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Shared E-Scooters and the Promotion of Equity across Urban Public Spaces—A Case Study in Braga, Portugal

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Abstract: Shared e-scooters were introduced in urban public spaces as a way to promote a modal shift from cars in short-distance trips, as well as to improve sustainability, resilience, and equity in urban transport. However, the expansion of shared e-scooter services in 2019 proved that this mode of transport, without integrated planning strategies, can bring some problems to cities, which are related to the illegal parking of e-scooters, an increase in head injuries, and the lack of population diversity among users. Regarding the latest, this research work aims at conducting a case study in the city of Braga, Portugal to reveal who the actual and potential users of shared e-scooters are and how their socioeconomic profile (e.g., gender, age, income range, literacy, occupation) and usage patterns related to the ones found in other cities. For this, a revealed preference survey was deployed on the case study site, and the respondents' profiles were statistically correlated with the socioeconomic characteristics of the city's general population in order to assess if this mode of transport provides an equitable service. Results show that shared e-scooters are not equally used by people of different genders, ages, and income ranges. Information on e-scooter usage inequalities across the population is useful for the city to proceed with more socially equitable mobility policies.

Keywords: micromobility; shared e-scooters; equity in micromobility

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1. Introduction

Public spaces are key for sustainable communities and are part of the Sustainable Development Goals (SDG) through target 11.7, which states that, by 2030, cities must provide universal access to safe, inclusive, and accessible green and public spaces, particularly for women and children, older persons, and persons with disabilities [1,2]. However, most of the shared micromobility services, including shared bicycles and e-scooters, were never implemented in public spaces to target equity and social justice problems, but only environmental burdens associated with economic goals to stimulate urban renewal [3].

In this context, the first-ever shared e-scooter services were deployed in the USA in 2017, and, in the following year, in Europe, with a promise to improve urban mobility and well-being in cities while decreasing the greenhouse gas (GHG) emissions from the transport sector and providing a resilient and equitable mode of transport [4].

In the first years of deployment, shared e-scooter services were responsible for more than 38.5 million trips in the USA, which surpassed the number of station-based bike share trips (36.5 million), shared e-bike trips (6.5 million), and shared dockless bike trips (9 million) [5]. In Europe, shared e-scooter services had an increase in the number of users from 1.7 million in 2018 to more than 16 million users in 2019 [6]. Only one shared e-scooter company was responsible for more than 16 million rides in more than 35 European cities in August of 2018; 12% of these shared e-scooter trips replaced car trips, taxis, or ride-hailing services [7].

This increased usage of e-scooters can contribute to the reduction of air pollution in cities if they can replace cars in short-distance trips. In Germany, for example, shared e-scooters can represent a shift towards sustainable mobility, as they can represent a reduction

of up to 5500 tons of daily CO_{2eq} [8]. On the other hand, a study conducted by Kubik (2022) [9] shows that the decrease in GHG emissions promoted by shared e-scooter usage can be greatly influenced by the source of energy (i.e., coal-powered power plants, solar energy) to charge their batteries and the type of pavement that shared e-scooters are riding on.

Shared e-scooters can also represent a risk for users and the general population of cities. The quick sprawl of this service in urban environments, combined with the lack of legislation for users and proper infrastructure for journeys, have culminated in a rise in injuries related to the usage of this new mode of transport [10]. The e-scooter itself, as a micro vehicle, combined with the high speeds that can be reached, leaves riders extremely vulnerable to traumatic injury on major roads [11].

Moreover, the ridership and parking of shared e-scooters can be the origin of some problems in cities, since they can cause difficulties for pedestrians on sidewalks. It has been reported that shared e-scooters are responsible for disrupting pedestrian travel and blocking their right-of-way, as these vehicles are regularly parked undesirably on sidewalks, ramps, curb cuts, and handrails [12–16]. The problems are mostly caused by the service users, who are usually males with high incomes, with an average revenue of 2500 EUR/month in the USA and 2202 EUR/month in Europe [17].

Regarding the benefits and drawbacks of shared e-scooter services, this mode of transport can allow a significant improvement in local transport if proper planning and integration into the transport and land use system are performed [18]. Thus, the operation of shared e-scooter services needs to be based on fair population coverage and needs to take into account socioeconomic differences to provide a mode of transport for all [19].

Thus, this paper aims at filling the literature gap by providing an overview of the fairness and equity of shared e-scooter services, and how diverse socioeconomic groups are represented among users of this service, more specifically in the Portuguese context. To the best knowledge of the authors, this research represents the first in Portugal to address equity issues around the provision of shared e-scooter services. Additionally, this research contributes to expanding the knowledge of shared e-scooter usage patterns in urban contexts. It contributes to a better understanding of the interaction of this mode of transport with city dwellers and the range of influential aspects that need to be addressed such that e-scooter services could reach all individuals equally.

Equity can be defined as "the morally proper distribution of benefits and costs (burdens) over members of society" [20,21], and, according to Bruzzone et al. [22], more studies need to be addressed in this matter, since a clear definition for the concept is still missing, and the debate on the extent of equity within the field of transport is still open.

For this, a case study in the city of Braga, located in the north of Portugal, is developed to better understand who the actual and potential users of the shared e-scooter service in the city are, and if this service is offered equally to the population despite their socioeconomic characteristics. Therefore, the research questions are:

- Who are the actual and potential users of the shared e-scooter service in Braga, Portugal?
- What are the social characteristics of the actual users and potential users of these shared e-scooters in Braga?
- Is this service provided in an equitable way across the population of different socioeconomic profiles?

The remainder of this paper is organized as follows: Theoretical Framework, Methodology, Results, where the case study is presented, Discussion, and Conclusion.

2. Theoretical Framework

2.1. Equity in Urban Mobility

Transport planning in cities must comply with not only the fair spatial distribution of infrastructure but also with actions that promote equitable services across the population

of different socioeconomic characteristics [23]. Three main perspectives take into account equity in how urban mobility is established [23]:

- Uneven distribution of travel resources;
- The inequalities implied in travel behaviors;
- Accessibility (differences in conditions of access to transport modes, infrastructure, and urban space).

The benefits from the provision of equity in transport services are related to the increase in accessibility to destinations of interest and the improvement of opportunities for using transport services [24]. However, attention needs to be paid in order to minimize the direct environmental harms caused by the use of transport services, such as air pollution exposure, the degradation of infrastructure, and longer waiting times before interventions take place. Moreover, the benefits and burdens should be fairly distributed in society (distributive justice) through transport justice, which includes the fairness of processes and procedures of decision and distribution (procedural justice) [25].

According to the Guidelines and Roadmap for EU equity planning [26], the main equity goals that need to be achieved in cities are the fair allocation of transport resources, the provision of equal opportunities to enable people to be mobile and have access to important activities in their life, and the reduction of the adverse effects of the transport system, which includes pollution, accidents, and social exclusion. Figure 1 shows a diagram of elements that need to be considered for an equitable mobility planning policy.

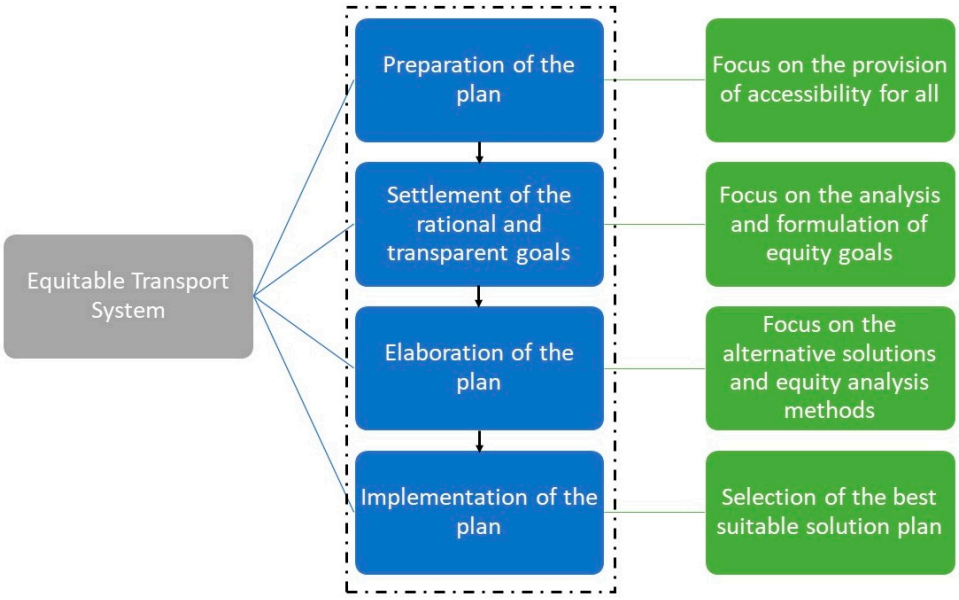


Figure 1. Strategic elements for an equitable mobility planning policy. Source: [26].

Regarding the implementation of fairness in cities and transport systems, the proposition and creation of Sustainable Urban Mobility Plans (SUMPS) should take into account the elements for equity planning, as well as to meet social equity issues [27]. Therefore, SUMPS should work as a strategic tool to ensure that all citizens are offered transport options that meet their needs and enable access to key destinations and services, improve the efficiency and cost-effectiveness of the transport of people and goods, and contribute to enhancing the attractiveness and quality of the urban environment and urban design for the benefits of citizens, the economy, and society as a whole [28].

The current transport planning for most cities around the world still prioritizes the car as a mode of transport for the majority of the displacements. However, reforms need to be created to promote a more equitable transport system that relies upon multimodality [29]. For this, equitable planning reforms in transport systems need to consider all the factors that affect accessibility, including multiple modes, network connectivity, land use factors

such as density and mix, and user costs [30]. In addition, mobility plans that value equity need to consider all significant community goals, including cost-efficiency, affordability, public health and safety, economic opportunities, community livability, and environmental protection, as well as recognize the unique and important roles that non-auto modes play in reaching an efficient and equitable transport system [29].

Another means of improving transport equity has emerged in recent years, with the introduction of transport technologies that enable services of shared mobility (e.g., car sharing and micromobility sharing). This new addition to the transport system is seen as a way to reduce the equity gap within the current transport network; micromobility-sharing programs can be used to feed public transport in areas with reduced accessibility [31]. Regardless of the implementation of shared services in cities, it is important to highlight that, without proper planning and policies, shared mobility may intensify transport equity issues [32].

2.2. Social Equity in e-Scooter Usage

Micromobility services are often offered in cities by private businesses that tend to prioritize the maximization of profit, while there is no provision of equal access to their vehicles to the population [33]. Therefore, differences are often identified in the usage of shared micromobility services concerning the socioeconomic profile of users [34]. No equal opportunities are given to the population of cities to have access to this kind of service, as operators usually have control over the prices and the area of coverage of the service.

The barriers to micromobility usage are usually associated with differences related to the socioeconomic characteristics of the population, such as gender and income. The possibility of being a victim of harassment and the perceived lack of safety contribute to the reduction of the use of micromobility services by females [35]. On the other hand, people who have higher incomes are more likely to use shared micromobility services, and to know friends and family members that use the same service, which can demonstrate that the usage of shared micromobility services can be somewhat influenced by social connections in certain socioeconomic environments [36,37].

Some of the constraints with micromobility usage can be also related to the income range of certain groups, which is related to their employment status since they need to have the financial stability to pay for the costs associated with the service. This is added to the responsibility with the micro vehicle, and the need to have an online payment method (e.g., credit card) to pay for the service, as well as access to a smartphone and an internet connection [37].

2.3. Shared e-Scooter Adoption and Patterns

Shared e-scooters schemes started in cities in 2017, and, up to 2022, they were present in more than 620 cities in 53 countries across the USA, Europe, and Asia [38]. The success of the expansion of this mode can be related to factors such as (i) e-scooters can be more energy-efficient than other traditional modes of transport; (ii) they have the ability to expand transport options; (iii) they can enable a car-free lifestyle; (iv) they are a convenient replacement for short trips by car; and (v) they are complementary to public transport [39,40].

This mode of transport is mostly used for recreational purposes, to commute, and to connect with public transport in the USA [5], while, in Europe, this service can be primarily used for commuting, business trips, and leisure [41]. These trips made by shared e-scooters can contribute to a modal shift from motorized traffic in cities, but the modal shift can also represent a change in people's walking and bicycling patterns. In cities such as Denver and Portland in the USA, nearly 50% of the trips made by shared e-scooters replaced walking and cycling [42]. In France, more than 40% of the local users would have walked to take their last trip instead of using a shared e-scooter, while 30% would have used public transport [43].

The trips made by shared e-scooters are categorized depending on the average distances traveled. In Germany, trips made on Tier e-scooters had an average length of 1.96 km

in September of 2019, while trips made by VOI had an average of 1.81 km in the same period. For Lime users, the average trips was 1.75 km [44]. In Faro, a city in the south of Portugal, the average trip distance in September 2019 was 1.85 km [45]. To corroborate the similar results for average trip distance, the cities of Chicago and Tucson in the USA also reported, in 2019, an average distance of trips of 1.5 km and 1.3 km, respectively [46,47].

2.4. Where Shared e-Scooters Are Used and by Whom

The usage of shared e-scooters in cities has been influenced by temporal, socioeconomic, and built-environment variables. This work focuses on socioeconomic variables for the usage of this service in order to evaluate the potential of shared e-scooters to reach a diverse group of people, in other words, how equitable the usage of shared e-scooters is in cities.

Therefore, some researchers have indicated that shared e-scooters are more used in areas with more employment rates between residents, and where the presence of bicycle infrastructure is higher [48]. Moreover, mixed-use regions have the smallest portion of non-recreational trips, while downtown areas have the highest usage of shared e-scooters for non-recreational trips, along with institutional-oriented mixed-type regions [49].

Moreover, the presence of commercial regions, along with encouraging environments for active transport (i.e., walking and cycling), as well as the proximity to public transport stations and hubs, were also correlated with high usage of shared e-scooters, which can suggest that this mode of transport is associated positively with sustainable development [50,51].

In addition, the presence of shared e-scooters near and on university campuses, combined with the ability to appreciate the ease of use of this "new" mode of transport, and the availability of smartphones and online payments, make university students a strong group of shared e-scooter services around the world [52].

Students and other specific groups of users have been reported to be a constant in shared e-scooter usage even if this service is located in different cities and urban contexts. In Paris, for example, shared e-scooter users are usually 18-to-29-year-old males who have a high educational level; they can be either students or executives who are significantly wealthier than the general French population [51,53,54]. Similar results were obtained in Vienna, Austria, where the majority of e-scooter users are young to middle-aged and highly educated men [55]. Table 1 presents the socioeconomic characteristics of users among cities in Europe and America in order to draw a profile of the public covered by shared e-scooters services.

Table 1. Socioeconomic profile of shared e-scooter users.

Location	Profile				
	Gender	Age	Educational Level	Occupation	Income Level
Paris, France	Male	18–25 years old	High	Students/executives	High income
Vienna, Austria	Male	26–35 years old	High	Students/employed	-
Thessaloniki, Greece	Male	18–27 years old	-	-	Medium income
Zurich, Switzerland	Female	21–30 years old	High	Employed	High income
Trondheim, Norway	Male	18–35 years old	-	-	-
Gdansk/Gdynia/Sopot, Poland	Male	31 years old	-	Student/employed	Medium income
Great Golden Horseshoe, Canada *	Male	25–40 years old	High	-	-
Chicago, USA	Male	25–34 years old	High	-	High income
Austin, USA	Male	-	High	-	Low income

Source: [10,51,53–59]. * Intention to use shared e-scooters.

Table 1 shows that users of shared e-scooters are usually young men who have high educational levels and medium-to-high-income levels; only in Zurich are women the most predominant gender amongst users. This illustrates the possible gender, age, and income disparities promoted in cities when this new mode of transport is introduced. These differences can be also stimulated by the locations where shared e-scooters are deployed in cities. They are usually available in downtown areas, business districts, and near a university campus, which can influence the type of public that is exposed to this mode of transport.

3. Methodology

This section presents the methodology used in order to perform the case study in the city of Braga, Portugal. In addition, the structure of the revealed preference survey is shown, along with data from the site of the study.

3.1. Site of Study

Braga is located in the north of Portugal and has a population of more than 190,000 inhabitants in an area of 183 km^2, which represents a population density of more than 1000 inhabitants per km^2 [60], distributed in 37 parishes (Figure 2). In Braga, 68% of the resident population is between 15 years old and 64 years old, which is the active population. In addition, 25% of the population is between 20 years old and 39 years old [60], which are the most representative ages for shared e-scooter usage according to the data presented in Table 1. The average monthly income of the population is EUR 1145.8, but for men, it is as high as EUR 1228.6, while for women it only reaches EUR 1033.6 [60].

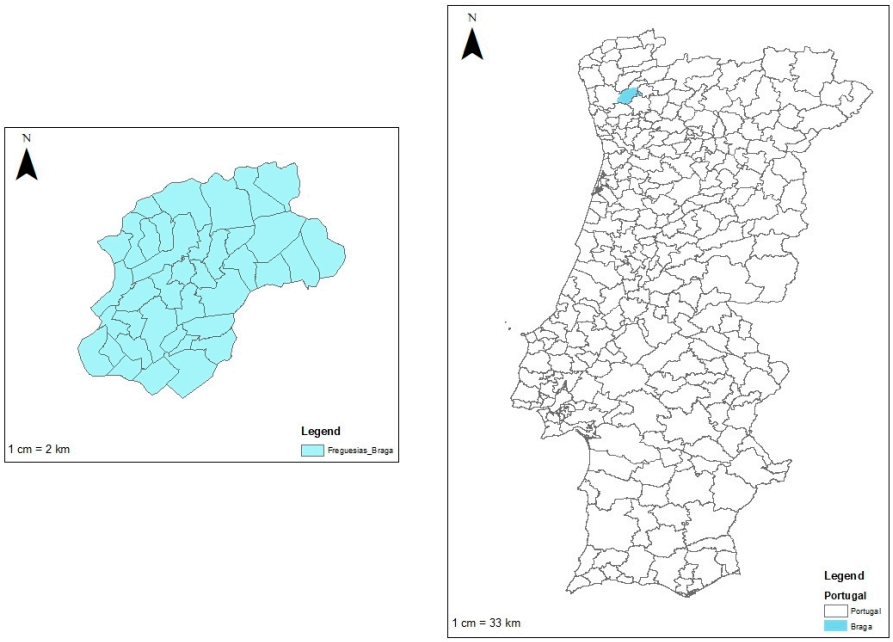


Figure 2. The location of the study site.

From 2001 to 2021 the elderly population in Braga (i.e., 65 years old or more) almost doubled, followed by a decrease of 2.5% in the population between 15 years old and 64 years old [60], which represents a decrease in the younger population and strong increase in the elderly population. However, the presence of higher education centers, such as the University of Minho, and research hubs, such as the International Iberian Nanotechnology Laboratory—INL, can stimulate the presence of younger people in the city while contributing to the diversification of the economy and the development of advanced services, as well as the promotion of newer, shared, and technology-based modes of transport [61].

In Braga, more than 170,000 commuting trips are generated daily, 84% of them within the municipality, which represents a total of more than 140,000 trips that are made by working individuals (66.7%), followed by trips made by students, which represent 33.3% of the displacements [61]. The most common modes of transport used in these trips are cars (69.7%), followed by walking (15.8%) and bus (10.3%) [62].

In order to encourage residents to reduce the usage of cars for short-distance trips, the shared e-scooter service started its operation in the city of Braga in the second semester of 2019, with only one company operating about 80 e-scooters distributed around the city center, with expected expansion in the short term by the Municipality. In 2020 and early 2021, the service was shut down because of the COVID-19 mobility restrictions imposed in Portugal. In the first months of 2021, three different companies started offering about 500 shared e-scooters around the city center of Braga, and near the University of Minho campus in the parish of Gualtar (Figure 3).

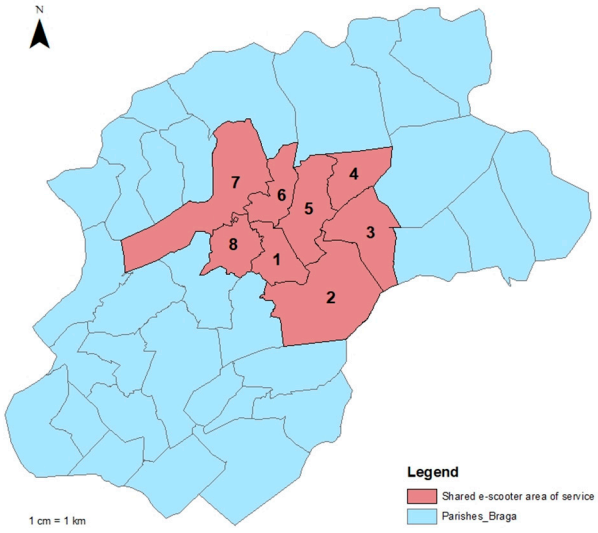


Figure 3. Area served by shared e-scooters in Braga.

Figure 3 represents the actual area covered by e-scooter services in the city of Braga, encompassing only eight out of thirty-seven parishes in Braga. The parishes and their respective population are as follows: (1) São José de São Lázaro e São João do Souto (14,791 inhabitants); (2) Nogueira, Fraião e Lamaçães (15,015 inhabitants); (3) Nogueiró e Tenões (5946 inhabitants); (4) Gualtar (6761 inhabitants); (5) São Victor (32,876 inhabitants); (6) São Vicente (13,974 inhabitants); (7) Real Dume e Semelhe (13,682 inhabitants); and (8) Maximinos, Sé e Cividade (15,087 inhabitants). The resident population in the area served by shared e-scooters corresponds to more than 60% of the total population in Braga.

3.2. Survey

The revealed preference (RP) survey used in Braga to collect information from users and potential users of shared e-scooters was structured in three different parts. Firstly, the respondents had to answer if they use or do not use the shared e-scooter service in Braga. Then, if the answer was negative, the respondents were forwarded to a selection of questions regarding the main factors for them not to use the service, and if they were willing to start using shared e-scooters if the current perceived negative factors were solved. If the respondents use the service, then they were forwarded to a series of questions regarding the main motivations for them to use this mode of transport, and how they use the vehicle and the service across the municipality (e.g., origin–destination, frequency). In the end, all respondents were asked socioeconomic questions. In order to better identify the profile of the population (actual and potential users) that is served by shared e-scooters, some key aspects were collected, as shown in Table 2.

Table 2. Key aspects collected in the survey.

Key Questions of the Survey	Information Retrieved
Riding Experience	
Do you use shared e-scooters in Braga?	If respondents use or not the service
Perceived Barriers for Non-Users	
What are the main barriers to not using shared e-scooters?	Information regarding the main factors for not using shared e-scooters (e.g., lack of proper infrastructure, high traffic speed . . .) and the willingness to start using the service if improvements are made
Motivations for Users	
What are the main motivations for you to use shared e-scooters?	Information regarding the main motivations for using shared e-scooters (e.g., price, travel time . . .)
Socioeconomic profile	
Socioeconomic information	Information regarding gender, highest educational degree completed, age, average monthly family income, size of the family, area of residence

The online and face-to-face survey was disseminated from 24 January to 10 July 2022 in downtown Braga and near school districts, as well as with the University of Minho community (i.e., students and staff); 541 answers were collected, but 108 had to be discarded due to inconsistent answers, which resulted in 433 valid answers to estimate the results. The sampling of respondents was around locations in the vicinity of shared e-scooters stations that comprise the main traffic generators in the city, such as educational poles (University of Minho and colleges) [4]. The above sample was statistically representative of the population of users at a 95% confidence level (margin of error of 2%). Following previous research, shared e-scooters are mostly used by younger people [63,64], and heavy e-scooter traffic is expected to occur in downtown and university campus areas [65,66].

It is important to mention that from the 433 valid answers, 78 represent current users of shared e-scooters in Braga, while 355 represent potential users (i.e., people that do not use shared e-scooters but could start using if some improvements were made) of the service. This sample size (N = 433) was calculated to represent a margin of error of 5%, with a confidence level of 95% [67], from a population of 193,324 people who live in Braga [62].

After the data collection, the correlation of the results was obtained through the chi-square goodness of fit tests, as shown in equation 1, which allows for testing whether the observed distribution of socioeconomic categories among users and potential users of shared e-scooters differs from or has similarities with the distribution of the population in Braga [68], that is, if socioeconomic characteristics (categories) of respondents (users and potential users) differ from or are related to the general profile of the resident population in Braga according to the 2021 census results [62].

$$X^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i} \quad (1)$$

where X^2 is the chi-square test statistic, $\sum$ is the summation operator, O is the observed frequency in category i, and E is the absolute expected frequency in category i.

Firstly, data regarding the current users' profiles were evaluated to assess the present equity of the service in Braga. Then data from users and potential users were evaluated to estimate the potential equity of the shared e-scooters if improvements in the provision of the service are made.

4. Results

4.1. The Evolution of Shared e-Scooter Services in Braga

Shared e-scooter services in Braga have been developing since 2019, when they were introduced in the city. Starting with only one company in 2019, there are now two different companies responsible for offering the service to the population. From August to December 2019, more than 20,000 trips were made by about 80 e-scooters. The year 2020 was marked by the mobility restrictions imposed by the COVID-19 pandemic, and thus there is a lack of data from this year. In 2021, when the service resumed in April, more than 230,000 trips were made until December of the same year. Then, in 2022, when two different companies made available more than 500 e-scooters, more than 270,000 trips were made from January to December (Figure 4).

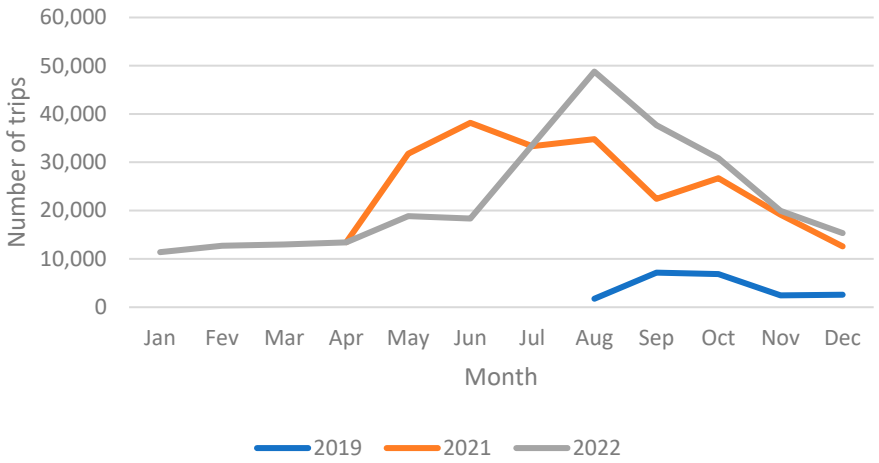


Figure 4. The number of trips by shared e-scooter usage in 2019, 2021, and 2022 in Braga.

As shown in Figure 4, shared e-scooters in Braga reveal different usage patterns according to the period of the year and the year itself. In 2019, the newness of the service allowed an increase in the number of trips from August until October, when the rainy season started. On the other hand, data from 2021 reveals an exponential growth starting in April, when mobility restrictions were suspended and people had the urge to go out and enjoy the good weather during spring and summer. In 2022, there was a constant increase in the number of trips since January, reaching the peak in the number of trips during summer. When comparing the data from the three years, it is possible to infer that, in Braga, the usage rate of shared e-scooters is related to the weather conditions, since the peak of usage occurs in spring and summer, and a considerable decrease occurs during fall and winter months.

Another aspect of shared e-scooter usage that changed in Braga over time is the duration of the trips. Comparing data from 2019 and 2021, the total number of kilometers traveled increased by five times from August to December of each year. The comparison of kilometers traveled from April to December of 2021 and 2022 shows consistency in shared e-scooter usage, and the total length traveled remains almost constant.

4.2. Profile of Users and Potential Users of Shared e-Scooters in Braga

After the collection of data from the survey in Braga, the profiles of the users and potential users were compared. Current users of the service in Braga are male (67.95%), students (74.36%) that are between 20 to 34 years old (55.13%), and have incomes between EUR 1000 to EUR 1500 (19.23%). This socio-economic profile is befitting with data from different countries and regions already presented in Table 1.

When considering current users and potential users, it is possible to infer that the proportion of males and females using shared e-scooters would be balanced. The age category with the most representativeness is between 20 years old and 34 years old. Most of

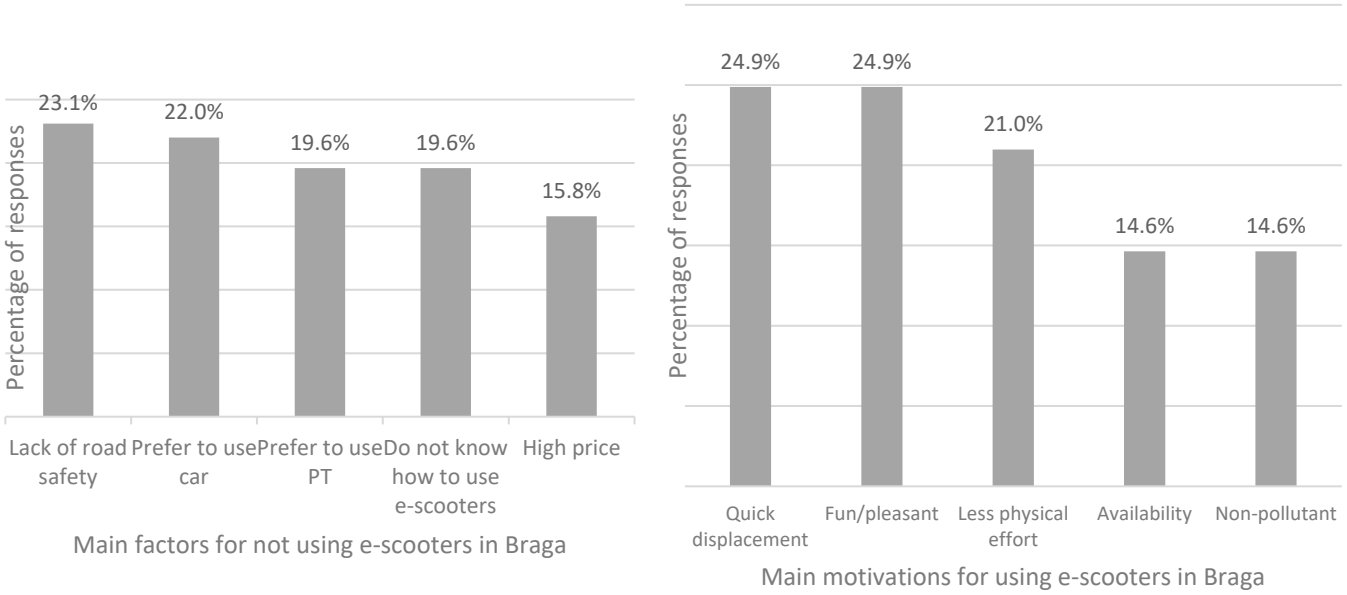
the respondents are students or are employed, and have a medium to high family monthly income, as can be seen in Table 3.

Table 3. Profile of respondents (users and potential users) in Braga.

Category	Subcategory	*N*	%
Gender	Male	207	47.8%
	Female	214	49.4%
	Other	2	0.5%
	Prefer not to say	10	2.3%
Age	Up to 19 years old	115	26.6%
	20–34 years old	228	52.7%
	35–49 years old	54	12.5%
	Above 50 years old	36	8.3%
Employment status	Student	306	70.7%
	Employed	116	26.8%
	Employer	5	1.2%
	Unemployed	6	1.4%
Educational level	Up to secondary education	241	55.8%
	Bachelor's or equivalent	130	30.1%
	Master's and Doctoral	61	14.1%
Household monthly income	Up to EUR 665	17	3.9%
	EUR 666-EUR 1500	128	29.6%
	EUR 1501-EUR 2500	92	21.2%
	EUR 2501-EUR 3500	31	7.2%
	Above EUR 3501	16	3.7%
	Do not know	79	18.2%
	Prefer not to say	70	16.2%

Since one of the objectives of the survey was to investigate shared e-scooter acceptance among the population of Braga, as well as how socioeconomic characteristics can affect their usage, it was important to see that, from all answers, more than 80% of respondents said they do not use shared e-scooters. The low utilization rate is related to the lack of road safety that is felt by the respondents, followed by the preference to use private vehicles and public transport, as well as the lack of knowledge on how to use shared e-scooters and the high price of the service. However, if these improvements are made, they are willing to start using shared e-scooters.

On the other hand, the main motivations to use the service in Braga concern the quick displacement that is allowed by shared e-scooters, the fact that the ride is pleasant, the possibility to have longer trips with less physical effort, and the availability of this mode of transport when the public transport service is reduced at night and early in the morning. Figure 5 shows the main factors affecting the usage or not of shared e-scooters in Braga.



(**a**) (**b**)

Figure 5. The main factors affecting shared e-scooter usage in Braga: (**a**) Main factors for not using shared e-scooters in Braga; (**b**) Main motivations for using shared e-scooters in Braga.

Regarding the main factors for not using shared e-scooters, it is reported that women suffer more than men due to the lack of road safety in riding this mode of transport ($\rho < 0.001$). In addition, with the advancement of the age of respondents, one feels more unsafe being on the road on a shared e-scooter. The preference for car usage in spite of this micro vehicle is also more prominent for women than men; In addition, the increase in family income is proportional to the preference for using a car instead of a shared e-scooter. The contrary is found with the preference to use public transport instead of e-scooters, since the preference to use PT decreases as the family income increases.

Women are also more affected by the lack of knowledge on how to use a shared e-scooter compared to men, and with the increase in the educational level of respondents, the knowledge of how to ride e-scooter increases. Price affects usage on all educational levels almost equally, and affects more men than women.

Furthermore, considering the main motivation to use shared e-scooters, men consider shared e-scooters more pleasant to ride than women do, but women are the ones who revealed that they would use this mode more frequently in order to reduce the physical effort in trips, and in situations where public transport is not available or its availability is reduced. The choice to ride an e-scooter due to its non-air-pollutant aspect was a constant influential factor across all socioeconomic groups.

In addition, when asked if shared e-scooter services could help in increasing equity in transport, a high percentage of respondents said they feel neutral that this new mode of transport would promote gender equity in the transport system (42,3%). Likewise, 38.1% of respondents feel neutral when asked if shared e-scooters could help in promoting equity for different social groups.

4.3. Equity in the Usage of Shared e-Scooters in Braga

This section correlates the socioeconomic profiles of users and potential users (i.e., people that are exposed to the shared e-scooter and would start using it if some improvements were made in the service) with the socioeconomic profile of the population in Braga that is provided by the latest census available [62]. The aim is to assess if the general population is represented in the usage of the service.

Among current users (N = 78), statistical observations show that shared e-scooters lack in providing a service with equity for the diverse population of Braga (Table 4). In reference to gender differences, women are underrepresented compared to men, since the distribution of the data from shared e-scooter users is not consistent with the distribution of the data from the 2021 census. In this case, a higher representation of women was expected among users of the service, as the number of observations for women (N = 23) was lower than expected for the population of Braga (N = 39.8).

Table 4. Chi-square goodness of fit test for shared e-scooter users in Braga (N = 78).

Socioeconomic Characteristics	Chi-Square Goodness of Fit	Df	ρ
Gender	14.932	1	<0.05
Age	98.288	3	<0.05
Educational level	18.016	2	<0.05
Employment status	122.855	1	<0.05

The correlation of education level shows that people with higher education are overrepresented, while people with lower educational levels are underrepresented. In this case, the number of observations of respondents who completed their undergraduate studies (N = 27) was higher than expected for the population of Braga (N = 14), while the number of observations for people who have completed their high school degree (N = 42) is lower than the number of observations expected for the population of Braga (N = 58).

The professional status of the population is also another aspect of inequity among shared e-scooter users, since students are the most prominent group of people served (observed N = 58, expected N = 17.4), while unemployed people (i.e., people with reduced economic means) are left behind.

When potential users are added to the full sample in Braga (N = 433), the representation of the general population in the usage of shared e-scooters somewhat changes, but this mode of transport is still deficient in enabling equitable service across the population (Table 5). Interestingly, if potential users start riding shared e-scooters in Braga, gender differences would reduce, as more women would start riding this micro vehicle. Considering the improvement in gender representativeness, men and women would have shares of almost 50% in usage, as the number of observations for men is N = 207, and the expected number of observations for this gender would be N = 200.4. The number of observations for women is N = 214, and the expected number of observations for this gender would be N = 220.4.

Table 5. Chi-square goodness of fit test for shared e-scooter users and potential users in Braga (N = 433).

Socioeconomic Characteristics	Chi-Square Goodness of Fit	Df	ρ
Gender	0.415	1	0.519
Age	431.799	3	<0.05
Educational level	70.225	2	<0.05
Employment status	639.346	3	<0.05

However, shared e-scooters would continue providing an inequitable service across all other socioeconomic groups surveyed, even though there was an expansion in the number of dedicated parking spots for shared e-scooters that now covers more areas of the city, as well as the implementation of low-speed zones (i.e., 20 km/h and 30 km/h) across the most used routes by shared e-scooters.

Regarding the age of users, people from 20 years old to 34 years old would still be overrepresented, since the number of observations for this group is N = 228, and the

expected number of observations in Braga would be N = 77.6. People 35 years old and above are underrepresented because the expected number of observations for Braga would be N = 100.1, and the actual number of observations was N = 54.

The educational level of users, in this scenario, continues to overrepresent people with high educational levels, mainly people that graduated from the university and pursue a master's or doctoral degree. Respondents who concluded their undergraduate studies have a number of observations of N = 130, and people with master's or doctoral degrees have a number of observations of N = 61, while the expected number of observations would be N = 76.8 and N = 37.4, respectively.

People at an economic disadvantage, or who are unemployed, are still under-served by shared e-scooters, while the most prominent group of users are students. In this case, the observed number of unemployed people is N = 6, and the expected number of observations for the population of Braga would be N = 18.2.

It is important to mention that the increment of potential users is due to some expected changes in the provision of shared e-scooters in Braga. Nevertheless, more efforts need to be made to increase equity issues through other measures, such as the ones mentioned by respondents of the survey, which includes the implementation of more dedicated infrastructure (e.g., cycle lanes), which could influence road safety perception, as well as the creation of specific zones where shared e-scooters, and micromobility in general, have priority over cars, and implement other payment methods other than credit cards.

5. Discussion

Studies performed in different urban contexts, such as in France, Austria, Greece, Norway, Poland, Canada, and the USA, show that the usage of shared e-scooters is mostly restricted to a specific public, which is represented by young males that have a high educational level, are students or employed/executives, and have medium to high-income ranges [10,51,53–55,57–59]. However, in some specific situations, shared e-scooters can provide a service to a more diverse stratification of the population, which is the case in Switzerland, where females are the most prominent users of the service [56]. However, the service still does not attend to the share of the population that has lower income, is unemployed, or does not have a higher degree of education.

In the case study developed in Braga, to access the profile of the user of shared e-scooters and the equity promoted by this service, a survey was conducted so the socioeconomic data retrieved from users and potential users could be compared and correlated to the general socioeconomic characteristics of the population of the city. This research provides useful insights into opportunities for the usage of shared e-scooters in Braga, along with a further understanding of the range of attributes that are perceived by individuals for using shared e-scooters in the near future, which can help to deter the use of private cars in short-distance trips.

Braga presents a standard pattern in the volume of trips according to the time of the year. The number of trips starts to rise when it gets warmer in late spring and summer, with the peak of trips being reported in late August and September when school and university classes start. A case study performed in Indianapolis, USA, showed that, from September to October, the number of trips, total duration, and total distance traveled also increase, but start to drop in November due to the cold weather and the holidays [69]. Additionally, Caspi et al. [66] showed that shared e-scooters could work well in university cities or near and on campus because of the volume of trips generated near these poles.

Moreover, the utilization of shared e-scooters in Braga throughout the year generates inequity across the population, considering the socioeconomic profiles identified, namely gender, age, education, and employment status. This is because riders of shared e-scooters are mostly represented by young males, who are students and have a medium to high monthly income.

On the other hand, if improvements in the service, such as the implementation of more dedicated infrastructure, parking spots, zoning, and the provision of alternative

payment methods are made, the diversity in the users' profiles can be increased. In this case, more women would be willing to ride shared e-scooters, as the perception of road safety would be increased. Nonetheless, more efforts need to be made to allow more people from different educational levels, employment statuses, and ages to be able to use shared e-scooters.

In Braga, Thessaloniki, Greece [70], and Austin, USA [66], shared e-scooters attract mostly recreational trips, since users choose this mode of transport because it is pleasant and fun to ride. A modal shift from personal vehicles may not be observed, since most of the respondents said they do not use shared e-scooters because they prefer to use a car. In addition, they use e-scooters to make little physical effort in their trips, which can make them replace walking for riding an e-scooter; this situation was also reported in Tempe, USA, when university students and staff were surveyed about their shared e-scooter usage patterns [71].

It is important to mention that, before the implementation of shared e-scooter services in cities, pilot programs can be performed to measure if equity standards will be achieved with this mode of transport. The pilot program performed in Chicago, USA, allowed the identification of shared e-scooter availability for people with lower income and diverse races, and also the creation of a special payment program for unbanked riders [46]. The city of Tucson, USA also relied on a pilot program to assess if e-scooters could expand transport opportunities and access for the underserved population, which allowed the deployment of these micro vehicles in lower-income areas that have fewer public transport options, as well as a discount in trips for lower-income residents [47]. In London, the city council is working with different groups to understand their views and concerns regarding shared e-scooters [72].

The provision of special programs to address people in vulnerable situations (e.g., located in neighborhoods with no access to public transport) could be a key point to increase equity in shared e-scooter usage. In addition, the data from Braga seems to indicate that other measures, such as dedicated infrastructures, can influence safety perception for this mode, which can increase the female share in shared e-scooter usage, although, for lower-income and unemployed people to use the service, other measures should be taken, such as the examples in Chicago, USA, and Tucson, USA, where payment options and discounts were offered for the people under these conditions.

6. Conclusions

Shared e-scooter services came to life in cities with a proposal to improve urban mobility by replacing cars for short-distance trips, as well as acting in the last mile of trips as a connection to public transport. This mode of transport could also benefit the environment in urban centers, as they do not emit any GHG while being ridden. However, the promise to reach a diverse number of people and address equity issues in urban public spaces and the transport system has not yet been achieved in most city cases.

This research work provides new evidence in the context of shared e-scooter patterns and equity around the provision of e-scooter services in the city of Braga in Portugal. Shared e-scooter usage is somewhat related to the warmer period of the year and the beginning of the school/university year, which is also true in other cities where shared e-scooters are present. In addition, the research provides insights into opportunities for the usage of shared e-scooters in Braga, the main perceived attributes to ride this mode of transport in the near future, and the users' profiles. The findings can also be useful in providing indicators for the future integration of public transport with shared e-scooters, in the city context, to address social equity.

Moreover, the high price of shared e-scooters in Braga, as a prominent attribute for not using this mode of transport, is an indicator that new business models need to be developed to attract more people to shared micromobility, deterring the use of private cars. On the other hand, improvements still need to be made for providing adequate information

to the population on how to use e-scooters safely and securely, since even the younger respondents reported a lack of knowledge on how to use this mode.

In short, shared e-scooters, as a new transport option in the urban environment, need to be better evaluated before and after their implementation, including in the context of social equity. Overall, it is recommended to follow an integrated approach in planning such services, adopting the sustainable urban mobility planning tool.

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