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Shared Electric Scooter Users and Non-Users: Perceptions on Safety, Adoption and Risk

Shiva Pourfalatoun, Jubaer Ahmed and Erika E. Miller *

Department of Systems Engineering, Colorado State University, Fort Collins, CO 80523, USA; shiva.pourfalatoun@colostate.edu (S.P.); jubaer.ahmed@colostate.edu (J.A.)
* Correspondence: erika.miller@colostate.edu

Abstract: Shared electric scooters (e-scooters) offer a potential strategy to mitigate environmental concerns and congestion. However, successfully addressing these issues with e-scooters requires adoption across a diverse array of consumers. Understanding the differences between users and non-users can improve shared e-scooter appeal, operation and safety. The objective of this paper is to compare shared e-scooter users and non-users in terms of their perceptions on safety, trip behaviors, other shared modes, risk propensity and willingness to adopt technology. A survey was conducted involving 210 (51.3%) users and 199 (48.7%) non-users of shared e-scooters. Binary logistic regression and chi-squared tests were performed. The results reveal that users demonstrated a higher risk propensity and were more likely to be early adopters of new technologies. Non-users tended to place higher importance on helmet use, while users have an overall increased feeling of safety associated with riding e-scooters in vehicle lanes, on sidewalks and being passed by e-scooters as a pedestrian. Overall, users also have a more positive perception of e-scooter sanitary levels than non-users, and a more positive perception on the sanitary levels and usability of e-scooters over e-bicycles. These findings can provide guidance to urban planners, municipal authorities and micromobility providers in developing infrastructure and policies to better support micromobility adoption.

Keywords: micromobility; shared mobility; e-scooter; survey; human factors; transportation

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1. Introduction

Urban populations around the globe are rapidly growing and are expected to account for more than half of the world's population by 2050 [1]. As urbanization increases, transportation systems and networks face heightened challenges related to capacity constraints. Emerging technologies in transportation offer new opportunities to address these challenges, as existing systems and networks likely cannot meet these increasing demands. For example, Barajas and Brown [2] highlighted the current gaps in access (i.e., coverage and frequency) to public transit, resulting in limited access to jobs, healthcare and/or education, which is disproportionately experienced by lower income, minoritized individuals. To address these coverage gaps and the growing demands on transportation systems, novel solutions and improvements to current infrastructure are needed. This paper explores micromobility as such a solution, with a focus on who is and is not served by electric scooters (e-scooters).

This paper begins with a literature review of relevant work (Sections 1.1.1–1.1.4) and the gaps in the literature that this paper seeks to address (Section 1.1.5). The Section 2 then describes the survey study approach we used to answer our research questions. Followed by the Section 3, which presents the findings relative to the differences between users and non-users of e-scooters. Our findings are then discussed in the context of other publications (Section 4). Lastly, the Section 5 summarizes the key contributions and takeaways from our paper.

1.1. Literature Review

1.1.1. Micromobility

Micromobility has emerged as a viable and sustainable alternative to diversify mobility, as it can reduce traffic congestion, improve air quality and help decarbonize the transportation fleet [3,4]. Micromobility refers to a mode of transport consisting of smaller, lightweight devices that are electric or human powered, such as bicycles, electric bicycles (e-bikes) and e-scooters [5]. These devices can be privately owned by an individual or shared for immediate use on an on-demand basis. Shared micromobility is often promoted as an environmentally friendly and innovative mode of transportation [5,6]. These devices can reduce automobile dependence and serve as first/last mile solutions.

Dockless micromobility, in particular, has been rapidly growing across cities in recent years; for example, in the US, dockless services went from practically none in 2017 to accounting for over 38.5 million trips in 2018 [7,8]. However, the literature has not kept pace with these trends, and dockless services remain largely under researched in comparison to docked services [8].

One of the more rapidly growing micromobility services is the e-scooter, which has been deployed in countless cities and countries, accounting for a significant share of trips [6]. These devices are deployed under the dockless service model. In 2022, dockless e-scooters were available in 158 cities across the US, a rise from 0 cities in 2017 to 58 cities in 2018 [9]. While it is believed that e-scooters can minimize climate change impacts through reduced traffic congestion and pollution [10,11], this novel, shared mode of transport may also have unanticipated effects on the transportation network.

1.1.2. Safety

Road behaviors and related safety outcomes for e-scooter users have attracted the attention of transport planners, policymakers and researchers. According to a survey conducted in Greece, safety is one of the most important concerns for both users and non-users of e-scooters; moreover, safety concerns are one of the main reasons why non-users do not use e-scooters [12]. Users are especially susceptible to trauma from falls given the ergonomics of e-scooters, in particular their expedient nature and the absence of protective gear [13]. A survey of 439 participants in Saudi Arabia reported that the majority (82%) of respondents who had previously used an e-scooter believed they were safe, whereas only a minority (18%) considered them unsafe [14]. Similarly, a survey study in Italy indicated that electric micromobility users consider these devices fun and easy to use, while more broad public opinion perceives them as unsafe and dangerous [15]. To ensure the safe use of e-scooters, it is important to examine the factors that are of concern to both users and non-users, such as the perceptions and individual factors that influence their decisions regarding e-scooter use.

1.1.3. Infrastructure

The recent and rapid growth of shared micromobility services and, in particular e-scooters, has given city planners and engineers little time to evaluate and assess the impact on the existing infrastructure and the necessary safety measures to meet user needs [16]. E-scooters face the challenge of navigating a city in an environment that often prioritizes motor vehicles on the road, leaving little room for other road users in many areas. As a result, traveling through a city on an e-scooter can be unpleasant and dangerous at times, limiting the safe and sustainable adoption of these devices. Moreover, the nature of the device leaves e-scooter users physically unprotected, as there is no crumple zone, meaning that users are likely to suffer serious injuries if a crash occurs with a vehicle [17]. Similarly, the lack of infrastructure for e-scooters also leads to potential conflicts with pedestrians, as e-scooter users often weave between the sidewalk and shoulder of the road [18,19]. In addition, the high center of gravity of e-scooters and their smaller wheels make them less stable [20], potentially leading to adverse outcomes during conflicts. Hence, there are serious barriers to the adoption of e-scooters, due to their perceived and real safety risks [21].

According to studies, shared e-scooters create a service that meets the mobility needs of areas without a well-developed public transit system, as well as providing a fun means of transportation for adults [12,22]. Their rapid and massive rate of acceptance has also been attributed to the fact that younger individuals tend to prefer mobility options priced based on frequency of use, rather than purchasing for private ownership [23]. A survey of shared micromobility users in Poland identified that riders of shared e-scooters are younger than riders of shared e-bikes, with e-scooters being used primarily for leisure trips and e-bikes being used for commuting [24].

1.1.4. Trip Behavior

Several studies have investigated the trip behaviors of e-scooter users. Recent research in the UK found that e-scooters are used for a variety of trip purposes, including commuting, leisure and shopping, and that they are often utilized as a substitute for walking or cycling [25]. A study in the US state of Utah indicated that e-scooter users tend to take shorter trips and are more likely to use them for leisure activities than for commuting [26]. A study in the US state of Virginia found that e-scooter riders notice paths blocked by e-scooters significantly less often than other road users (21% of e-scooter users vs. 75% of non-users) [27]. It has also been reported that younger riders of e-scooters are more likely to engage in risky behaviors [28,29]. It is important to note, however, that gender differences in risky behaviors vary depending on the domain of behavior [30]. For example, Gioldasis et al. [28] analyzed data in Paris, France and found that male e-scooter riders were more likely to engage in risky behavior than female riders, including riding after drinking alcohol, using drugs and riding while using a mobile device. In contrast, a survey of 210 e-scooter users in the US found that females were more likely to engage in risky behaviors, such as riding on the sidewalk [31]. Meanwhile, a study in Norway reported no difference in risky behaviors between male and female riders when analyzing the speed of e-scooters [28].

1.1.5. Research Gaps

Despite the popularity of shared e-scooters, the public has expressed concerns about aggressive riding behaviors, safety issues and the abuse of street space. Gossling [11] performed a content analysis on 173 media reports from 10 major cities and found that the top 3 frustrations experienced due to e-scooters in many cities were irresponsible riding, safety/injuries and e-scooter clutter. Further literature is still needed to understand the disconnect between proponents and opponents of e-scooters, which could identify opportunities to expand e-scooter ridership to more diverse users. Previous literature has predominantly focused on the user-based perception on shared e-scooters [19]. However, there is an increasing need to better understand the decision process of both users and non-users, and how certain factors can either deter or encourage shared e-scooter adoption.

The main objective of this paper is to understand the differences between shared e-scooter users and non-users, and to identify the factors that influence their decisions to use or not use shared e-scooters. A lack of risk perception, awareness and regulation have been cited as key barriers to cycle logistic implementation across European cities [32]. In this regard, we investigate how shared e-scooter users and non-users perceive e-scooters differently on different topics concerning demographics, trip characteristics, safety, comparisons to shared e-bicycles, perceptions on risk taking and technology adoption profiles. More specifically, we seek to answer the following research questions: (1) what demographic (e.g., age, gender, employment, residential location, commute) differences exist between users and non-users; (2) how risk-taking propensity and technology adoption tendencies predict ridership; (3) how perceptions relating to safety (e.g., helmet use, lane use, speed, infrastructure) influence ridership; and (4) do users and non-users perceive shared e-scooters and e-bicycles differently.

Moreover, a major contribution by this study is the comparison of users and non-users in terms of perceptions, technology adoption and risk-taking characteristics. These contributions can have the following impacts:

- Provide insights into factors influencing adoption and risk perception, informing decisions about user preferences and barriers to wider adoption;
- Guide policymakers, urban planners and safety organizations in developing appropriate infrastructure, regulations and safety interventions for e-scooter systems;
- Inform targeted marketing and educational initiatives. This promotes safe riding practices, raising awareness on the potential risks, providing a better user experience regarding the personas of e-scooter users and non-users, and driving technological advancements in e-scooter systems.

This integrated approach ensures a holistic understanding of the factors that influence scooter adoption and allows for the development of targeted interventions to promote the safe and responsible adoption of shared e-scooter systems.

2. Materials and Methods

A survey study was developed and administered to compare shared e-scooter users and non-users. The survey was thoroughly vetted and approved for human subject testing by an Institutional Review Board (IRB), ensuring that it adhered to ethical standards and protected the rights and welfare of the participants. Informed consent was obtained at the beginning of the survey.

2.1. Design and Procedure

The survey was administered online using the Qualtrics survey software (version 2022), which is a reliable and widely used tool for online data collection. This method was chosen for its convenience, accessibility and its ability to reach a broad audience for recruitment. Survey responses were gathered over a two-month period from December 2022 through to January 2023. The survey took, on average, 9.5 min to complete. The data was collected using a paid survey panel recruited through Qualtrics. Residents of the US state of Colorado were recruited with a target sample size of 400 complete responses. A stratified random sampling method was employed, targeting approximately 200 shared e-scooter users and 200 non-users, to provide comparable groups for analysis.

The survey focused predominantly on shared e-scooters, rather than other shared modes or personal e-scooter ownership. It employed previously validated instruments to ensure the reliability and validity of the data. Specifically, the survey consisted of questions related to participant demographics, typical commuting behaviors, frequency using various transportation modes, perceived safety concerns and usefulness of shared e-scooters, and compared the perceptions on shared e-scooters versus shared electric bicycles. These methods have been used and validated in previous studies, supporting the reliability and validity of our data [14,33,34]. Furthermore, our survey incorporated the General Risk Propensity Scale (GRiPS) [35] and assessed participants' technology adopter category, as characterized by Rogers' [36] five classifications for the diffusion of innovations. Both the GRiPS and Rogers' categories have been shown to be valid and consistent in previous studies, thus lending credibility to our results in the context of e-scooter use. By using such validated instruments, we aimed to ensure the rigor of our study and the robustness of the findings.

2.2. Survey Participants

A minimum age of 18 years old was required for all participants, and all participants had to reside within the state of Colorado. Participants who had never used a shared e-scooter were grouped as non-users, and those who reported using a shared e-scooter at least monthly were grouped as users. The survey received a total of 409 responses from 210 (51.3%) users and 199 (48.7%) non-users. The average age of the participants was 39.6 years old (SD = 16.3). The sample consisted of 11 (2.7%) participants with less than a high school degree, 227 (55.5%) with a high school diploma, 106 (25.9%) with a bachelor's degree, 58; (142%) with a post-graduate degree as their highest level of education completed, and 7 (1.7%) preferred not to answer. Additionally, we had 266 (65.0%) White, 64 (15.6%) Hispanic or Latino, 36 (8.8%) Black or African American, 18 (4.4%) two or more races, 10 (2.4%) Asian or Pacific Islander, 6 (1.5%) Native American, and 9 (2.2%) other participants. There were 181 (44.3%) participants with a household income of less than USD 50k, 132 (32.3%) with between USD 50k to USD 100k, 95 (23.2%) with greater than USD 100k, and 1 (0.2%) preferred not to answer. A further overview of the respondent demographics is provided in Table 1.

Table 1. Participant demographics by shared e-scooter user groups.

Demographic	User (N = 210) N (%)	Non-User (N = 199) N (%)	All (N = 409) N (%)
Gender			
Male	62 (31.1%)	50 (23.8%)	112 (27.4%)
Female	135 (67.8%)	158 (75.2%)	293 (71.6%)
Other	2 (1.0%)	2 (0.9%)	4 (1.0%)
Age			
18–24	53 (26.6%)	35 (17.1%)	88 (21.8%)
25–34	68 (34.1%)	34 (16.6%)	102 (25.25%)
35–44	49 (24.6%)	34 (16.6%)	83 (20.54%)
45–54	21 (10.6%)	33 (16.1%)	54 (13.37%)
55–64	5 (2.5%)	34 (16.6%)	39 (9.7%)
65 and over	3 (1.5%)	35 (17.1%)	38 (9.4%)
Employment Status			
Student	32 (16.1%)	22 (10.5%)	54 (13.2%)
Employed	133 (66.8%)	109 (51.9%)	242 (59.2%)
Not Employed	34 (17.1%)	79 (37.6%)	113 (27.6%)
Residential Location			
Rural	25 (12.6%)	39 (18.7%)	64 (15.7%)
Suburban	92 (46.5%)	120 (57.4%)	212 (52.1%)
Urban	81 (41.0%)	50 (24.0%)	132 (32.3%)

While the survey population was not entirely representative of the general population in Colorado, it was appropriate for our research objective, which was to investigate the differences between e-scooter users and non-users. When compared to US census data, for example the proportion of females in the sample was higher than the general population in Colorado (71.6% vs. 49.3%). While the proportion of participants from rural areas in the sample was closer to that in the general Colorado population (15.7% vs. 13%). Similarly, 59.2% of our sample was employed, compared to 67.8% of the Colorado population age 16 and over in the civilian labor force. The state of Colorado was 67% White, compared to our 65%. Lastly, the proportion of our sample with a bachelor's degree or higher was 40.1%, compared to 42.8% for the state of Colorado.

2.3. Data Analysis

Data cleaning and analysis were conducted using Python (version 3.6.12), SPSS (version 28.0.0.0) and Tableau (version 2022.4). Initial data cleaning was conducted by Qualtrics for quality control, where incomplete responses were removed and responses completed in one-half of the median completion time were removed, which resulted in 409 complete responses used in the analysis. Statistical significance was evaluated at $\alpha = 0.05$. Binary logistic regression, chi-squared tests, Cochran's Q tests and McNemar tests were performed to compare users and non-users of shared e-scooters.

Dependent Variable

The dependent variable used in the analysis was shared e-scooter group membership, which was a binary variable coded as shared e-scooter user or non-user. A shared e-scooter user was a familiar user, defined as someone that reported using a shared e-scooter at least monthly. A shared e-scooter non-user was defined as someone that reported never having ridden one.

3. Results

3.1. Demographics by User Group

The basic demographic profiles of the shared e-scooter users and non-users from our respondents were compared to gain insights about characteristic differences between the user groups. A binary logistic regression model was used with the dependent variable shared e-scooter user (1) and non-user (0), see Table 2. Hence, the model predicted the likelihood of being a user, where variables with a positive coefficient value increased the likelihood of being a user. Based on these results, shared e-scooter users were significantly younger (negative coefficient for increasing age variable), were employed (i.e., not students), lived in urban areas and have commutes longer than 1 mile.

Table 2. Logistic regression predicting users based on demographics.

Variable	Coeff.	SE	z	*p*
(Intercept)	0.027	0.673	0.040	--
Age	−0.059	0.009	−6.513	<0.001
Female *(ref: male)*	−0.305	0.257	−1.188	ns
Employed *(ref: student)*	1.067	0.486	2.193	0.028
Not Employed *(ref: student)*	0.866	0.547	1.582	ns
Suburban Residential *(ref: rural)*	0.253	0.333	0.760	ns
Urban Residential *(ref: rural)*	1.098	0.363	3.022	0.003
Commute 1–5 miles *(ref: <1)*	1.144	0.387	2.957	0.003
Commute 6–10 miles *(ref: <1)*	1.181	0.397	2.975	0.003
Commute >10 miles *(ref: <1)*	1.124	0.418	2.688	0.007

Note: Nagelkerke R^2 = 0.301.

3.2. Risk Propensity and Technology Adoption in Predicting User Groups

The General Risk Propensity Scale, GRiPS [35], was used to measure risk-taking behavior. GRiPS uses eight questions to measure the general risk propensity on a scale of 1 (strongly disagree) to 5 (strongly agree), where a higher average score equates to being more of a risk taker. The range of responses and average response for each question by user group is shown in Figure 1. For all eight questions, the average score was lower for shared e-scooter non-users than users. Moreover, the overall average score across all eight questions revealed a significant difference between the two groups, where shared e-scooter users have a higher mean risk score (M = 3.29, SD = 0.87) compared to non-users (M = 2.61, SD = 1.03): t (400.11) = 7.285, $p < 0.001$.

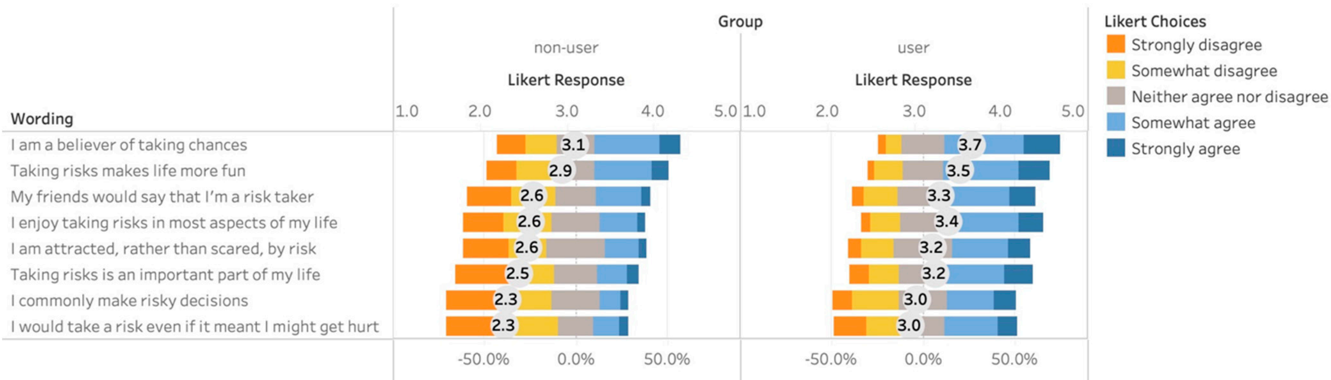

Figure 1. Comparison of the responses for each risk propensity question by user group, where the average scores are denoted in each circle.

Participants were asked about their general affinity to adopting new technologies, which aligned with Rogers' [36] five classifications for the diffusion of innovations. We used their response to define their technology adoption profile as either: innovator, early, early majority, late majority or laggard, see Figure 2. There were noticeably more "innovators" and less "laggards" in the user group, as compared to the non-user group.

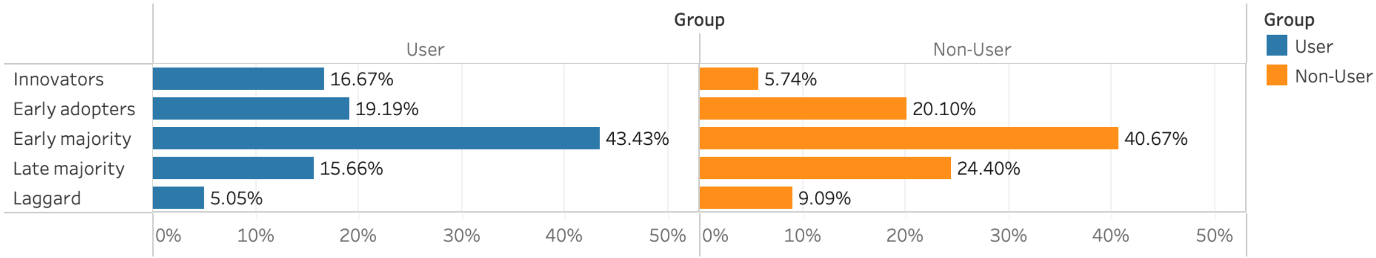

Figure 2. Comparison of the technology adoption profiles by user group.

Next, binary logistic regression was conducted to predict user group membership based on risk propensity and technology adoption profiles. Age was also included in this model because it tends to be associated with risk propensity and user group. The model is summarized in Table 3. The regression results indicate that both technology adoption and risk propensity significantly predict shared e-scooter usage. Specifically, each one unit increase in the average risk score increased the odds of being a shared e-scooter user by 0.423. Shared e-scooter users were also more likely to be early majority or innovators in terms of technology adoption profiles.

Table 3. Logistic regression predicting users based on risk and technology profiles.

Variable	Coeff.	SE	z	*p*
(Intercept)	−0.322	0.697	−0.462	--
Average Risk Score	0.423	0.130	3.259	0.001
Technology Adopter Profile (ref: Laggard)				
Late Majority	0.520	0.496	1.050	ns
Early Majority	0.912	0.458	1.989	0.047
Early Adopter	0.573	0.488	1.175	ns
Innovator	1.563	0.563	2.778	0.005
Age	−0.045	0.008	−5.472	<0.001

Note: Nagelkerke R^2 = 0.265.

3.3. Perceptions Relating to Safety

3.3.1. Helmet Use

Participants were asked to what extent they thought helmets were necessary while riding shared e-scooters. There was a significant relationship between user group and perceived importance of wearing a helmet: χ^2 (4, N = 409) = 19.61, $p = 0.001$. Specifically, non-users were more likely to consider a helmet extremely necessary while riding a shared e-scooter. Whereas, there was no strong opinion about whether helmets are necessary among users, see Figure 3.

3.3.2. Speed and Riding Scenarios

Additionally, participants were asked whether they felt safe or unsafe regarding the speed of shared e-scooters and different hypothetical riding scenarios, see Figure 4. Chi-squared tests were performed to compare the users versus non-users regarding each scenario. The results indicate that there was a significant difference between users and non-users in their safety perceptions on shared e-scooters, where users considered it safe to ride shared e-scooters on the sidewalk (χ^2 (1, N = 409) = 34.63, $p < 0.001$), to get passed by a rider as a pedestrian on the sidewalk (χ^2 (1, N = 409) = 24.45, $p < 0.001$), to ride in the vehicle lane (χ^2 (1, N = 409) = 17.28, $p < 0.001$) and they also felt safe regarding the speed of the device (χ^2 (1, N = 409) = 27.66, $p < 0.001$). On the other hand, non-users considered these as unsafe.

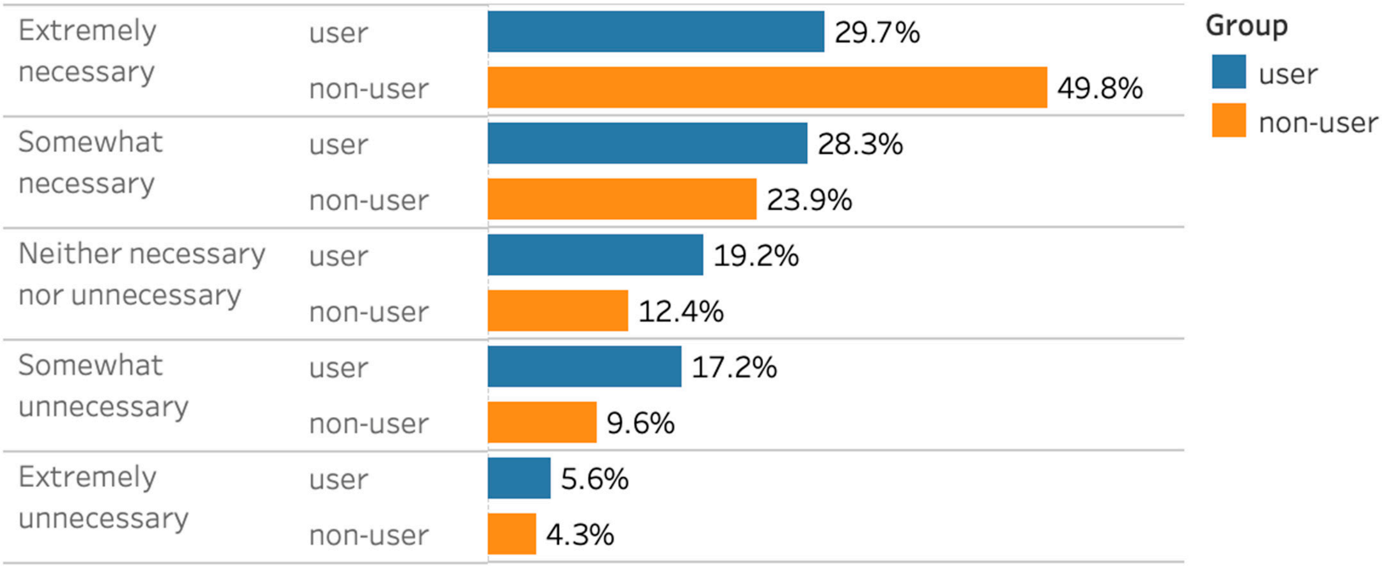

Figure 3. Perceptions on the importance of helmets while riding a shared e-scooter.

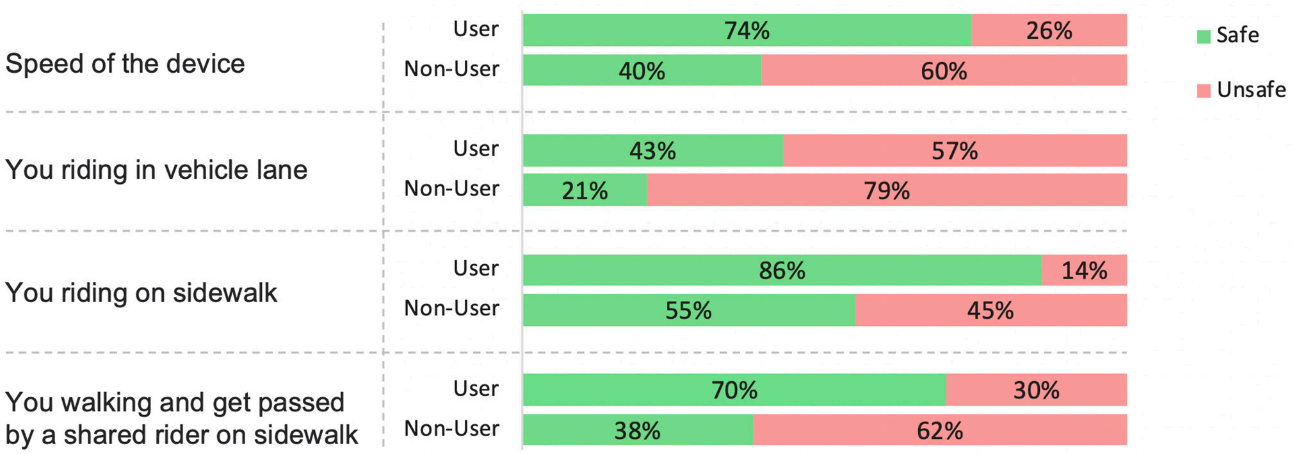

Figure 4. Comparing safety perceptions regarding speed and riding scenarios by user group.

3.3.3. Infrastructure Needs

Participants were asked what changes in infrastructure would increase their perception of safety on or around shared e-scooters. This question allowed respondents to select multiple options, see Table 4. According to Cochran's Q test, the choices made by the two groups differed significantly: χ^2 (5, N = 409) = 179.16, $p < 0.001$. Based on chi-squared tests as a post hoc test, non-users were more likely to feel safer if separated bike lanes with a physical barrier existed ($p = 0.03$). No other significant difference was observed between the other infrastructure options. Both users and non-users tended to agree that a smoother pavement was important and that no ride zones were the least important.

3.4. Differences in Perceptions on Shared E-Scooters vs. Shared E-Bikes

A common question amongst academics and practitioners is whether shared e-scooters are serving a different population from shared bicycles. We compared various perceptions on these two modes between shared e-scooter users and non-users, see Figure 5. Chi-squared tests were performed to compare the users versus non-users within a mode, e.g., comparing the opinion about "feeling safe riding a shared e-scooter" between users and non-users, and about "feeling safe riding a shared e-bicycle" between users and non-users, etc. McNemar tests were used to compare within user groups across modes, e.g., comparing the opinion about "feeling safe riding a shared e-bicycle" versus "feeling safe riding a shared e-scooter" for users and, again, for non-users, etc. Hence, the chi-squared tests yielded differences in the perceptions between user groups, while McNemar tests yielded differences in the perceptions between transportation modes. McNemar tests were used because the data was paired, as there was an observation from the same participant regarding their perception on shared e-scooters and shared e-bicycles. The results from these tests are shown in Figure 5.

Table 4. Preferences on the infrastructure changes to enhance safety.

Infrastructure Improvement	User (N = 210) N (%)	Non-User (N = 199) N (%)
Smoother Pavement	114 (54.3%)	102 (51.3%)
Wider Bike Lanes	97 (46.2%)	98 (49.2%)
Separated Bike Lanes with Physical Barrier	91 (43.3%)	117 (58.8%)
Designated E-Scooter Parking	70 (33.3%)	63 (31.7%)
Wider Sidewalks	64 (30.5%)	63 (31.7%)
No Ride Zones for E-Scooters	31 (14.8%)	47 (23.6%)

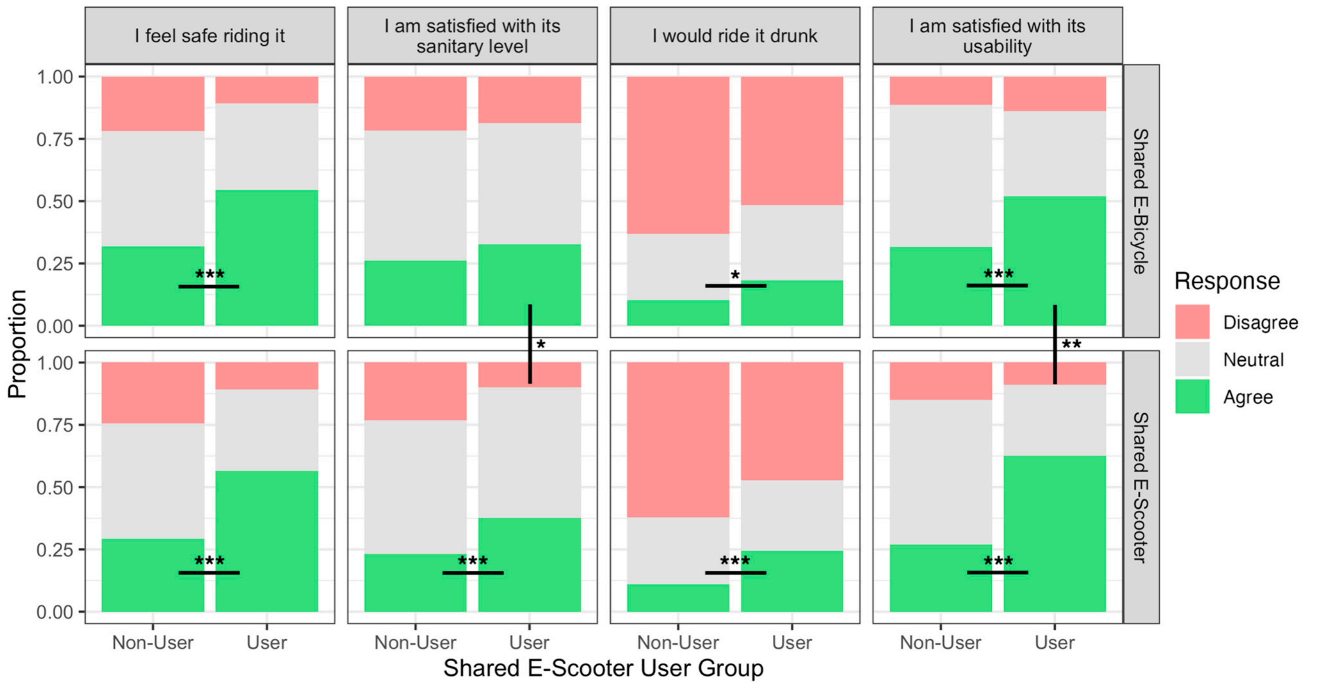

Figure 5. Differences in perceptions on shared e-scooters and shared e-bicycles based on user group, where the lines connecting the bars denote a significant pairwise comparison. Note: * denotes $p < 0.05$, ** for $p < 0.01$ and *** for $p < 0.001$.

The chi-squared results indicate that there was a significant difference between users and non-users in their perceptions on shared e-scooters, where users overall have more positive perceptions on the safety (χ^2 (2, N = 409) = 32.69, $p < 0.001$), sanitary level (χ^2 (2, N = 409) = 17.31, $p < 0.001$), comfort riding intoxicated (χ^2 (2, N = 409) = 14.60, $p < 0.001$) and usability (χ^2 (2, N = 409) = 51.55, $p < 0.001$) of shared e-scooters, as compared to non-users. These trends were similar for their perceptions on shared e-bicycles, however there was no difference in user versus non-user perceptions on the sanitary levels of shared e-bicycles; the safety (χ^2 (2, N = 409) = 22.18, $p < 0.001$), sanitary level (χ^2 (2, N = 409) = 2.03, *p* = ns), comfort riding intoxicated (χ^2 (2, N = 409) = 6.95, $p = 0.03$) and usability (χ^2 (2, N = 409) = 20.93, $p < 0.001$) of shared e-bicycles.

McNemar's tests showed that there were no differences in the perceptions on shared e-bicycles versus shared e-scooters for non-users. However, users were more positive towards the sanitary levels of e-scooters over e-bicycles (χ^2 (3, N = 409) = 8.21, $p = 0.04$), and about the usability of e-scooters over e-bicycles (χ^2 (3, N = 409) = 11.27, $p = 0.01$). Meanwhile, there were no differences in users' perceptions on safety or riding intoxicated between shared e-scooters and shared e-bicycles.

3.5. Trip Purposes for Shared E-Scooters

Another binary logistic regression was conducted to predict the likelihood of being a shared e-scooter user or non-user based on shared e-scooter use for various trip purposes: commuting to work/school, commuting to remote parking areas, for leisure/fun, for personal tasks (e.g., grocery shopping, going to the bank) and for exploring a new city. Shared e-scooter users were asked how frequently they used shared e-scooters for these various trips and non-users were asked how frequently they would consider using shared e-scooters for the various trips. For each trip purpose, the responses were coded as "rarely/never" or "at least once a month." The analysis revealed significant associations between shared e-scooter use for specific purposes and the likelihood of being a shared e-scooter user, see Table 5.

The intent to use a shared e-scooter for commuting to work/school significantly predicted being a user (odds ratio = 2.79). Similarly, those who intended to use shared e-scooters for commuting to remote parking (odds ratio = 2.24) and for leisure/fun (odds ratio = 7.87) were also more likely to be users. However, shared e-scooter use for personal tasks and exploring a new city did not significantly predict the likelihood of being a user or non-user in this study ($p > 0.05$).

Table 5. Logistic regression predicting users based on trip purpose.

Variable	**Coeff.**	**SE**	**z**	***p***
(Intercept)	−2.807	0.349	−8.038	--
Commute to Work/School	1.026	0.345	2.978	0.003
Commute to Remote Parking	0.807	0.334	2.415	0.016
For Leisure/Fun	2.063	0.472	4.373	<0.001
For Personal Tasks (e.g., grocery)	0.428	0.335	1.280	ns
For Exploring a New City	0.607	0.374	1.621	ns

Note: Nagelkerke R^2 = 0.578.

3.6. Motivations for Using Shared E-Scooters

Lastly, participants were also asked about the reasons that would motivate (non-users) or have motivated (users) them to use a shared e-scooter, which included: to save time, to save money, for parking convenience, for fun/adventure, or for environmental reasons. Participants were instructed to select all that applied, i.e., not limited to one selection. The responses were recorded for each group and analyzed to determine the most common motivations, see Table 6.

Cochran's Q test showed a significant difference between the motivational factors chosen by the two groups: χ^2 (4, N = 409) = 127.05, $p < 0.001$. Chi-squared tests were used as a post hoc test, which showed that e-scooter users were mostly motivated by "saving money" and "saving time" in comparison with non-users not being motivated by these factors ($p < 0.001$). In both user groups, "fun/adventure" was the most selected factor for wanting to use shared e-scooters.

Table 6. Comparison of the motivational factors among users and non-users.

Motivational Factor	User (N = 210) N (%)	Non-User (N = 199) N (%)
For Fun/Adventure	120 (57.1%)	128 (64.3%)
To Save Money	99 (47.1%)	61 (30.7%)
To Save Time	82 (39.0%)	49 (24.6%)
For Parking Convenience	80 (38.1%)	74 (37.2%)
For Environmental Reasons	50 (23.8%)	67 (33.7%)

4. Discussion

This study examined how shared e-scooter users and non-users perceive shared e-scooters differently in various situations regarding safety, trip behavior and in relation to other shared modes, as well as their risk-taking propensity and their acceptance of new technologies. Participants who had never used a shared e-scooter were categorized as non-users (N = 199) and those who reported using a shared electric scooter at least monthly were categorized as users (N = 210).

Perceptions on safety, particularly in relation to helmet usage, exhibited considerable variation between the user groups. Non-users, whose opinions might have been shaped by observations or anecdotal information rather than personal experience, deemed helmets to be of utmost importance. In contrast, users expressed more moderate views on helmet necessity. These findings are aligned with a recent study, which stated that users consider e-scooters safe, while non-users consider them as unsafe [15]. Contrary to non-users, users reported feeling safe regarding the speed and in a variety of e-scooter scenarios, including riding on sidewalks and walking and being passed by an e-scooter. Both cohorts, however, concurred that infrastructure improvements, including smoother pavements, dedicated bike lanes, and physical barriers, were essential for promoting safety. Notably, non-users emphasized the significance of physical barriers in fostering a secure environment for e-scooter riders. Similarly, Sievert et al. [37] reported that protected bicycle lanes were perceived as the safest infrastructure for riding e-scooters, amongst 329 surveyed riders. While helmet usage was mostly a concern of non-users, infrastructure was a concern for both users and non-users, and public policy could be improved by emphasizing protected bicycle lanes, rather than helmet mandates, as a means of protecting all vulnerable road users from the dangers associated with e-scooters.

Overall, both users and non-users of e-scooters expressed feeling unsafe riding them in vehicle lanes. Considering that both groups reported feeling safe riding these modes on sidewalks, one explanation could be that car speeds and their presence in the same shared lane makes them less in control and more vulnerable, resulting in more serious injuries. These findings are supported by a recent case study that discussed injuries sustained by micromobility riders, concluding that micromobility riders are more vulnerable to severe injuries in crashes with vehicles, due to having to share transportation facilities with others and their inherent vulnerability compared to cars [38].

When comparing shared e-scooters and e-bikes, users generally had more positive perceptions of e-scooters, specifically in terms of their sanitation and usability. However, there were no significant differences in the perceptions on safety and riding while intoxicated between the two modes for the users. This finding suggests that shared e-scooters possess a unique appeal, but further research is necessary to explore the factors that influence user preferences and distinguish shared e-scooters from other transportation options.

Additionally, users in our study exhibited a higher propensity for risk taking and were more likely to be early technology adopters compared to non-users. Our binary logistic regression analysis demonstrated that both risk propensity and technology adoption profiles significantly predict shared e-scooter usage. These findings align with previous research on the psychology of early adopters and risk-taking behavior, suggesting that shared e-scooter users are more open to exploring innovative modes of transportation and may exhibit a greater tolerance for potential risks associated with their use [39]. In contrast, non-users tend to exhibit more conservative attitudes, potentially avoiding shared e-scooters due to concerns about safety, unfamiliarity with the technology, or a preference for traditional transportation methods.

We also found that having fun was the primary motivator for both shared e-scooter users and non-users who would consider using a shared e-scooter. This indicates that the enjoyable experience of riding an e-scooter is a key factor in attracting people to the service. For users, saving money and saving time were the next most important factors, suggesting that these users appreciate the cost and time efficiency provided by shared e-scooters. These findings are consistent with a survey study in Tampa, Florida regarding factors influencing shared e-scooter usage, in which fun, getting around faster and saving money were reported to be among the top three motivating factors [40]. In contrast, non-users placed greater importance on commuting to parking lots and preserving the environment, indicating that they might be more likely to adopt shared e-scooters if these aspects were emphasized or improved. Similarly, Eccarius and Lu [41] reported that the top motivations for e-scooter usage in Taiwan were environmental concerns and convenience.

The logistic regression model based on demographics revealed that younger, employed individuals with commutes longer than 1 mile and living in urban areas were more likely to be shared e-scooter users. These findings strongly align with existing literature on the demographic characteristics of shared e-scooter users [29,39,41,42]. Younger individuals tend to be more tech savvy and comfortable with adopting new technologies. The use of shared e-scooters often requires smartphone applications and familiarity with digital interfaces, which may be more accessible to younger users. Similarly, urban areas typically have better developed infrastructure to support e-scooters, such as dedicated bike lanes and accessible charging stations, which may encourage their use among urban residents. Moreover, shared e-scooters can be more cost effective than owning a personal vehicle or relying on public transportation, particularly in urban areas where parking fees and traffic congestion can be significant deterrents.

These distinctions between user groups highlight the importance of tailoring communication and outreach strategies to address the differing concerns and preferences of these distinct demographics. For instance, targeted marketing campaigns and educational initiatives for non-users could focus on addressing safety concerns, providing clear instructions for proper e-scooter use and emphasizing the benefits of e-scooters as an alternative to traditional transportation options. Such efforts may help mitigate apprehension and encourage broader adoption of shared e-scooters.

Moreover, understanding the psychological factors that influence shared e-scooter adoption can inform the design and implementation of policies and infrastructure that cater to the needs of both user groups. For example, policymakers could consider implementing measures to enhance safety, such as designated e-scooter parking zones and speed limits, to address the concerns of more risk-averse individuals. By acknowledging and accommodating the distinct perspectives of users and non-users, city planners and e-scooter companies can develop strategies that foster a more inclusive and sustainable urban transportation ecosystem.

Our study has some limitations that should be acknowledged. First, the study relied on self-reported data, which may be subject to social desirability and recall biases. Future research could benefit from using more objective measures, such as e-scooter usage data or observations on rider behavior. Additionally, our sample may not be representative of the broader population, as it was limited to individuals with internet access who were willing to participate in an online survey (Supplementary Materials). Moreover, all participants resided in the state of Colorado, which is a state that promotes environmentally friendly transport modes. Further research is needed to determine whether our results can be generalized to other cities with different infrastructure, regulations, or cultural norms around e-scooter use, and should seek to collect data from a more diverse and representative sample to ensure generalizability of the findings. Lastly, future research could group users/non-users into more granular groups based on ridership frequency, such as weekly versus a few times per year versus never. As these differentiations and motivations for using or not using e-scooters at these levels could provide further insights into different user types.

5. Conclusions

This study contributes to the growing body of literature on shared e-scooter adoption by examining the differences in demographics, trip purposes, motivations, safety perceptions, risk-taking behaviors and technology adoption profiles between users and non-users. Non-users, likely influenced by observations and anecdotal information, placed more emphasis on helmet usage, whereas users were more moderate in their helmet necessity views. Infrastructure improvements were deemed necessary by both groups for enhancing safety. Interestingly, users exhibited a higher propensity for risk taking and were more likely to be early technology adopters. Fun was identified as the primary motivator for both groups, with users also valuing cost and time efficiency, and non-users expressing interest in the environmental benefits. Our logistic regression model indicated that younger, employed individuals living in urban areas with longer commutes were more likely to be users. The findings provide a more nuanced understanding of the factors that influence shared e-scooter adoption and have implications for operators, policymakers and researchers.

For operators, understanding the demographics, motivations and trip purposes of shared e-scooter users can inform targeted marketing campaigns and service offerings. For example, operators could emphasize the time and cost-saving benefits of e-scooters to attract potential users, while focusing on providing services for work/school commutes and leisure activities. Additionally, operators should consider implementing safety features and educational programs to address concerns related to helmet use and risk-taking behaviors.

Policymakers should recognize the importance of infrastructure improvements, such as smoother pavements, separated bike lanes and physical barriers, in promoting shared e-scooter adoption and ensuring rider safety. By investing in safer and more accessible infrastructure for e-scooters and other micromobility options, policymakers can encourage the use of these sustainable modes of transportation and help reduce congestion, pollution and the dependence on personal vehicles in urban areas.

Researchers should continue to explore the factors influencing shared e-scooter adoption, including barriers to use among non-users and the role of social norms and peer groups. Longitudinal studies with more diverse and representative samples will help to establish causal relationships between variables and provide a more comprehensive understanding of shared e-scooter adoption patterns. Moreover, comparative studies between shared e-scooters and other micromobility options can offer insights into the unique appeal of each mode of transport and inform strategies for promoting their use.

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