



# Exploring micromobility services: Characteristics of station-based bike-sharing users and their relationship with dockless services

Daniela Arias-Molinares<sup>a,\*</sup>, Raky Julio<sup>b</sup>, Juan C. García-Palomares<sup>a</sup>, Javier Gutiérrez<sup>a</sup>

<sup>a</sup> Transport, Infrastructure and Territory Research Group, Universidad Complutense de Madrid, Profesor Aranguren S/N, Ciudad Universitaria, Madrid 28040, Spain

<sup>b</sup> Transport Research Centre, TRANSyT, Universidad Politécnica de Madrid, Spain

## ARTICLE INFO

### Keywords:

Shared mobility  
Micromobility  
Docked  
Dockless  
Bike-sharing  
Scooter-sharing

## ABSTRACT

As shared mobility burst in different cities as one of the most innovative transport solutions, few efforts are found related to the exploration of dockless services and more specifically, to analysing opinions from those users that are subscribed to both, docked and dockless services simultaneously. Therefore, our study explores station-based bike-sharing users' preferences for other dockless services. To that end, we firstly divide the sample into two groups: Group 1 being users that only use Bicimad (Madrid's station-based bike-sharing) and Group 2 being Bicimad users that are also subscribed to other dockless services. Results show that both groups have similar users' profiles according to their socio-demographic characteristics (male, 35–49 years old, well-educated, medium income and employee), although Group 2 shows a slightly higher rate of under-26-year-olds, which could be supporting the idea that these services are more attractive for the youngest. Moreover, our findings show that approximately 12% of station-based bike-sharing users are also subscribed to dockless services. At a higher rate, those subscribed to dockless services live outside the city centre, where the bike-sharing system is not available, showing that the two models may essentially have a complementary relationship, especially in the peripheries. Finally, results point at the importance of bike-sharing systems having a positive impact on its users, as they are keener to try new dockless options and a reduced willingness to use private cars. Insights may help to better inform public policy and promote the use of shared micromobility.

## 1. Introduction

Collaborative economy and the irruption of technological advances in social media and Information and Communication Technologies (ICT) are rapidly changing people's lifestyles and thus, their mobility behaviour. In the Transport Arena, shared mobility has been described as one of the three revolutions in urban passenger travel (Fulton, 2018), becoming a topical subject. Shared mobility is defined as the short-term access to shared vehicles according to the user's needs and convenience, instead of requiring vehicle ownership (Shaheen et al., 2016). More recently, the term "micromobility" has been coined as the shared use of a bicycles, motorcycles, scooters or other low-speed modes on an as-needed basis (Shaheen & Cohen, 2019). These services include different transport modes as moped-style scooter-sharing, bike-sharing and scooter-sharing; they can be station-based (also called docked services), meaning that the vehicle is picked-up from and returned to a fixed station, or free-floating (also known as dockless services) where the vehicle is picked up and returned to any location within a certain geographic area (also known as the service's geofence) (Shaheen & Cohen, 2019). Most studies focus on station-based services as they have been operat-

ing for more than a decade, while only few efforts are found regarding dockless ones, as they have gained attention more recently (Arias-Molinares & García-Palomares, 2020; Degele et al., 2018; Hardt & Bogenberger, 2019; McKenzie, 2019; Reiss & Bogenberger, 2015). Consequently, their impact on urban mobility dynamics is yet to be clarified, offering a burgeoning new sub-field with numerous avenues of exploration.

One of them is the exploration of users' opinions regarding the different models and more importantly, those particular users subscribed to both models (station-based or dockless) as they can offer interesting insights when comparing the services. Hence, from the point of view of Bicimad users (Madrid's public and station-based bike-sharing system), we explore opinions and preferences for other dockless services available. We aim to answer the following three questions: (1) To what extent have station-based bike-sharing subscribers also adopted other dockless services? (2) Are there any differences with respect to socio-demographic characteristics, mobility behaviour or preferences between users that are only subscribed to Bicimad and those also subscribed to other dockless services? (3) Is the relationship between both models complementary or competitive?

\* Corresponding author.

E-mail address: [daniar02@ucm.es](mailto:daniar02@ucm.es) (D. Arias-Molinares).

Responses from a Bicimad satisfaction survey are analysed. This is an annual questionnaire that explores opinions related to the service's performance and users' satisfaction levels. The Bicimad survey constitutes a great data source as we support (Fellesson & Friman, 2012) when stating that customer satisfaction highlights the link between what a company does (in terms of the service offered) and how its customers react, making this link a key concern. We think analysing this link is of great importance, and especially for the recently introduced micromobility services. Consequently, we take the perspective of service dimension used by previous studies related to public transport (Fellesson & Friman, 2012; Hensher & Stanley, 2003) and apply it to micromobility services, analysing and comparing users' opinions regarding docked and dockless services. We consider five service dimensions which are demand patterns, price, comfort of ride, ease of use and spatial availability. By comparing Bicimad users' satisfaction levels and preferences for station-based and dockless services simultaneously, we could offer insights to policymakers about what they consider important, as well as the perception about how the existing services are performing in these dimensions. The rest of the article is organised into four sections. Section 2 provides background. Next, we present in Section 3 the study area and methodology used. Section 4 describes the main results and finally in Section 5 we offer discussion and conclusions.

## 2. Background

Regarding shared mobility literature, station-based bike-sharing is by far, the most studied (Fishman, 2015; Pucher et al., 2010). Some authors have explored users' demographics (LDA Consulting, 2012; Wang et al., 2018), others have visualised their dynamics identifying trends (Borgnat et al., 2013; Romanillos, 2018; Zaltz Austwick et al., 2013), usage rates, demand models and the location of bases (García-Palomares et al., 2012; Goodman & Cheshire, 2014; Rojas-Rueda et al., 2011). A study made by Munkácsy (2017) analysed Bicimad's users' profiles and intentions to adopt the service, finding that users were usually young, well-educated males. More recently, Velázquez Romera (2019) studied the factors that impact on the adoption of mobility solutions, one being bike-sharing systems, finding that user's satisfaction influenced the most.

Nevertheless, compared to bike-sharing, the research body related to dockless services is relatively smaller, which is understandable as free-floating mobility has gained unprecedented popularity only in the last years. As a result, even though dockless services have been rapidly deployed in different cities, and only in the US, they went "from being virtually non-existent in 2017 to facilitating over 38.5 million trips in 2018" (Younes et al., 2020, p. 308), its specialised bibliography is still in its nascent stage and their usage in many cities is timidly growing. In general, studies related to dockless services could be classified in three main groups. The first one related to definitions and guidelines as made by Shaheen and Cohen (2019). A second group of studies are those entirely devoted to analysing a certain mode, especially scooter-sharing as in Jiao and Bai (2020) and Zhu et al. (2020), but also dockless bike-sharing as in Paul and Bogenberger (2014), Paul et al. (2016) and Reiss and Bogenberger (2015), 2016, 2017. In the case of Reiss and Bogenberger (2017) they study Munich's dockless bike-sharing service travel patterns and urban dynamics using GPS datasets, in order to propose vehicle relocation strategies that make the system more efficient. We can highlight that one of their main results was a demand model that considered different factors like seasons, weather conditions, time of the day and holidays/weekends, fleet distribution by area and time slots. And lastly, the third group of studies are those few that focus on comparing docked and dockless services simultaneously, which is the path we intend to follow in this research. In this group we could mention the work conducted by Lazarus et al. (2020), that compared station-based and dockless bike-sharing systems and found that station-based bike-sharing trips tended to be short, flat commute trips, mostly connecting to/from major public transit stations, while dockless bike-sharing

trips were longer, more spatially distributed and more heavily servicing lower-density neighbourhoods. Similarly, Zhu et al. (2020) compared dockless bike-sharing and scooter-sharing services, and found that scooters have spatially compact and quantitatively denser distribution compared with bicycles, and that their high demands were associated with places such as attractions, metros, and the dormitory. All these mentioned references analysed travel patterns based on GPS datasets, however the path followed in this research is quite different. We focus on users' opinions (not their travel behaviour) and our results are based upon survey's responses (not GPS datasets). Our contribution to research literature is made by analysing how docked and dockless services interact from the point of view of its customers.

## 3. Study area and methods

### 3.1. Study area

The selection of Madrid is of special interest as the city has been known as one of Europe's top living labs for shared mobility, allowing its residents to be familiar with the emerging transport options, especially micromobility services. Madrid has a multiple and varied shared mobility supply, great diversity of land use and high densities of population and employment with more than 6 million people in the Metropolitan Region, and half located in the Municipality of Madrid (Instituto Nacional de Estadística, 2018). The road network is structured by a radial motorway system, with three ring roads that allow the distribution of traffic within the metropolitan area: M-30, M-40 and M-50. According to the 2018 Madrid Mobility Survey, only 11,29% of Madrilenians live inside M-30 urban area, while the rest of the population (88,71%) resides outside of this important road. The modal split involves 39% of trips by car/motorcycle, 24% by public transport, and 34% by active modes (walking and cycling). The trend towards environmental-friendly modes increases within the city of Madrid (inside the M-30), with 20% of trips made by car/motorcycle, 34% by public transport, 40% on foot, and 0.5% by bicycle (Comunidad de Madrid, 2018). In general, as Fig. 1 shows, the main trip purpose is work/study (42,75%), followed by leisure/recreational activities (16,37%) and visiting friends/family (12,53%). Additionally, most residents own at least one vehicle per home (41,34%) and make 4 to 10 trips weekly (43,87%) (see Fig. 2).

Moreover, Madrid's mobility survey indicates that its residents mostly walk (33,60%) or use their own cars (30,48%) to conduct their daily activities (see Fig. 3). When considering only bicycle modes and shared services (micromobility) we see that most residents (66,67%) have their own bicycles and many of them use car-sharing (23,17%) or bike-sharing (5,66%), which demonstrates that shared services are gaining importance in the city.

Regarding Madrid's cycling infrastructure, it is still relatively low with only 43 km of cycling tracks (segregated cycle lanes). Concerning shared mobility, Madrid holds one of the largest fleet, with approximately 20.000 vehicles (Arias-Molinares & García-Palomares, 2020; Bernardo, 2019; Granda & Sobrino, 2019). All the operating companies, except for Bicimad, are free-floating models. These services usually work by using a mobile application where their clients register and locate vehicles. In the case of Bicimad, the system has been operative since 2014 and it is currently being managed by Municipal Transport Company (EMT), with around 75.000 subscribers (Ayuntamiento de Madrid, 2019). Since its launch in 2014, four expansions have taken place and it is now operating 264 stations with a total of 2.900 bicycles. All Bicimad's fleet is electric and equipped with GPS trackers and a pedal assistance up to 25 km/h.

On the other hand, Mobike, a Chinese private company spread in many cities worldwide, is operating in Madrid since 2016, offering dockless bike-sharing and managing approximately 1.000 electric bicycles. Moreover, scooter operators are multiple (more than 15) and manage a large fleet of vehicles with approximately 10.000 vehicles (Arias-Molinares & García-Palomares, 2020). Most of them have been oper-

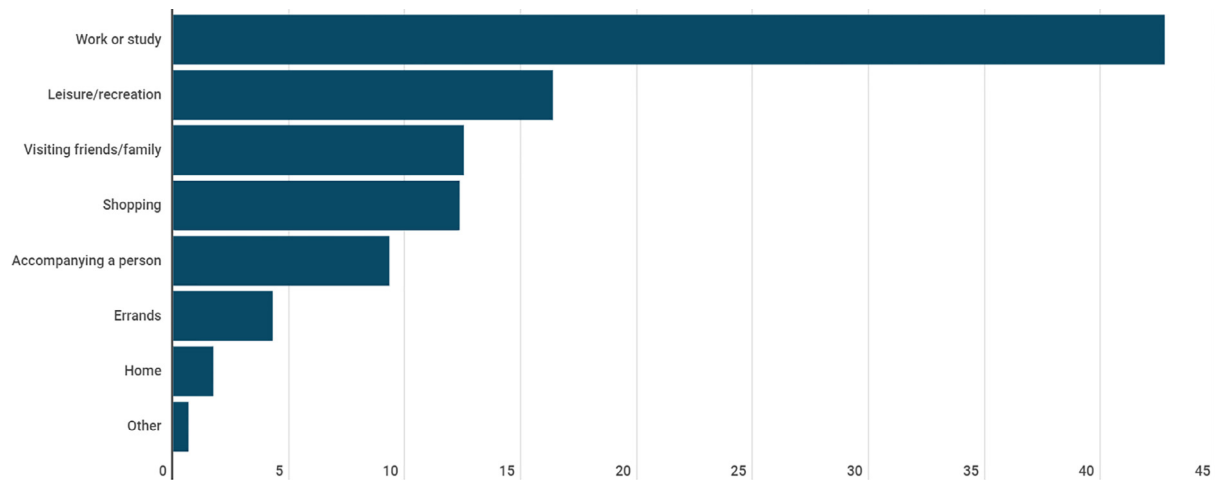


Fig. 1. Main trip purpose for most usual trip (EDM2018).  
Source: (Comunidad de Madrid, 2018)

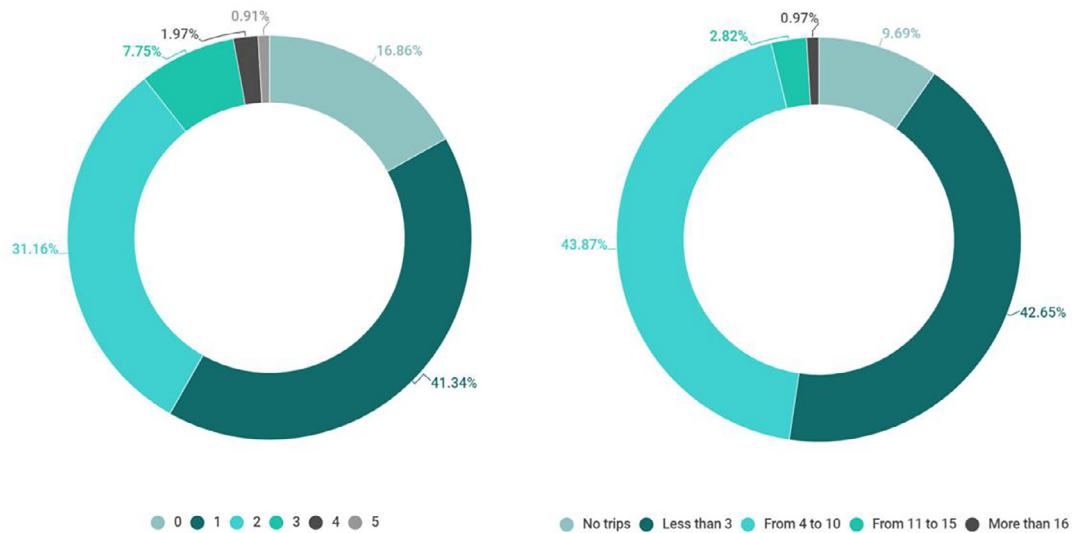


Fig. 2. Number of vehicles (left) and average weekly trips per home (right).  
Source: (Comunidad de Madrid, 2018)

ating since 2019 and all vehicles are electric with a pedal assistance of up to 25 km/h. In the survey, the dockless services analysed are Mobike and the different scooter-sharing companies.

Regarding the cost of the services, Bicimad is the cheapest one (0,25€ per a 15 min ride), followed by Mobike (0,75€/15 min) and finally the rest of the scooter-sharing services (2-3€/15 min) that are relatively more expensive. In the case of scooters, some companies also charge users to unlock the vehicles (generally 1€) which increases the total cost of the trip. All these micromobility services (docked and dockless) enjoy the privilege of free on-street parking and are allowed to circulate anywhere in the city (including the city centre which was partly restricted to vehicles with Madrid Central low emission zone during 2019).

### 3.2. Methods

The research workflow included two main stages. The first one related to obtaining and processing the survey responses and offering the socio-demographics descriptive results. A second stage involves comparing both models (station-based and dockless) based on two approaches: (1) conducting statistical analysis of the two user groups (Group 1- only

Bicimad and Group 2- Bicimad+ other dockless services) and (2) identifying similarities and differences in their service dimensions.

#### 3.2.1. Bicimad survey

The Bicimad Survey is a yearly questionnaire made by EMT and sent to all Bicimad's subscribers to evaluate the service's performance based on their opinions. We have used the last survey conducted in 2019, that intended to explore users' characteristics and declared and revealed preferences for docked and dockless services. Our objective was to identify the extent to which Bicimad users have also adopted dockless models, to evaluate differences/similarities between those only subscribed to Bicimad (we called them Group1- Bicimad only users) and those also subscribed to other services (called Group 2- Bicimad+ other users) and finally to define the type of relationship between both models. Our hypothesis is that Bicimad (a public and efficient micromobility service) is becoming crucial for the transformation in urban mobility dynamics. The system is prompting the use of other micromobility programs and thus it is enabling new concepts like Mobility as a Service to emerge in the city. Hence, we hypothesized that a considerable amount of Bicimad users is also trying new modes and that their preferences (Group 2) probably differ from those in Group 1. With respect to the type of

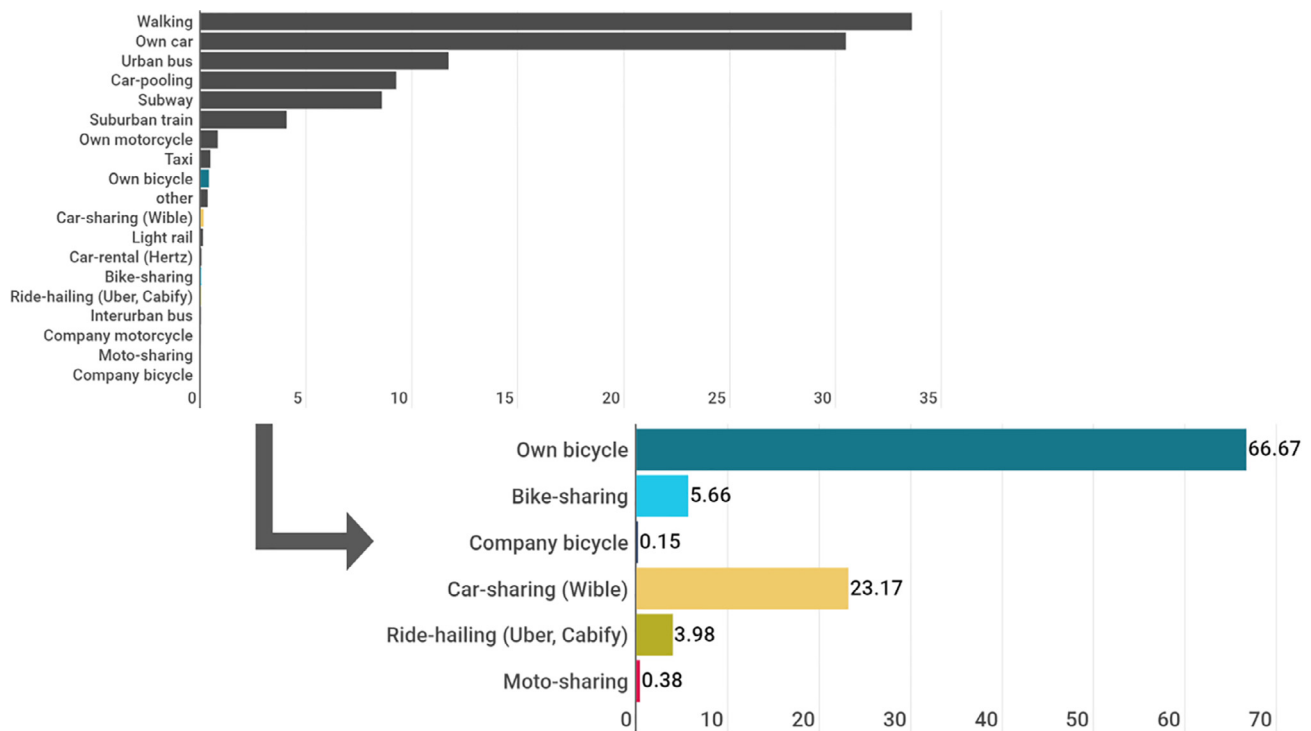


Fig. 3. Prior transport mode in general (top) and when considering only certain modes (bottom).  
Source: (Comunidad de Madrid, 2018)

relationship, our hypothesis is that the systems complement each other as micromobility services are just beginning to operate. In the questionnaire, individuals are asked about:

- General socioeconomic and demographic information: gender, age, education level, occupancy, monthly income, environmental consciousness and zip code of residence and work/study.
- Mobility and travel-related variables: subscriptions to bike-sharing/dockless bike-sharing/ scooter-sharing services, trip frequency in different modes of transport, mobility patterns in week-days/weekends.
- Bicimad usage: trip frequency, trip purpose, trip time, previous mode used before Bicimad, mode that they will use if Bicimad is not available, satisfaction levels with Bicimad and cycling infrastructure.
- Perceptions and use of dockless services: trip frequency, trip purpose (only for scooter-sharing and Bicimad), proximity to user, satisfaction with service and best attributes for adoption.

A 5-point Likert-type scale was used on the questionnaire for all items to measure satisfaction levels, frequency of use, changes in travel behaviour and environmental consciousness. From March to August of 2019, 5,540 responses were received. Answers were codified to process information more efficiently and after the cleaning process (un-completed forms or typo errors), we obtained 5,218 valid responses. We then processed the survey counting and coding responses in categorical data. After valid responses were obtained, a descriptive analysis of results was made, summarising users' main characteristics, travel behaviour and preferences for Bicimad and dockless services.

### 3.2.2. Station-based and dockless services: comparison analysis

The second stage of the study involved analysing the two groups (Group 1 and 2), by using two approaches: statistical tests and service dimensions. When analysing them statistically, we used the statistical method called the Chi-square test, as it is the most appropriate when evaluating categorical data. The chi-square test is intended to test how likely it is that an observed distribution is due to chance. It is also called

a "goodness of fit" statistic because it measures how well the observed distribution of data fits with the distribution that is expected if the variables are independent (Ling, 2008). The null hypothesis ( $H_0$ ) is that there is no variation between both groups, while the alternative is the contrary. With a 95% confidence ( $p$ -values under 0,05) indicator we can reject or accept the null hypothesis evaluating whether the two groups present significant variations. Based on the two sample groups, we used this method to compare user's characteristics and other variables regarding preferences and mobility behaviour. Moreover, when analysing them from the service dimension perspective, we identified five dimensions: demand patterns (how do their demand behave?), price (what's the cost?), comfort of ride (how comfortable it is?), ease of use (how easy it is to ride one?) and spatial availability (how easy it is to find a vehicle?). All these dimensions were evaluated through each survey question allowing us to conduct better comparison analysis. The spatial dimension is analysed with the home/activity location of docked and dockless services' users, using the zip code information given by respondents. These maps were based on a subset of 3,851 people (73,80% of the sample), that completed the home/work-study zip code questions.

## 4. Results

### 4.1. Bicimad survey: socio-demographic characterisation

Table 1 shows respondents according to their subscriptions. As it can be observed, 11,92% of Bicimad's users (622 out of 5,218) have subscriptions to other dockless services. This figure is relatively low; however, it does reflect a considerable amount of people who are trying dockless services once they have tried Bicimad. Thus, their experience with the BSS could be making them keener to use other shared dockless services. Interestingly, there are more users subscribed to scooter-sharing rather than Mobike, which could be related to users finding it redundant to have two bike-sharing subscriptions (even though Mobike differs from Bicimad as it is dockless) and thus they are more attracted to a scooter-sharing service.



**Table 1**  
Percentage of Bicimad's users subscribed to other dockless services.

Subscribed to Bicimad since	Respondents (Total)	Bicimad + Mobike	Bicimad + scooters	Bicimad + Mobike + scooters
2014	901	63	66	13
2015	921	53	53	12
2016	885	48	51	7
2017	1.036	61	72	13
2018	1.041	80	87	19
2019	434	26	33	7
<b>Total</b>	<b>5.218</b>	<b>331</b>	<b>362</b>	<b>71</b>
<b>Bicimad's users subscribed to other services (%)</b>		<b>11,92% (331 + 362 / 71 = 622)</b>		

Source: own elaboration.

Once we measure to what extent are Bicimad's users subscribed to other services, we can also highlight some of their main socio-demographic characteristics (see Table 2). We have included the EDM2018 survey results for some variables to clarify that Bicimad is a very targeted and specific survey, having low representativeness of the general population of Madrid. As we see, and supporting all the previous similar studies, most respondents were male (64,3%). Regarding age groups, most respondents are 35 to 49 years old (45%). When further analysing normalised values, a higher rate of dockless users is found in the age group "under 26": for every user on this age group that only has subscription to Bicimad, there are 0,21 users that subscribed to other dockless services. Moreover, most of the sample (91,5%) acquired a bachelor's degree or higher education level, but in the case of those subscribed to dockless services, a higher rate is observed in undergraduates, which could mean that this mode is more attractive for younger population. Mostly, respondents are employees (86,5%), followed by unemployed (4,7%) but interestingly, when contrasted, a higher rate of house keepers and students are subscribed to dockless services. The chi-square results point at significant differences between Group 1 and 2 with respect to genre, age, occupation, and monthly income. We noticed for Group 2 less females than expected, younger population and more students. In relation to monthly income, most respondents reported to earn between 1.300 and 2.000 €/month. Nevertheless, in the case of Group 2, rates and chi square results show the same trend: dockless users seem to earn more or be more parent/couple-dependent than those only subscribed to Bicimad. Furthermore, 86,28% of respondents reported that environmental consciousness is important or extremely important, however, a higher rate of dockless service users is found in the "indifferent" group.

These results suggest that docked and dockless users share similar socio-demographic characteristics: they are mostly males, from 35 to 49 years old, with high education level, employed with medium monthly incomes and environmentally conscious. Some slight differences point at dockless services attracting younger (under-26) males, ungraduated students or high-income employees with an indifferent attitude towards environmental issues.

#### 4.2. Station-based and dockless services: comparison analysis

##### 4.2.1. Demand patterns

When comparing their demand patterns, Group 1 and 2 share similarities. On average, all respondents travel 12 times in weekdays (Monday-Friday) (2,4 trips per day) and five on weekends (Saturday and Sunday) (2,5 trips per day). The average trip duration reported resulted in 29 min in line with Madrid's Mobility Survey findings (Comunidad de Madrid, 2018). In the case of dockless service users exclusively, on average, they travel 11, 5 (Mobike) and 13 (scooter services) times in weekdays and 4,5 and 5,1 times on weekends, respectively, showing a similar pattern to the whole sample. The most frequent mode used for work/study purposes is public transport (38%), followed by bicycle (18%) and car (14%) (see Fig. 4) being quite different from the EDM2018 survey results (1)walking, (2) own car and (3) urban bus).

Walking is the preferred mode for shopping (50%), errands (66%) and leisure (55%) activities, whereas public transport is preferred for night life with 46% of the trips. The car is mostly preferred for visiting friends and other long trips (24 and 36%, respectively).

When further analysed according to the two groups of the sample, chi-square test results show differences regarding the most frequent mode for work purpose (value: 11,6 and  $p$ -value 0,04) (see Fig. 5). They both seem to use public transport, but Group 2 uses more cars and motorcycles (related also with higher income population), whereas Bicimad only users use more walking and bicycles.

In the case of Bicimad-only users the average Bicimad trip duration reported by respondents was calculated in 18 min, similar to findings in Romanillos (2018) (17,15 min). In relation to the frequency of use and purposes (see Fig. 6), findings show that at least once a week or more, 46% of respondents use Bicimad for work/study purposes (of which 22% use it on a daily basis). Visiting, errands and leisure activities are also important purposes, whereas shopping is the least important, which could be related to the need for carrying heavy objects and bags which is less comfortable in bicycles. Interestingly, 14% of Bicimad users reported using it for delivery activities (of which 3% use it daily). This is quite a considerable figure reflecting the increasing number of riders and delivery services in the city, a phenomena also captured by Romanillos (2018).

Around 70% of respondents reported to notice no change in travel behaviour after using Bicimad, while around 20% of them reported an increased usage of walking and bike-sharing, as well as new dockless services (around 10%) (see Fig. 7). On the contrary, a vast number of users reported to be using less public transport (64%) or walking (46%), but also fewer private cars (49%). Hence, although Bicimad could be competing with public transport and walking, results suggests that it is being an alternative to the private car as well.

When analysed according to Group 1 and 2, significant variations are noticed in travel behaviour changes after using Bicimad for walking, bike-sharing, cars, char-sharing and moto-sharing (see Fig. 8). Group 2 seems to be walking more (17% vs 14% in Group 1), cycling more (20% vs 14% in Group 1), and using moto-sharing (7% vs 4% in Group 1), while cars' usage is reported to be reduced (58% vs 48% in Group 1).

In the case of Bicimad-other users (Group 2), Fig. 9 shows that respondents are more familiar with Mobike, as 92% reported using it at least once (of which 7% use it twice or more per week and 2% on a daily basis), whereas this figure drops down to 44% in the case of scooter-sharing services. This result is understandable, as Mobike arrived first at Madrid (around 2016) in comparison with the most recent implemented scooter-sharing companies that arrived mostly in the summer of 2018 (Arias-Molináres & García-Palomares, 2020). Work/study and leisure activities were the most common purposes for using a dockless mode, while nightlife and shopping the least common (see Fig. 10).

Moreover, a key concern in micromobility research has been to explore the extent to which it could substitute car trips, which is the main objective of sustainability-oriented policies. In other words, the ideal situation is that micromobility could attract car drivers to use more active modes. Nevertheless, some studies show that sometimes, the contrary happens, with car drivers maintaining or even increasing car use

**Table 2**  
Socio-demographic characteristics of Micromobility users in Madrid.

Characteristics		Group 1-Bicimad only		Group 2-Bicimad + dockless services		Total		EDM2018	For each Bicimad only user...there is “x” Bicimad + other services user	
Genre	Female	1.704	37,10%	161	26,00%	1.865	35,70%	45,86%	1	0,09
	Male	2.892	62,90%	461	74,00%	3.353	64,30%	54,14%	1	0,16
									Chi-square test	Value 29,9 (p = 0,000)
Age	Under 26	286	6,20%	59	9,00%	345	6,60%	22,73%	1	0,21
	From 26 to 34	1.367	29,70%	191	31,00%	1.558	29,90%	7,54%	1	0,14
	From 35 to 49	2.058	44,80%	288	46,00%	2.346	45,00%	22,66%	1	0,14
	Above 49	885	19,30%	84	14,00%	969	18,60%	47,08%	1	0,09
									Chi-square test	Value 19,0 (p = 0,000)
Education Level	Non-university	383	8,30%	63	10,00%	446	8,50%	62,28%	1	0,16
	University	4.213	91,70%	559	90,00%	4.772	91,50%	37,72%	1	0,13
									Chi-square test	Value 2,3 (p = 0,132)
Occupancy	Employee	3.976	86,50%	536	86,00%	4.512	86,50%	44,61%	1	0,13
	Unemployed	224	4,90%	23	4,00%	247	4,70%	7,93%	1	0,1
	Retired	93	2,00%	6	1,00%	99	1,90%	20,07%	1	0,06
	Student	289	6,30%	54	9,00%	343	6,60%	20,59%	1	0,19
	House keeping	14	0,30%	3	0,00%	17	0,30%	6,79%	1	0,21
									Chi-square test	Value 10,2 (p = 0,0379)
Environmental consciousness	Not at all important	85	1,85%	12	1,93%	97	1,86%		1	0,14
	Slightly important	327	7,11%	42	6,75%	369	7,07%		1	0,13
	Indifferent	216	4,70%	34	5,47%	250	4,79%		1	0,16
	Very important	2229	48,50%	305	49,04%	2534	48,56%		1	0,14
	Extremely important	1739	37,84%	229	36,82%	1968	37,72%		1	0,13
									Chi-square test	Value 1,0 (p = 0,913)
Monthly Income	Not declared	48	1,00%	8	1,00%	56	1,10%		1	0,17
	Less than 800€/month	343	7,50%	39	6,00%	382	7,30%		1	0,11
	800–1.300 €/month	871	19,00%	111	18,00%	982	18,80%		1	0,13
	1.300–2.000 €/month	1.580	34,40%	179	29,00%	1.759	33,70%		1	0,11
	2.000–3.200€/month	1.191	25,90%	176	28,00%	1.367	26,20%		1	0,15
	More than 3.200 €/month	414	9,00%	85	14,00%	499	9,60%		1	0,21
	dependent (parents or couple)	149	3,20%	24	4,00%	173	3,30%		1	0,16
									Chi-square test	Value 21,1 (p = 0,001)
Total		4.596		622		5.218				

Source: own elaboration.

age and instead, micromobility stealing users from public transit, cycling or walking (Hendersen, 2019; Tirachini, 2019; Tirachini Hernández, 2018). In order to analyse this issue, we asked the question “before using Bicimad, what mode did you use to do the same trip?”. We found 71% of respondents reported to use public transport previously, followed by 12% that walked. Other users used their private car, motorcycle, bicycle or did not make the same route with 4%, respectively. Hence, we may infer that Bicimad is competing with public transport and walking, which is not a sustainable pattern to follow, as it will be if Bicimad took most of its trips from motorised private modes (cars/motorcycles). However, if we consider that achieving a sustainable shift is progressive challenge, we could appreciate that Bicimad, in its nascent six years, is substituting 8% of previously motorised trips (private cars and motorcycles with 4%, respectively).

When asked “if Bicimad is not available anymore, which other mode would you use?”, an even clearer sustainable pattern is found. Only 3% would take their cars, reducing car trips by 1% in comparison with the pre-Bicimad choice (see Fig. 11). Choosing a bicycle increases from 4%

(pre-Bicimad) to 9%, showing that previous experience with the BSS increases the usage of bicycles. And more interestingly, 9% of respondents would now choose a dockless service, of which moped scooters were the most preferred (5%). Thus, Bicimad could be allowing users to experience with micromobility and trying new modes, which was also supported by Aguilera-García et al. (2020).

When we analyse these responses by each group of users (Group 1 and 2), we noticed some differences (see Fig. 12). Group 1 mostly used public transport and walking before using Bicimad, and they will mostly go back to public transport, walk or using their own bicycle if Bicimad become inoperative. On the other hand, Group 2 has a considerable amount of people also coming from private cars and a relatively bigger reduction of 3% (from 6 to 3%) in their willingness to go back to driving their cars. Additionally, Group 2 also shows a higher willingness to go back to using different dockless shared mobility modes if Bicimad was not available (bike-sharing 11%, moto-sharing 9% and scooter-sharing 8%). From this figure we could infer that Bicimad is becoming crucial to promote the use of other dockless modes.

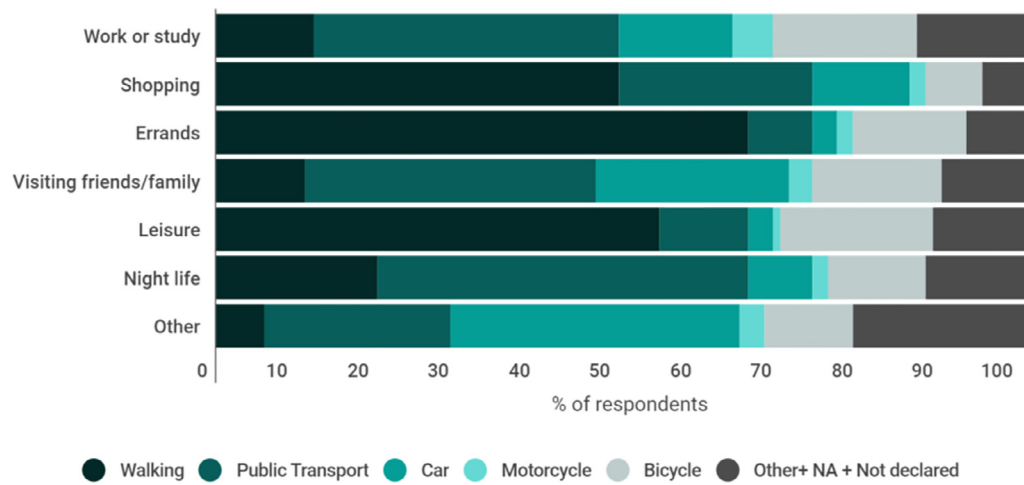


Fig. 4. Most frequent mode of transport of general sample.  
Source: own elaboration.

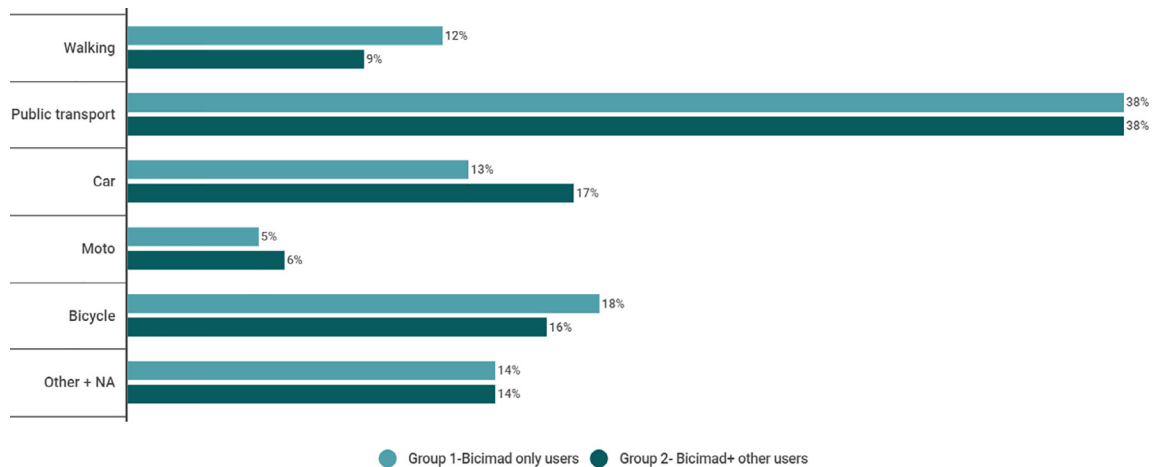


Fig. 5. Frequent mode used for work purposes according to each user group.  
Source: own elaboration.

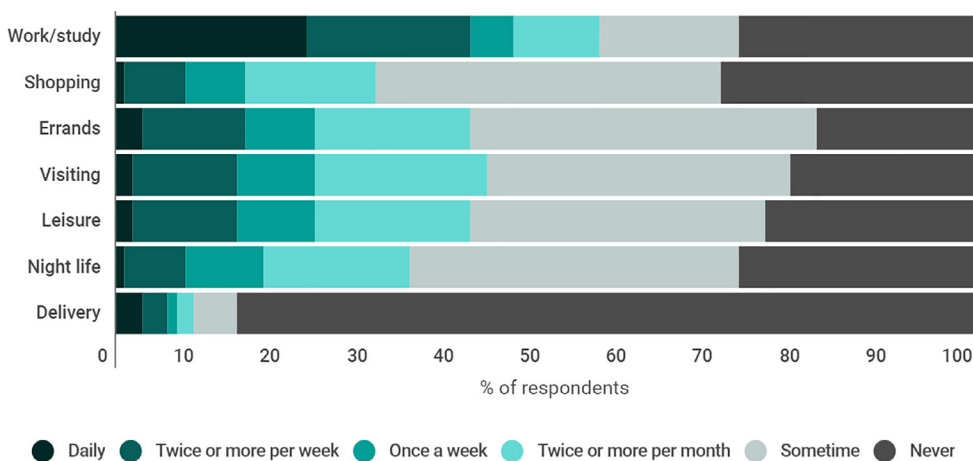
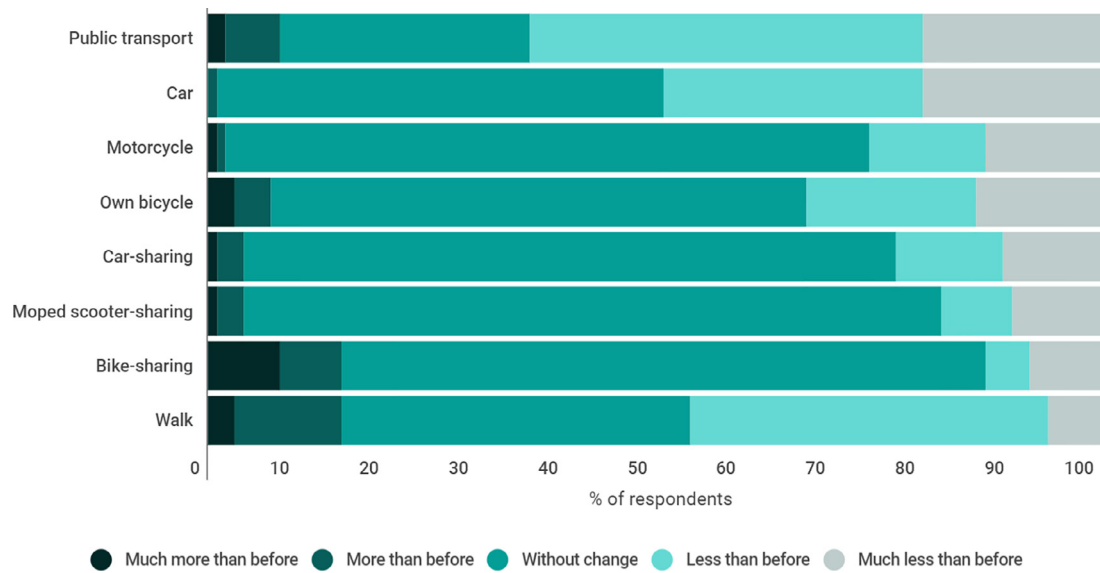


Fig. 6. Bicimad usage frequency by trip purposes for general sample.  
Source: own elaboration.

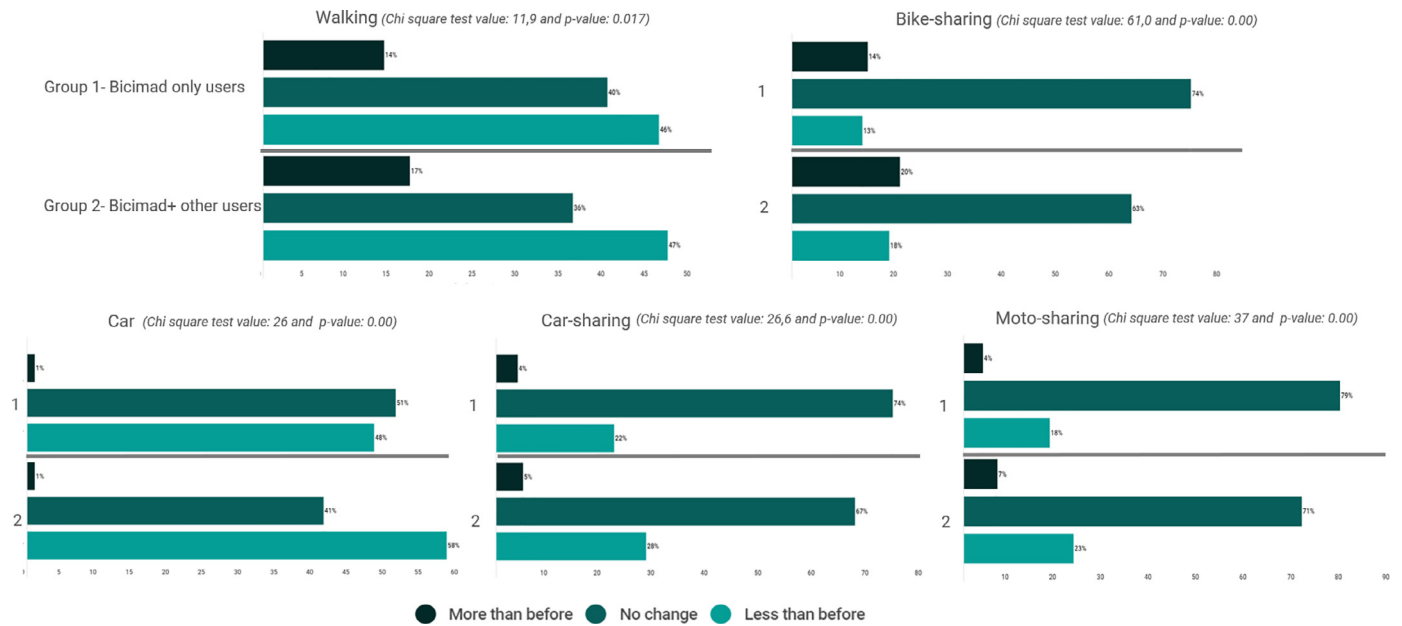
#### 4.2.2. Price, comfort of ride and ease of use

In order to better understand why users could be interested in trying new micromobility modes, we asked “which of the following attributes you find more attractive about the service (Mobike and scooters)?”. In both cases the majority of respondents (Mobike with 75% and scooter-sharing with 57%), answered the fact that it was a “dockless service” as the

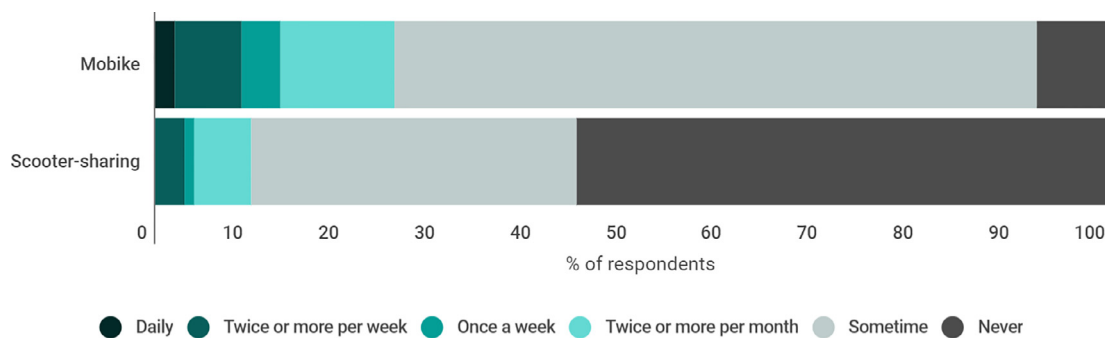
most attractive attribute (see Fig. 13). This important insight yields that many users may prefer dockless modes because they do not have to worry about knowing where to find or leave a vehicle (ease of use), allowing them to have a more seamless door-to-door experience in their trips. In the case of Mobike, the second most attractive attribute was the decreased trip time (11%) which could be related to the convenience of



**Fig. 7.** Travel behaviour change with Bicimad for general sample.  
Source: own elaboration.

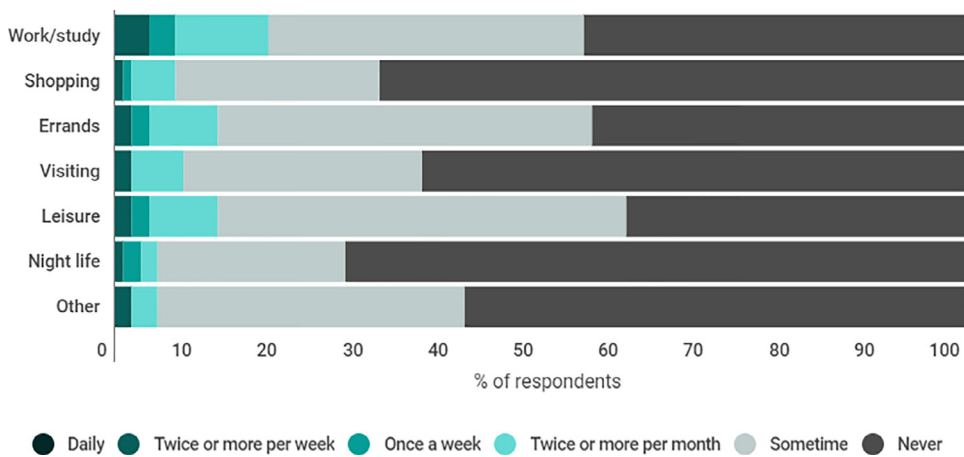


**Fig. 8.** Changes in travel behaviour after using Bicimad according to each user group.  
Source: own elaboration

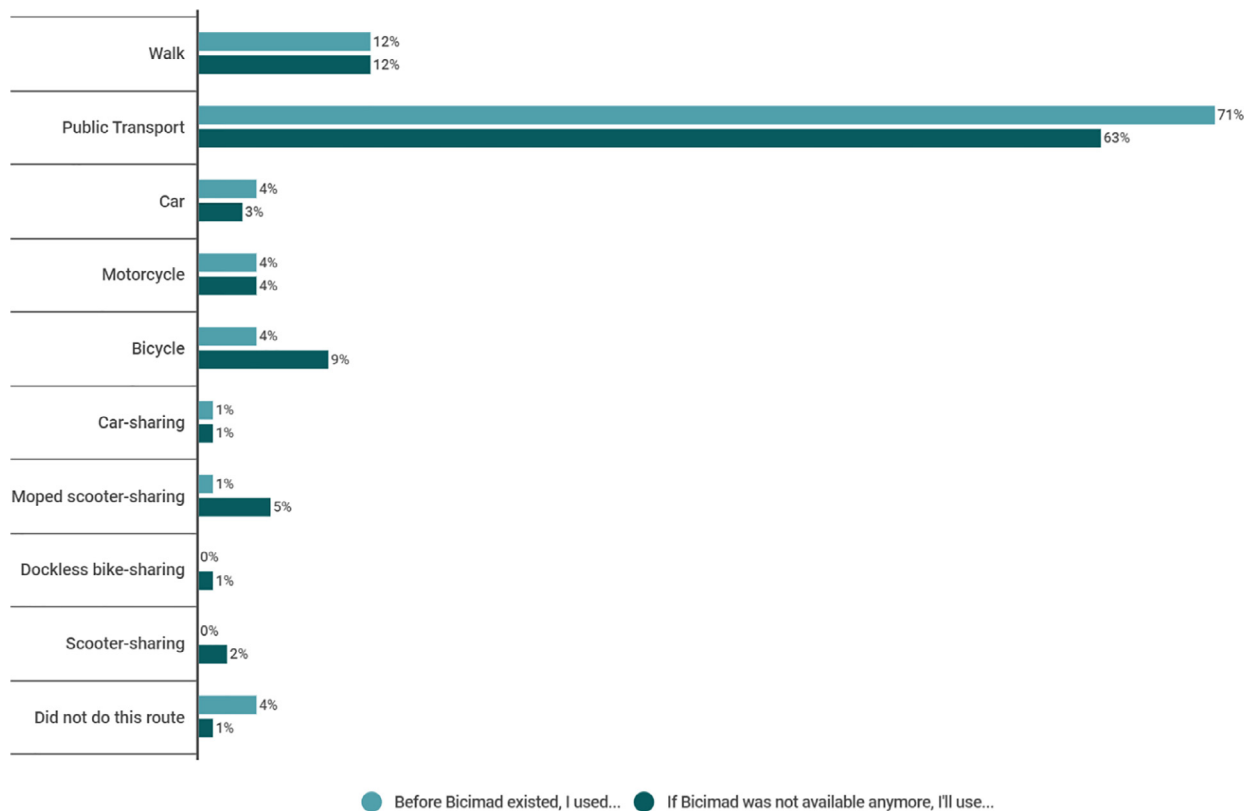


**Fig. 9.** Use frequency of dockless shared services.  
Source: own elaboration.





**Fig. 10.** Dockless service usage frequency according to different trip purposes. Source: own elaboration.



**Fig. 11.** Modal choice before Bicimad and modal choice if Bicimad stops being available for general sample. Source: own elaboration.

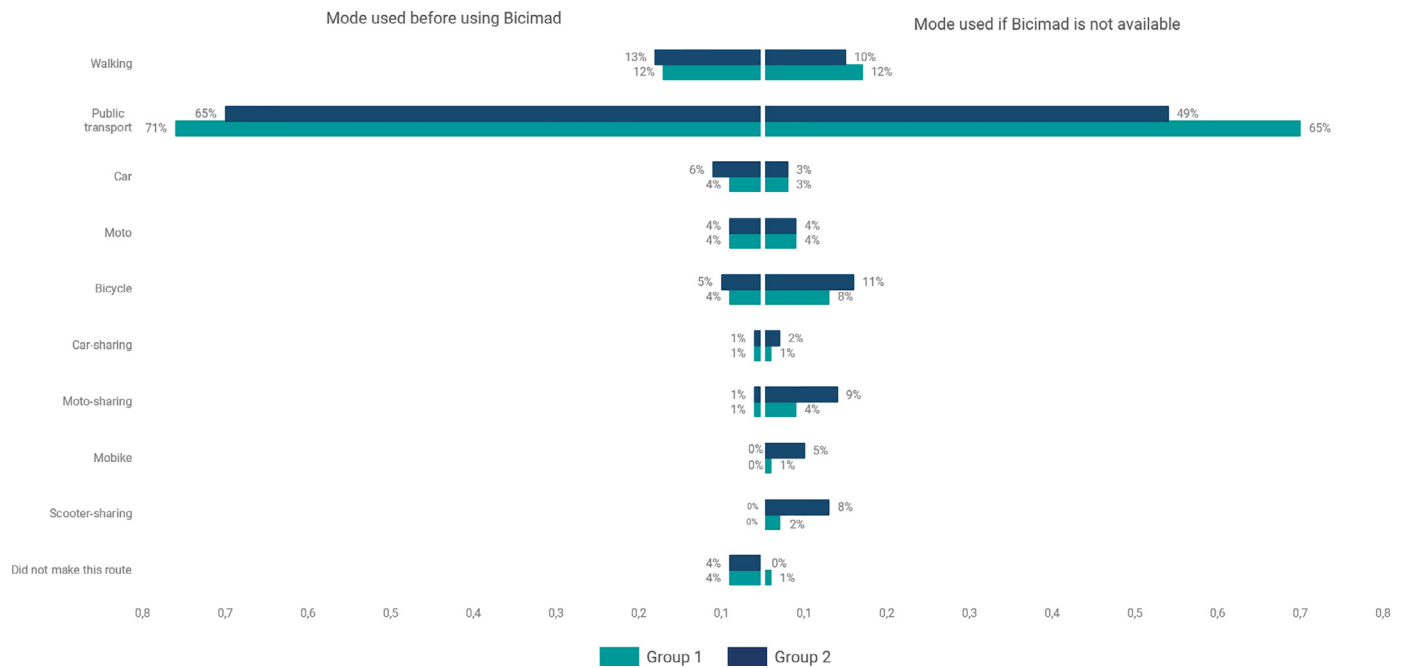
ending a trip at the actual destination rather than a nearby docking station, also reported by Younes et al. (2020). Interestingly, in the case of scooters, the second most attractive attribute was “it is fun” to ride one (comfort of ride), in tune with findings in socio-demographics about the predominance of younger people and study or work being one of the most common purposes to use them. On the other hand, service fares (price) were declared unattractive for both Mobike and scooter-sharing users, which could mean that they may be finding the service too expensive.

In regard to satisfaction levels, Group 1 (Bicimad-only users) show higher levels, but low ones with respect to cycling infrastructure quality as shown in Fig. 14. Results show that 88% of respondents are satisfied or extremely satisfied with Bicimad, while this figure drops down to 34% in the case of the cycling infrastructure. Most of the sample (50%) is unsatisfied or extremely unsatisfied with the infrastructure re-

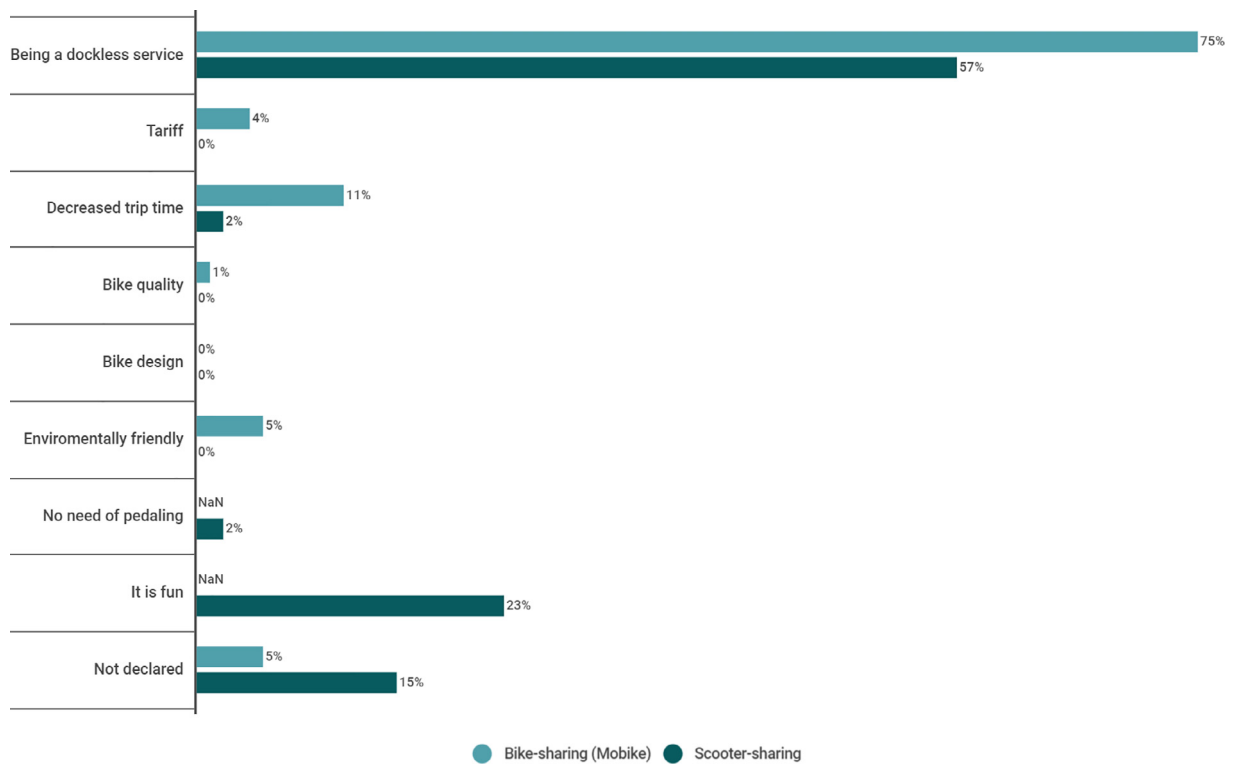
porting scarce or almost inexistent cycle tracks (segregated bike lanes) and poor safety conditions for cycling. In the case of dockless services (see Fig. 15), Mobike stands out as a slightly better service with 40% of respondents reporting to be satisfied or extremely satisfied, whereas this same figure drops to 34% in the case of scooter-sharing services. The “indifferent” category is higher in the case of scooter-sharing with 33%, which could be related to younger generations being predominant in this group.

#### 4.2.3. Spatial analysis

At last, this section analyses the home/work or study location of respondents based on 73% of the sample that completed the zip code information in the questionnaire ( $n = 3,851$  out of 5,218 responses). In general, we found that most users live and work/study inside the M-30 urban zone (71%) as summarised in Table 3, which was expected as the



**Fig. 12.** Modal choice before and after using Bicimad according to each group.  
Source: own elaboration.



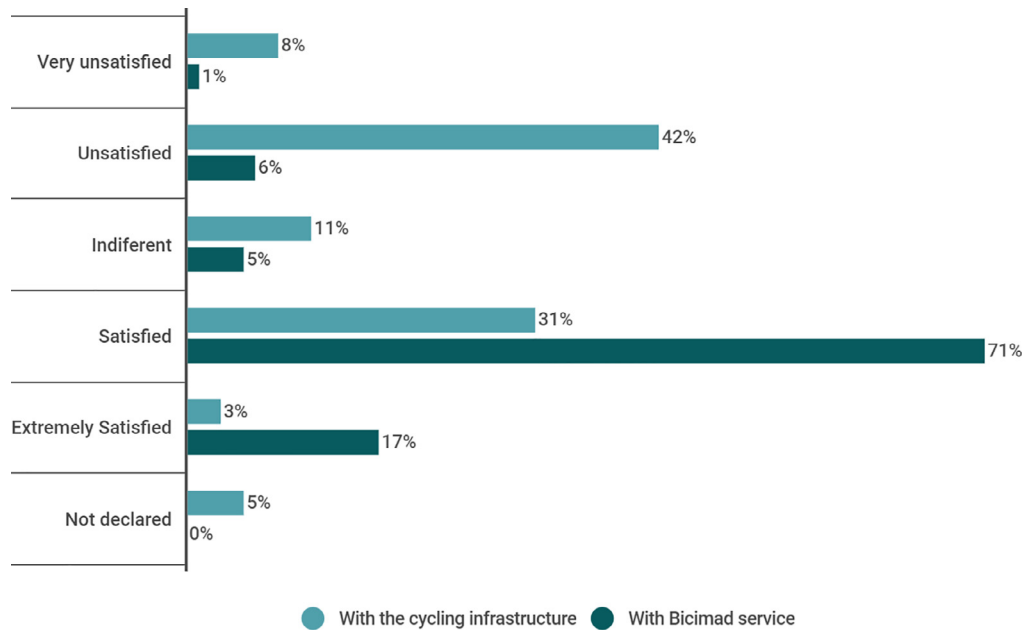
**Fig. 13.** Most attractive attributes from dockless shared services.  
Source: own elaboration.

survey is nested in Bicimad users, and the service is mostly available inside M-30 highway. This area also represents the space where most jobs, commercial zones and public facilities are concentrated offering a great supply of social, educational and cultural places, various entertainment events and public activities (Comunidad de Madrid, 2018).

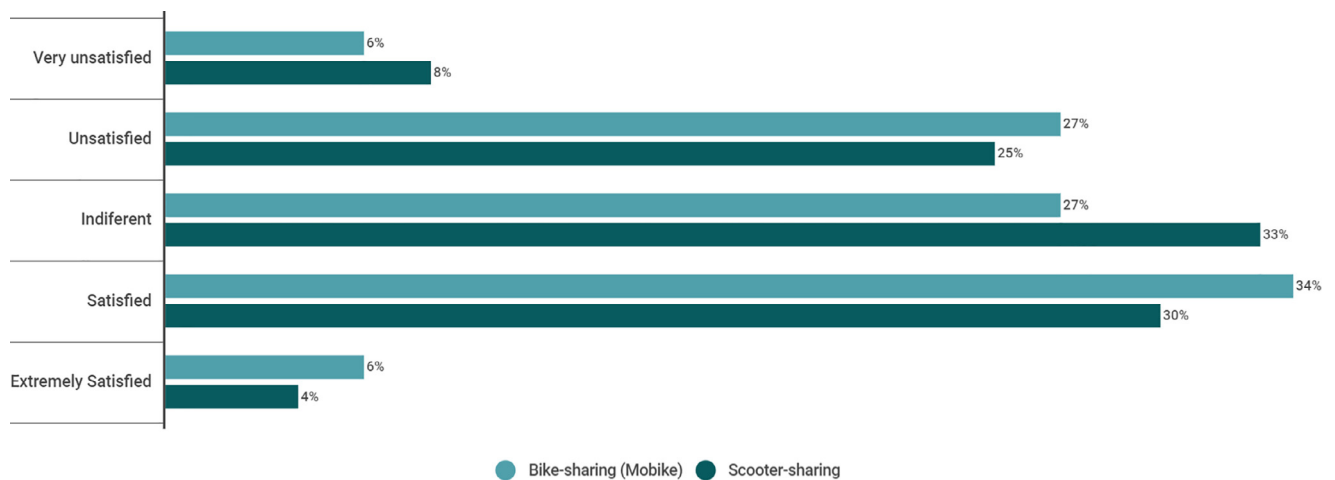
Moreover, other findings regarding proximity to dockless vehicles, show that 72% of Mobike users reported that it was easy to find a dock-

less bicycle within a 10 min walk from home, whereas in the case of scooters this percentage drops to 56% (spatial availability) (see Fig. 16). This is understandable with most respondents living inside M-30 urban zone, where most shared vehicles are deployed as stated by Arias-Molinares and García-Palomares (2020).

When analysing the zip locations of respondents' home and work/study places (see Appendix 1) it is noted that they mostly live



**Fig. 14.** Satisfaction levels with Bicimad.  
Source: own elaboration.



**Fig. 15.** Satisfaction levels with dockless shared services.  
Source: own elaboration.

**Table 3**  
Home and work location of respondents ( $n = 3.851$ ).

	Bicimad-only		Bicimad-other		Total	
	Users	%	Users	%	Users	%
Lives within M-30	2780	82,5	369	76,4	3149	81,8
Lives outside M-30	588	17,5	114	23,6	702	18,2
Subtotal	3368	100,0	483	100,0	3851	100,0
Works within M-30	2916	86,0	387	83,8	3303	85,8
Works outside M-30	473	14,0	75	16,2	548	14,2
Subtotal	3389	100,0	462	100,0	3851	100,0
Lives and works within M-30					2.745	71%
Lives and works outside M-30					144	4%
Lives within M-30 and works outside M-30					404	10%
Lives outside M-30 and works within M-30					558	14%

Source: own elaboration.

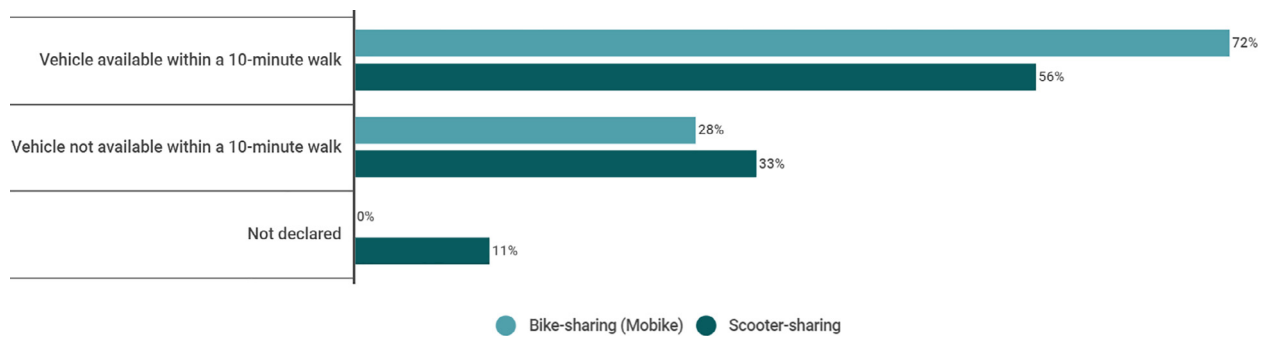


Fig. 16. Proximity to dockless shared vehicles in a 10-min walk from home.  
Source: own elaboration.

around the city centre while work/study areas are more spread to the north where most office buildings are located. Additionally in Appendix 3, the map shows the home locations for those respondents that, previously to ride in Bicimad, used their cars or motorcycles (motorised modes) and those that are willing to use their cars or motorcycles if Bicimad stopped being available. These areas are mostly the high-income districts (Salamanca and Chamberí). These findings could be important to target or focus policies and infrastructure that could help change travel behaviour in these zones (education campaigns, Bicimad discounts, more shared mobility offer, infrastructure, etc.).

When analysing dockless users exclusively (Group 2), Fig. 17 shows that as the distance from the city centre increases, the proportion of dockless service users is higher. This may be due to the fact that most shared mobility services are concentrated inside M-30 highway, including Bicimad, increasing the transport supply. In the peripheries though, with less options and Bicimad not available, users are more captive of dockless services. These results, may suggest that docked and dockless systems in Madrid are, rather than competing, complementing each other, as the case of San Francisco described by Lazarus et al. (2020). Hence, we may infer from results, that dockless services are most attractive and needed in the peripheries. Micromobility regulations could promote dockless services to be deployed in suburban areas where there are no Bicimad stations and public transport routes are less frequent, making Mobike and scooters more convenient to cover the first/last mile of the trip.

## 5. Discussion and conclusions

Our study explores the opinions of Bicimad users in relation to other dockless services.

Our two sample groups (Group 1 and 2) are socio-demographically similar; however some slight differences are observed. When contrasting the normalised values and analysing chi-square results, we observe that different socio-demographic characteristics apply for those that use dockless services: they seem to be mostly young men, especially university students or high-income employees, with neutral/indifferent environmental consciousness. Group 2 of users reported “fun” as one of the most important attributes to subscribe to the dockless service. All these insights could better inform public policy designing targeted campaigns knowing that dockless services (especially scooters) attract younger generations compared with station-based bike-sharing services.

In its nascent stage, we found that only 11,92% of Bicimad users have also subscribed to other dockless services. However, this result along with the increased preference for dockless services if Bicimad stopped being available, suggests that the BSS is actually making users keener to try new options, which is similar to what other authors have found regarding users’ experience as a prompter for adopting different travel modes (Matyas & Kamargianni, 2018; Strömberg et al., 2018). Furthermore, it was found that even though Bicimad is mostly used by people

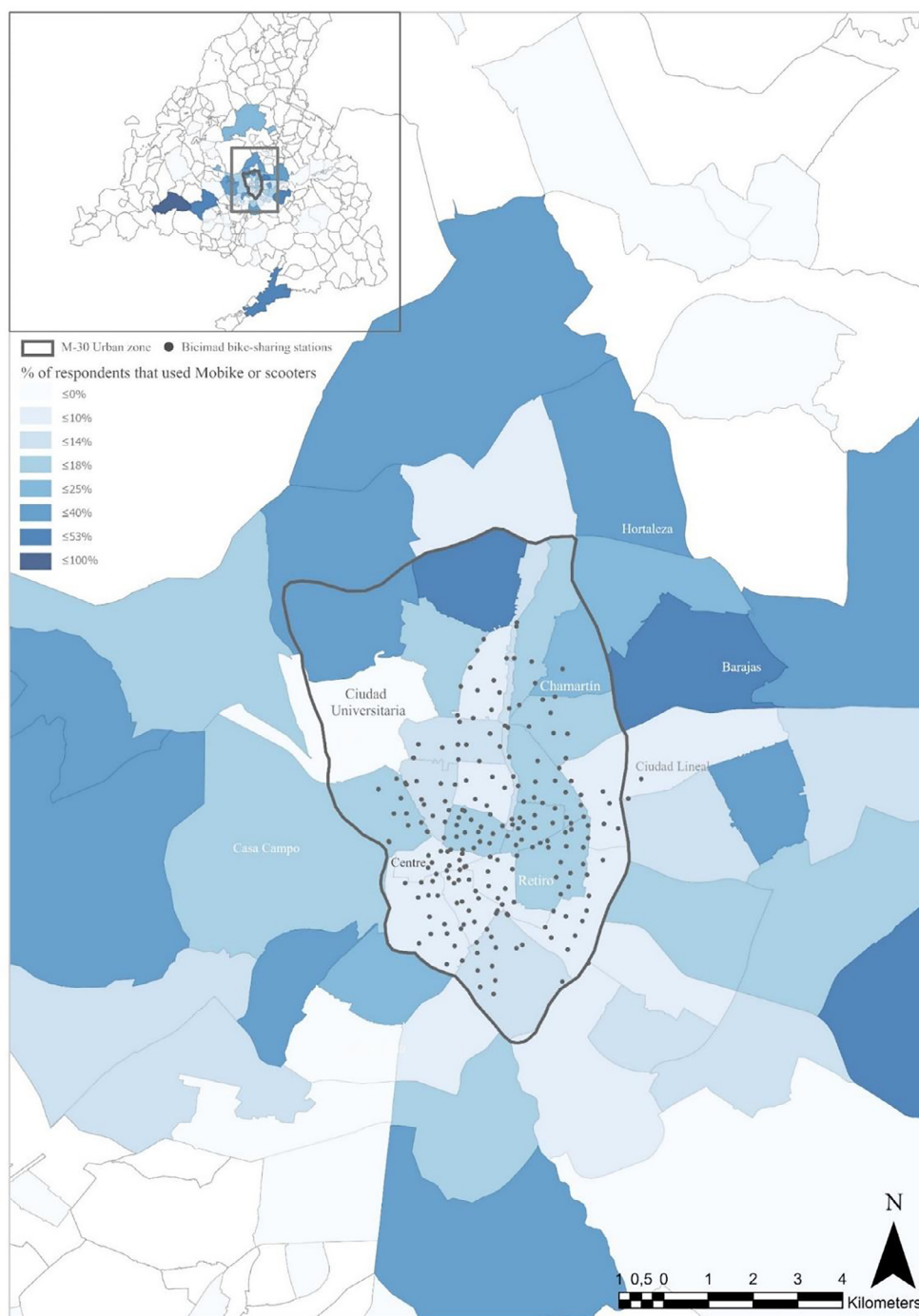
who previously travel on public transport or walking, which is not a desirable path, it could be also substituting 8% of previously motorised trips (cars and motorcycles).

Regarding satisfaction levels, we find that Bicimad stands as the better service, which also is related to a more familiar option due to its six years of operation in Madrid, compared to other dockless services that are more recent (2016 for Mobike and 2018 for scooters). However, the levels of satisfaction with cycling infrastructure were found low, which means that users are satisfied with the public bike-sharing system, but rather unsatisfied with cycling infrastructure. In terms of management, we could say that the public company EMT stands out as a good operator for the system. Secondly, this largest quality gap shows that more cycling infrastructure is needed, and thus transport planners and authorities should plan to extent segregated bike lanes, to create bicycle parking and other infrastructure. In regard to dockless services satisfaction, we could conclude that proportions are very similar, with Mobike slightly standing as a better service.

When comparing trip purposes, we found some trends. In the case of station-based service, it seems like the predominant profile is an employee who uses it for work purposes as they may already be familiar with the stations near their home/work locations. Instead, in the case of dockless services, the profile points to a young student that uses the scooter/bicycle mostly for leisure activities or study purposes. Thus, Bicimad seems to respond to routine trips like work where users already have identified the stations to plug/unplug bicycles, whereas dockless services seem to be used mostly for recreation trips where not much trip pre-planning is needed.

Finally, spatial analyses showed important insights. On one hand, a proximity to dockless vehicles was predominant (72% Mobike and 56% scooter-sharing), however this could be influenced by the fact that most respondents live within M-30 urban zone (71%) where all micromobility options are concentrated. On the other hand, respondents’ homes were mostly located around southern Madrid inside M-30 highway, whereas work/study densities were more homogeneously distributed to the north of the city. These patterns follow the expected distribution of vehicles according to land uses, with work/study areas being mostly around the north-south axis of La Castellana and residential zones located in the north or south surroundings of M-30 highway.

We have also found that a higher proportion of subscribers to dockless shared services lived outside M-30 zone, which supports that docked and dockless systems in Madrid have a complementary relationship, especially in peripheral areas; users in outer areas with no Bicimad, are keener to use dockless services (they are more captive). These insights are of great importance to better inform public policy, as dockless vehicle supply could improve by offering more vehicles in the city’s peripheral areas where no Bicimad station is available yet. Based on the survey’s responses, 1% of Bicimad users were previously driving their cars, and in the case of Group 2, these percentage increases to 3%. Although these results are not conclusive yet, they point to the potential of these ser-



**Fig. 17.** Home locations for dockless users (Group 2).

Source: own elaboration.

vices to replace car trips, which is a line of research that should be better explored.

As main conclusions we have that our exploration serve to better understand the relationship between docked and dockless services in Madrid. We found that a considerable amount of Bicimad users is also subscribed to other services (12%) and identified some differences and similarities between both groups. In the context of new emerging concepts like Mobility as Service (MaaS), the relationship of different modes will have an important impact. If pre-existing bike-sharing programs contribute to promote the use of other dockless modes, this will be positive in future MaaS applications where all services are displayed and available in one single platform.

As main limitations of the study, we can highlight the fact that results cannot be generalised, as some groups of the population are unrepresented (women for example) as well as the population living outside M-30 highway. This is mostly due to Bicimad being offered inside M-30 highway ring, especially in 2019 when the survey was conducted (in 2020 a new expansion of the system has taken place). With future expansions of Bicimad to outer peripheral areas (outside M-30), it will be possible to capture a more representative picture of the city. Service expansions may reach areas that are now being poorly served with travel options and where users may be more captive of dockless services. Additionally, by analysing results based on a nested survey of Bicimad users conducted in 2019, we could have misrepresented the preferences of



those users that only use dockless services. Future studies could address this limitation by conducting a survey exclusively to dockless service users and by making a panel research that considers multiple years to see if preferences change over time. Other future studies may also be oriented to increase the sample size and conduct regression analysis to model responses and predict willingness to use certain modes in a future MaaS context. An evaluation of preferences based on services' fares (total travel cost) is also recommended, as this was found to be relevant in the survey (Appendix) (Appendices 1–3).

#### Declaration of Competing Interest

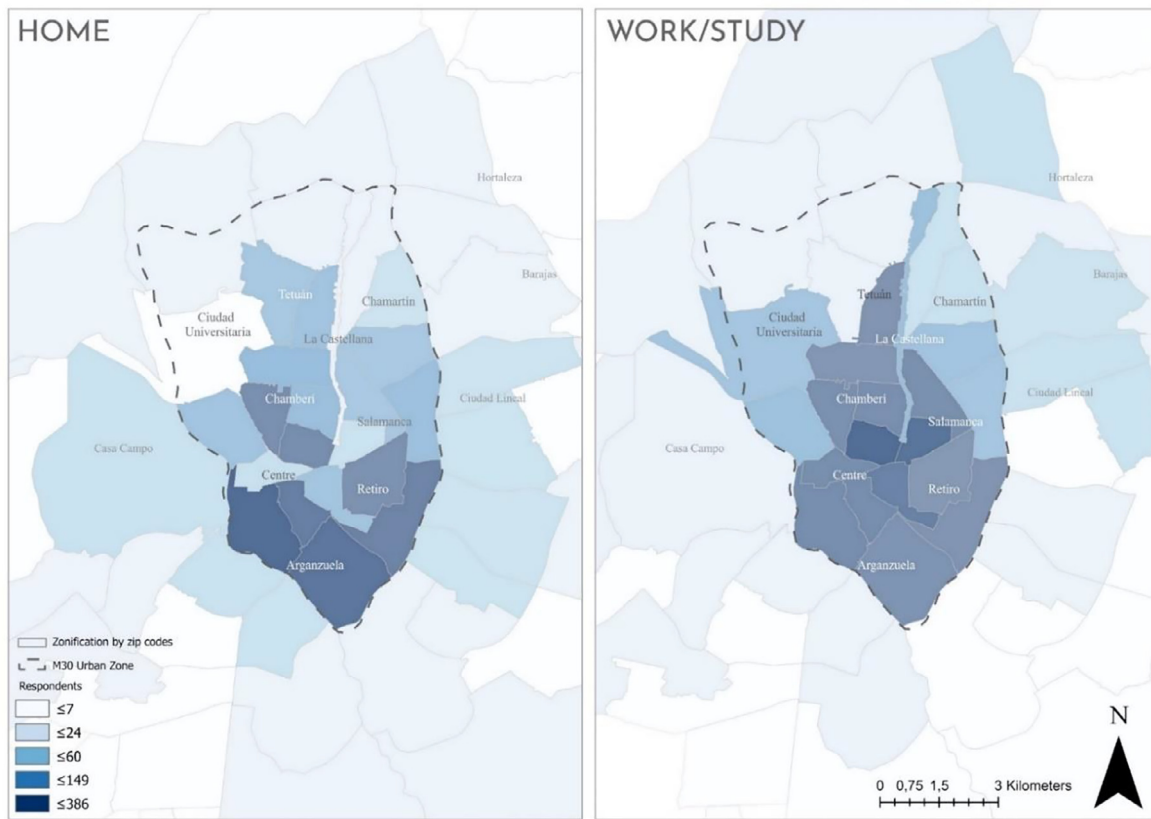
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

#### Acknowledgments

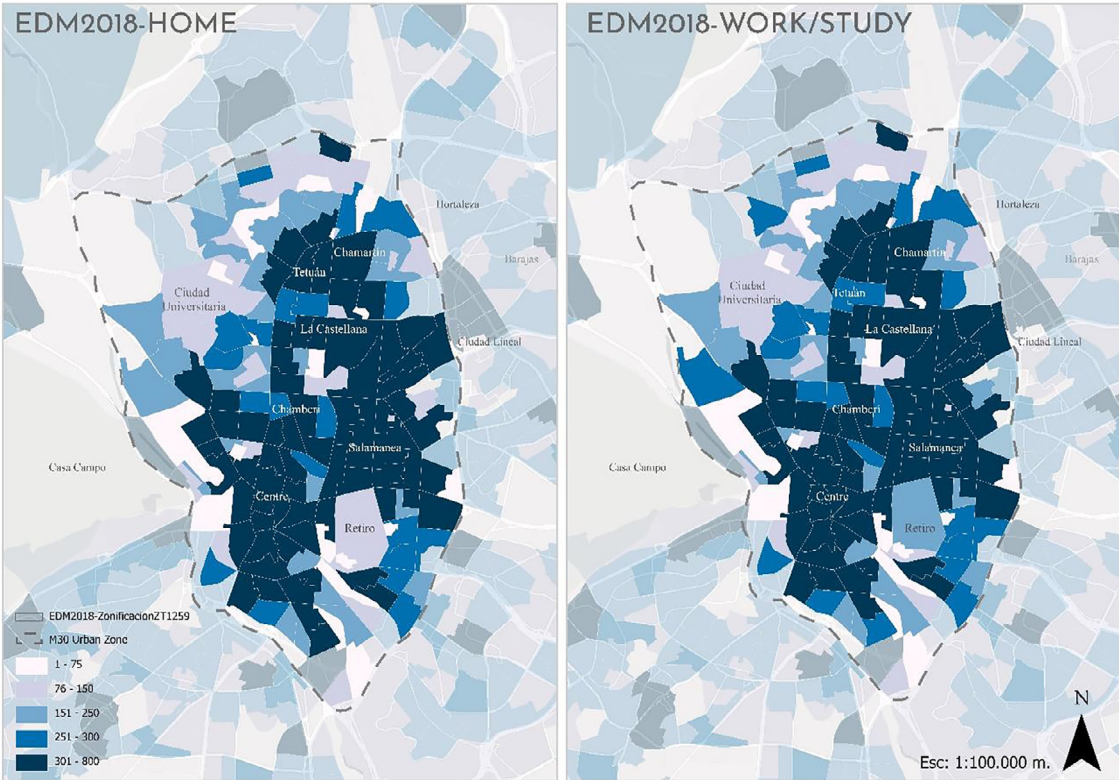
The authors gratefully acknowledge funding from Ministerio de Ciencia e Innovación (MCIN) through Agencia Estatal de Investigación (AEI) and cofunded by the European Regional Development Fund (FEDER, UE) through the Project "RTI2018-098402-B-I00" as well as funding from the same European Regional Development Fund and Comunidad de Madrid through the project (INNJOBMAD-CM, H2019/HUM-5761) and MCIN-AEI/10.13039/501100011033/(PID2020-116656RB-I00). Additionally, the study falls within the framework of the UCM-EMT collaboration project called "Cátedra Extraordinaria de Movilidad Ciclista" (Cycling Mobility Lectureship).

#### Appendixes. Appendix

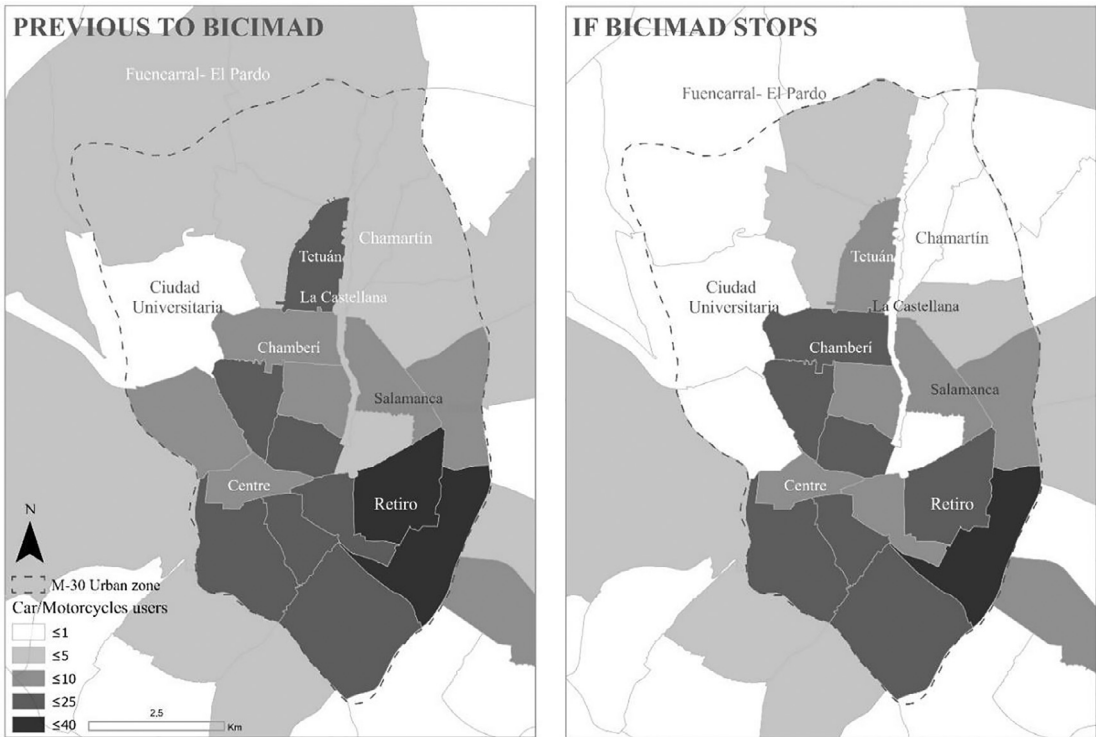
None.



**Appendix Fig. 1.** Home/work zip location density from BICIMAD Survey respondents.  
Source: own elaboration.



Appendix Fig. 2. Home/work zip location density from EDM2018 respondents.  
Source: own elaboration.



Appendix Fig. 3. Density of previous/future motorised drivers if Bicimad was not available.  
Source: own elaboration.

## References

- Aguilera-García, Á., Gomez, J., & Sobrino, N. (2020). Exploring the adoption of moped scooter-sharing systems in Spanish urban areas. *Cities (London, England)*, 96(July 2019), Article 102424. [10.1016/j.cities.2019.102424](https://doi.org/10.1016/j.cities.2019.102424).
- Arias-Molinares, D., & García-Palomares, J. C. (2020). Shared mobility development as key for prompting mobility as a service (MaaS) in urban areas: The case of Madrid. *Case Studies on Transport Policy*, 8(3), 846–859. [10.1016/j.cstp.2020.05.017](https://doi.org/10.1016/j.cstp.2020.05.017).
- Ayuntamiento de Madrid. (2019). *Portal de datos abiertos del ayuntamiento de madrid. Bici-mad*.
- Bernardo, E.D. (2019). City snapshot: Mobility-as-a-service in Madrid. Intelligent Transport. <https://www.intelligenttransport.com/transport-articles/92375/city-snapshot-mobility-as-a-service-in-madrid/>.
- Borgnat, P., Robardet, C., Abry, P., Flandrin, P., Rouquier, J., & Tremblay, N. (2013). A dynamical network view of Lyon's Vélo'v shared bicycle system. *Dynamics on and of complex networks: 2*. New York, NY: Birkhäuser. [10.1007/978-1-4614-6729-8](https://doi.org/10.1007/978-1-4614-6729-8).
- Comunidad de Madrid. (2018). Documento síntesis: Encuesta domiciliaria de movilidad de la Comunidad de Madrid 2018. <https://www.crtm.es/conocenos/planificacion-estudios-y-proyectos/encuesta-domiciliaria/edm2018.aspx>.
- Degele, J., Gorr, A., Haas, K., Kormann, D., Krauss, S., Lipinski, P., et al. (2018). Identifying E-scooter sharing customer segments using clustering. In *Proceedings of the IEEE international conference on engineering, technology and innovation (ICE/ITMC)*: 8. [10.1109/ICE.2018.8436288](https://doi.org/10.1109/ICE.2018.8436288).
- Fellessen, M., & Friman, M. (2012). Perceived satisfaction with public transport service in nine European cities. *Journal of the Transportation Research Forum*, (3), 47. [10.5399/osu/jtrf.47.3.2126](https://doi.org/10.5399/osu/jtrf.47.3.2126).
- Fishman, E. (2015). Bikeshare: A review of recent literature. *Transport Reviews*. [10.1080/01441647.2015.1033036](https://doi.org/10.1080/01441647.2015.1033036).
- Fulton, L. M. (2018). Three revolutions in urban passenger travel. *Joule*, 2(4), 575–578. [10.1016/j.joule.2018.03.005](https://doi.org/10.1016/j.joule.2018.03.005).
- García-Palomares, J. C., Gutiérrez, J., & Latorre, M. (2012). Optimizing the location of stations in bike-sharing programs: A GIS approach. *Applied Geography*, 35(1–2), 235–246. [10.1016/j.apgeog.2012.07.002](https://doi.org/10.1016/j.apgeog.2012.07.002).
- Goodman, A., & Cheshire, J. (2014). Inequalities in the London bicycle sharing system revisited: Impacts of extending the scheme to poorer areas but then doubling prices. *Journal of Transport Geography*, 41, 272–279. [10.1016/j.jtrangeo.2014.04.004](https://doi.org/10.1016/j.jtrangeo.2014.04.004).
- Granda, M., & Sobrino, R. (2019). Madrid, capital del vehículo compartido con 21.600 unidades. CincoDías. [https://cincodias.elpais.com/cincodias/2019/06/28/companias/1561742193\\_436512.html](https://cincodias.elpais.com/cincodias/2019/06/28/companias/1561742193_436512.html).
- Hardt, C., & Bogenberger, K. (2019). Usage of e-scooters in urban environments. *Transportation Research Procedia*, 37(September 2018), 155–162. [10.1016/j.trpro.2018.12.178](https://doi.org/10.1016/j.trpro.2018.12.178).
- Hendersen, W. (2019). Friday transportation seminar : From confrontation to partnership. City Regulation of Micromobility. Ride Report. <https://trec.pdx.edu/events/professional-development/friday-transportation-seminar-11152019>.
- Hensher, D. A., & Stanley, J. (2003). Performance-based quality contracts in bus service provision. *Transportation Research Part A: Policy and Practice*, 37(6), 519–538. [10.1016/S0965-8564\(03\)00006-5](https://doi.org/10.1016/S0965-8564(03)00006-5).
- Instituto Nacional de Estadística. (2018). *Padrón municipal de la comunidad de madrid*. INE <https://www.ine.es/jaxiT3/Datos.htm?t=2852>.
- Jiao, J., & Bai, S. (2020). Understanding the shared e-scooter travels in Austin, TX. *ISPRS International Journal of Geo-Information*, 9(2). [10.3390/ijgi9020135](https://doi.org/10.3390/ijgi9020135).
- Lazarus, J., Pourquier, J. C., Feng, F., Hammel, H., & Shaheen, S. (2020). Micromobility evolution and expansion: Understanding how docked and dockless bikesharing models complement and compete – A case study of San Francisco. *Journal of Transport Geography*, 84, Article 102620. [10.1016/j.jtrangeo.2019.102620](https://doi.org/10.1016/j.jtrangeo.2019.102620).
- LDA Consulting. (2012). 2011 Capital Bikeshare Member Survey Report (Issue (June), ).
- Ling. (2008). Tutorial : Pearson's chi-square test for independence. Ling. <https://www.ling.upenn.edu/~clight/chisquared.htm>.
- Matyas, M., & Kamargianni, M. (2018). The potential of mobility as a service bundles as a mobility management tool. In *Proceedings of the transportation research board 97th annual meeting* (pp. 1–18). [10.1007/s11116-018-9913-4](https://doi.org/10.1007/s11116-018-9913-4).
- McKenzie, G. (2019). Urban mobility in the sharing economy: A spatiotemporal comparison of shared mobility services. *Computers, Environment and Urban Systems*. [10.1016/j.compenvurbsys.2019.101418](https://doi.org/10.1016/j.compenvurbsys.2019.101418).
- Munkácsy, A. C. (2017). Potential user profiles of innovative bike-sharing systems: The case of BiciMAD (Madrid, Spain) [Universidad Politécnica de Madrid]. *Escuela de caminos. Canales y Puertos*. [10.11175/eastsats.4.621](https://doi.org/10.11175/eastsats.4.621).
- Paul, F., & Bogenberger, K. (2014). Evaluation-method for a station based urban-pedelec sharing system. *Transportation Research Procedia*, 4, 482–493. [10.1016/j.trpro.2014.11.037](https://doi.org/10.1016/j.trpro.2014.11.037).
- Paul, F., Bogenberger, K., & Fink, B. (2016). Evaluation of Munich's cycle route planner data analysis and customer survey. *Transportation Research Procedia*, 19(June), 225–240. [10.1016/j.trpro.2016.12.083](https://doi.org/10.1016/j.trpro.2016.12.083).
- Pucher, J., Dill, J., & Handy, S. (2010). Infrastructure, programs, and policies to increase bicycling: An international review. *Preventive Medicine*, 50. [10.1016/j.ypmed.2009.07.028](https://doi.org/10.1016/j.ypmed.2009.07.028).
- Reiss, S., & Bogenberger, K. (2015). GPS-data analysis of Munich's free-floating bike sharing system and application of an operator-based relocation strategy. In *Proceedings of the IEEE conference on intelligent transportation systems, ITSC*. [10.1109/ITSC.2015.102](https://doi.org/10.1109/ITSC.2015.102).
- Reiss, S., & Bogenberger, K. (2016). Validation of a relocation strategy for Munich's bike sharing system. *Transportation Research Procedia*, 19(June), 341–349. [10.1016/j.trpro.2016.12.093](https://doi.org/10.1016/j.trpro.2016.12.093).
- Reiss, S., & Bogenberger, K. (2017). A Relocation strategy for Munich's bike sharing system: Combining an operator-based and a user-based scheme. *Transportation Research Procedia*, 22, 105–114. [10.1016/j.trpro.2017.03.016](https://doi.org/10.1016/j.trpro.2017.03.016).
- Rojas-Rueda, D., De Nazelle, A., Tainio, M., & Nieuwenhuijsen, M. J. (2011). The health risks and benefits of cycling in urban environments compared with car use: Health impact assessment study. *BMJ*, 343(7819), 1–8 (Online). [10.1136/bmj.d4521](https://doi.org/10.1136/bmj.d4521).
- Romanillos, G. (2018). *The digital footprint of the cycling city: Gps cycle routes visualization and analysis*. Universidad Complutense de Madrid (UCM).
- Shaheen, S., & Cohen, A. (2019). Shared micromobility policy toolkit: Docked and dockless bike and scooter sharing. 10.7922/G2TH8JW7.
- Shaheen, S., Cohen, A., & Zohdy, I. (2016). Shared mobility: Current practices and guiding principles. FHWA-HOP-16-022.
- Strömberg, H., Karlsson, M., & Sochor, J. (2018). Inviting travelers to the smorgasbord of sustainable urban transport: Evidence from a MaaS field trial. *Transportation*, 45(6), 1655–1670. [10.1007/s11116-018-9946-8](https://doi.org/10.1007/s11116-018-9946-8).
- Tirachini Hernández, A. (2018). MaaS y tecnologías disruptivas de movilidad (Issue (November)). 10.13140/RG.2.2.27541.17126.
- Tirachini, A. (2019). Ride-hailing, travel behaviour and sustainable mobility : An international review. *Transportation*. [10.1007/s11116-019-10070-2](https://doi.org/10.1007/s11116-019-10070-2).
- Velázquez Romera, G. (2019). *Behavioral factors underlying the adoption of smart mobility solutions*. Universidad Politécnica de Madrid.
- Wang, K., Akar, G., & Chen, Y. J. (2018). Bike sharing differences among Millennials, Gen Xers, and Baby Boomers: Lessons learnt from New York City's bike share. *Transportation Research Part A: Policy and Practice*, 116(April), 1–14. [10.1016/j.tra.2018.06.001](https://doi.org/10.1016/j.tra.2018.06.001).
- Younes, H., Zou, Z., Wu, J., & Baiocchi, G. (2020). Comparing the temporal determinants of dockless scooter-share and station-based bike-share in Washington, D.C. *Transportation Research Part A: Policy and Practice*, 134(August 2019), 308–320. [10.1016/j.tra.2020.02.021](https://doi.org/10.1016/j.tra.2020.02.021).
- Zaltz Austwick, M., O'Brien, O., Strano, E., & Viana, M. (2013). The structure of spatial networks and communities in bicycle sharing systems. *PLoS One*, 8(9). [10.1371/journal.pone.0074685](https://doi.org/10.1371/journal.pone.0074685).
- Zhu, R., Zhang, X., Kondor, D., Santi, P., & Ratti, C. (2020). Understanding spatio-temporal heterogeneity of bike-sharing and scooter-sharing mobility. *Computers, Environment and Urban Systems*, 81(March), Article 101483. [10.1016/j.compenvurbsys.2020.101483](https://doi.org/10.1016/j.compenvurbsys.2020.101483).