is spatially and chronologically represented to capture transportation usage and accident reports across many locations on campus for 2024. As reported by a subset of respondents, usage data includes several modes of transportation such as walking, cycling, driving, public transit, and e-scooters. The dataset also provides integer accident statistics that are representative of the total number of accidents documented during the year. Accident severity is recorded based on each respondent's most recent crash incident, with occurrences classified as no injury, minor injury, or severe injury. The crash incidents also asked for the crash type and cause, with collision examples including “Collision with cyclist” “A slip or swerve that resulted in a fall” and “Collision with an e-scooter rider”. So the CTS data provides information on the modal type of the riders, injury severity of recent crashes, and crash interactions with all modal types.

For analytical purposes, we assume that respondents' socio-demographics and other characteristics that can influence their choice of transportation are similar to those of the general population in their role group (freshmen, sophomores, etc.). As a result, we weight the sample by gender and role group. Here are the used weightings for the population.

Role	Female	Male	Nonbinary	Unknown
Freshman	3,428	2,269	110	139
Sophomore	3,599	2,440	120	136
Junior	4,857	3,376	176	163
Senior	6,531	4,678	180	172
Master	1,345	1,217	29	194
PhD	2,115	1,669	93	169
Faculty	789	920	8	230
Staff	5,332	3,771	94	1087
TOTAL				**51,436**

Table 2 *Population weightings for UC Davis*

Hotspot Analysis

Hotspot analysis is an established method for identifying high-risk areas in transportation networks, allowing for targeted safety interventions. Studies have demonstrated its effectiveness in analyzing crash patterns and prioritizing mitigation efforts (Alkaabi, 2023; *Analyzing Traffic Accidents in Space and Time—Analytics | Documentation*, n.d.; Bíl et al., 2019). Traditional approaches often use spatial statistical tools like kernel density estimation or Getis-Ord Gi* in ArcGIS to detect clusters of crashes. However, due to the absence of temporal data and lack of access to ArcGIS, we used DBSCAN (Density-Based Spatial Clustering of Applications with Noise) for hotspot identification. DBSCAN effectively serves the same purpose by detecting areas with a high concentration of crashes without requiring predefined cluster numbers. As a density-based clustering algorithm, it allows for the identification of statistically significant crash clusters while filtering out isolated incidents, ensuring that the identified hotspots accurately represent locations with persistent safety concerns.

The dataset consisted of crash locations recorded with latitude and longitude coordinates, as well as severity classifications (No injury, minor or possible injury, severe injury). The data was first cleaned to only include locations of bike and e-scooter crashes since these account for most of the crashes. Then, invalid entries where both bicycle and e-scooter crash coordinates were present were removed, as well as entries with missing information. The study area was restricted to a specific geographic boundary around UC Davis to ensure relevance.

To assess the severity of each identified hotspot, a weighted severity score was computed based on injury cost estimates from the Federal Motor Carrier Safety Administration. Specifically, we accounted for the Quality-Adjusted Life Years (QALY) cost component, excluding healthcare and vehicular damage costs (*FMC-PRE-240812-001-Federal Motor Carrier Safety Administration Crash Cost Methodology Report 2024 | FMCSA*, n.d.). The QALY costs were defined as a fraction of the Value of a Statistical Life (VSL), determined by the severity of the injury using the Maximum Abbreviated Injury Scale (MAIS). Table 3 details how survey responses were mapped to VSL fractions, which were then used as severity weights. The total severity score for each hotspot was determined by summing the weighted severity values of all crashes within a cluster. The representative location for each hotspot was selected as the crash point closest to the cluster centroid. Finally, the hotspots were visualized on an interactive map using Folium, with marker sizes scaled proportionally to the total severity score, enabling easy identification of the most critical areas requiring safety interventions.

A sensitivity analysis was conducted to evaluate the robustness of the severity weighting system. In this analysis, the weight for 'No apparent injury' was increased (0.001), and the weight for 'Severe injury' was reduced to be five times that of 'Minor or possible injury' (0.015). This adjustment aimed to assess the impact of varying the severity weight distribution on the identification of crash hotspots. However, the results showed no significant change in the size or distribution of the hotspots, indicating that the hotspot identification process was relatively insensitive to these changes in the severity weight assignments. This suggests that the severity weights applied in the original model are sufficiently robust to minor adjustments in their values.

	MAIS Severity Assigned	Example of injury	VSL fraction
No apparent injury	MAIS 0	-	0
Minor or possible injury	MAIS 1	Superficial laceration	0.003
Severe injury	MAIS 2	Minor bone fracture	0.047

Table 3 *MAIS severity mapping to CTS severity*

Results

The preliminary analysis of the CTS survey reveals trends in micro-mobility usage on the UC Davis campus, such as e-bike and e-scooter usage accident rates. discuss usage and accidents varying according to modal type and demographic factors. The appendix contains additional visualizations of these trends, such as detailed breakdowns of user demographics, and accident frequency severity.

Exploratory Data Analysis

Accident Rates

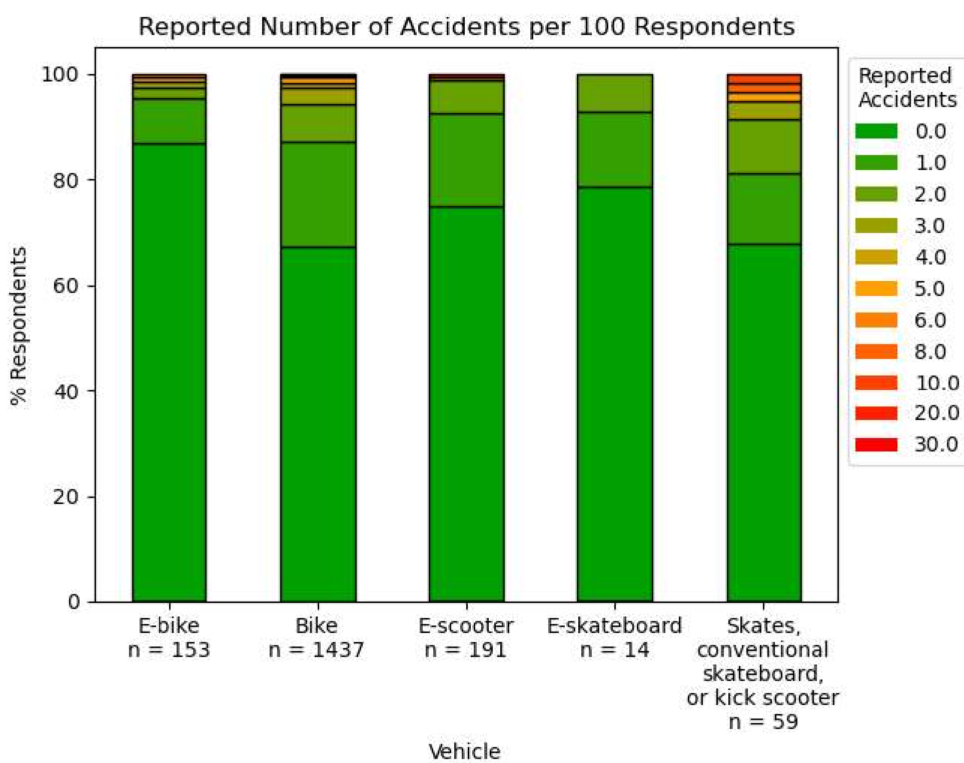

Fig. 9 *Reported Number of Accidents per 100 Respondents to the CTS in the year prior*

This figure shows the number of accidents that respondents to the CTS reported to have experienced within the year prior to the CTS. Across the five micro-mobility modes surveyed, most users of every mode claimed to have experienced no accidents within the last year.

Accident Severity

The data reveals how injury severity varies across different means of transportation. Out of all respondents who reported injuries, those on bicycles made up the greatest share (n = 468), followed by walking/wheelchair users (n = 133) and e-scooter users (n = 48). Users of e-bikes, e-skateboards, and other modes reported fewer injuries.

Notably, e-scooters had the largest proportion of severe injuries (18.8%), which is substantially more than bicycles (4.9%) and e-bikes (5%). In contrast, E-bikes had the largest proportion of minor injuries (80.0%) and the lowest proportion of no apparent injuries.

Additionally, e-skateboards, despite having a small study size (n = 3), reported a large proportion of minor injuries (66.7%) with no severe injuries, which indicates a higher propensity for less serious accidents, but remains limited in its applicability to the wider UC Davis campus.

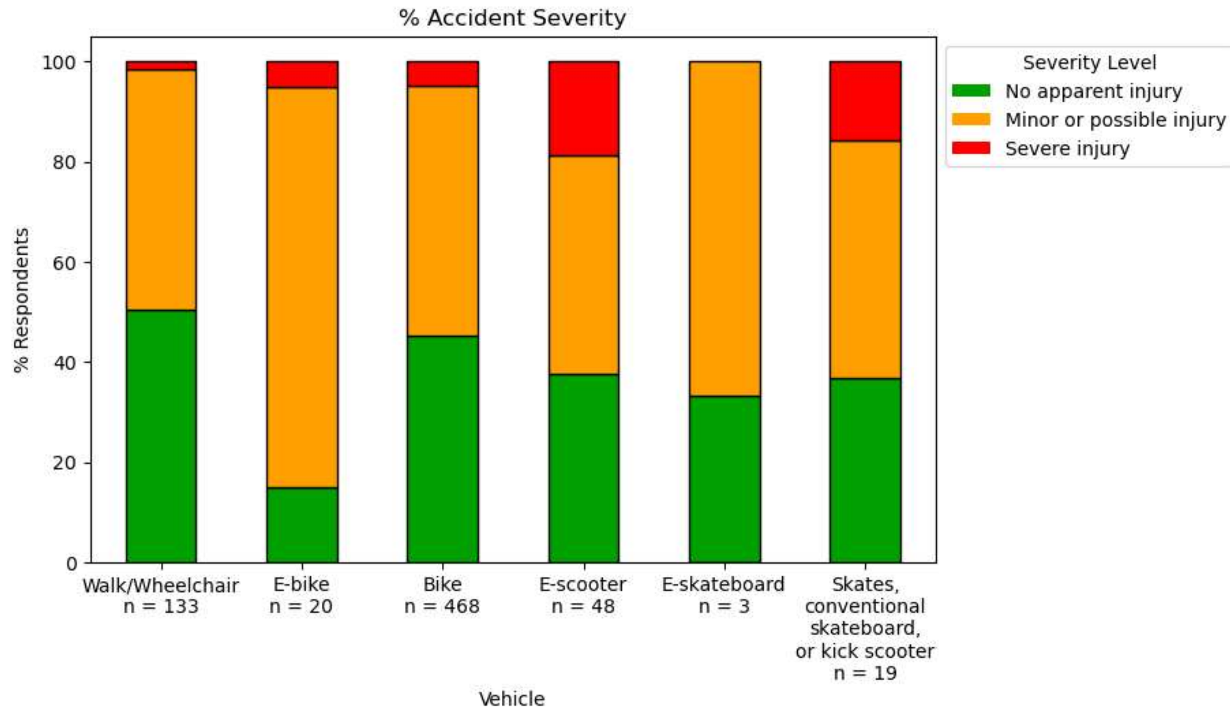

Fig. 10 *Severity Level of Accidents Reported in the CTS by Mode, normalized by total number of users of each mode*

Out of the users of each type of transportation who reported an accident within the last year, the severity of their most recent accident is shown above. Among the five most widely used modes, most respondents reported either "no apparent injury" or "minor or possible injury", with a minority reporting their most recent accident resulting in "severe injury". Out of all types, users of e-scooters report the greatest share of their most recent crash as resulting in "severe injury".

Severity	Walk/ Wheelchair n = 133	E-Bike n = 20	Bike n = 468	E-Scooter n = 48	E-Skateboard n = 3	Other n = 19
No Injury	50.3	15.0	45.3	37.5	33.3	36.8
Minor Injury	48.1	**80.0**	49.8	43.8	66.7	47.3
Severe Injury	1.5	5.0	4.9	**18.8**	0.0	15.7

Table 4 *Reported Crash Severity Percentage Attribution*

Crash Types

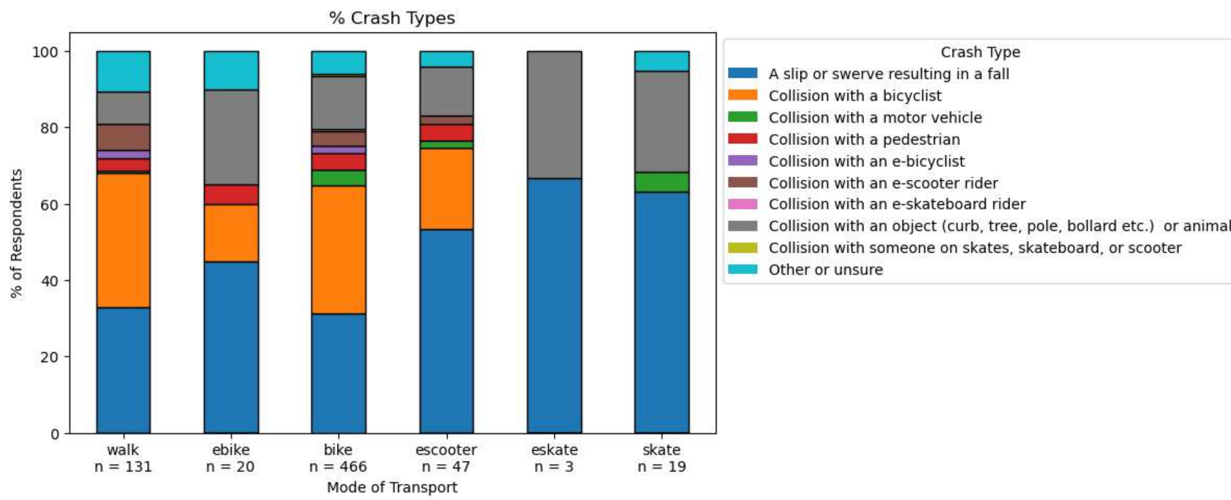

Fig. 11 *Causes of Accidents Reported in the CTS by Mode, normalized by total number of users of each mode*

This figure compares the causes of a respondent's most recent crash reported in the CTS by mode. Across all modes, a plurality of users who reported a crash attributed their most recent crash to their own reason, not involving another person ("A slip or swerve resulting in a fall" in dark blue). Across the 3 most widely used modes, the most common cause of a crash involving another person is a collision with a bicyclist (in orange). This matches our intuitions, as bicycles are the most common type of micro-mobility used on campus. The most common cause of a crash involving another person for users of e-bikes is collision with an e-scooter. Somewhat bizarrely, users of e-scooters did not attribute any of their most recent accidents to collisions with e-bikes, despite them comprising similar numbers of users experiencing one or more crashes.

In general, the causes of collisions reflect the use of shared spaces across micro-mobility modes. We expect pedestrians and e-scooters to occupy the same space (principally sidewalks), and we expect users of bikes and e-bikes to occupy the same transportation infrastructure.

Gender and Role Survey Results

In order to shed light on the connections between different demographic groups' accident frequencies and transportation behaviors from the CTS, this analysis looks at the differences in utilization rates and accident frequency across different modal types. To provide a thorough view of the data, we present both raw and weighted accident counts, which are broken down by gender and role category. The raw counts are the unadjusted number of reported incidents from the survey, which provides an overview of total accident occurrences. However, changes in group size can skew these raw counts. To address this, we also give weighted counts of the UC Davis campus demographics to adjust for any over- or under-representation of specific groups and subsequently make the data more representative of the entire campus population, as can be found in Table 5. The raw and weighted demographic statistics by modal use and accidents can be found in Tables 6 and 7.

Campus Weighting			
Gender	**Raw Count By Gender**	**Population Weight[1]**	**Weighted Count**
Female	2,817	0.544288	1533.259296
Male	1,142	0.395443	451.595906
Genderqueer or Nonbinary	163	0.015748	2.566924
Prefer Not to Say	130	0.044521	5.78773
Unknown (-99)	4	N/A	0
Role	**Raw Count By Role**	**Campus Weighting**	**Weighted Count**
Senior	889	0.1156	102.7684
Staff	620	0.1224	75.8880
Junior	587	0.1668	97.91160
Freshman	568	0.2248	127.6864
PhD	554	0.0542	30.0268
Sophomore	549	0.0787	43.2063

Faculty	340	0.0379	12.8860
Master	322	0.2000	64.400
Not Affiliated	51	0.1156	5.8956
Notes: 1. Campus demographic weighting provided by the Institute of Transportation Studies, University of California, Davis			

Table 5 *Campus weighting*

Raw Counts By Mode					
Gender	**E-bike**	**Bike**	**E-scooter**	**E-skateboard**	**Skates/Kick Scooter**
Unknown (-99)	0	1	0	0	0
Female	87	903	105	8	24
Genderqueer/Nonbinary	7	72	9	1	5
Male	62	475	87	7	29
Prefer not to say	6	49	7	1	5
Role	**E-bike**	**Bike**	**E-scooter**	**E-skateboard**	**Skates/Kick Scooter**
Unknown (-99)	0	1	1	0	1
Faculty	16	138	8	0	3
Freshman	2	11	5	3	2
Junior	21	266	39	2	8
Master	11	70	13	2	7
PhD	19	269	28	2	7
Senior	34	351	56	4	21

Sophomore	22	265	38	2	7
Staff	37	129	20	2	7
Not Affiliated	0	0	0	0	0

Table 6 *Raw counts by mode*

Raw Accidents By Mode						
Gender	**Walk/Wheelchair**	**E-bike**	**Bike**	**E-scooter**	**E-skateboard**	**Skates/Kick Scooter**
Unknown (-99)	0	0	0	0	0	0
Female	247	27	494	66	1	15
Genderqueer or Nonbinary	18	0	65	1	1	4
Male	32	9	242	23	2	22
Prefer Not to Say	20	0	36	2	0	8
Role	**Walk/Wheelchair**	**E-bike**	**Bike**	**E-scooter**	**E-skateboard**	**Skates/Kick Scooter**
Unknown (-99)	1	0	0	1	0	0
Faculty	19	2	26	1	0	9
Freshman	5	0	8	0	0	0
Junior	35	4	191	51	0	4
Master	13	10	38	1	0	3
PhD	32	2	110	9	2	1
Senior	106	8	170	17	2	22

Sophomore	81	7	276	10	0	9
Staff	25	3	18	2	0	1
Not Affiliated	0	0	0	0	0	0

Table 7 *Raw accidents by mode*

Furthermore, we standardize accident counts per 100 people in each category to improve comparability. This standardization accounts for differences in group size, making it easier to identify patterns in accident occurrence relative to the population of each subgroup. A more comprehensive picture of how various groups experience accidents in relation to their size is painted when the data is presented in terms of accidents per 100 people. This dual approach, which combines raw, weighted, and standardized data, allows for a more nuanced interpretation of the results, emphasizing both incident frequency and relative risk to each group.

Role Based Analysis

The role-based analysis highlights variations in accident incidence across different academic roles. This dataset provides insights into the transportation preferences and accidents of different academic and professional groups, including Faculty, Students (Freshman, Sophomore, Junior, Senior, Master's, PhD), and Staff. Table 8 below provides the weighting of the survey data according to campus population. This ensures that the results accurately reflect the broader university community. Table 9 provides the data presented in terms of accidents per 100 people; the majority of the analysis provided relies on the standardized accident counts.

Role	**Walk (or Wheelchair)**	**E-bike**	**Bike**	**E-scooter**	**E-skateboard**	**Skates, Conventional Skateboard, or Kick Scooter**
Freshman	0.1156	0.0000	0.4624	0.0000	0.0000	0.0000
Sophomore	2.6925	0.3672	17.8682	0.8567	0.0000	0.3672
Junior	2.6665	0.3333	16.832	2.4998	0.0000	0.3333
Senior	11.0135	1.3486	22.0269	3.1467	0.4495	1.7981
Master	0.3249	0.1624	1.1912	0.0541	0.0000	0.1083

PhD	1.1013	0.1573	5.4276	0.5506	0.0787	0.0787
Faculty	0.3028	0.0379	0.5678	0.0379	0.0000	0.0757
Staff	3.5989	0.5998	2.9991	0.3999	0.0000	0.1999

Table 8 *Weighted accident counts (Role)*

For undergraduate students, accident rates are highest among sophomores and juniors for bikes and e-scooters, suggesting potential behavioral or exposure-related factors influencing these trends. For seniors, lower bike accident rates (28.9 per 100 people) compared to juniors (39.5) and sophomores (57.5) may reflect increased experience commuting on campus or shifts in modal habits. However, seniors exhibit higher risk profiles for skates and skateboards (66.7 per 100) and could indicate potential vulnerabilities associated with these modes.

Role	**Walk (or Wheelchair)**	**E-bike**	**Bike**	**E-scooter**	**E-skateboard**	**Skates, Conventional Skateboard, or Kick Scooter**
Freshman	6.67	0.00	44.44	0.00	0.00	0.00
Sophomore	6.83	15.00	57.48	20.00	0.00	42.86
Junior	4.11	10.00	39.45	39.47	0.00	28.57
Senior	7.83	18.75	28.91	26.92	66.67	40.00
Master	5.04	33.33	32.84	10.00	0.00	28.57
PhD	3.62	10.53	27.38	26.92	50.00	16.67
Faculty	3.29	6.25	11.28	16.67	0.00	66.67
Staff	4.47	8.57	11.90	11.11	0.00	16.67

Table 9 *Accidents per 100 People (Role)*

Among graduate students, master's students report notably high e-bike accident rates (33.3 per 100), suggesting that e-bike adoption may be associated with unique risk factors for this group. In contrast, PhD students demonstrate relatively low bike-related accident rates (27.4 per 100), which could either result from a lower reliance on micro-mobility for commuting, or their increased experience with modal transport on bikes.

Faculty and staff exhibit consistently low accident rates across all modes reflecting their experience, caution, or representative trip rate on campus. However, a strikingly high skateboarding/skate accident rate (66.7 per 100) among faculty members suggests either a high-risk subgroup or a potential sample size anomaly.

Gender-Based Analysis

The gender-based analysis reveals significant variations in accident incidence across different modes of transportation. Table 12 provides weighted accident counts while Table 13 provides standardized accident counts per 100 people. Standardizing accident rates per 100 individuals allows for a more meaningful comparison across gender demographics and to account for differences in population size.

The raw weighted accident numbers show that females had the largest absolute number of accidents in all forms of transportation. For example, females are responsible for 148.59 bicycle accidents, greatly exceeding the 58.53 observed for males. Similarly, they report 55.52 walking-related accidents, compared to only 6.33 for men. This pattern shows that a higher proportion of female survey respondents reported accidents, or that women are more likely to use active transportation modes on campus.

Meanwhile, males have fewer total accidents in most categories, with the exception of slight variations in skateboard-related accidents (3.56 vs. 3.27). Nonbinary and genderqueer people, as well as those who prefer not to reveal their gender, have relatively low absolute accident counts because of their limited representation in the sample.

Gender	**Walk (or wheelchair)**	**E-bike**	**Bike**	**E-scooter**	**E-skateboard**	**Skates, Conventional Skateboard, or Kick Scooter**
Female	55.52	8.71	148.59	14.7	0.54	3.27
Male	6.33	1.58	58.53	7.51	0.40	3.56
Genderqueer or Nonbinary Gender	0.08	0.00	0.50	0.02	0.02	0.05

Prefer Not to Say	0.53	0.00	0.76	0.04	0.00	0.04

Table 10 *Weighted Accident counts (Gender)*

Women report the highest number of accidents overall, which aligns with their greater representation in the survey data. However, when adjusted for population size, genderqueer or nonbinary individuals exhibit the highest accident rates across multiple modes, particularly for biking (45.7 per 100 people), skates and conventional skateboards (60 per 100 people) e-skateboards (100 per 100 people). This could suggest a heightened risk profile for this group, potentially due to differences in riding behavior, infrastructure accessibility, exposure to unsafe conditions, or a statistical anomaly due to the small sample size.

Among men and women, bike accidents per 100 people are nearly equivalent, with men at 32.1 and women at 31.3. However, e-scooter accident rates are notably higher for women (27.8 per 100) compared to men (23.2 per 100), which may be indicative of differences in e-scooter usage patterns or safety outcomes. Conversely, men report a slightly higher accident rate for skates and conventional skateboards (31.0 per 100) compared to women (27.3 per 100), which could be attributed to behavioral differences or mode preference trends.

Gender	**Walk (or wheelchair)**	**E-bike**	**Bike**	**E-scooter**	**E-skateboard**	**Skates, Conventional Skateboard, or Kick Scooter**
Female	6.10	18.82	31.34	27.84	14.29	27.27
Male	2.32	6.78	32.1	23.17	14.29	31.03
Genderqueer or Nonbinary Gender	4.90	0.00	45.71	12.5	100.00	60.00
Prefer Not to Say	14.63	0.00	36.96	14.29	0.00	20.00

Table 11 *Accidents per 100 people (Gender)*

Furthermore, people who choose not to reveal their gender had disproportionately high accident rates while walking (14.63 per 100) and biking (36.96 per 100). This could indicate an underrepresented population with special mobility issues that require additional examination.

SPIN Data

We received a summary of statistics relating to Spin mobility usage in 2024 from TAPS that we studied to understand the state of shared mobility usage in Davis. We report the relevant statistics in the table below (Table 14). A total of 152,833 trips shows that the service was used extensively. Of these, 55044 trips, about a third, were on e-bikes while the rest were on e-scooters. The e-scooters saw a utilization rate roughly thrice that of the bikes (1.57 rides per day vs 0.6 rides per day). The average trip length in minutes was 10.43. Assuming the riders average 10 mph, this indicates an average trip distance of 1.7 miles, reflecting that shared mobility was used both for last mile transit and longer trips. Although initially contracted to maintain 2 e-bikes for each scooter, given the higher usage of e-scooters, Spin is working to reverse the ratio to be 2 scooters per e-bike. Thus, the campus and city need to be prepared for increased e-scooter use in the future. The city received 160 311-complaints about Spin vehicles. In total 4636 riders were warned and 201 were fined. The average fine was $5, we assume mostly for incorrect parking.

Total number of rides	152833
Bikes Trips	55044
Bike Utilization Rate (RPD)	0.60
Scooter Trips	96892
Scooter Utilization Rate (RPD)	1.57
Average length of trip (minutes)	10.43
Average number of trips per month from repeated user	4.13
311-Complaints	160
Riders Warned	4636

Riders Fined	201
Total Dollar value	1040
Average Idle Time	20.91

Table 12 *Number of Rides by mode*

Hotspot Analysis

Raw Analysis

The first map (Fig. 12) displays the locations of all bike and e-scooter crashes, serving as a reference for analyzing the crashes that make up identified hotspots. The next map (Fig. 13) highlights 23 hotspots where at least three crashes occurred. These locations were classified into 4 types - roundabouts, roadway intersections, bikeway intersections, and others.

Contrary to expectations that roundabouts would dominate, only 10 of the 23 hotspots were roundabouts. The remaining hotspots included 5 roadway intersections, 9 bikeway intersections, and 1 classified as "other"—the Teaching and Learning Complex parking lot. Notably, the Russell at Sycamore hotspot was classified as both a roadway intersection and a roundabout due to the aggregation of two nearby crash sites. Additionally, the crossing connecting the ARC to Sprocket was classified as both a bikeway and roadway intersection.

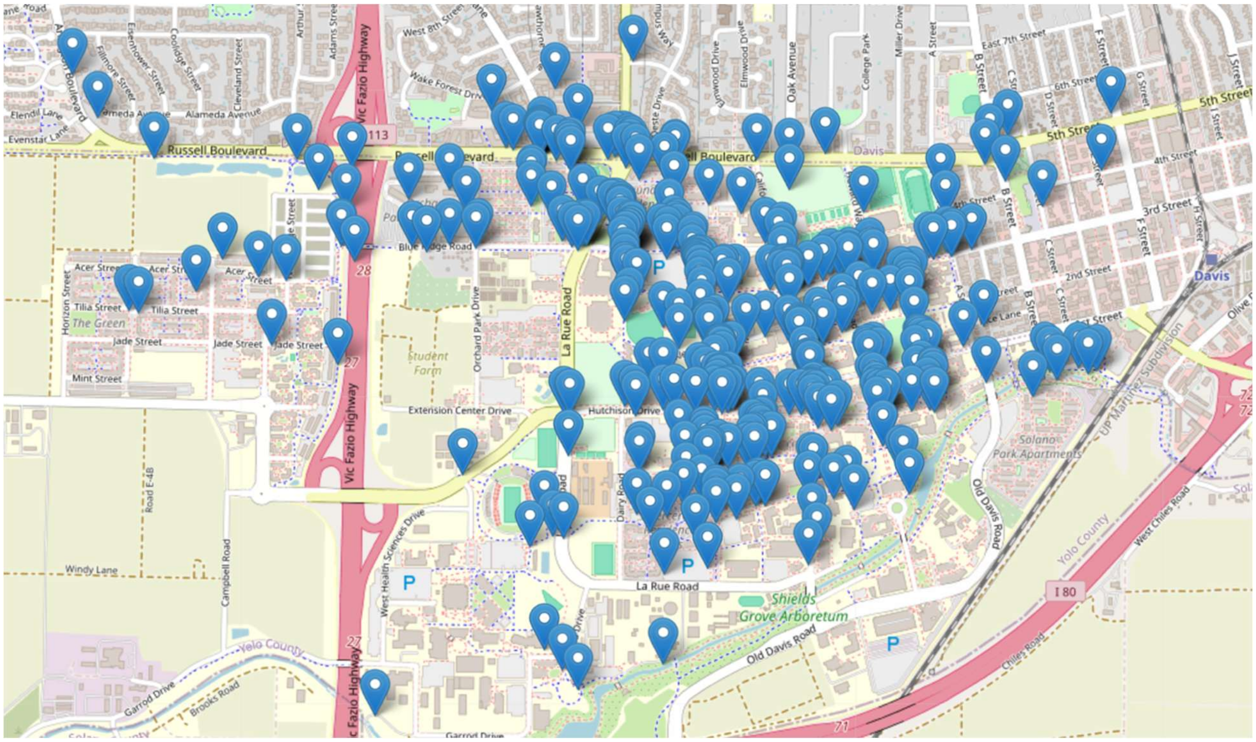

Fig. 12 *Locations of all bike and e-scooter crashes recorded in the CTS*

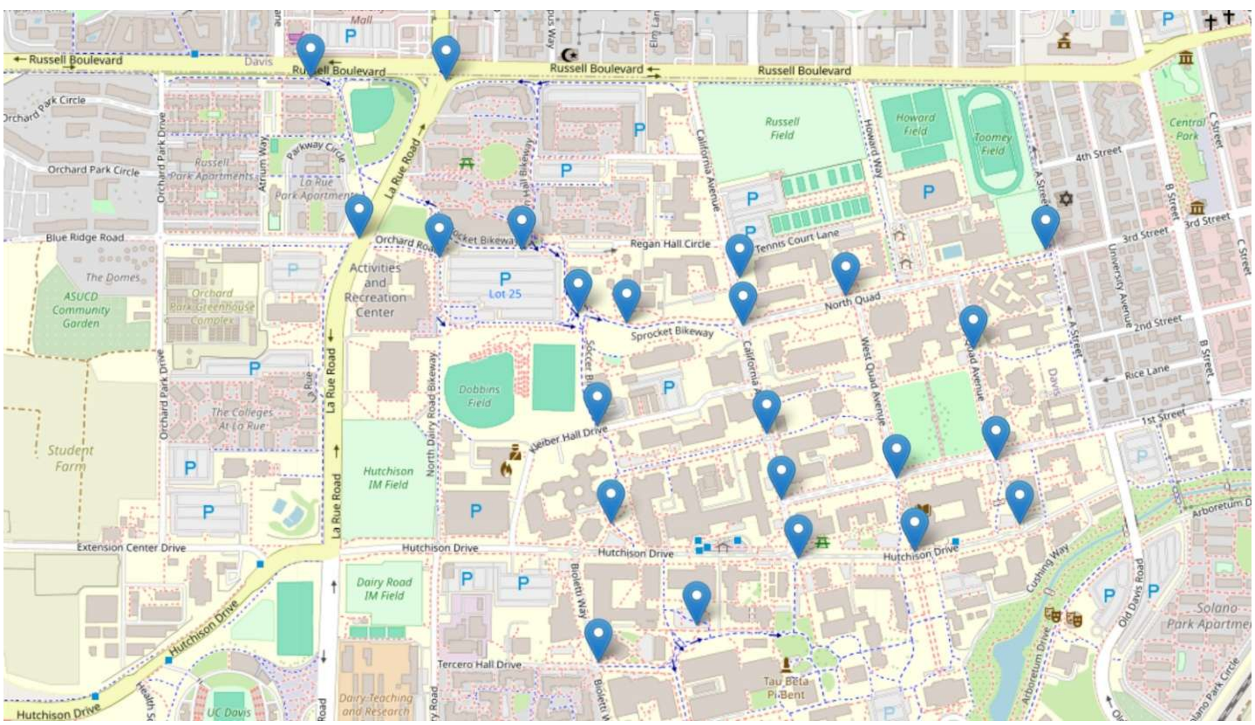

Fig. 13 *Locations of hotspots identified from the CTS*

Roadway intersection hotspots are particularly concerning due to their proximity to high-speed traffic. Addressing safety concerns at these locations may require collaboration between the University and the City of Davis, given jurisdictional complexities. For all hotspots, we recommend conducting in-person site inspections as part of a root cause analysis. However, given the significant resources required for such assessments, we weighted hotspots based on crash severity to identify the ones requiring immediate attention.

Weighted Analysis

As detailed in the methodology section, crashes were weighted using injury cost estimates from the Federal Motor Carrier Safety Administration, expressed in terms of VSL fractions. The resulting severity-weighted hotspot map (Fig. 14) displays circles sized according to the total injury cost of crashes in each hotspot. In addition, another map shows all recorded severe crashes, to help inform analysis of specific hotspots. Since these crashes have a larger impact on hotspot weight, labels indicate the number of severe crashes in hotspots where at least one occurred. Zoomed in maps showing locations of severe crashes are included in the appendix.

All the severe crashes are shown below (Fig. 15). Our method first created hotspots based on the number of crashes close by and then weighted for severity. An alternative method could be starting with the severe crashes and creating hotspots around them to ensure all severe crashes show up in the hotspot analysis.

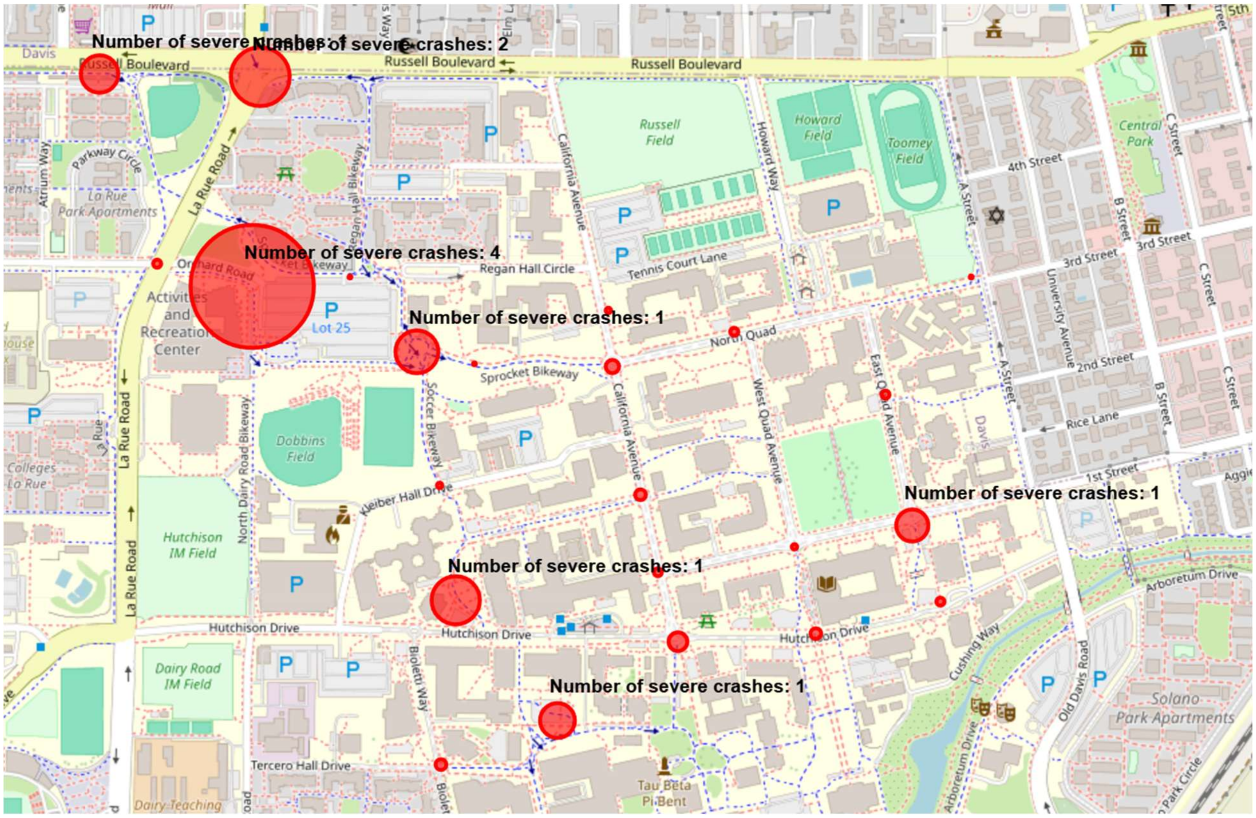

Fig. 14 *Severity-Weighted hotspot map*

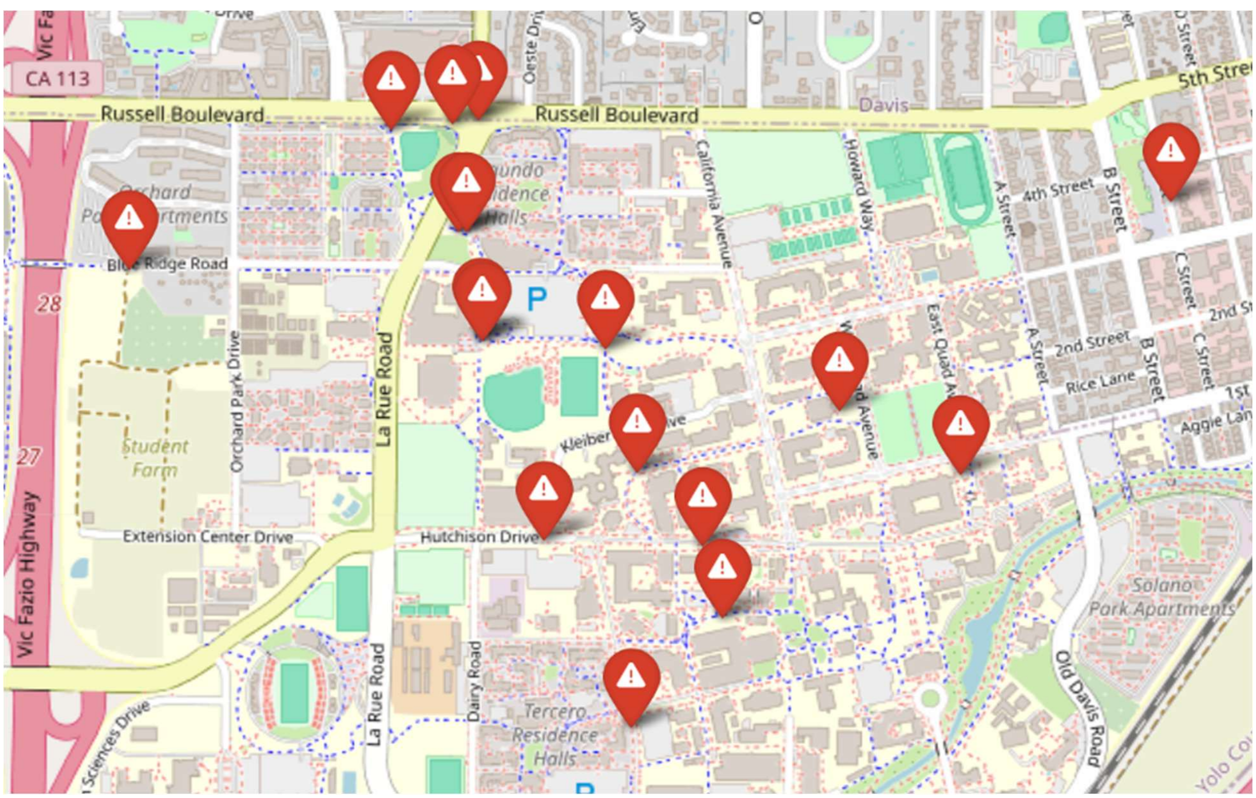

Fig. 15 *Locations of all severe crashes identified in the CTS*

The weighting analysis clearly reveals substantial differences in injury costs among the identified hotspots. Most hotspots have relatively low weights, indicating that they primarily involve non-serious, low-speed crashes. A few hotspots stand out with moderate weights, driven by the presence of at least one severe crash. One location, however, exhibits a significantly higher injury cost than the rest—the crossing at Orchard Road between the ARC bikeway and Sprocket. This hotspot has recorded four severe crashes—twice as many as the next highest location. In the following section we discuss these important hotspots in more detail.

Detailed Discussion of Hotspots

The ARC Parking Lot at Orchard Road

The area experiences complex interactions among pedestrians, micro-mobility users, and motorized vehicles entering the parking lot. As seen below in Fig 16, several crashes occur at the Orchard Road crossing to get from the ARC to Segundo Dining Commons. Additionally, its proximity to bike parking introduces further conflict points, as micro-mobility users slow down, pull over into parking spots, or unexpectedly enter the path of others. This can be seen in the crashes on the path next to the bike parking. The risk of collisions involving cars is particularly concerning, highlighting the need for a closer examination of the specific crashes that make up this hotspot to determine which modes of transportation were involved. However, the severe crashes that make this hotspot so severe do not occur at this corner. Instead, two occur at Sprocket near the Segundo entrance, and the other two occur at the roundabout opposite the ARC Peet's. It is possible that these two pairs of crashes represent pairs of respondents reporting the same crash. The Sprocket bikeway near Segundo is a high-risk area due to riders entering and exiting the subway underneath La Rue Blvd at high speeds. The roundabout near Peet's often sees riders going the wrong way, as well as pedestrians entering and exiting the ARC unaware of riders.

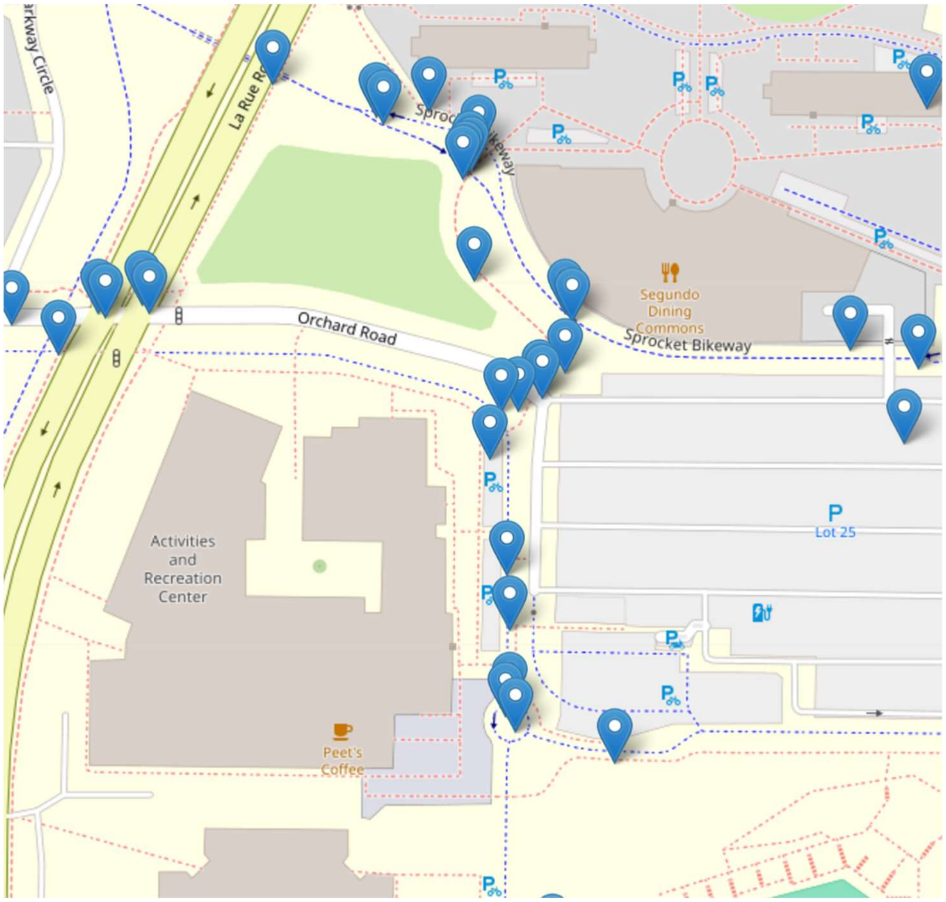

Fig. 16 *Highlighted map frame of the ARC complex*

Roadway Intersections at Russell Blvd

The next largest hotspot is the roadway intersection at Russell and La Rue, another location where the risk of crashes involving cars is high. However, this intersection likely falls under the jurisdiction of the City of Davis. The same applies to the intersection at Russell and Sycamore.

There are 4 other notable hotspots located within the central campus - the roundabout at Sprocket and Soccer bikeways, the bikeway intersections near the Katherine Esau Science Hall, the Teaching and Learning Complex (TLC) parking lot, and the roundabout at Shields and East Quad. Of the hotspots with no severe crashes, the California at Hutchison roundabout is the most serious. Due to the interaction with buses, this intersection also warrants closer inspection.

Intersection at Sprocket and Soccer Bikeways

The intersection at the Sprocket and Soccer bikeways stands out as particularly complex. In addition to the roundabout itself, the area experiences frequent interactions between pedestrians and micro-mobility users at multiple points—pedestrians crossing to and from the ARC parking lot, as well as those crossing Soccer and Sprocket bikeways (Fig 17.). The intersection between the bike path along the ARC parking lot and the Sprocket roundabout is another point of concern, often leaving novice riders uncertain about the right of way. The combination of a small roundabout radius, high traffic volume, and closely spaced entrances and exits contributes to hesitation and misjudgments among riders attempting to merge or exit, increasing the likelihood of collisions. Additionally, it is common for riders traveling north on Soccer bikeway to take a left turn into the ARC bike path against oncoming traffic instead of using the roundabout, further elevating the risk of crashes due to unexpected movements. That is also where the severe crash occurred.

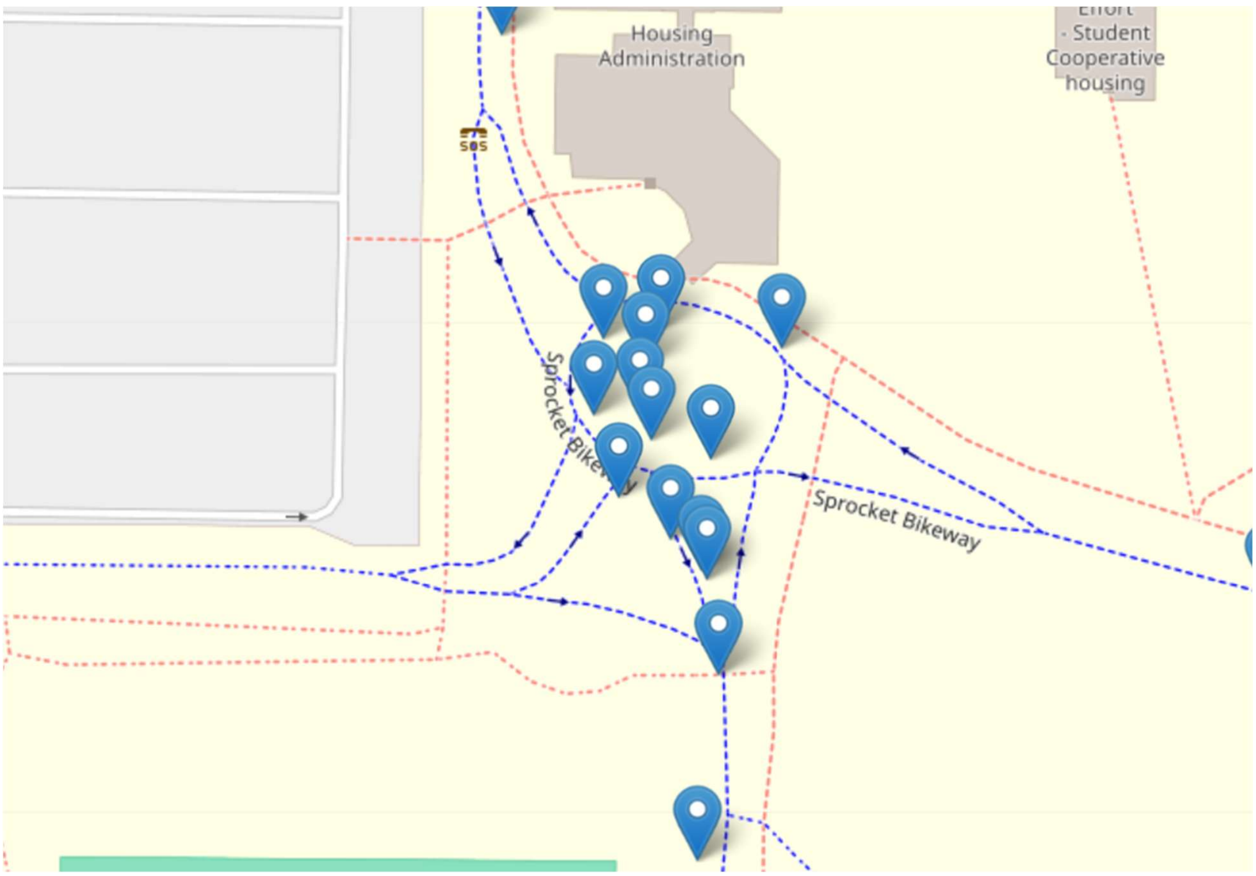

Fig. 17 *Highlighted map frame of the Soccer and Sprocket bikeway crossing*

Bikeway along Katherine Esau Science Hall

The bikeway near the Katherine Esau Science Hall consists of multiple intersecting bikeways, with the primary intersection between the Soccer bikeway and the path along Storer Hall experiencing a high concentration of crashes. This is likely due to conflicts between southbound riders turning left toward Storer and northbound riders turning left to remain on the Soccer bikeway. Given the high volume and speed of traffic at this intersection, the likelihood of high-speed, head-on collisions—one of the most dangerous crash types—is significantly elevated. This is also where the severe crash took place.

Additional incidents occur along the stretch where multiple pedestrian paths connect the bike parking lot of Khaira Hall to the Sciences Hall. Riders on the bikeway have limited visibility of pedestrians entering or exiting the parking lot while traveling at high speeds. Furthermore, some riders make abrupt turns into the parking lot without sufficient warning to others, increasing the risk of collisions. Given these risks, the entire section of the Soccer bikeway along the Sciences Hall would benefit from a thorough root cause analysis to identify and implement potential safety improvements.

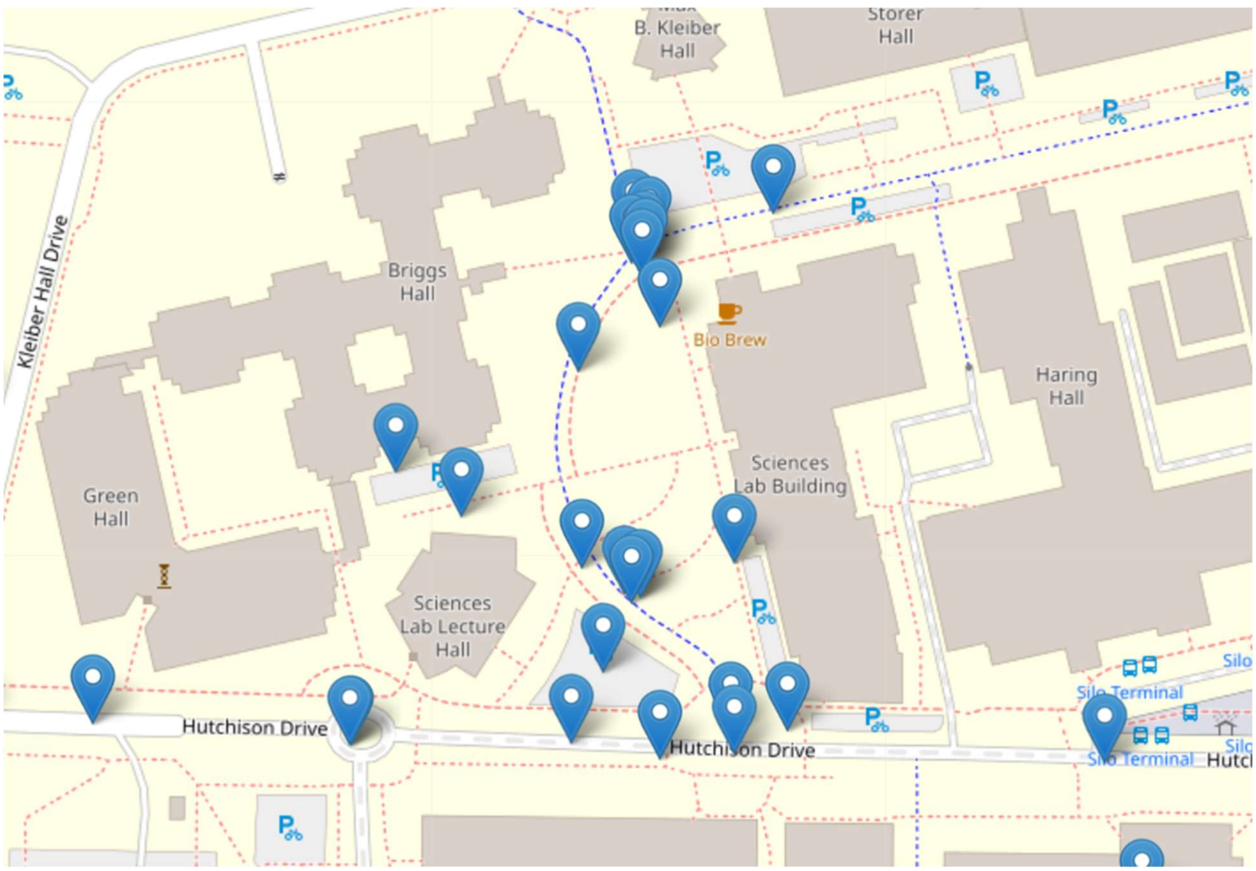

Fig. 18 *Highlighted map frame of the Katherine Esau Science Hall*

TLC Parking Lot

Looking closer at the crashes near the TLC parking lot, out of the 10 crashes that make up the hotspot, 5 occurred within the parking lot itself, 2 at the roundabout nearby, 2 at the parking lot exit and one was marked inside the TLC. The severe crash occurred near the parking lot exit to the bikeway along the Diane Bryant Engineering Student Design Center. A deeper analysis of the metadata might help understand the cause of the crash.

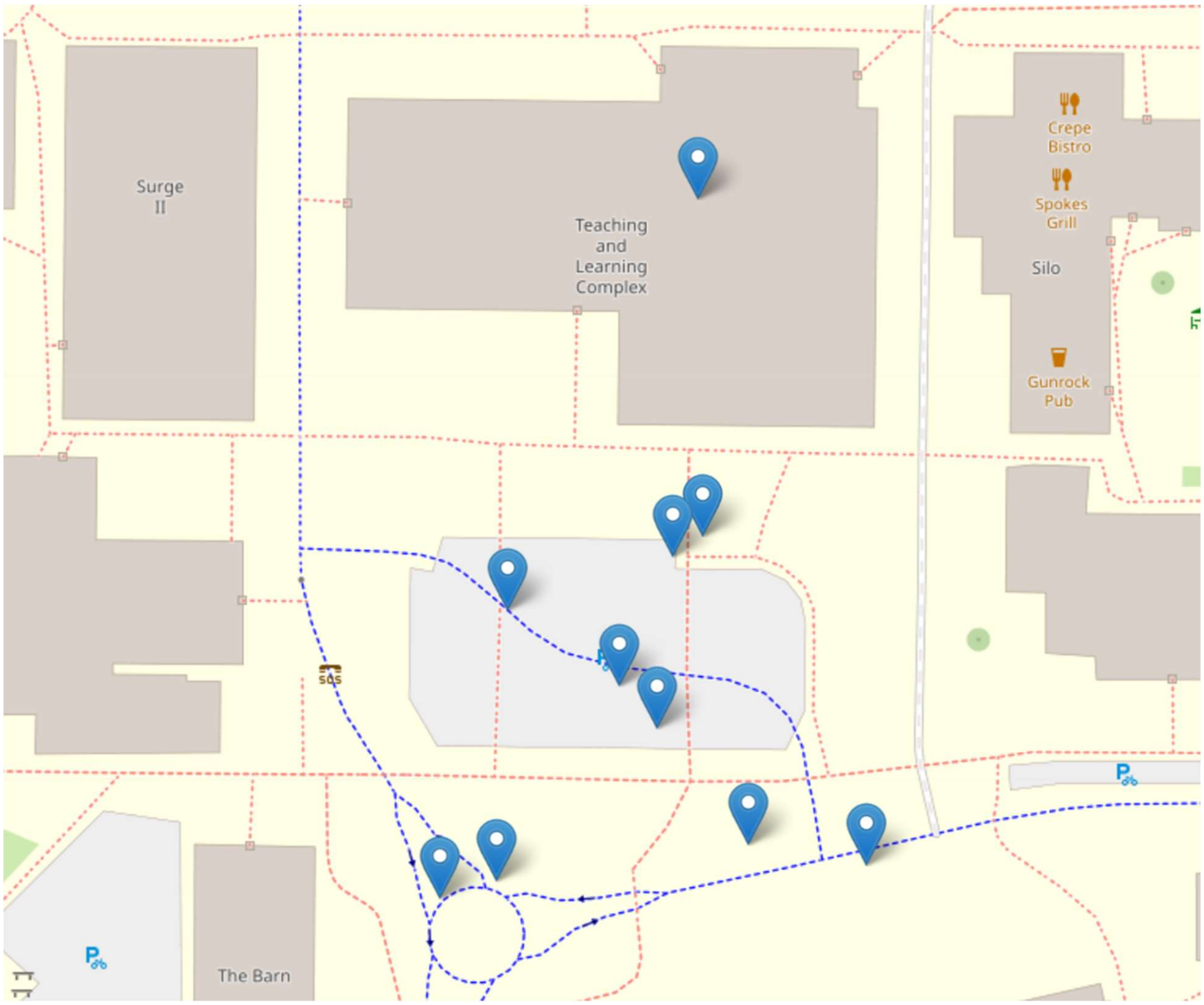

Fig. 19 *Highlighted map frame of the TLC Parking Lot*

Shields and East Quad Roundabout

For the Shields and East Quad roundabout, 4 out of 6 crashes are at the roundabout, with the other 2 occurring in adjacent parking lots. Similar to other discussed hotspots, hesitant and unpredictable riders trying to exit the roundabout into the parking lots may be the cause of incidents. The severe crash in this hotspot occurred in the parking lot next to the Shields library next to the roundabout. Again, an analysis of the metadata is required to ascertain the cause.

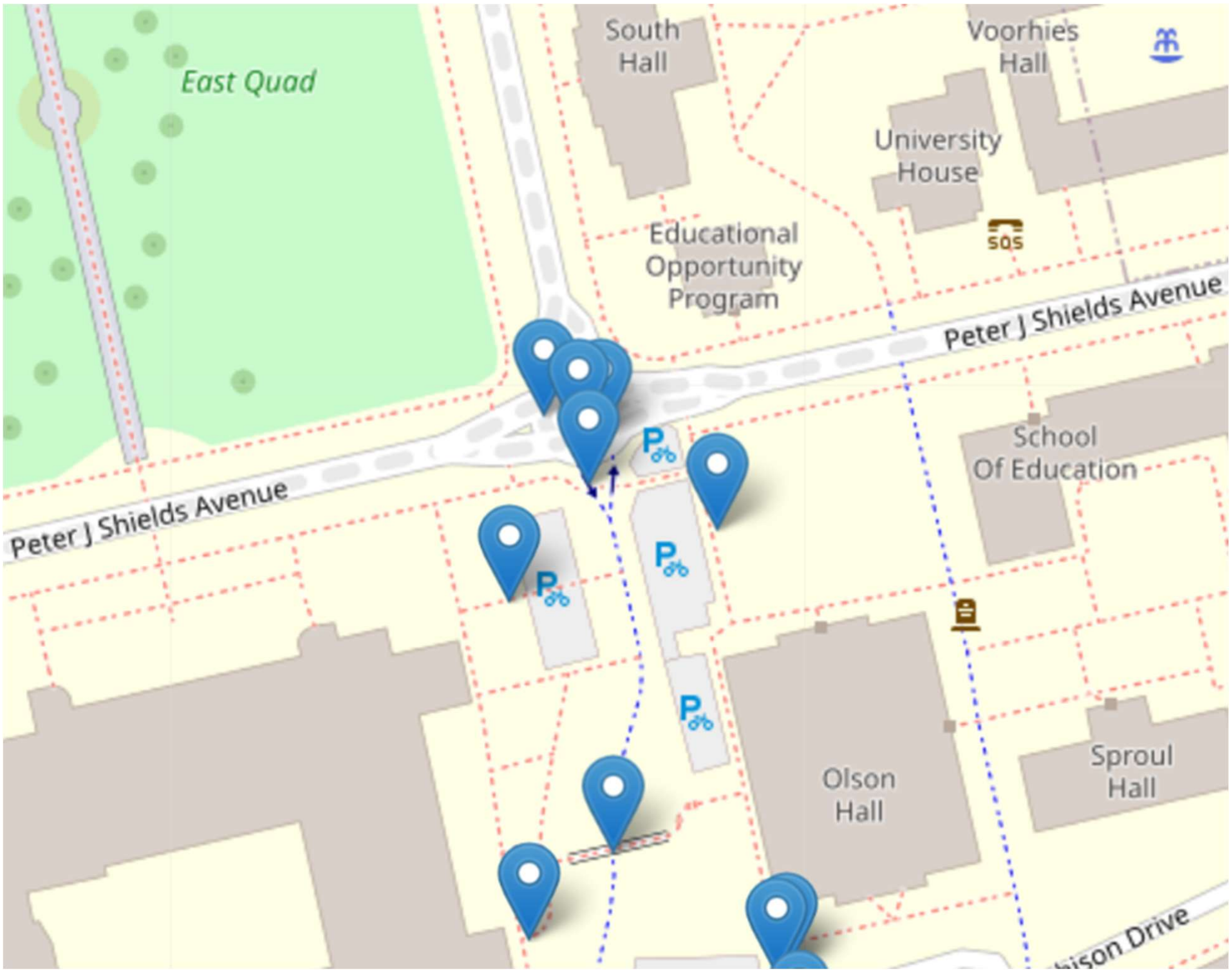

Fig. 20 *Highlighted map frame of the Shields and East Quad Roundabout*

California at Hutchison

This roundabout is one of the busiest intersections on campus, seeing heavy traffic throughout the day. In addition, the presence of the Silo Bus Station introduces heavy foot traffic as well as bus traffic. An analysis of the metadata is required to see if any accidents occurred with a bus here. Otherwise, it is a location for a high concentration of low speed, lower risk crashes from riders weaving in and out of the roundabout.

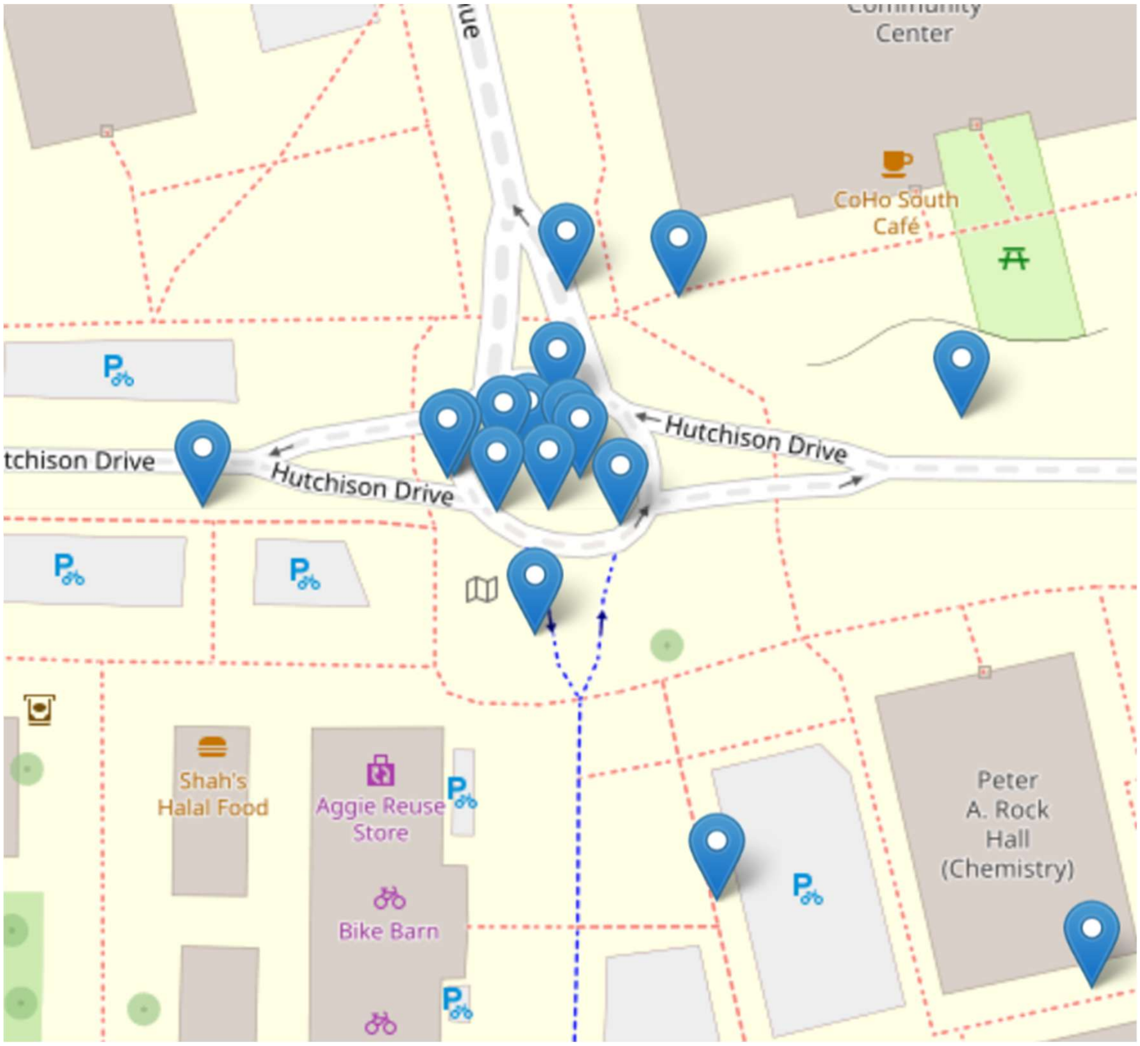

Fig. 21 *Highlighted map frame of the California at Hutchison intersection*

Recommendations

Improvements to the Campus Travel Survey

Include Receptivity Questions

The survey should include receptivity questions.

- It is conceivable that the gender gap that exists in use of active transit on other campuses, which is considered to be driven primarily by safety concerns, does not exist at UC Davis because of the university's commitment to safe micro-mobility infrastructure. If a correlation does exist, pairing receptivity questions with usage questions would provide quantifiable justification for the university to reaffirm this commitment.
- If not, or if those who indicate low receptivity do not emphasize safety as a dominant concern, this would provide an opportunity to address whatever concerns do arise.

The survey should include academic major.

- This may support the development of targeted information campaigns.
- If STEM students show more resistance to shared micro-mobility at UC Davis, as they do at Griffith University (Queensland, Australia), interventions that address their concerns may prove fruitful (Eccarius et al., 2021b).
- Conversely, investments made toward enhancing the infrastructure that supports the groups which are already more receptive to shared electric micro-mobility might be a better use of resources. Either way, inclusion of receptivity questions would both inform resource allocation decisions and provide a foundation for research.

The survey should assess helmet use rates and receptivity.

- Helmet use has been proven to prevent the most serious head and face injuries. Assessing rates of helmet use with the increase in e-mobility use will help inform future policy and campaigns on safety.
- Assessing receptivity to helmet use and safety perceptions can similarly inform policy and campaigns to make them more effective in increasing rate of helmet use.

Ultimately, this exploration is targeted at the question of resource allocation; university infrastructure planning must strike a balance between (A.) increasing accessibility to those who are more receptive to micro-mobility and (B.) addressing concerns (including safety concerns) of those who are less receptive to micro-mobility.

Improve Injury Severity Questions

Our analysis of the severity data could be significantly improved with two basic changes to the severity related questions in the campus travel survey.

1. Including an option for a ‘moderate’ injury. Currently, the options are ‘no apparent injury’, ‘minor or possible injury’, and ‘severe injury’. The perceived gap between a minor and severe injury is very large and would lead to confusion in respondents about which option to choose. Additionally, when doing a weighted hotspot analysis, severe injuries tend to dominate the data due to the low weight associated with a minor injury.

2. Providing an example for the injury severity categories. Without an example, survey respondents must subjectively decide the severity of their injury, and the researchers analyzing the results then need to subjectively decide what the respondents meant. Providing a simple example for each severity e.g. minor injury (cut or bruise), moderate injury (needed medical assistance), severe injury (bone fracture or worse), would help reduce the subjectivity of the question and increase confidence in analysis.

Infrastructure Improvements

Root Cause Analysis of Crash Hotspots

Based on the results of the hotspot analysis, several high-risk locations have been identified where micro-mobility crashes occur frequently. The severity-weighted hotspot map highlights areas where crashes not only occur in high numbers but also where severe injuries are more likely. However, data-driven spatial analysis alone is insufficient to fully understand the underlying causes of these incidents. Thus, we recommend that an in-person root cause analysis be conducted at the hotspots. The severity-weighted data can be used to inform prioritization of hotspots to be studied. Direct observation of infrastructure deficiencies, rider behavior, pedestrian interactions etc. will help inform better decision-making towards improving safety. Potential solutions could include:

- Improved lane marking and signage to clarify right of way and reduce rider confusion at complex intersections.
- Traffic calming measures such as speed humps or raised crossings at high-risk intersections.

- Intersection redesigns to improve visibility and reduce high-speed conflicts.
- Grade separated micro-mobility lanes.
- Deployment of sensors or cameras at high-risk intersections to gather real time data on crashes and near-miss incidents.

Bikeway Widths

Based on recommendations by the Rails to Trails Conservancy, bikeways that experience heavy traffic should be 12-14 ft in width. While most bikeways on campus conform to these standards, there are still some places where path-widening could help reduce risk of incidents. Once again, the hotspots can be used as a way to prioritize areas on campus that could potentially use path-widening (*Micro-mobility Devices on Multiuse Trails*, n.d.).

Improved Data Collection Methods

Data on micro-mobility crashes is hard to obtain and is often collected in a haphazard manner. The Davis Police Department's recent implementation of modernized guidelines on micro-mobility crash data collection will help alleviate this issue. We recommend a similar guideline be prepared with the Student Health Center to get better data on the safety trends of micro-mobility use. This could take the form of an automated anonymized survey sent out to patients who get treatment for a micro-mobility accident.

Regulations

Our review of the literature revealed mixed opinions on the effectiveness of regulations. While regulations are important and serve as a benchmark for how bikeways are expected to be used, rules are rarely enforced, and enforcement can often be discriminatory. Yet, the UC Davis campus officially has a 15 mph speed limit. We recommend that regulations on the types of vehicles allowed on the bikeways be considered. Due to the fuzziness around the definition of e-mobility, vehicles capable of speeds upwards of 25 mph or those of a high weight freely operate on the bikeways. These vehicles pose higher risks to riders due to higher momentum and speed differential. Possible ways of defining the rule can be based on:

- Speed, disallowing vehicles capable of speeds much faster than traditional bicycles (20+ mph). This would disallow mopeds, pedelec bikes, dirt bikes etc.

- Mass, the Rails to Trails Conservancy strongly recommends considering a device weight limit of 75 to 100 pounds on trails to limit safety risks associated with device mass. Choosing 100 pounds would match the current federal e-bike definition. An exception should be made for assistive mobility devices. Additionally, the Society of Automotive Engineers (SAE) has developed a classification system for e-mobility based on vehicle weight, width, top speed and power source. This could provide clear guidance for deciding which vehicle classes should be allowed for use on campus bikeways (*J3194_201911*, n.d.).
- Fuel, restricting ignition combustion engine vehicles from operating on the bikeways. While not a big concern, the occasional dirt bike is seen on campus.

The enforcement of any regulations will be challenging; however, knowledge of their existence can deter some violations. More awareness of speed limits and vehicles allowed could help achieve similar results.

Student Projects

Student projects can be an effective way to combine education, research and work on campus safety. We recommend a student project be undertaken annually to do a micro-mobility vehicle count on campus. This could be in the form of counts at intersections or counts of parked vehicles in parking lots. This will help inform trends on micro mobility use on campus. Additionally, we also recommend that a student project could be used to do an initial observation of the identified hotspots. As part of a case study for a design or transportation studies project, students would learn how to identify conflict points, potential causes for incidents and provide a first-pass analysis that can be built on by professionals. These serve as great opportunities for boots-on-the-ground learning that are also useful to the campus.

Shared Mobility Systems (SPIN)

With more than 152,000 trips in 2024, UC Davis' Spin dockless e-mobility program has enjoyed high usage. Notably, e-scooters have a much greater usage rate than e-bikes, which is causing an inversion in SPINs fleet composition policy from a current 2:1 bike-to-scooter ratio to 2:1 scooter-to-bike. Current deployments by SPIN are: 466 scooters, and 308 bikes; as a ratio of 1.5:1 (Interview with Bruchez, Jeff). With an average trip distance of 1.7 miles, shared micro-mobility is suitable for both last-mile transit and lengthier commutes. However, the SPIN system has some potential improvements, including inappropriate parking, safety issues, and neighborhood objections. To assure the program's sustained success and sustainability with UC Davis safety initiatives, we propose the following recommendations: improve infrastructure, increase rider compliance, and address community concerns.

Infrastructure, Rider Safety, and Compliance

a. Periodic safety workshops should be held, with incentives such as ride credits offered to promote participation.
b. Mandating a short safety quiz within the Spin app for new users before their first ride can help teach good riding habits from the start.
c. Furthermore, extending helmet distribution initiatives in partnership with Spin and the university can help to promote safety and reduce the chance of injury.
d. Improving lighting and visibility at key intersections and high-use areas can further mitigate risks and enhance user confidence.
    - Consider a collaboration with Spin to pilot an AI-based collision warning system in areas of high pedestrian traffic that can provide an additional layer of safety for both riders and pedestrians.

Community Concerns

a. Addressing community concerns is critical to enhancing public perception and creating a favorable climate for shared micro-mobility. Data from 311 complaints can be analyzed to find persistent problems, such parking infractions or abandoned cars, and to guide customized solutions.
b. Introducing an ambassador program, in which student volunteers help to educate riders and address community concerns, can increase involvement and collaboration.
c. Improving communication with the city to match rules and enforcement methods is also critical for the successful integration of shared micro-mobility into the urban scene.

Study Limitations and Future Research

Exploratory Data Analysis

For a more informed campus transportation safety analysis, future research can increase the accuracy and application of findings by fine-tuning outlier handling, role-based accident patterns, and weighting approaches.

Outliers and Regression Analysis

One significant limitation of this analysis is the presence of possible outliers in accident counts and age demographics. Some respondents may report an unusually high number of accidents, which can skew both weighted accident counts and standardized accident rates. Future research should assess whether these outliers are reflective of the larger campus population or if they are the result of data entry errors, misinterpretations of survey questions, or unusual individual circumstances. Statistical tools like z-score analysis or interquartile range (IQR) filtering could aid in identifying and evaluating the impact of these extreme numbers. Furthermore, qualitative follow-up (e.g., targeted interviews) could shed light on whether these high accident rates represent true trends in campus mobility risks or anomalous individual behaviors.

Implementing regression analysis between normalized rates of accidents across different modalities (e.g., walking, cycling, e-scooting) for the same demographic group can help identify relationships, correlations, and causal pathways between variables of interest. By conducting such an analysis, future can achieve the following objectives:

1. Identify Risk Factors
2. Understand Modalities' Impact on Safety
3. Examine Confounding Variables (e.g. weather conditions)

Statistical Demographic Anomalies

The differences between weighted accident counts and standardized accident rates per 100 individuals point to underlying mobility patterns that require more examination. For example, the lower female pedestrian (walk/wheelchair) accident rate per 100 individuals, despite a higher absolute number of accidents among female responders, raises concerns about exposure risks or individual respondents' risk profile. This could be influenced by variations in travel behavior (e.g., trip frequency, pedestrian-heavy routes), infrastructure use (e.g., crossing design, sidewalk quality), or external risk factors (e.g., traffic density, nighttime walking exposure).

Further investigation of the CTS data may reveal behavioral or structural variables that contribute to these discrepancies. Future research should look into whether different demographics are more likely to take specific routes through campus, travel at high-risk times of day, or meet infrastructure gaps that raise their chances of an accident. Other opportunities could be found in examining journey duration, modal combinations (for example, switching between bicycling and walking), and encounters with high-traffic locations may provide a more detailed picture of role- and gender-based risk differentials.

Underrepresented Demographic Outreach

While weighting by campus population helps to account for survey answer biases, future research should investigate whether the weighting factors effectively reflect mobility trends across different demographic groups. If populations, such as nonbinary or genderqueer people, or those who choose not to reveal their gender, are underrepresented in the sample but overrepresented in demographic based accident rates, more outreach and specialized sampling tactics may be required. This could entail oversampling underrepresented groups in future surveys or combining campus transportation injury reports to cross-validate results.

Shared Mobility Systems

Finally, future research should combine the acquired data on ownership styles and the availability of e-mobility on campus. This information can be compared to SPIN data to acquire a better understanding of any differences in usage and accidents between privately owned and shared e-mobility.

Hotspot Analysis

While a sensitivity analysis on the proximity of crashes to be included in a hotspot was performed, after reviewing the results, we believe it could be improved further. Some hotspots which were particularly severe, like the Orchard Road at ARC parking lot and the Sprocket roundabout, included crashes from separate intersections and roundabouts. Repeating the analysis with a higher fidelity for hotspot identification, i.e. reducing the distance between nearby crashes, will help break down these hotspots into more accurate ones.

Another consideration is the potential use of GIS methods, spatial statistical tools like kernel density estimation or Getis-Ord Gi* in ArcGIS to detect clusters of crashes. These methods are more traditionally used in literature and proven to work well. We were not able to use these due to lack of experience using GIS, as well as access to ArcGIS. Additionally, the Getis-Ord Gi* method is more often used for spatio-temporal analyses and not simple spatial analyses.

Lastly, we recommend examining the meta-data of severe crashes to identify details about causes, modes involved, demographics etc to gain an improved understanding of the worst crashes. Particularly, when looking at the weighted hotspots, looking at the meta-data for all component crashes in the most severe hotspots could help understand common causes for crashes which would help inform mitigation decisions.

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Appendix

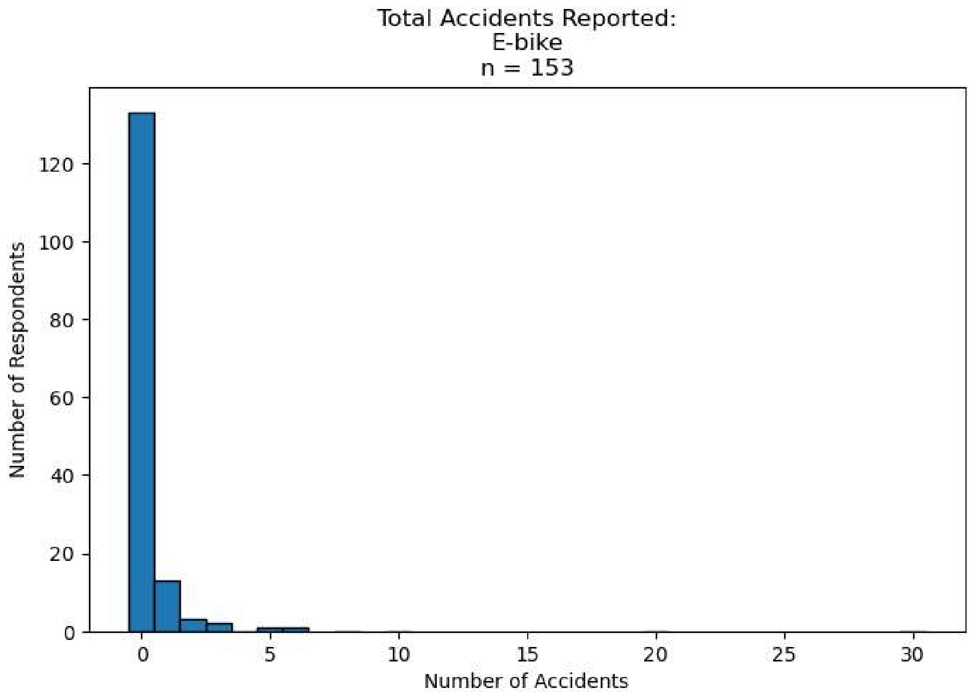

Fig. 22 *Histogram of Accidents Reported in the CTS for E-bike Users*

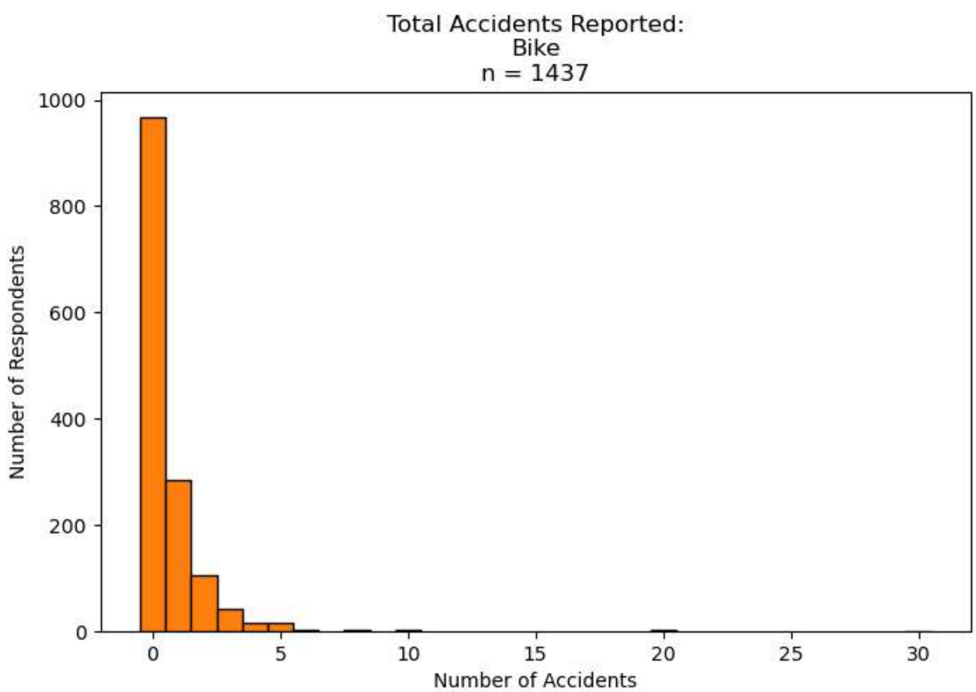

Fig. 23 *Histogram of Accidents Reported in the CTS for Bike Users*

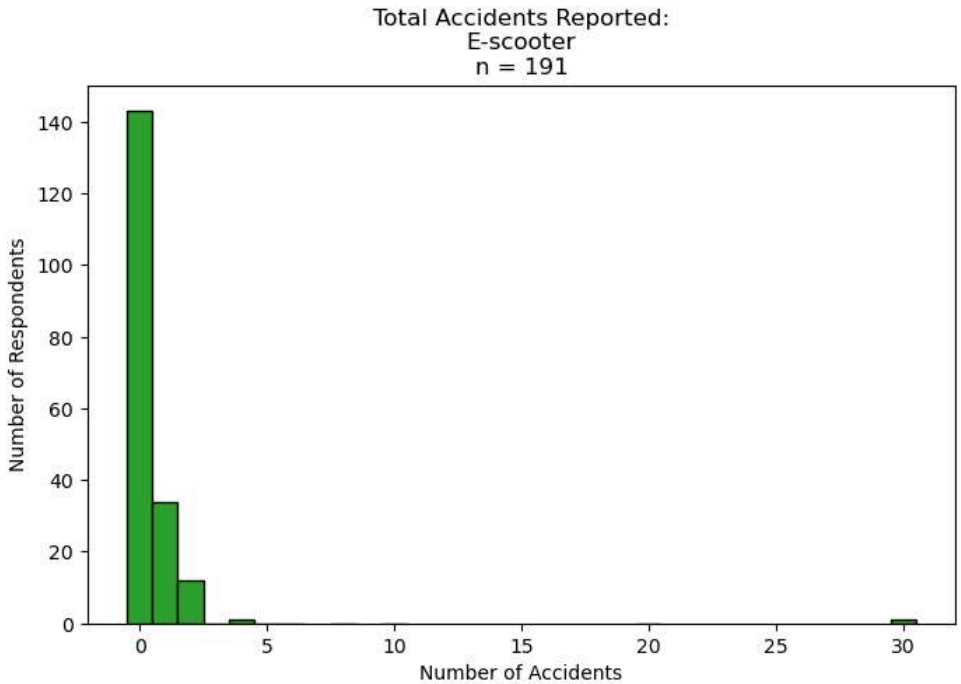

Fig. 24 *Histogram of Accidents Reported in the CTS for E-scooter Users*

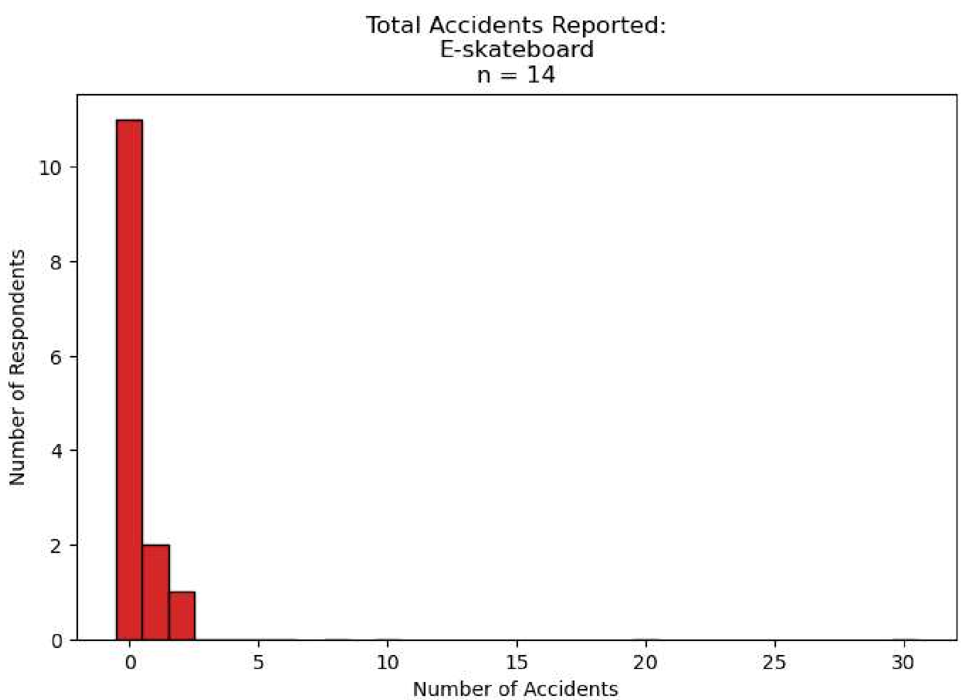

Fig. 25 *Histogram of Accidents Reported in the CTS for E-skateboard Users*

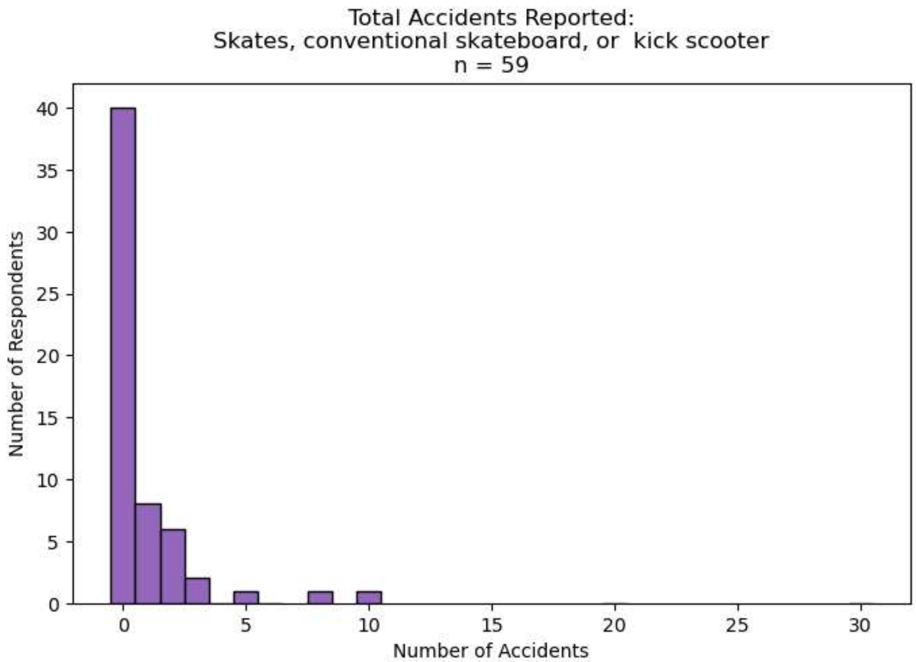

Fig. 26 *Histogram of Accidents Reported in the CTS for Users of Skates, conventional skateboard, or kick scooter*

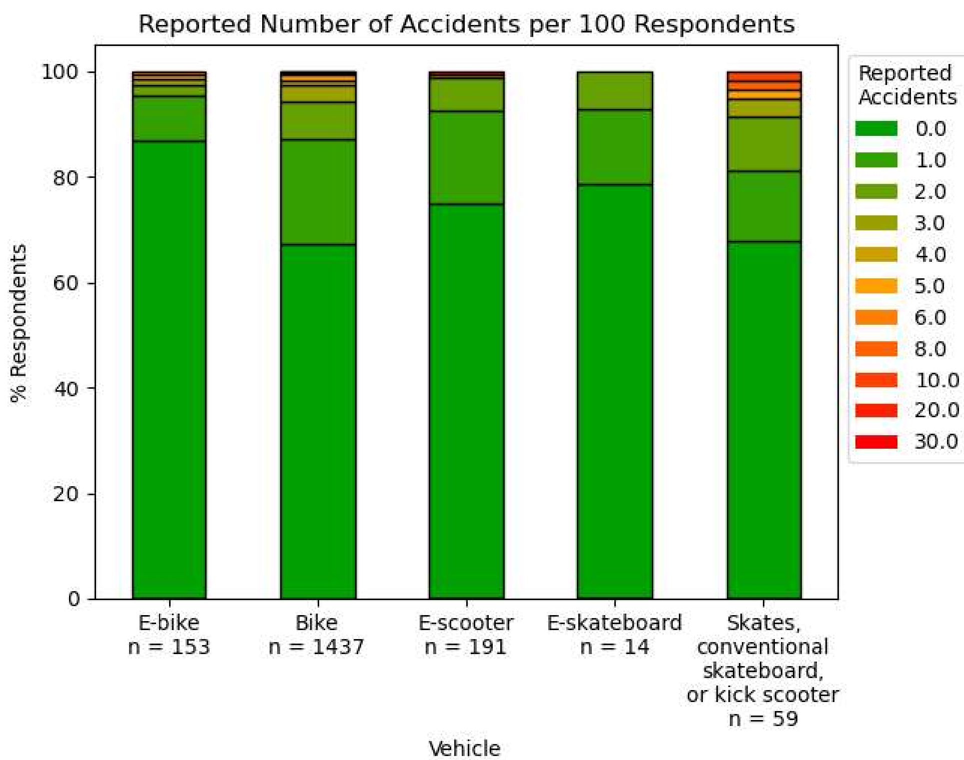

Fig. 27 *Reported Number of Accidents per 100 Respondents to the CTS in the last year*

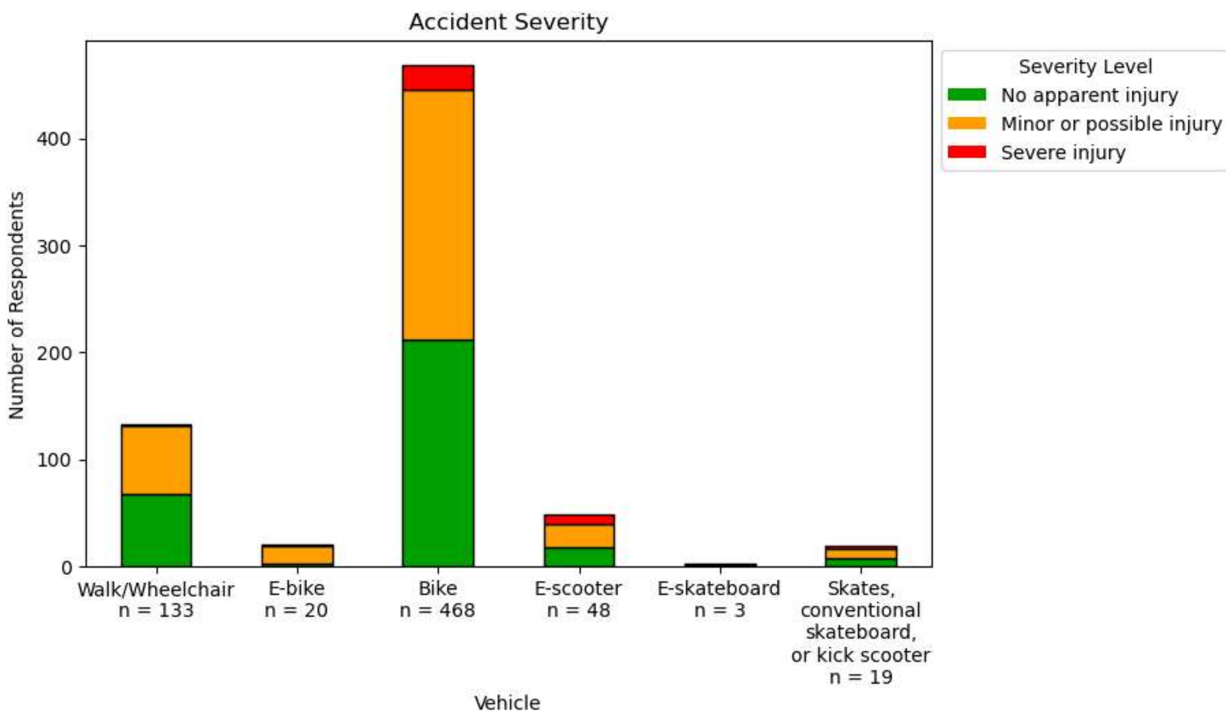

Fig. 28 *Severity Level of Accidents Reported in the CTS by Mode*

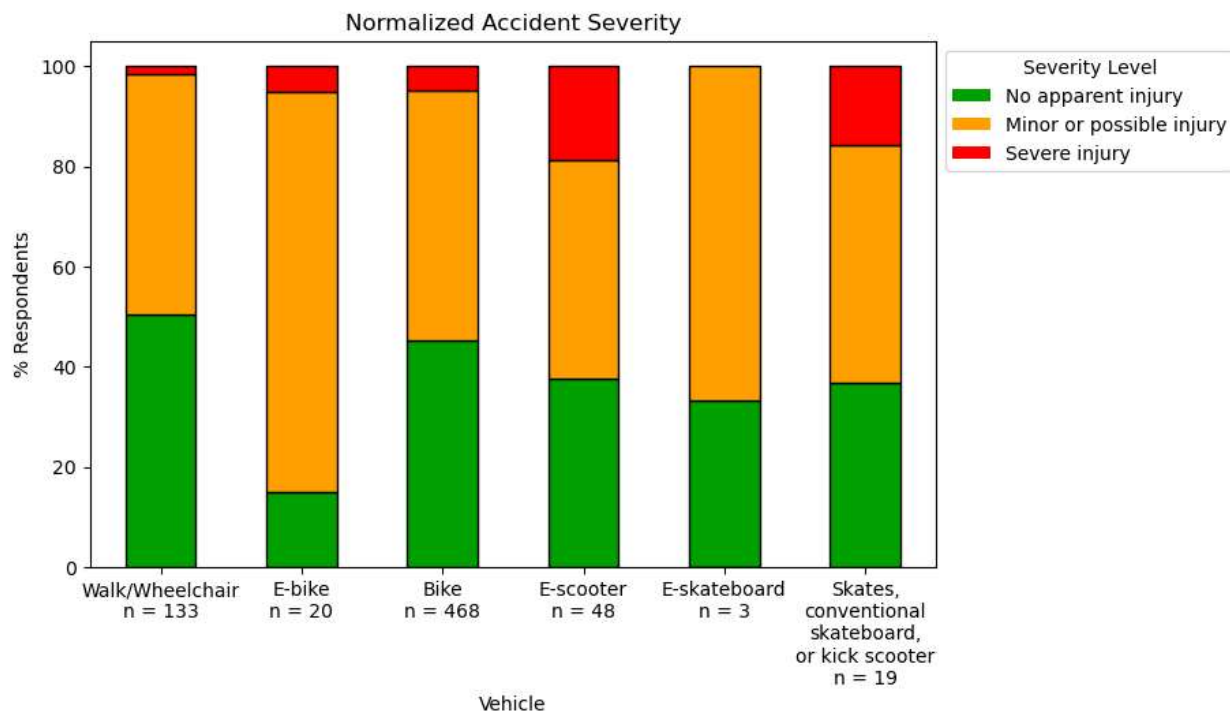

Fig. 29 *Severity Level of Accidents Reported in the CTS by Mode, normalized by total number of users of each mode*

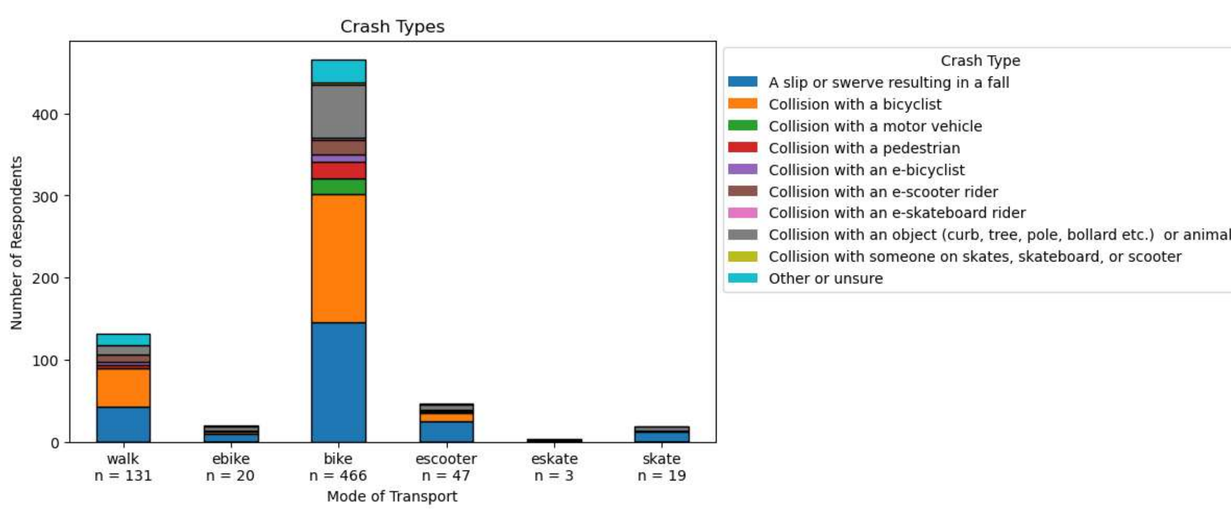

Fig. 30 *Causes of Accidents Reported in the CTS by Mode*

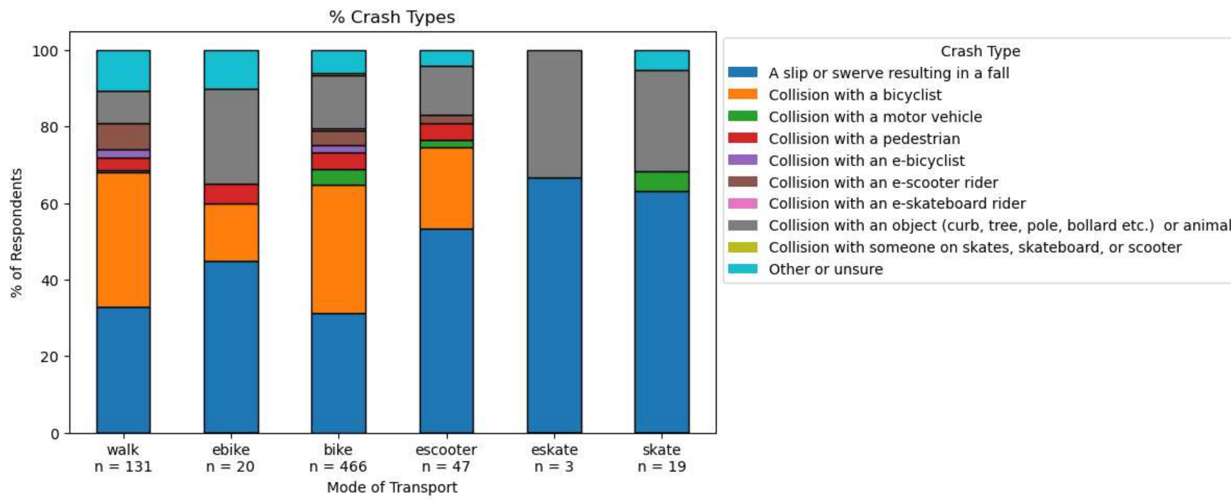

Fig. 31 *Causes of Accidents Reported in the CTS by Mode, normalized by total number of users of each mode*

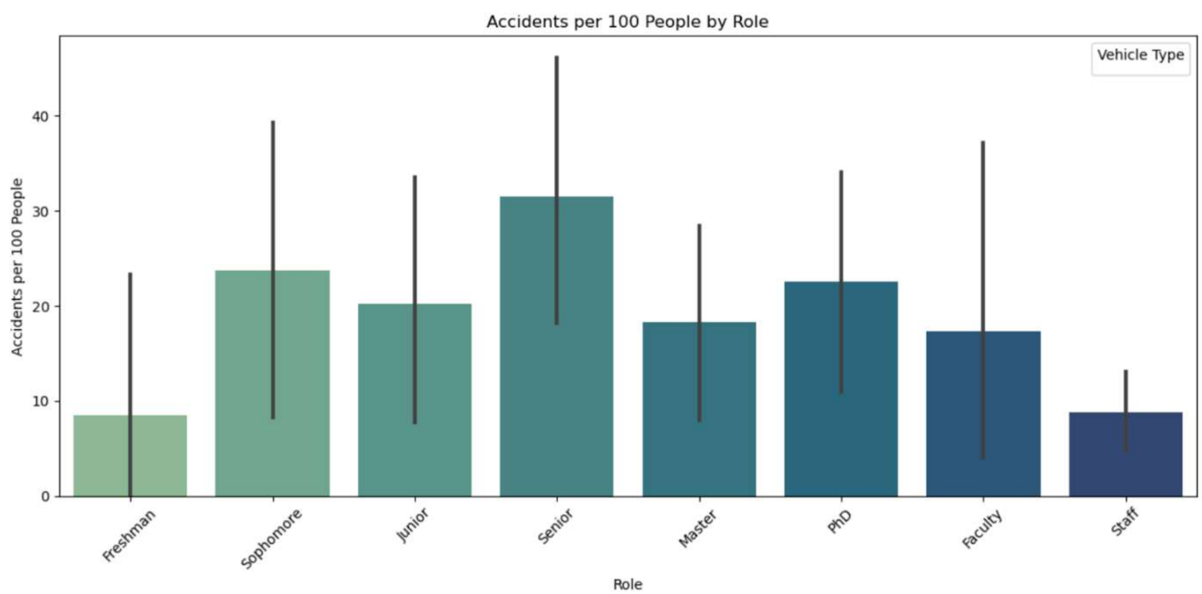

Fig. 32 *Accidents per 100 people by role*

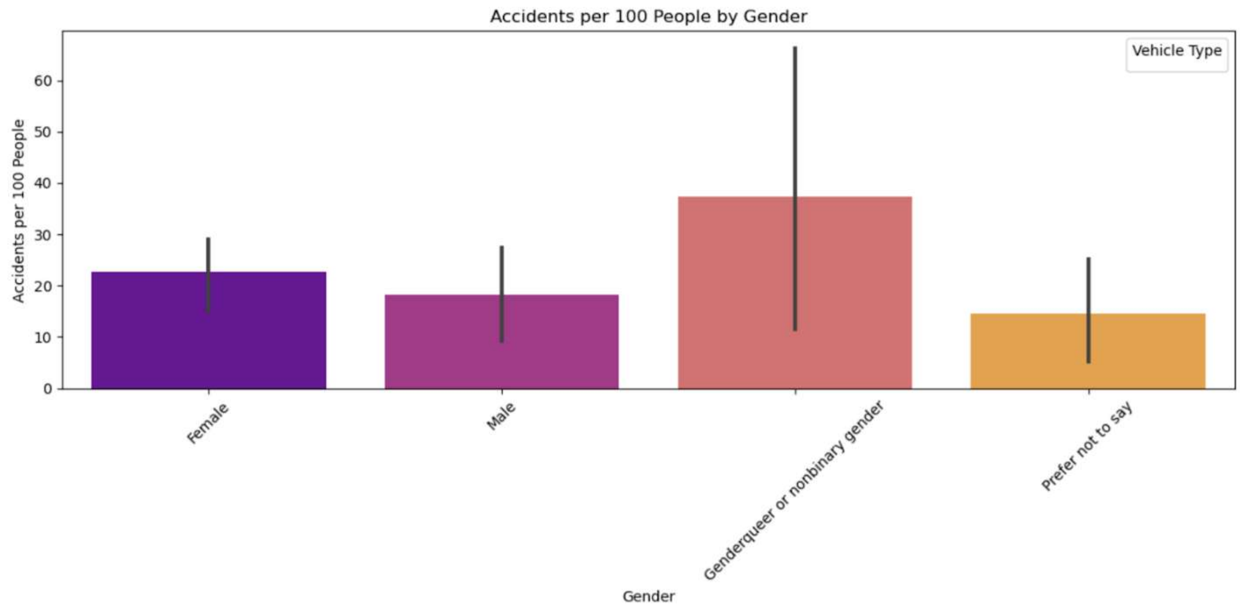

Fig. 33 *Accidents per 100 people by gender*

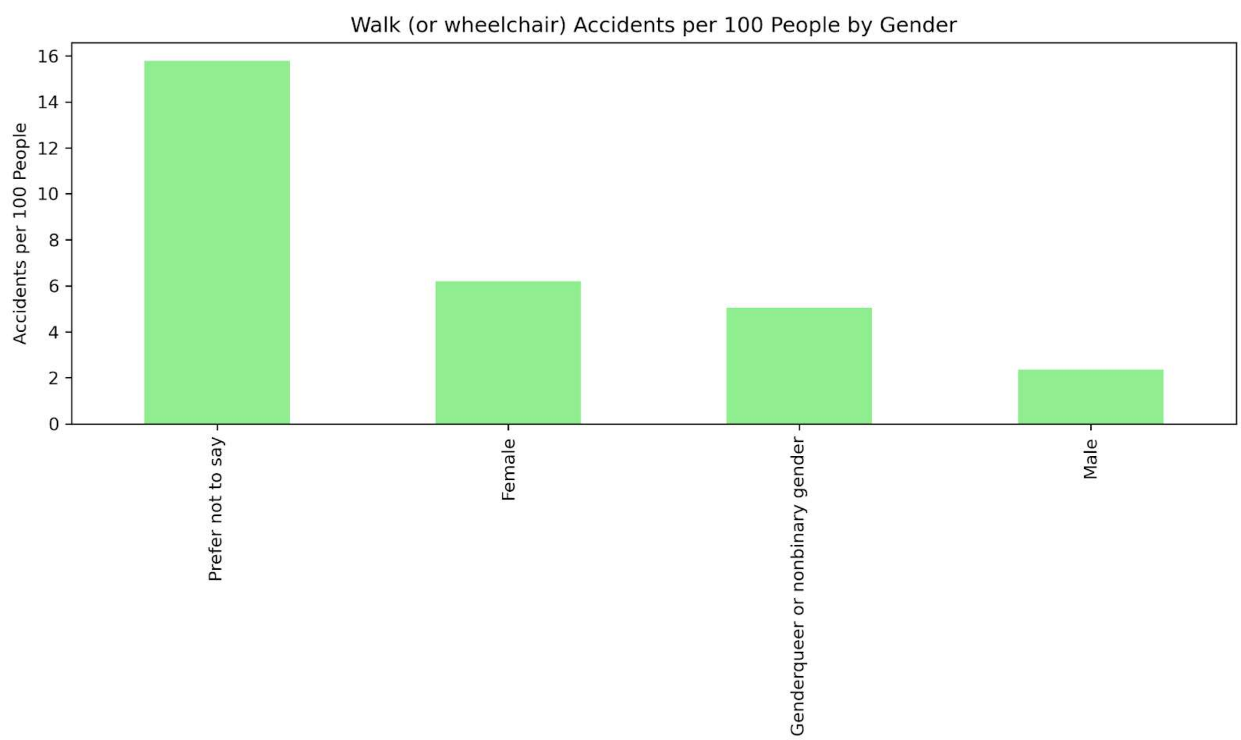

Fig. 34 *Walk (or wheelchair) accidents per 100 people by gender*

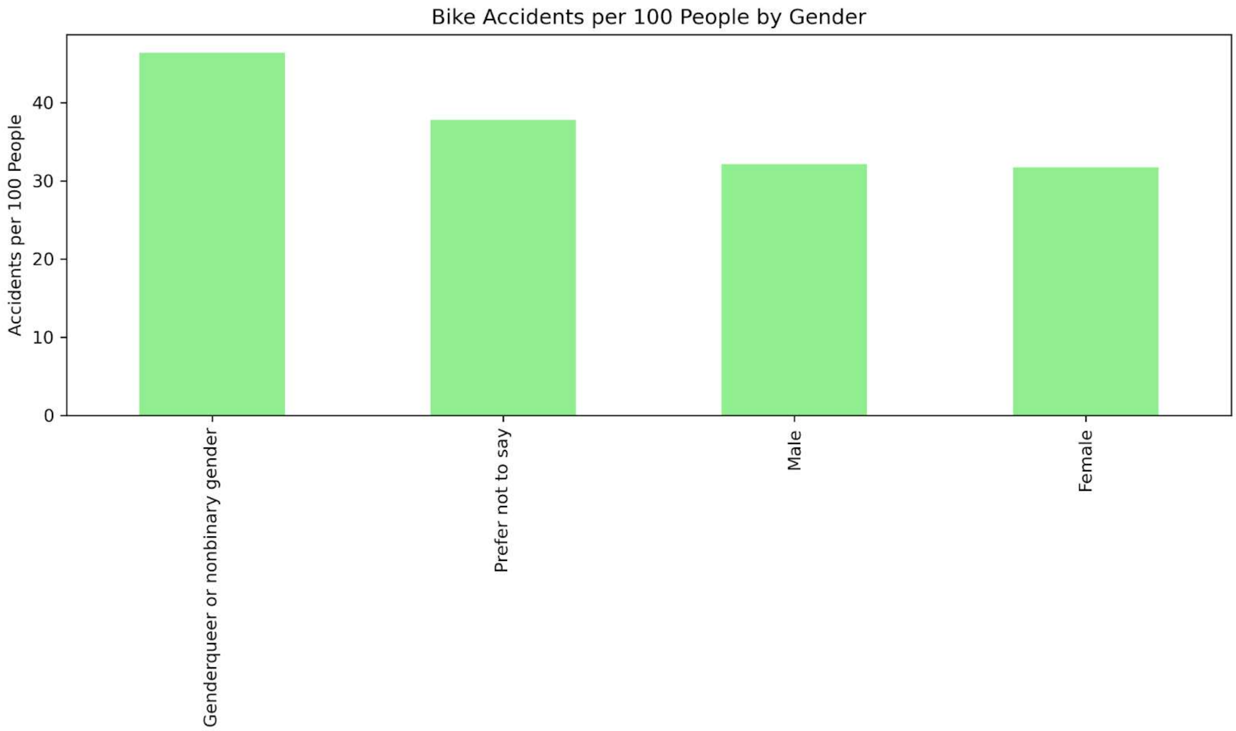

Fig. 35 *Bicycle accidents per 100 people by gender*

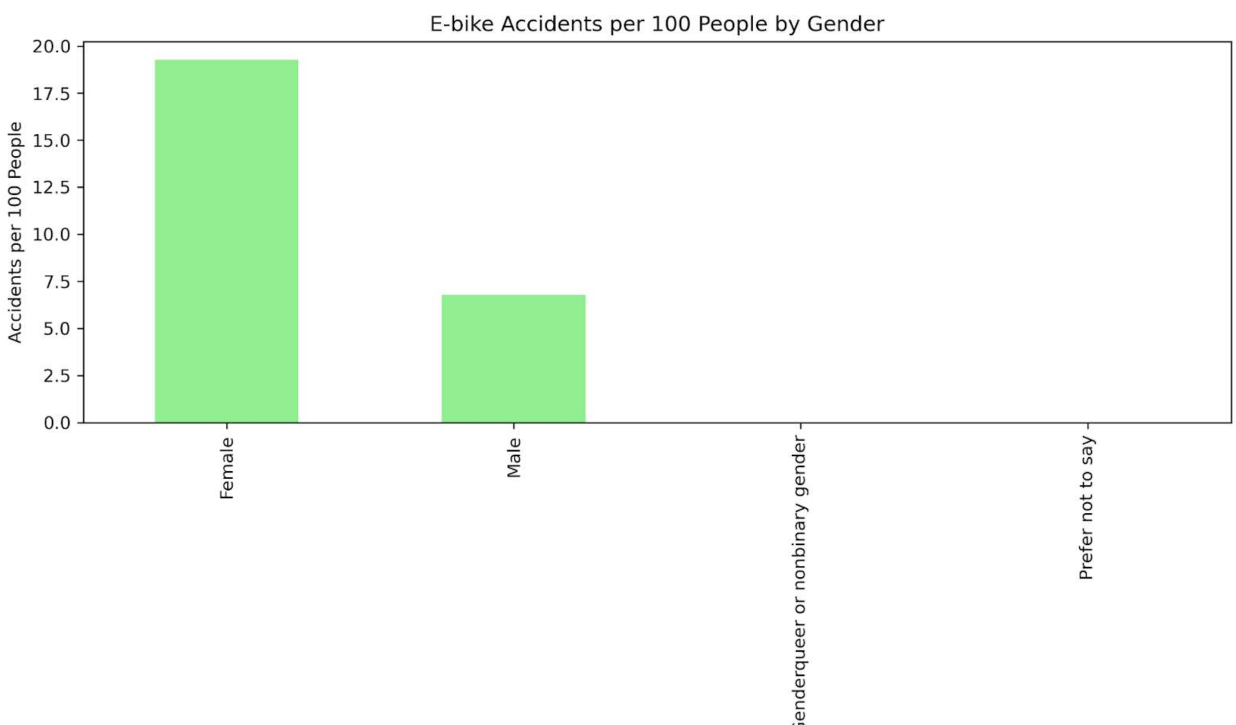

Fig. 36 *E-Bike accidents per 100 people by gender*

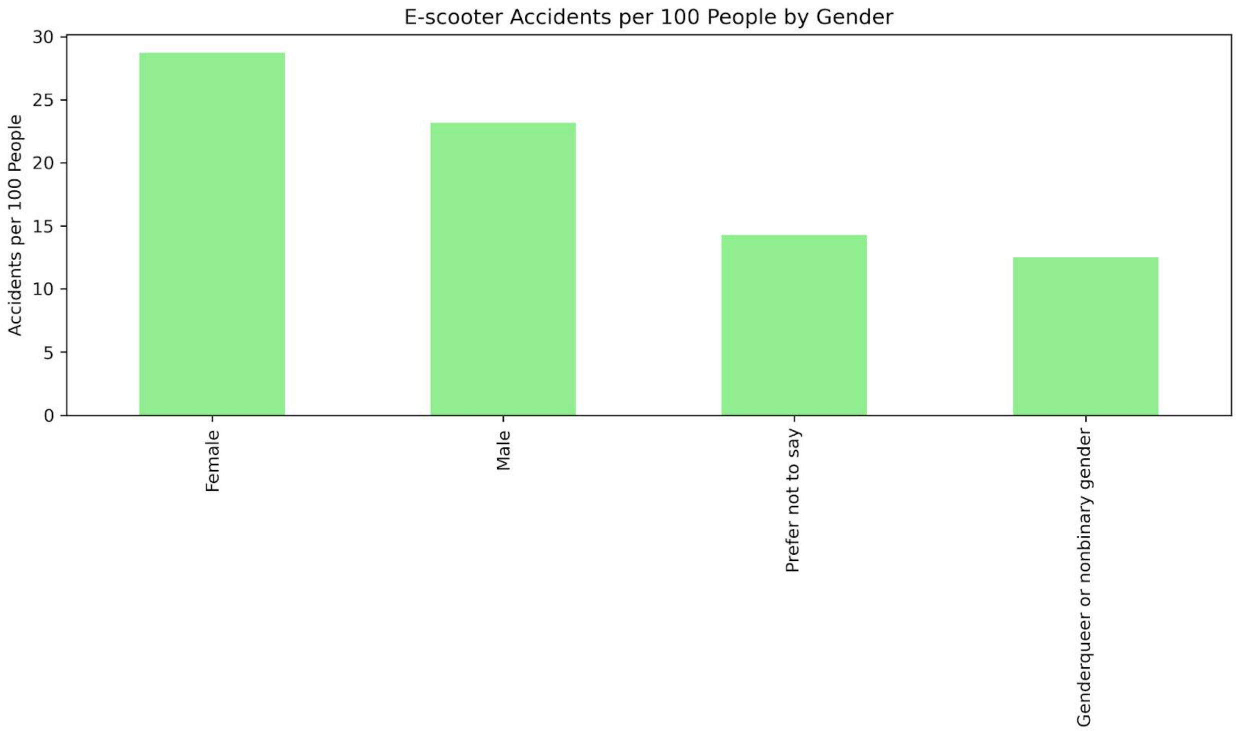

Fig. 37 *E-scooter accidents per 100 people by gender*

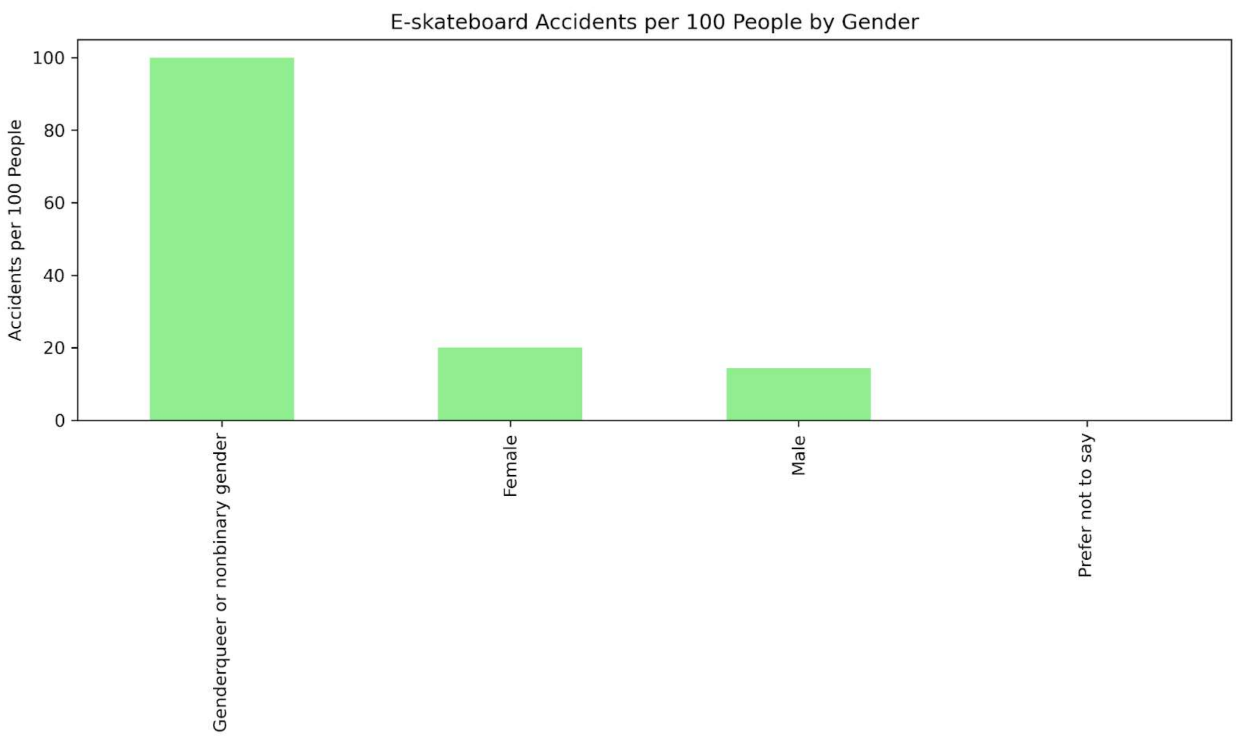

Fig. 38 *E-Skateboard accidents per 100 people by gender*

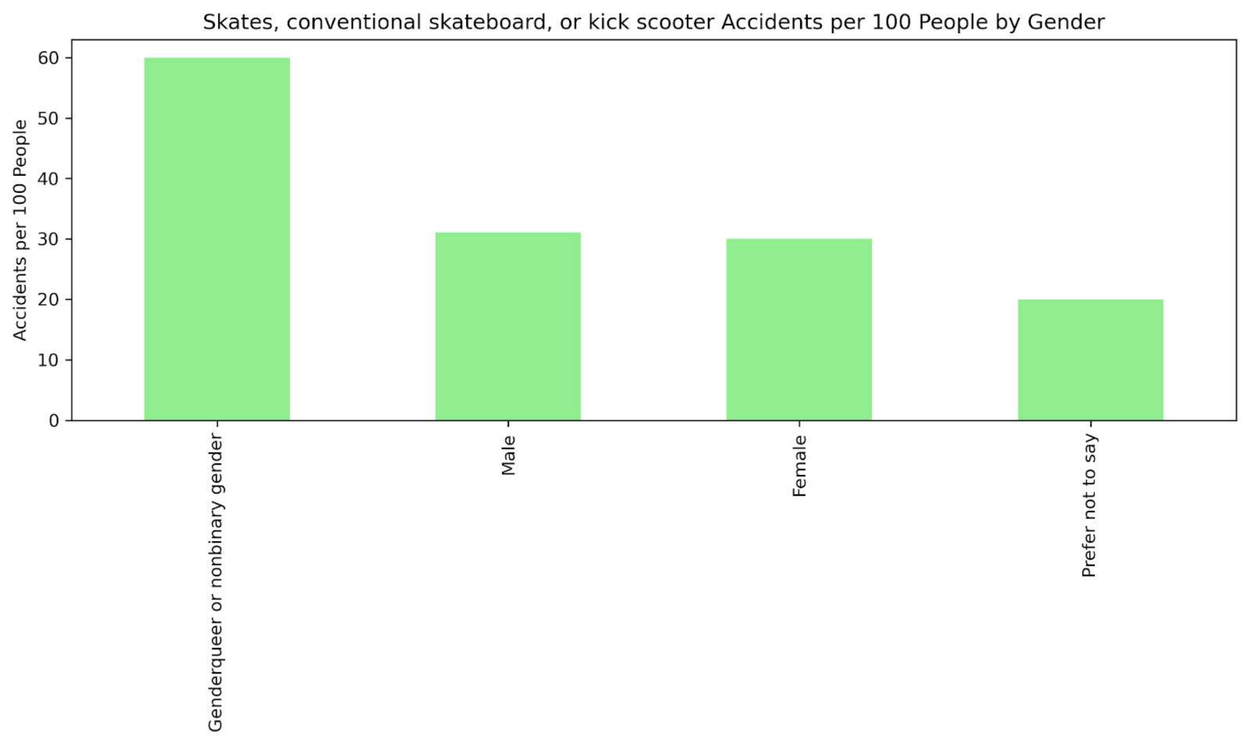

Fig. 39 *Skates, Conventional skateboard, or kick scooter accidents per 100 people by gender*

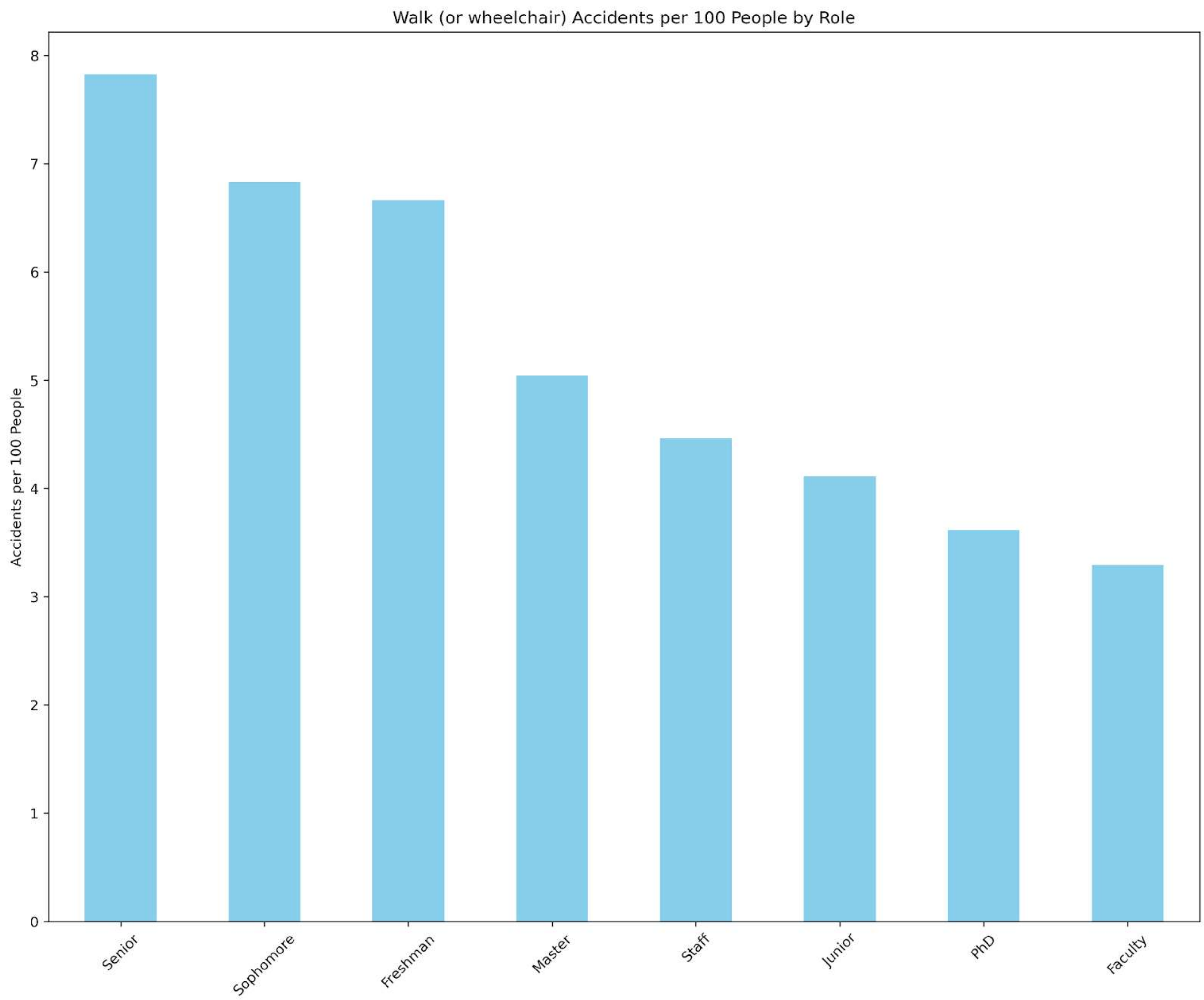

Fig. 40 *Walk (or wheelchair) per 100 people by role*

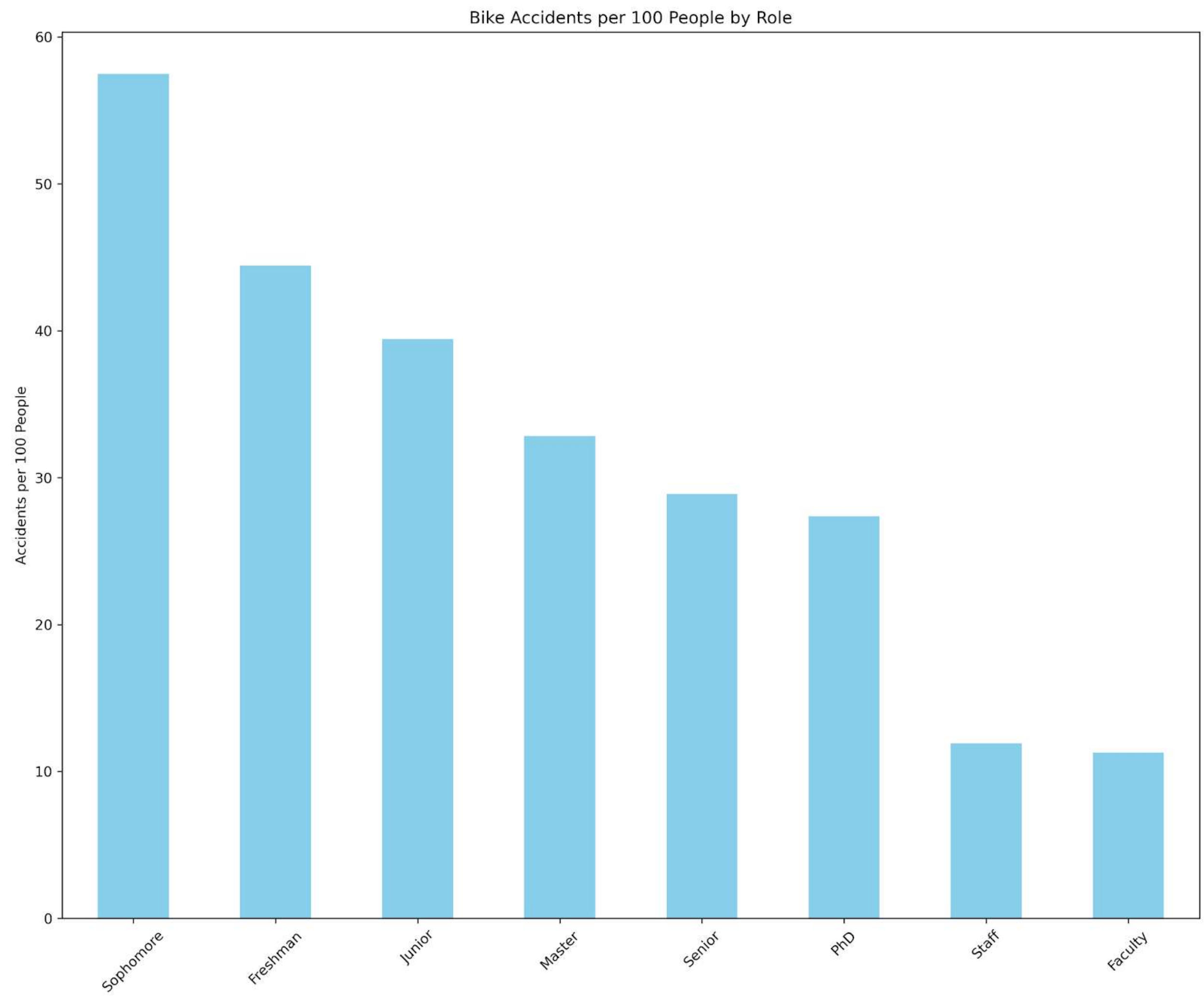

Fig. 41 *Bicycle per 100 people by role*

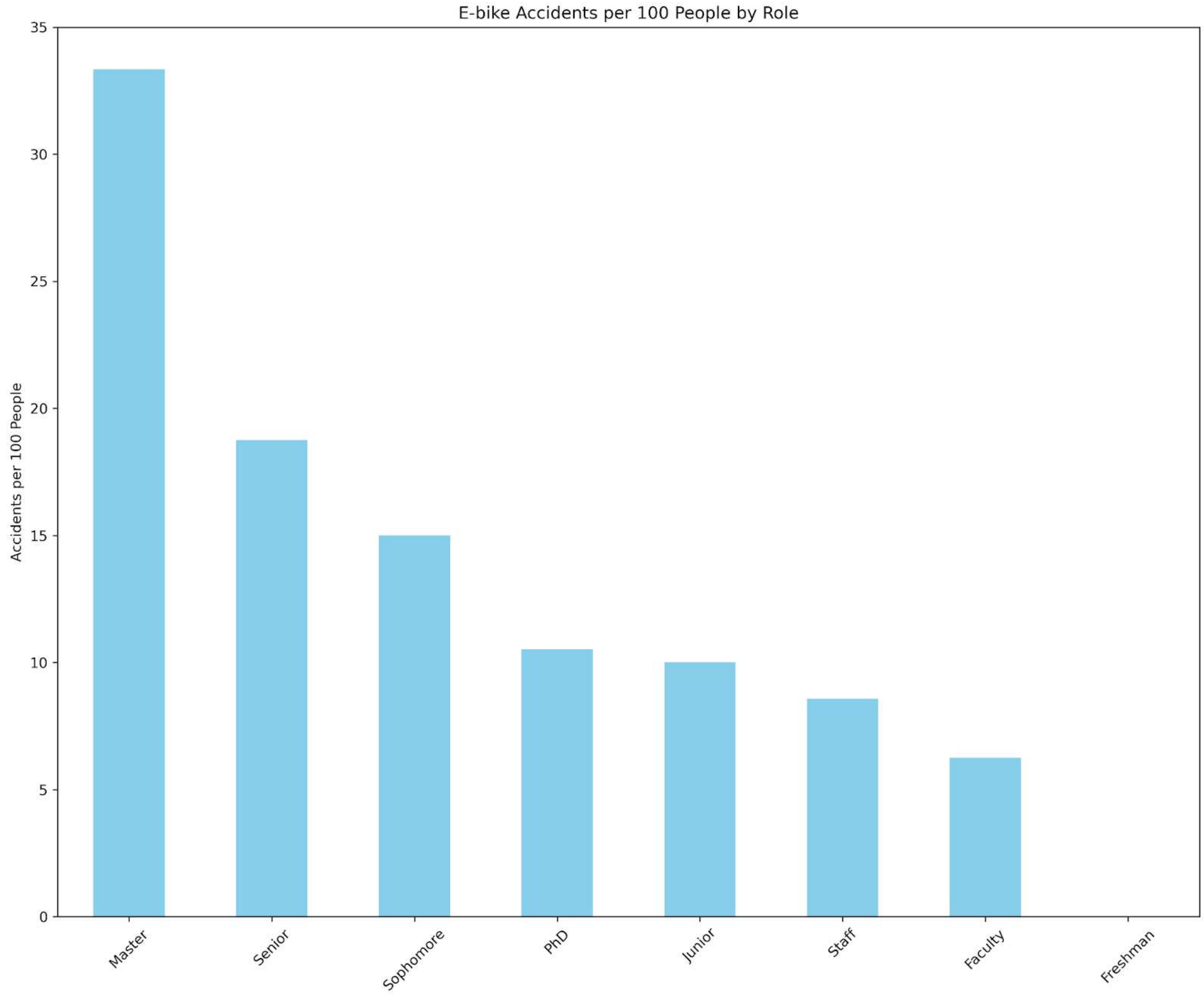

Fig. 42 *E-Bike accidents per 100 people by role*

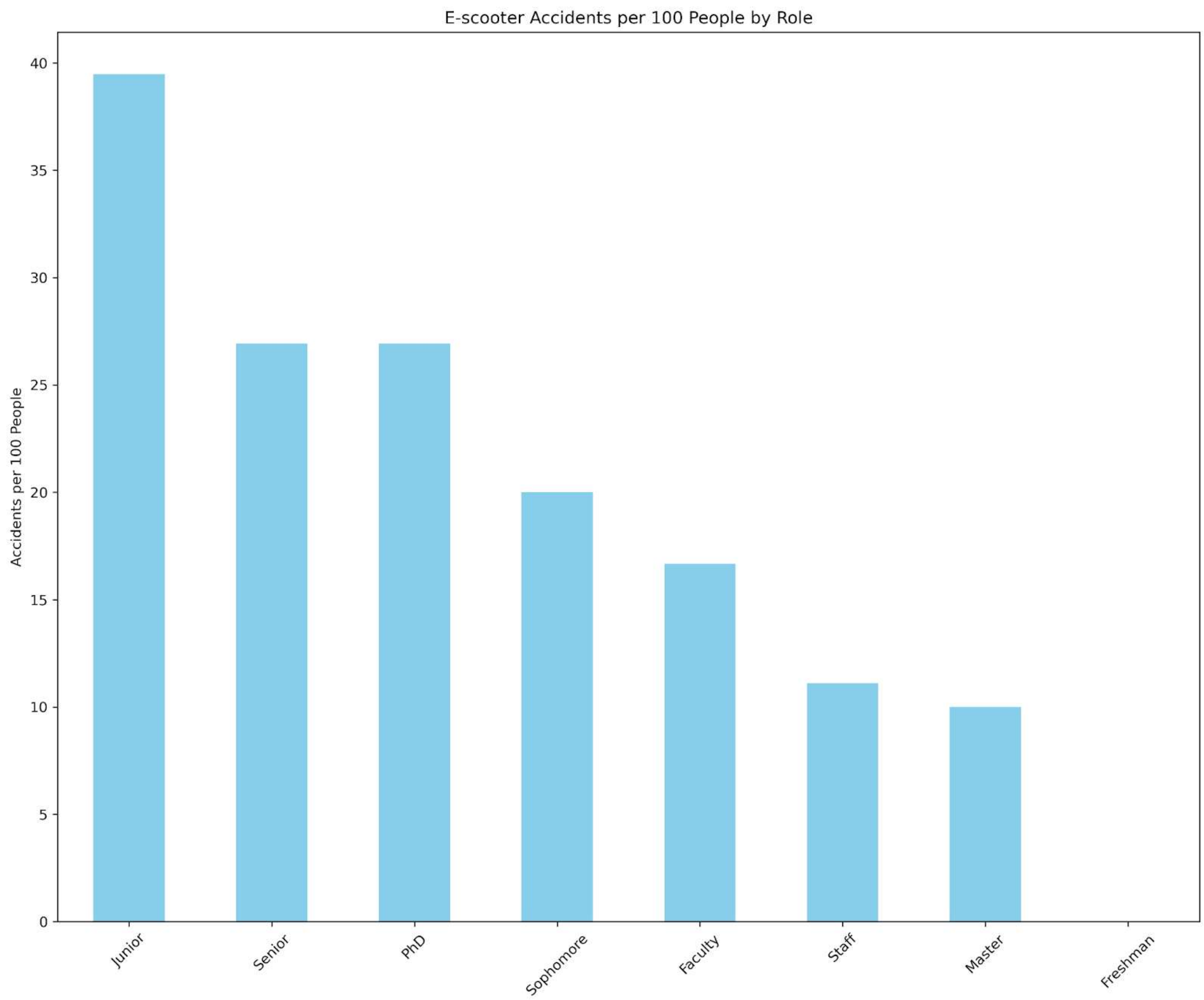

Fig. 43 *E-scooter accidents per 100 people by role*

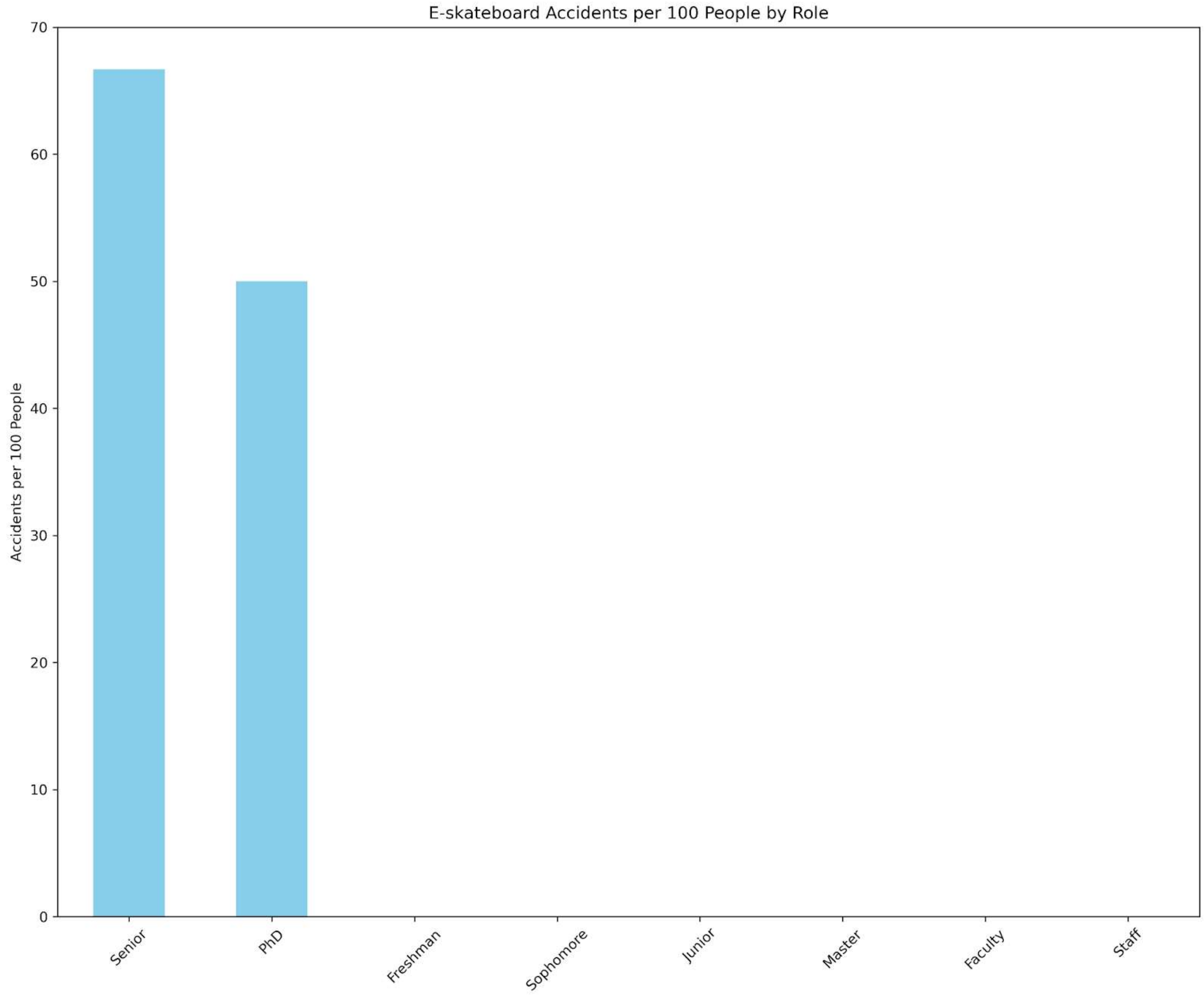

Fig. 44 *E-Skateboard accidents per 100 people by role*

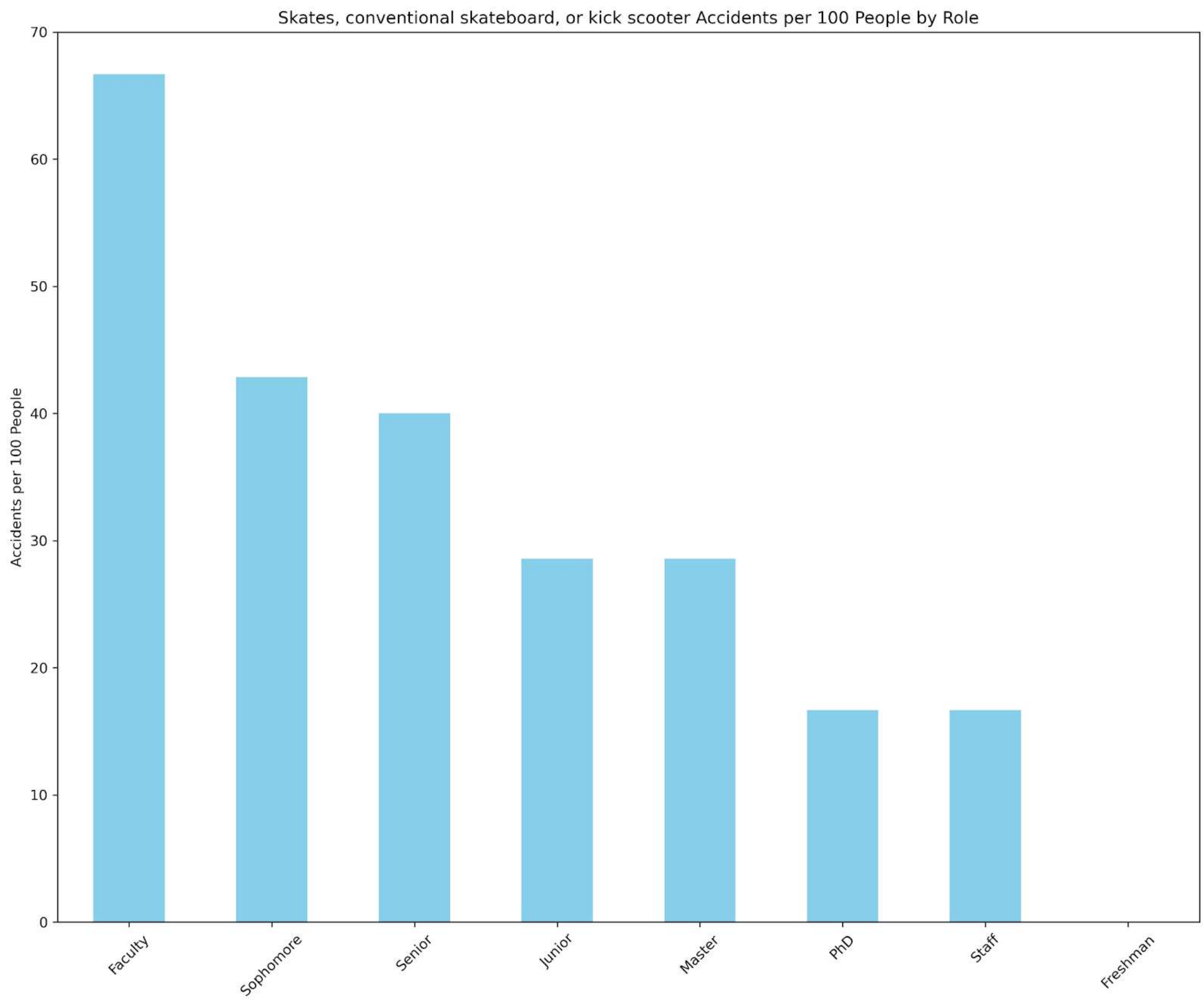

Fig. 45 *Skates, Conventional skateboard, or kick scooter accidents per 100 people by role*

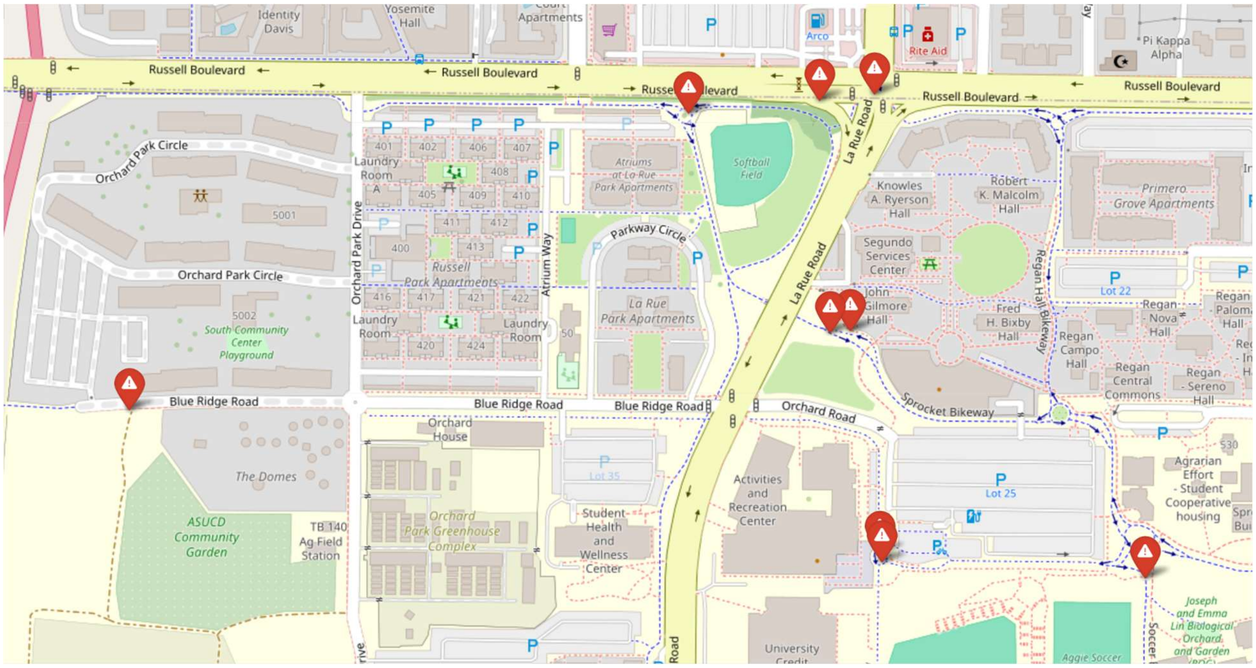

Fig. 46 *Zoomed in map of severe crashes, North-West*

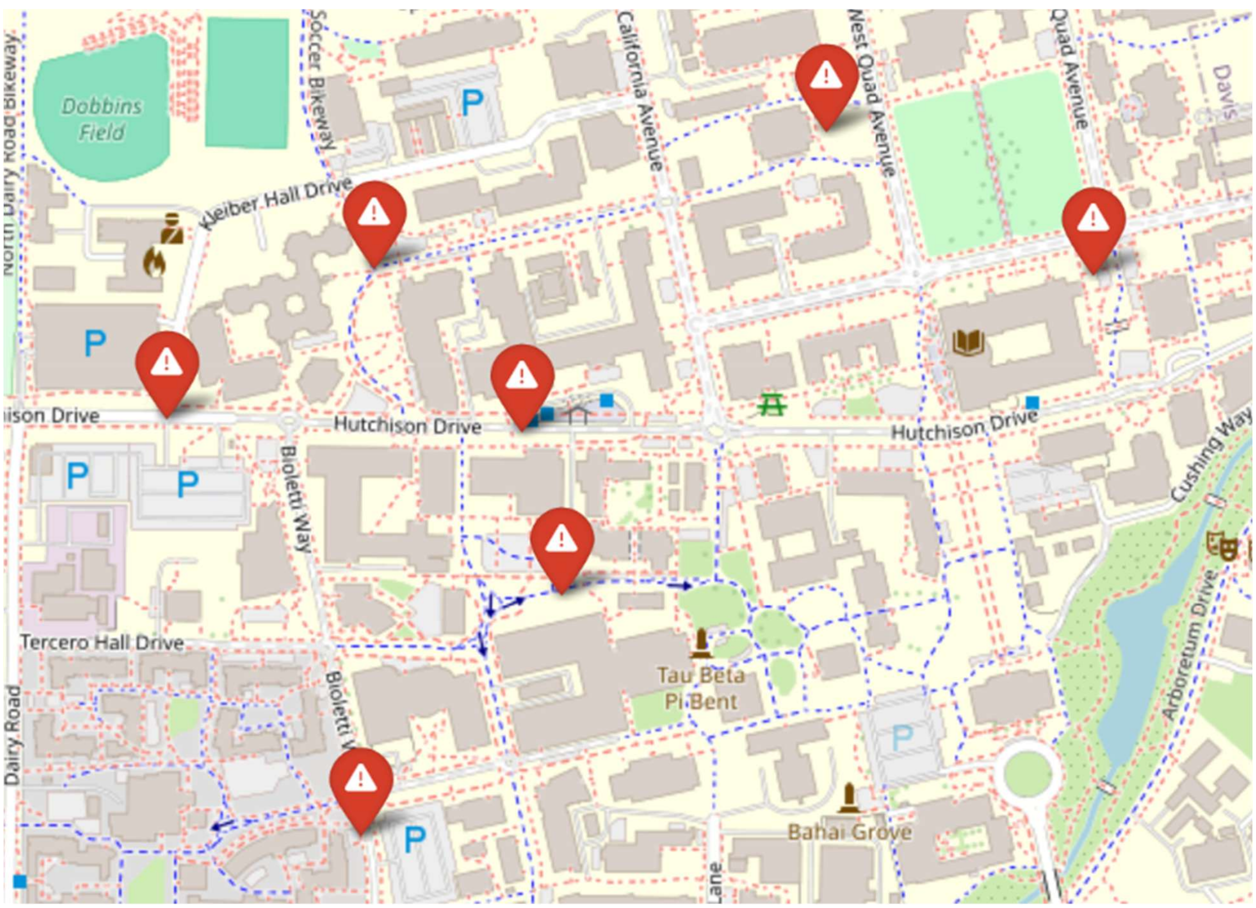

Fig. 47 *Zoomed in map of severe crashes, South*

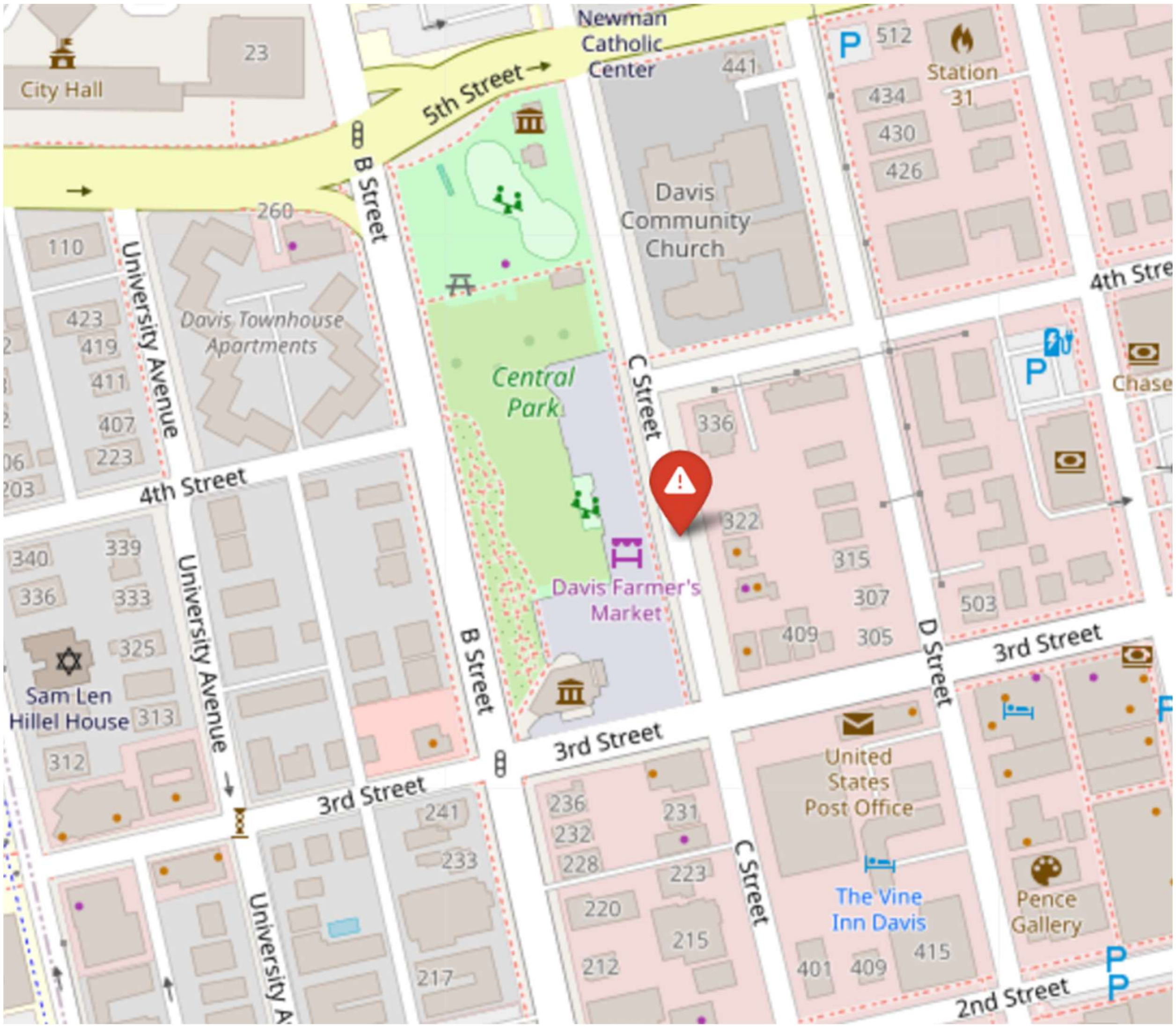

Fig. *48 Zoomed in map of severe crashes, East*