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Determinants of shared e-scooter usage and their policy implications. findings from a survey in Braga, Portugal

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Abstract

Shared e-scooter systems have become an alternative for micromobility users in cities since 2017. The success of the shared e-scooter service can be related to the provision of more last-mile flexibility and convenience to users. They can also be seen as a replacement for private cars and on-demand ridesharing, especially in highly crowded urban environments. Therefore, the main objective of this research is to disclose the main characteristics that determine shared e-scooter usage and their policy implication in a medium-sized city in the North of Portugal. To meet this purpose, a survey was conducted, and statistical analyses were performed to correlate the sociodemographic characteristics of respondents with the willingness to use shared e-scooters. Results show that gender, origin of the trip, and the main mode of transport affect the usage of e-scooters, thus specific policies should be developed to decrease these inequalities. Special attention needs to be given to the creation and expansion of dedicated areas for e-scooter ridership, zoning, and some traffic calming measures to promote a safe, user-centric, and more pleasant environment for shared e-scooter riders.

1 Introduction

Shared e-scooter services were introduced in cities as an opportunity to improve the last-mile travelled, reducing traffic congestion by encouraging people to a modal shift from private cars to e-scooters, decrease local air pollution, and promote a sustainable and equitable urban environment [1–3]. However, the introduction of this emerging technology caused some undesired implications. For instance, the modal shift from walking or cycling to a less sustainable mode of e-scooter is undesired [4–6]. Furthermore, the coexistence of shared e-scooters and pedestrians sharing the same public spaces can lead to certain challenges. Reports have highlighted issues stemming from the haphazard parking of shared e-scooters on sidewalks, which not only pose safety concerns but also disrupt the movement of pedestrians and impede their right-of-way [7–9]. However, e-scooter riders often end up using sidewalks because most of the road infrastructure is designated for cars, thereby posing a risk to smaller and slower vehicles lacking dedicated infrastructure [10, 11]. Moreover, the availability of micromobility services and shared e-scooters in cities is usually restricted to central areas and zones where wealthier communities are located, which can jeopardize the promotion of equitable access to this mode of transport [12, 13]. This situation reflects the current scenario of usage and profile of shared e-scooter riders in cities, which are usually represented by young wealthy high-ranking employment males or students [14, 15].

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In order to minimize the problems caused by shared e-scooter ridership and improve the positive impacts they can bring to cities (e.g., environmental and mobility benefits), this mode of transport must be included in the planning process of the transport systems in urban centres [16, 17]. For this, the main sociodemographic characteristics that determine shared e-scooter usage must be known to better design the interaction of this mode of transport with the general population and the built environment [12].

Therefore, this research work brings insightful knowledge on how shared e-scooter usage is determined by the population's sociodemographic characteristics, which can lead to a specific understanding of how to manage this mode of transport to serve the entire population. Thus, to the best knowledge of the authors, no other research work has determined the usage of shared e-scooters due to sociodemographic information. Therefore, the determinants of shared e-scooter usage presented in this research work are based on the sociodemographic profile of the population. In addition, this data was combined with data from the main interventions needed to improve e-scooter usage, and in what manner it can implicate policy application and consequently promote this mode of transport.

The present work is an extension of the previous research developed by the authors [18–21]. In the first publication [18], the authors review the usage of shared e-scooters in different contexts and how shared e-scooters could contribute to the resilience of transport systems in disruptive events, namely the pandemic of COVID-19. The following publication [19] focuses on the assessment of the equity promoted by shared e-scooters amongst the dwellers of the city of Braga, which shows that this mode of transport is mostly essentially used by young males who have medium to high monthly income, the sampling of respondents used in this publication was around locations in the vicinity of shared e-scooter stations that comprise the main traffic generators in the city. The third and fourth publications are complementary [20, 21] since they are part of a collection of research papers and present the determinants of shared e-scooter usage among university students, with a case study in the city of Braga, where the presence of more cycle lanes would increase the usage of e-scooters. Following the shreds of evidence from the previous studies published, the present research work goes further and examines the determinants of shared e-scooter usage regarding the population of Braga, instead of focusing only on the university student population. One additional contribution from the present research (this manuscript) is that it addresses possible policies that can be implemented to improve shared e-scooter usage in the city.

Thus, the main objective of this research is to identify the determinants and attributes that affect the usage of shared e-scooters by the population exposed to this mode of transport, not only university students. Focusing on how the sociodemographic characteristics of the population affect their willingness to use or not use shared e-scooters, as well as the main interventions needed to increase the usage of this service. The research questions proposed by this research work are:

i. *how do the sociodemographic characteristics of the population (e.g., gender, age, employment status, income) determine the use or not use of shared e-scooter services, and how it can affect specific policy implementation?*
ii. *what are the main attributes considered by the population exposed to shared e-scooters to establish their willingness to use the service?*

For this, an online and face-to-face questionnaire was conducted in the city of Braga, north of Portugal with users and non-users of the shared e-scooter service. The survey was sent by e-mail to the University of Minho community, as well as a face-to-face interview was performed in the city centre of Braga and nearby school districts. The information retrieved was used to define the respondents' profile and how it is related to the willingness to use shared e-scooters.

The remainder of this research work is composed of Sect. 2 which provides background information on the main factors influencing shared e-scooter usage. Section 3 explains the methodology used. Section 4 presents the results of the data collection, Sect. 5 expounds the discussion, and Sect. 6 contains the conclusions of the research work.

2 Background

Shared free-floating schemes have effectively increased the attractiveness of micromobility when other transport alternatives are not competitive (e.g., low public transport frequency) [22] or when private vehicles (e.g., cars) are not available [1]. In addition, the possibility to have a door-to-door experience with a shared e-scooter, which is added to the fact that this micro vehicle can be related to the convenience of quicker trips ending at the actual destination rather than nearby, as well as the fun aspect of the trip makes this mode of transport more attractive in cities [23]. However, the profile of the population that is exposed to shared e-scooter services highly influences the usage of this mode of transport, hence the understanding of the relationship between the usage of shared e-scooters and the sociodemographic characteristics of the population can be crucial to the establishment of this mode of transport [24]. Recent studies show that shared

e-scooters reach their peak of usage in the middle of the day or the evenings, and the trips are focused on recreational and educational usage [25].

The main sociodemographic aspects that affect the usage of shared e-scooters in cities include gender, age, family size, employment status, educational stage, and family monthly income. Table 1 shows the most recent research that surveyed shared e-scooter users to identify the sociodemographic reasons for the use or not use of this service.

Table 1 shows that gender, age, and family size play an important role in shared e-scooter service usage when only users are surveyed. While employment status and family income are not always a determinant of the usage of the service. Some psychographic characteristics may affect shared e-scooter usage behaviour, such as the person's identification with a spirit of adventure and belief that they do not live a traditional life [30]. However, there is still a gap in the literature on other sociodemographic aspects that can influence shared e-scooter usage (e.g., the main mode of transport, area of origin, and destination of trips), which is going to be studied in this research work.

3 Methodology

3.1 Case study

3.1.1 Area of study

Braga is a municipality located in the North of Portugal that experienced an increase of 6.5% in the number of residents since 2011 and now counts more than 190,000 inhabitants in an area of 183 km^2 that is divided into 37 parishes (smallest municipal administrative division), which represents a population density of 989.6 inhabitants per km^2 [31] (Fig. 1). The city is located in a region where the population has experienced an increase in the number of ageing citizens over the past decade, but the presence of higher education centres (i.e., the University of Minho) and research hubs (i.e., the International Iberian Nanotechnology Laboratory– INL) can stimulate the presence of younger people in the city, which contributes to the diversification of the economy and the development of the advanced services [32, 33].

Currently, more than 113,000 commuting trips are generated daily in Braga, and the most common mode of transport used in these trips is the car (70%), followed by walking (16%), public transport (10%), and others (3%) that include bicycles, scooters, motorcycles, school buses and train [31]. The massive usage of cars places Braga in the top five most congested cities in Portugal, with an average of 106 h spent in traffic during rush hour every year [34]. However, more than 55% of trips made within the Municipality of Braga take up to 15 min [31], which could contribute to the use of shared micromobility and active modes.

3.1.2 Shared e-scooters in Braga

The shared e-scooter service started its operation in Braga in the latter half of 2019 with three companies providing more than 80 vehicles to the population, which were distributed in 25 parking spots allocated only in the city's central area, where school districts are located, as well as shopping centres, university campuses, and a research centre.

The dedicated parking spots were implemented to reduce the need for users to park e-scooters on the sidewalk. Besides, the e-scooter companies created a geofence area (red triangle-shaped area in Fig. 2) where the e-scooter is blocked to keep the safety of the users since these areas are pedestrian zones, the red lines represent arterial roads where shared e-scooters are blocked as well (Fig. 2).

The service was shut down in 2020 due to the mobility restrictions provoked by the pandemic and returned in May of 2021. Currently, two companies are offering the service in the city, with more than 700 e-scooters allocated near the central area of the city and major traffic generator hubs, such as shopping centres, supermarkets, schools, research centres, and the campus of the University of Minho. This culminated in the implementation of more parking spots near this educational institution to

Table 1 Recent references on determinants of shared e-scooter use

Source	Determinants					
	Gender	Age	Family size	Employment status	Educational stage	Family income
6-t bureau de recherche, 2019	x	x	x	x	x	
Laa & Leth, 2020	x	x	n/a	n/a	x	x
Mitra & Hess, 2021	x	x	x			
Guo & Zhang, 2021	x	n/a	n/a	n/a	n/a	n/a
Nikiforiadis et al., 2021	x	x	n/a	n/a	n/a	
Blazanin et al., 2022	x	n/a	n/a	n/a	x	n/a

Source: [5, 24, 26–29][1]

[1] The "x" mark on the determinants list means that the study found a statistical correlation between the determinant and the usage of shared e-scooters, whilst the lack of any mark indicates otherwise. The "n/a" means that the source did not consider that determinant in their study.

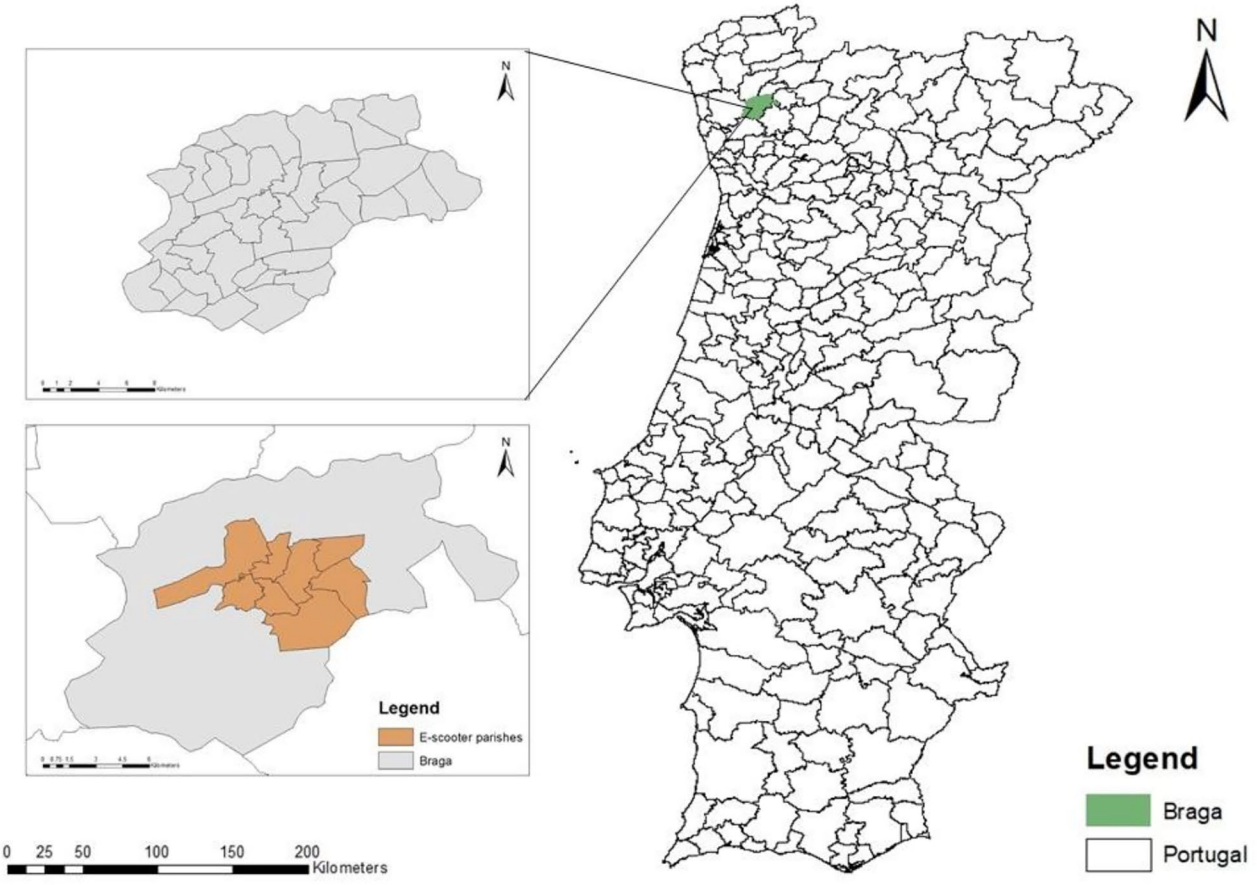

Fig. 1 Location of Braga, Source: own elaboration with data provided by the Municipality of Braga

stimulate the usage of shared e-scooters by students [18] (Fig. 3).

The increase in shared e-scooter usage in the city of Braga as a mode of transport is reported with a high number of trips made and the total distance travelled by riders, as can be seen in Table 2 which shows data from the first half of 2022 (from January 1st to June 30^{th,} 2022).

The increase in usage throughout time can be seen in Fig. 4, which presents the number of trips, total trip distance, and total trip duration by month of the first semester of 2022 in the city of Braga.

From January 2022 until June 2022, the usage of shared e-scooters in Braga faces an increase in demand, in January the total number of trips is 10,901, while in June the total number of trips is 17,356. As the number of trips increases, the distance travelled also increases. Special attention is given to the total trip duration, which enhances by more than 60% in six months, and shows an average of 137,975.33 min travelled.

3.2 Survey

[35] state that mobility in cities must be designed to meet people's needs regarding accessibility to activities, which is key to solving social equity issues. For this purpose, surveys are a prime source of data for impact assessment [36]. Therefore, to examine the key factors affecting the willingness of the city's residents in Braga to use or not use shared e-scooters, a survey was conducted in the city's central area, where the service is available and most frequently utilized.

Figure 5 shows a graphic representation of the methodology used, where the case study in the city of Braga allowed the gathering of the shared e-scooter trip information from the first semester of 2022, as well as the deployment of the survey to acknowledge how sociodemographic characteristics influence e-scooter usage, as well as the main attributes to boost the usage of this mode of transport, such as infrastructural needs of the population.

The survey was disseminated online and in person near high schools in the central area of the city, downtown Braga (where most of the shared e-scooters are available for users), and among students, academic staff, and employees of the University of Minho.

3.2.1 Survey structure

The survey was designed in four main sections, which are: (i) shared e-scooter usage; (ii) main motives for not

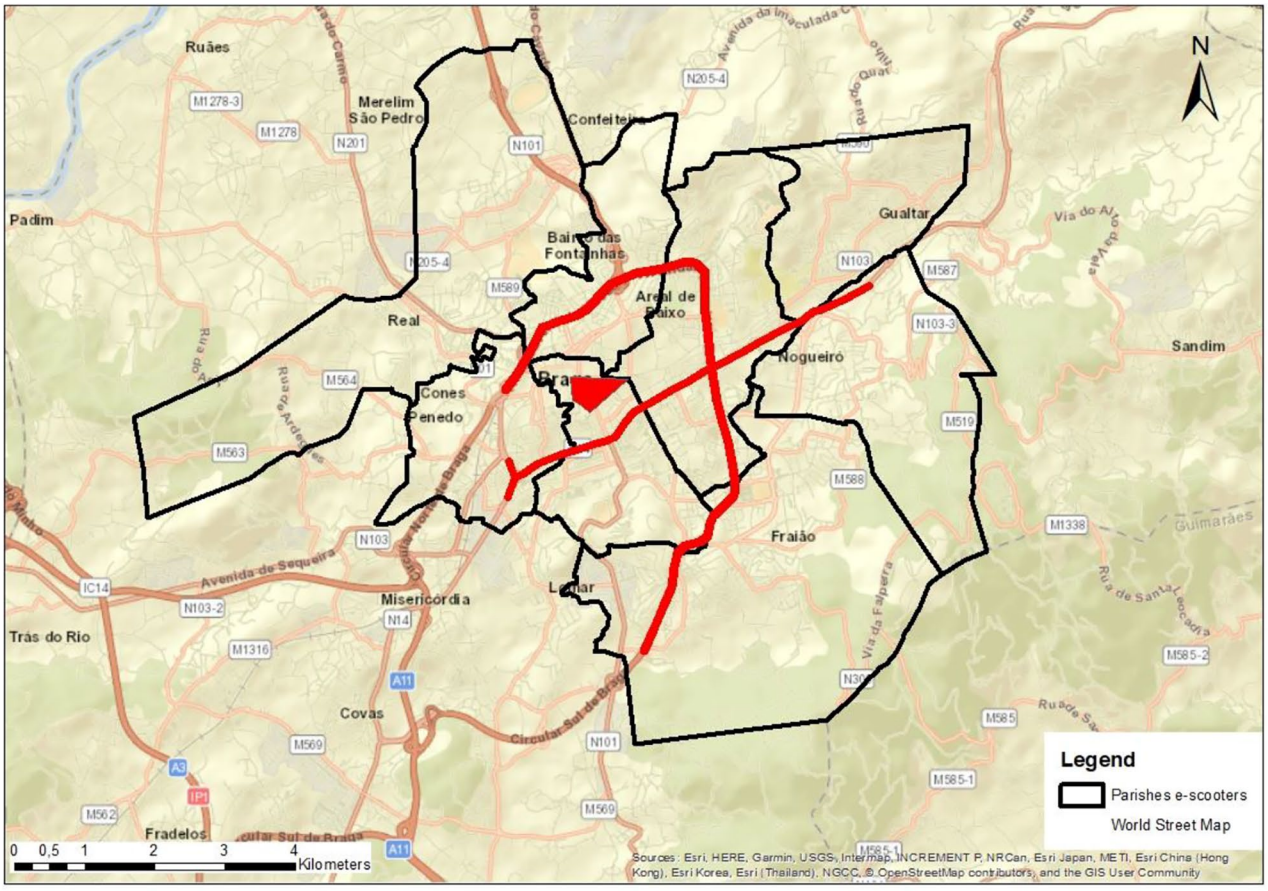

Fig. 2 Geofence area in Braga, Source: edited from OpenStreetMap with data provided by the Municipality of Braga

using shared e-scooters; (iii) motives for using shared e-scooters; and (iv) sociodemographic questions (Fig. 6).

Firstly, the respondents needed to state whether they use or not the shared e-scooter service available in Braga. Second, the respondents who do not use this mode of transport were asked to select the main reasons not to use e-scooters. Then, they were asked to answer sociodemographic questions. On the other hand, the respondents who use this mode of transport were asked to state their main motivations for using shared e-scooters, such as the fun aspect of the trip, the possibility of making quick displacements, and the possibility of arriving at their doorstep. These questions were also followed by a sociodemographic questionnaire.

After all the data was collected in the survey, the correlation between the profile of the respondents and the usage of the shared e-scooters could be performed to estimate the main determinants of the usage of shared e-scooters in Braga.

3.3 Data analysis

The shared e-scooter survey was carried out from January 24th to July 10th of 2022; 541 answers were collected, but 108 had to be discarded due to inconsistent answers (e.g., surveys that were left partially blank or when single-answer questions received more than one answer), which resulted in 433 valid answers (between users and non-users) to estimate the results. This number of answers can represent a margin of error of 5%, with a confidence level of 95%, from a population of 193,324 people who live in the Municipality of Braga [31]. The sample was determined following Eq. 1 [37].

$$\begin{aligned} x &= z(c/100)^2 r(100-r) \\ n &= N_x/((N-1)E^2 + x) \\ E &= Sqrt\left[(N-n)x/n(N-1)\right] \end{aligned} \tag{1}$$

Where n is the sample size, E is the margin of error, N is the population size, r is the fraction of responses that are of interest, and Z (c/100) is the critical value for the confidence level c.

After the data collection, the correlation of the results was obtained through Pearson's chi-square tests, which allows for testing whether two variables are independent (unrelated) [38], when Eq. 2 was used.

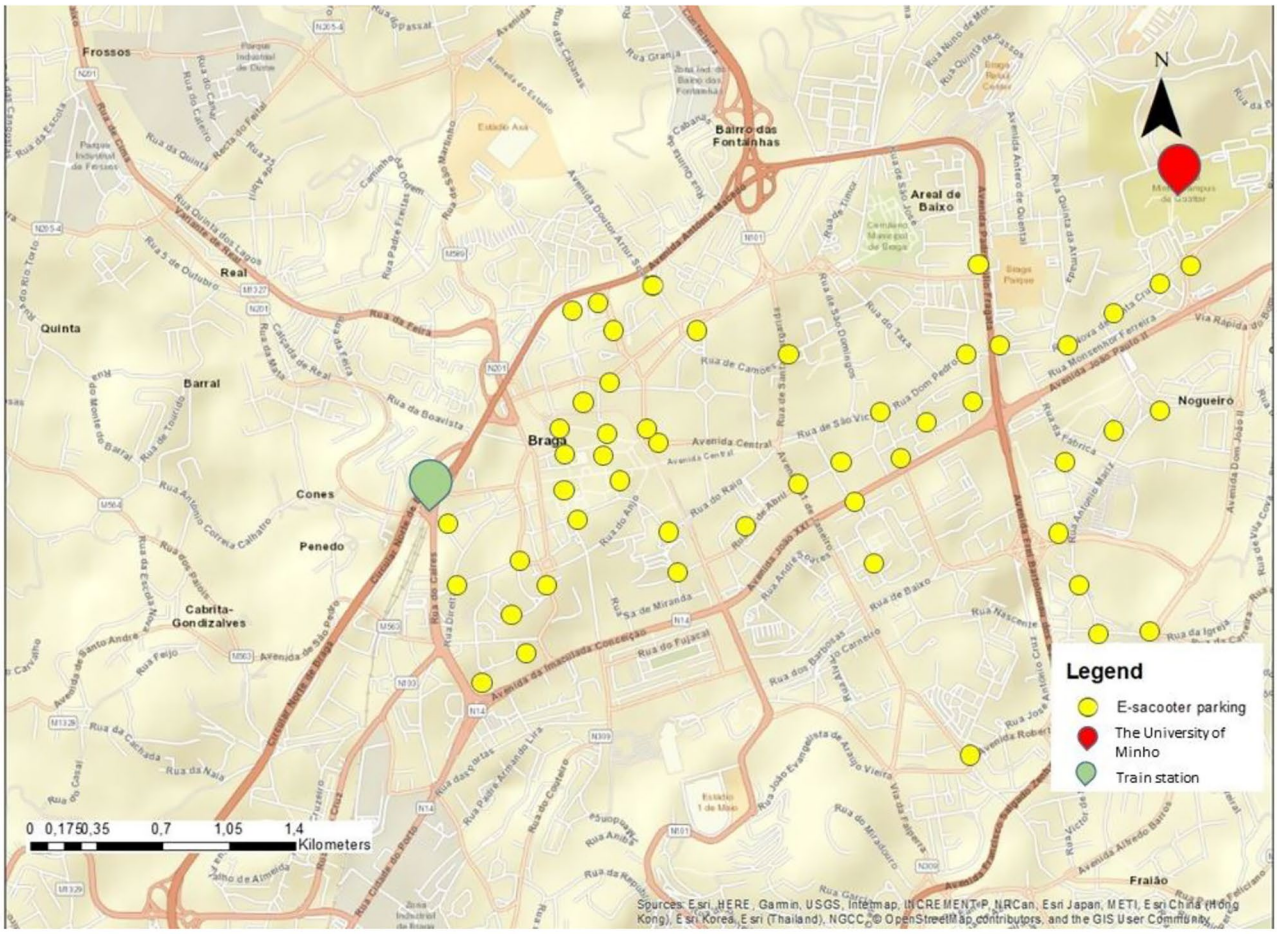

Fig. 3 Location of e-scooter parking spots in Braga, Source: edited from OpenStreetMap with data provided by the Municipality of Braga

Table 2 Shared e-scooter data in Braga (first semester of 2022)

Braga shared e-scooter trip data (1st semester of 2022)	
Total number of trips	83,294
Total trips distance	124,162 km
Total trip duration	827,856 min
Average trip distance	1.49 km
Average trip duration	9min56sec

$$X^2 = \sum \frac{(O-E)^2}{E} \quad (2)$$

Where X^2 is the chi-square test, Σ is the summation operator, O is the observed frequency, and E is the expected frequency.

To further investigate Pearson's chi-square results, the analysis of the residuals is performed, which helps to identify the specific cells or subcategories of respondents' profiles that make the greatest contribution to the chi-square test results [39]. For the sake of this research work, the contribution of the subcategory evaluated by the adjusted standardized residual (critical z) considers its correlation to the critical value of 1.96 for positive residuals and −1.96 for negative residuals [40]. To perform the chi-square test and to calculate the adjusted standardized residual, IBM SPSS software is used.

4 Results

This section presents the main results retrieved from the shared e-scooter survey that was deployed in Braga. It shows the respondents' sociodemographic profile, followed by the main determinants according to the population characteristics as well as the main attributes for the use or not use of the shared e-scooter service.

4.1 Profile of the respondents

The sample size of this research comprises 433 answers, of which 47.8% are male and 49.4% are female. Respondents belong mostly to the age range of twenty to twenty-four years old (38.3%), but all ages were represented in the data collection. Regarding the educational stage of the respondents, 54% finished high school and 27% have a bachelor's degree, which are the most prominent educational stages. When inquired about their employment status, 70.7% said they are students, and 26.8% are

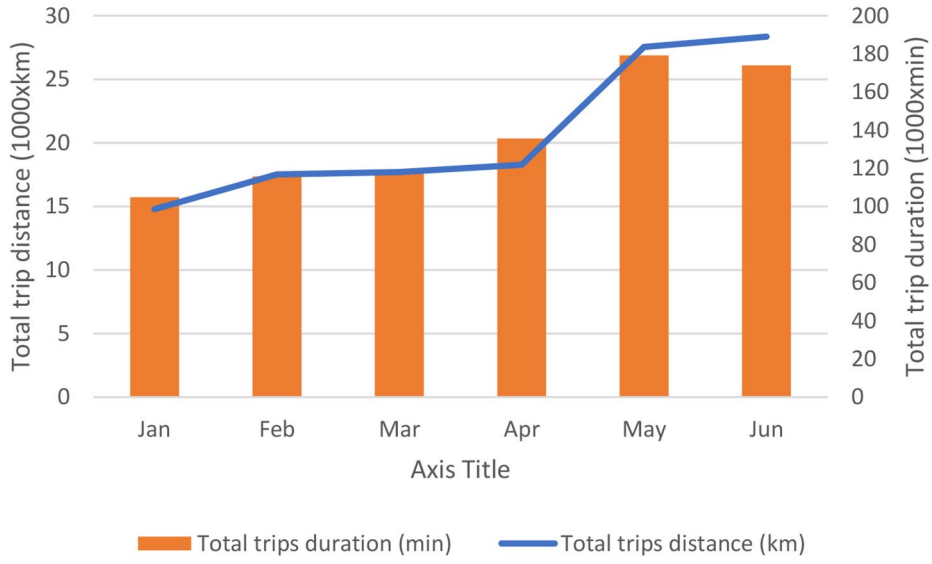

Fig. 4 Shared e-scooter usage in the first half of 2022

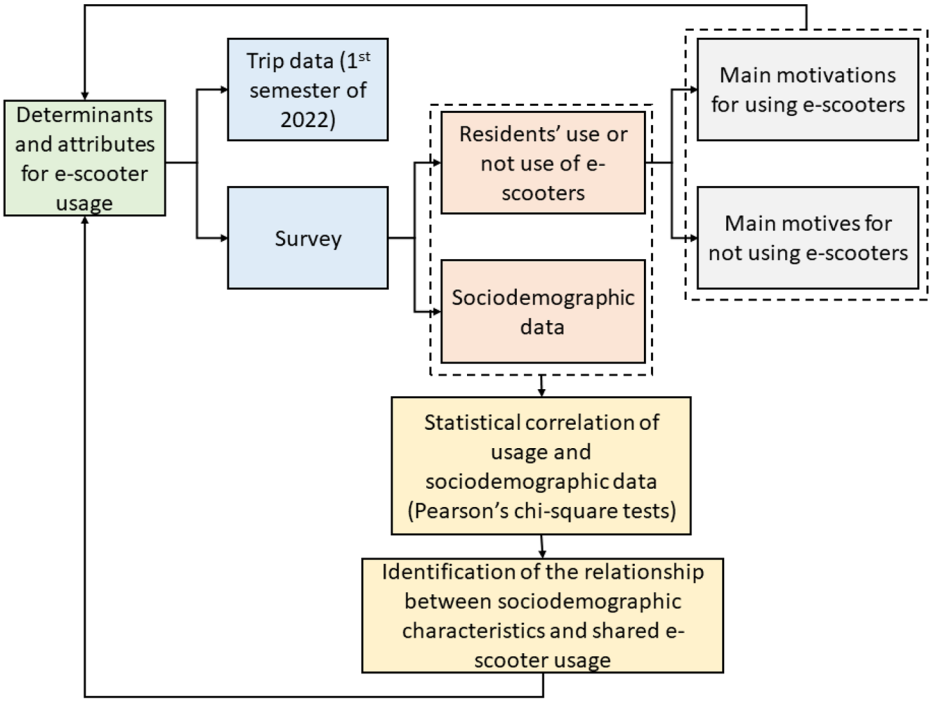

Fig. 5 Methodology to assess the determinants for shared e-scooter usage in Braga

employed and have monthly incomes from 1001 EUR to 1500 EUR. Table 3 shows the profile of respondents by category.

As shown in Table 3, the sample's sociodemographic characteristics are mostly aligned with the described population of the city of Braga, although there are specific deviations that can be explained considering the results of previous studies. The high number of respondents who are young adults (ages between 20 and 24 years old) is due to the fact that the main users of shared e-scooter systems in cities are in this age range [24, 26, 41]. This is considered the main reason for their expressive participation in the survey; therefore, their contribution is considered to be very important and statistically representative of the e-scooter market. Also, most of the respondents' occupation in the sample is to study (70.7%), whereas in

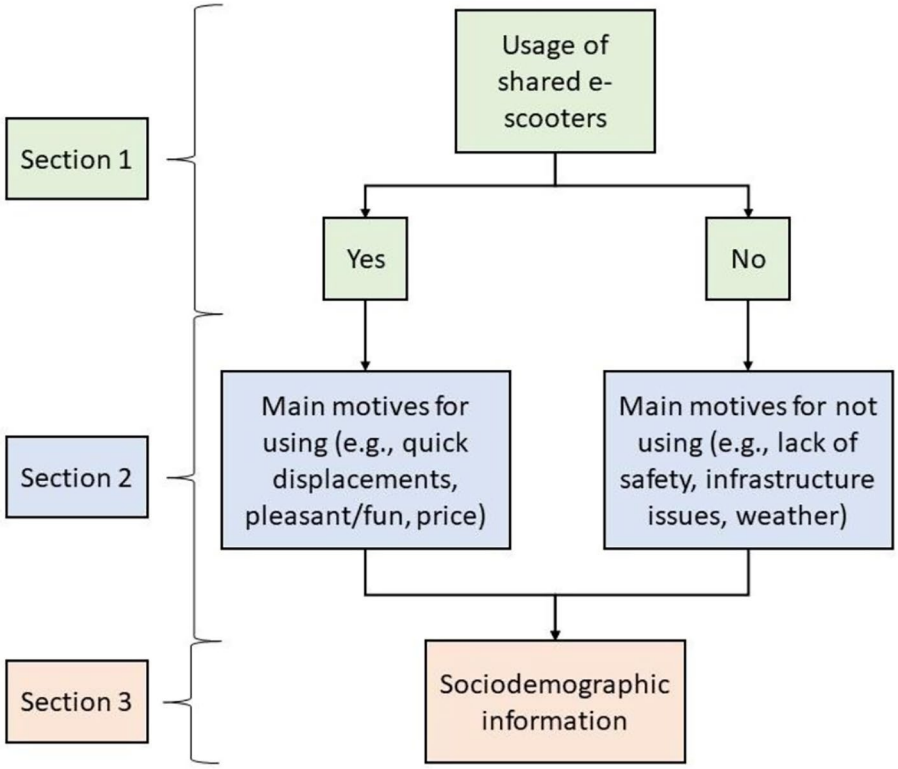

Fig. 6 Survey structure

the city of Braga, the majority are employed young adults commuting to work (46.8%), this deviation is related to the main age of the respondents of the questionnaire, who are in the schooling age range.

In addition to the sociodemographic questions in the survey, respondents were also inquired if shared e-scooters are available in the parish (smallest municipal administrative division) where most of their trips start and end. Of the respondents, 69.5% reported the presence of shared e-scooters in the parish where they initiated most of their daily trips, while 8.8% stated that shared e-scooters are typically accessible in the parishes they travel to.

4.2 Main determinants for the shared e-scooter usage

After analysing the profile of the population served by shared e-scooters in Braga, it was possible to audit the main determinants for the usage of this service. The determinants are related to the sociodemographic characteristics of the population, such as gender, age range, educational stage, employment status, family size, monthly income, parish of origin of most of the trips, parish of destination of most of the trips, and the mode of transport used daily. The results from the statistical correlation between the use or not use of shared e-scooters (yes or no) and the sociodemographic characteristics can be seen in Table 4.

It is possible to infer that there is evidence of a significant statistical association between the utilization of shared e-scooters and the gender of the respondents. It is because there is a lack of women participation in shared e-scooter usage in Braga (critical z = -4.0), while men are overrepresented as users (critical z=4.0). Thus, gender is likely to influence the willingness to use the service. This finding was also identified in the previous study performed by the authors [19].

The parish of origin of the trips also presents a significant statistical association with the use or not use of shared e-scooters. Thus, if a person lives in the central area of the city, where shared e-scooter services are available, the probability of using this mode of transport for daily trips is higher than people who live in peripheral regions. The critical z for this correlation is -5.1, and this is related to the uneven distribution of the e-scooter service in the city of Braga, since this mode of transport is only available downtown and in its immediate surroundings.

The main mode of transport used by respondents also influences the use or not use of shared e-scooters. People tend not to use the service if they have access to a car (critical z=2.5) or public transport (critical z=3.9). On the other hand, people tend to use shared e-scooter if they need to walk (critical z=4.7).

Table 3 Sample description

Category	Subcategory	N	%	% Braga
Gender	Female	214	49.4%	52.4%
	Male	207	47.4%	47.6%
	Other	2	0.5%	-
	Prefer not to say	10	2.3%	-
Age	Up to 19 years old	115	26.6%	19.3%
	20–24 years old	166	38.3%	5.9%
	25–29 years old	33	7.6%	5.9%
	30–34 years old	29	6.7%	6.1%
	35–39 years old	30	6.9%	7.1%
	40–44 years old	15	3.5%	7.9%
	45–49 years old	9	2.1%	7.8%
	50–54 years old	19	4.4%	7.6%
	55–59 years old	12	2.8%	7.4%
	Above 60 years old	5	1.1%	24.7%
Education	Up to secondary education	241	55.8%	63.7%
	Bachelor's or equivalent	130	30.1%	16.8%
	Master's degree	51	11.8%	5.6%
	Doctoral degree	10	2.3%	1.0%
Occupation	Students	306	70.7%	7.8%
	Employed	116	26.8%	46.8%
	Employer	5	1.2%	5.6%
	Unemployed	6	1.4%	3.9%
Family size	1 person	43	9.9%	7.3%
	2 persons	56	12.9%	11.4%
	3 or more persons	120	77.2%	18.6%
Household monthly income	Up to EUR 665	17	6.0%	Average income EUR 1146
	EUR 666– EUR 1000	45	15.8%	
	EUR 1001– EUR 1500	83	29.2%	
	EUR 1501– EUR 2000	54	19%	
	EUR 2001– EUR 2500	38	13.4%	
	EUR 2501– EUR 3000	17	6.0%	
	EUR 3001– EUR 3500	14	4.9%	
	EUR 3501– EUR 4000	8	2.8%	
	Above EUR 4000	8	2.8%	
The main mode of transport	Walking	113	26.1%	15.8%
	Private car	165	38.1%	69.7%
	Public transport	108	24.9%	10.3%
	Micromobility (bicycle or e-scooter)	47	10.9%	0.9%

However, shared e-scooters can act as a mode of transport that attends to the needs of people from multiple family sizes, incomes, employment status, and educational stages since there is no evidence of a significant statistical association between the use or not use of e-scooters and these determinants.

Respondents tend to use shared e-scooters regardless of their family's monthly income. This can be influenced by the fact that most of the respondents are students, who depend on their parents' incomes to pay for transport options. Also, most of the respondents earn more than EUR 1501, which is higher than the average income of EUR 1146 in Braga [31].

Table 4 Pearson's chi-square for the determinants of shared e-scooter usage

Utilization determinants	Use of shared e-scooters (yes or no)			
	Pearson chi-square	Df	Fisher's exact test	ρ
Gender	15.698	1	< 0.001	< 0.001
Age	7.367	9	0.751	0.602
Educational stage	1.401	3	0.702	0.707
Employment status	1.725	3	0.722	0.668
Family size	2.113	4	0.677	0.718
Monthly income	3.353	8	0.919	0.919
Parish of origin	26.020	1	< 0.001	< 0.001
Parish of destination	1.581	1	0.271	0.271
Mode of transport	37.979	3	< 0.001	< 0.001

In addition, the employment status of the population shows no significant statistical association with the use or not use of shared e-scooters in Braga, which shows that students, employed people, unemployed people, and self-employed people have the same willingness to use this mode of transport, which is also in line with the work by Mitra e Hess (2021) [27].

4.3 Main attributes for using or not using shared e-scooters

In order to acknowledge the main attributes or interventions for the usage of shared e-scooters in Braga, respondents needed to state if they are users of the shared e-scooter service and what are the main interventions they expect in order to improve e-scooter usage. More than 80% of the respondents said they do not use the service because they feel unsafe when riding an e-scooter, followed by the preference to make their daily trips by car or public transport. On the other hand, respondents said they use shared e-scooters in Braga because of the fun and pleasant aspect of the trip, the possibility of reaching their destination quicker, and the reduced physical effort to travel.

All respondents had to state the main interventions needed in the shared e-scooter service to start using this mode of transport (the case of non-users) or to continue using it (the case of users) as can be seen in Fig. 6.

The three main interventions pointed out by the respondents are the implementation of more dedicated infrastructure for e-scooters (e.g., cycle lanes), the creation of zones where micromobility and active modes have priority over cars (zoning of the city), and the implementation of more e-scooter parking spots. These changes in the urban fabric would increase the usage of shared e-scooters in the city, as people would feel safer and more comfortable using this mode of transport. Besides, non-user respondents said they would start

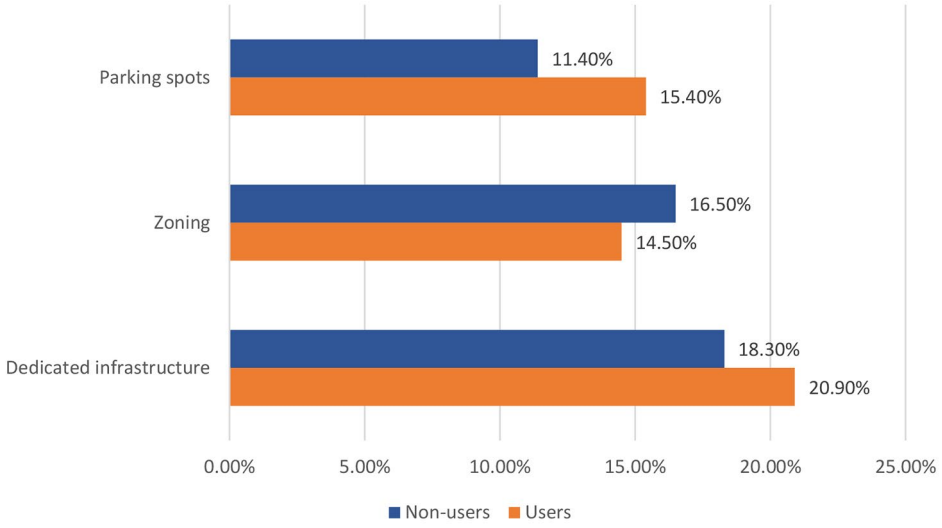

Fig. 7 Three main interventions for e-scooter usage

using shared e-scooters if the interventions presented in Fig. 7 were implemented.

In addition, the chi-square correlation between all sociodemographic characteristics of respondents and the top three interventions needed resulted in 45 interactions, therefore, only the ones that resulted in statistical correlation are presented here. Thus, the implementation of more parking spots is correlated with the characteristics of users and non-users. For non-users, gender ($\rho=0.030$), employment status ($\rho=0.001$), family size ($\rho=0.04$), the main mode of transport ($\rho=0.009$), and the parish of origin ($\rho=0.023$) are statistically correlated with the need for more parking spots. For users of shared e-scooters, the family size ($\rho=0.042$) is correlated to the need for more zoning, and the gender ($\rho=0.027$) is correlated to the need for more parking spots.

5 Discussion

The survey results for this case study revealed that gender has a great influence on people's readiness to use shared e-scooters. The lack of gender equity in transport is a long-established problem that needs to be addressed to improve mobility for both men and women at the same pace [42]. The survey results show that women are underrepresented in shared e-scooter usage, whilst men are more than twice as likely to use shared e-scooters. This reality is also present in other micro vehicles usage, such as bicycles, segways, and skateboards [43, 44], and it is because women are expected to perform activities (e.g., shopping, bringing kids to school) that are sometimes difficult to do on a light two-wheeler vehicle, they are more concerned with safety issues, physical design of the infrastructure and safety of vehicles [45, 46]. In addition, shared e-scooters are not believed to act as an enabler of transport-related equity issues, as was identified in previous studies by the authors [21].

The parish of origin of trips is also reported to affect the use or not use of shared e-scooters. The areas of the city where this mode of transport is deployed influence its use. Therefore, the central areas within the city of Braga where dedicated infrastructure is present, such as parking spots and cycle lanes make the usage of shared e-scooters more prominent, which is also the case reported in Puerto Rico [47], and Chicago [48].

The main mode of transport used by the respondent also influences people's readiness to use shared e-scooters. In Braga, shared e-scooters have a high possibility of replacing walking trips, although car users and public transport users would hold to their current mode of transport. This indicates that shared e-scooters have a higher potential to replace walking than car trips or public transport trips [49].

On the other hand, the employment status of respondents has no association with the use or not use of shared e-scooters, which was also found in the work by Mitra and Hess [27].

Since respondents use shared e-scooters because they provide a quick displacement and are pleasant and fun, the introduction of infrastructure that enables a safe and reliable trip would increase people's use of shared e-scooters. However, it is important to mention that shared e-scoters should replace car trips in cities, and act as a first/last mile option for public transport, whereas the replacement of walking is not expected [50].

In this situation, e-scooters need to be complementary to public transport, such as with the availability of this micro vehicle near bus stops and stations where people can use them for their first/last mile [51]. Moreover,

e-scooters and other micromobility modes need to be perceived as more attractive than cars to the population with the implementation of safety measures, such as dedicated infrastructure [51].

The provision of dedicated infrastructure is the main intervention needed by users and non-users of shared e-scooters to start or continue using this mode of transport. Currently, in other European cities, joint activities between governments and shared e-scooter companies have improved the infrastructure to expand this mode of transport usage among the resident population, with special attention to the expansion of trial periods such as what was made in London [52].

The creation of zoning in the city is also an intervention needed by users and non-users. These interventions could corroborate the improvement of the safety for e-scooter riders, which has been made in European countries such as Germany, the United Kingdom, Italy, Belgium, Sweden, and Finland which have been relying on implementing policies and regulations to improve safety in shared e-scooter usage. The latter reported a reduction in the proportion of e-scooter crashes after the implementation of a set of temporal and speed restrictions [53] in areas of the city. Road safety is improved in these countries by creating zones where e-scooters can be ridden on dedicated infrastructure, as well as where the maximum speed on roads is limited [54].

After the study of the top three interventions, the one that was found to have statistical significance was the improvement in the parking spot coverage for shared e-scooters, which was also seen as an opportunity to increase usage in previous studies [55, 56]. The present research also found that the gender, family size, employment status, and parish of origin of non-users have a statistical correlation with the choice of this intervention as a policy priority.

In Braga, some specific points should be taken into consideration when implementing policy for shared e-scooters. Firstly, more dedicated infrastructure and zoning (e.g., reduction of maximum speed for motorized traffic) should be enforced, so all dwellers with access to shared e-scooters would feel safer riding this mode of transport [46]. Infrastructure improvements could also benefit the modal shift from car users to micromobility. Likewise, to increase the covered area of service, specific planning should be done to make shared e-scooters an ally for first and last-mile connections of public transport in areas that are far from the city centre. The price for the shared e-scooter trip was found not to influence the usage or not usage of this service in the city. This fact is already pointed out as a drawback to the usage of this mode in some cities, such as Paris [5].

6 Conclusion

Shared e-scooter services were introduced in cities to make urban mobility more sustainable and efficient, as they can replace short car trips and solve first/last mile problems. Thus, as a new addition to urban environments, the problems involving shared e-scooters arose quickly (e.g., obstruction of sidewalks, and pedestrian accidents). In a way to decrease disruptive events caused by shared e-scooters, incorporating them in the transport system planning corroborated the improvement of urban mobility.

However, little is still known about shared e-scooter services and how they interact with the urban population. Thus, surveys must be conducted to better understand why and how people use this mode of transport, and what are the main determinants for its usage. This research work surveyed a middle-sized city in the North of Portugal with all people exposed to the shared e-scooter service (i.e., users and non-users), while most of the current survey works related to this matter consider only the users' responses.

Gender issues have been proven to be a crucial part of the inequality that can be caused by shared e-scooters in cities [15]. Women feel unsafe using these micro vehicles because little infrastructure is provided to accommodate e-scooters and grant a safe and comfortable ride.

Age, depending on the context, is also a great determinant of shared e-scooter usage, since younger people are more physically ready to jump on this vehicle and maintain their stability. While older people who have reduced mobility or any kind of difficulty in maintaining their balance are less likely to ride e-scooters.

On the other hand, e-scooters can contribute to making transport more inclusive for people of all income ranges and education statuses, since these two determinants little interfere with the usage of this mode of transport.

Moreover, the methodology used in this research work could also be replicated in other similar contexts to assess if shared e-scooter determinants (for using or not using this transport mode) diverge or converge depending on the city they are implemented, thus providing useful insights into policy implementation. The survey of the population exposed to shared e-scooter services is a beacon to guide future policies to improve the service and promote better mobility.

In short, the results from the survey in Braga show that gender plays an important role in shared e-scooter usage, especially when poor mobility conditions are offered, which decreases the ridership by women. Also, people who live in the central area of the city have better access to this mode of transport, therefore the service is restricted to these people. The main mode of transport also influences the willingness to use e-scooters, since people who have easy access to cars and public transport

prefer these modes. In addition, it has been reported that a good start to increase e-scooter ridership for the entire population would be the implementation of more dedicated infrastructure, as well as the creation of areas where micromobility has priority over cars and the increase in the number of parking spots for e-scooters. Only this way it will be possible to plan more sustainable, safer, more comfortable, and more involving modes of transport that can be used as a better option than cars for certain types of displacements.

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Data availability
Not Applicable.

Declarations

Competing interests
The authors declare no conflict of interest.

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