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Sociopsychological factors associated with the adoption and usage of electric micromobility. A literature review

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ABSTRACT

This paper aims to identify the main sociopsychological factors that individuals perceive as affecting their intention to adopt electric (e−)micromobility. Drawing from modal choice theory, the factors are classified into functional (money, time, and other convenience values) and non-functional (emotional, social, and epistemic values). Following a PRISMA systematic literature review of 67 papers, we observed the reported influence of several functional and non-functional factors over the decision on whether to use an e-micromobility mode of transport. Results indicate that non-functional factors such as environmental concern, innovativeness, and belonging can be even more influential for individuals than traditional functional factors such as speed, cost, and time savings. Users seem to perceive these services as socially beneficial, contributing to improved livability, equity of access, and diversity of choice. The present review contributes to our understanding of the complexity of modal choice, and the importance of accounting for the sociopsychological factors influencing user decisions regarding micromobility. Our findings can help improve the strategies and policies supporting e-micromobility adoption.

1. Introduction

Electric micromobility modes of transport (e-MM) are increasing their market share in cities around the world. The rise in the number of electric scooters, bicycles, and mopeds has been fuelled by the promise of solving some of the most prescient current urban problems such as congestion, air quality, and energy consumption (Moreau et al., 2020; Hollingsworth et al., 2019a; Nematchoua et al., 2020). Cities are promoting these new modes because they offer positive outcomes for the environment and society (Shaheen and Cohen, 2019). However, the exact nature of these benefits is still unclear, especially regarding their actual impact on social equity and justice (McQueen et al., 2021).

The term e-micromobility is a broad concept that has drawn multiple definitions. Consensus definitions seem to gather smaller-scale, lightweight vehicles, electrically powered, operating at speeds up to 25 km/h, that are mainly used for trips up to 10 km (Milakis et al., 2020; Institute for Transportation and Development, 2021). E-MM vehicles can be privately-owned or used through a shared service. Therefore, we find several vehicles that meet the presented definition, mainly e-bicycles (e-cargo bicycles, e-trikes) and e-scooters, but also one-wheeled or two-wheeled alternatives such as hoverboards or segways. Controversy exists on whether to include vehicles that can circulate at speeds over 25 km/h, therefore considering e-mopeds and small e-motorcycles as e-MM. In this line, the definition provided by the International Transport Forum (ITF) is more inclusive and defines e-micromobility as: “vehicles with a mass of no more than 350 kg (771 lb) and a design speed no higher than 45 km/h” (International Transport Forum, 2020). For this literature review, we define e-MM as lightweight vehicles (weighting less than 35 kg), which are electrically powered and with a maximum speed of 25 km/h, including then e-bikes and e-scooters. We are therefore excluding larger and more powerful vehicles, such as e-speed bikes, e-mopeds, and e-motorcycles. Also, this selected definition let us include other modes such as segways and hoverboards. However, these modes are usually let out of e-MM research as they are not present in many cities, so their usage is minor and limited to some regions and specific contexts (Fang, 2022; Fang et al., 2019).

To date, the e-MM literature has focused on testing some of the claims and potentials of these new forms of mobility. As such, several studies have examined the potential positive and negative impacts resulting from the deployment of a fleet of e-MM (Bieliński et al., 2020;

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Fearnley et al., 2020; Oeschger et al., 2020; Zagorskas and Burinskiene, 2020; De Geus and Hendriksen, 2015a; Teixeira et al., 2021; Chapman and Larsson, 2021; Johnson and Rose, 2013; Van Cauwenberg et al., 2019). Other studies focused on technical and operational aspects (Shaheen and Cohen, 2019; Ji et al., 2014; Gojanovic et al., 2011a; Moran et al., 2020; Shaheen et al., 2019); health benefits and physical activity (Bourne et al., 2018; Castro et al., 2019; Sperlich et al., 2012; Glenn et al., 2020; Alessio et al., 2021; Bernstein and McNally, 2017; Bini and Bini, 2020; De Geus and Hendriksen, 2015b; Gojanovic et al., 2011b; Hoj et al., 2018; Langford et al., 2017; Peterman et al., 2016); safety, injuries, and security concerns (Verstappen et al., 2021; Panwinkler and Holz-Rau, 2021; Brownson et al., 2019; Faraji et al., 2020; Kim et al., 2021; Kobayashi et al., 2019; Lavoie-Gagne et al., 2021; McGuinness et al., 2021; Moftakhar et al., 2021; Pétursdóttir et al., 2021; Trivedi et al., 2019; Watson et al., 2020; Qian et al., 2020; Traynor et al., 2021; Stoermann et al., 2020; Smit et al., 2021; Siebert et al., 2021; Savitsky et al., 2021; Wang et al., 2018; Oksanen et al., 2020; Beck et al., 2020; Bekhit et al., 2020; Blomberg et al., 2019; Bloom et al., 2021). There is also a body of research dedicated to economic aspects of e-MM such as rising fuel and congestion costs, wasted time, and resources (Pavlenko, Slowik, Lutsey; Compostella et al., 2020; Laurischkat and Jandt, 2018; Adler et al., 2019; Suchanek et al., 2018; Pietrzak and Pietrzak, 2021; Button et al., 2020; Kazmaier et al., 2020) and on environmental impacts such as contributing to climate change, air quality, and congestion (Moreau et al., 2020; Hollingsworth et al., 2019a; Nematchoua et al., 2020; Sousa-Zomer and Miguel, 2016; Hulkkonen et al., 2020; Weiss et al., 2020; Hsieh et al., 2018). Additionally, there is an emerging number of literature devoted to the social dimension of these new modes of transport, i.e., literature focused on the factors behind e-MM adoption, understanding why some individuals choose to start using these innovative alternatives, and why others are reluctant to do so, including studies on intentions and deterrents (Fearnley et al., 2020; Oeschger et al., 2020; Berge, 2019; Fyhri et al., 2017; McQueen et al., 2020; Almannaa et al., 2021; Dias et al., 2021; Cao et al., 2021; Edge et al., 2018; Glavić et al., 2021; Jones et al., 2016; Andersson et al., 2021; Zagorskas and Burinskiene, 2020; De Geus and Hendriksen, 2015a; Teixeira et al., 2021; Chapman and Larsson, 2021; Van Cauwenberg et al., 2019; Alessio et al., 2021; Bielinski and Wazna, 2020; Johnson and Rose, 2015); user characteristics and patterns (Rérat, 2021; Campbell et al., 2016; Chavis and Martinez, 2021; Kaplan et al., 2018; Yin et al., 2021; Christoforou et al., 2021; Campisi et al., 2021); modal shift (McQueen et al., 2021; Zagorskas and Burinskiene, 2020; Smith and Schwieterman, 2018; Jones et al., 2016; Fyhri and Fearnley, 2015; Wang et al., 2021; Fitch et al., 2021; Bourne et al., 2020; Dill and Rose, 2012; Jahre et al., 2019; Gössling, 2020a); the built and natural environment (Bieliński et al., 2020; Chavis and Martinez, 2021; Ding et al., 2019; Hawa et al., 2021; Hosseinzadeh et al., 2021); accessibility and connectivity (Milakis et al., 2020; Jones et al., 2016; Shaheen and Chan, 2016; Chen et al., 2021; Mooney et al., 2019); and socio-demographics (McQueen et al., 2021; Fearnley et al., 2020; Fitch et al., 2020; Winslott Hiselius and Svensson, 2017; Zagorskas and Burinskiene, 2020; Almannaa et al., 2021; Glavić et al., 2021; Rérat, 2021; Campbell et al., 2016; Kaplan et al., 2018; Yin et al., 2021; Christoforou et al., 2021). Nonetheless, a research gap exists on what specifically relates to the sociopsychological determinants of the adoption and usage of e-MM, with the existing contributions being limited and fragmented. Therefore, there is a need to review the existent available evidence to map all sociopsychological factors that have been found to influence e-MM adoption and usage.

Thus, the present paper aims at providing some clarity on how the main social and psychological factors influence the adoption and usage of e-MM. By reviewing the literature that has attempted to understand the social and psychological determinants of e-MM adoption we can advance on our understanding of these new micromobility modes and their contribution to urban transportation schemes.

2. Theoretical framework

Early transportation literature tried to explain modal choice by using tangible factors such as travel cost and time, as well as the demographic characteristics of the traveler, such as age, gender, income, or household size (Lisco, 1968; Oort, 1969; Quarmby, 1967; Williams, 1978). More recently, new theoretical models and empirical studies have incorporated a more holistic and multi-factorial approach (Klöckner and Matthies, 2004; Verplanken et al., 2008; van Acker et al., 2010; De Witte et al., 2013; Soria-Lara et al., 2017). Among these new modal choice factors, sociopsychological factors such as habits and social status were found to play a key role in comprehending travel-related choices of individuals (van Acker et al., 2010; De Witte et al., 2013; Soria-Lara et al., 2017).

Social and psychological factors can influence people's behavior when taking decisions and making preferences, and they have been found to be good predictors of actions such as the purchasing or adopting intention of consumers in transport research (Levin et al., 1977; Galdames et al., 2011; Hunecke et al., 2010). Psychosocial factors are often classified into functional and non-functional values (Sheth et al., 1991; Forsythe et al., 2006; Han et al., 2017). This classification originates from analytical literature (Holbrook and Hirschman, 1982; Woodruff, 1997; Leroi-Werelds et al., 2014) exploring factors that affect consumers' purchasing behavior, and how different authors (Gwinner et al., 1998; Roy, 1994; Babin et al., 1994; Schuitema et al., 2013; Whitelock, 1989) identify values and factors that are key to understanding why individuals purchase or use products. Sheth et al.(Sheth, 1983) offered a first five-dimension (functional, social, emotional, epistemic, and conditional) categorisation of values, which a subsequent study resulting in the two-dimension (functional and non-functional) classification presented (Sheth et al., 1991). This classification was also adopted by Forsythe et al. (2006), and more recently by Han et al. when analysing the intention to adopt electric vehicles (Han et al., 2017). Thus, functional values are defined as the tangible attributes and utilitarian functions such as the variety, price, convenience, and quality of the product; while non-functional values are related to the intangible characteristics of the product regarding social and emotional needs (Han et al., 2017; Ko et al., 2019; Queiroz et al., 2020; Li et al., 2020). Following the trends set by the most recent and advanced mode choice modelling (Kroesen and Chorus, 2020; Nordfjærn and Rundmo, 2018; Simsekoglu and Klöckner, 2019a; Shirgaokar, 2019), micromobility studies have also started to incorporate sociopsychological factors in their attempt to achieve a more realistic and complete representation of micromobility decision-making.

Early studies seem to indicate that the adoption of e-MM might be strongly dependent on several sociopsychological factors that often affect decision-making simultaneously (Han et al., 2017). In this regard, functional values are related to the traditional needs perceived by consumers when deciding which transport mode to use, which regarding e-MM adoption and usage will mainly be price, operation cost, performance, driving range, comfortability, convenience and charging time, together with the specific attributes of the service or product. On the other hand, non-functional values will be related to associations that individuals build with regard to these modesand those values associated with certain social, emotional, and epistemic needs such as environmental attitude, innovative personality and social beliefs (Sheth et al., 1991). Functional values can be thought to be one of the main rational causes for consumers to consider adopting any new transportation service, considering time or cost savings resulting from its use. However, consumers can also be influenced by other non-functional values linked with experience, status, and perception.

3. Materials and methods

A systematic literature review method was adopted to synthesize the existing studies, thus providing insights into the factors affecting the adoption intention and usage of e-MM. This review follows the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) procedure that includes four steps: identification, screening, eligibility, and inclusion.

3.1. Search strategy and selection criteria

A systematic literature search was performed across three electronic databases: Web of Science (WoS), Scopus, and Transport Research International Documentation (TRID). Due to the novelty of the transport modes analyzed, the search was limited to the period from 2010 until the present time. The search was conducted between December 2021 and January 2022. Papers were required to have been written in the English language.

The primary searches were carried out using a combination of keywords that related to e-MM (vehicles) and the sociopsychological factors or determinants. Before conducting the searches, terms were identified to specifically search for publications including both functional and non-functional factors, and/or social factors, determinants, or motivations to adopt or use e-MM. Then, several terms and spelling variations were used to first relate the light vehicles included in the e-MM concept (e-bicycles, e-scooters, and e-micromobility in general) with the socio-psychological attributes. All searches were constructed similarly, containing the e-MM vehicles AND the sociopsychological keywords (as shown in Table 1). It is important to clarify that vehicles included in this analysis follow the definition of having a speed up to 25 km/h, it is for that reason that e-speed bikes, e-mopeds and e-motorcycles are not considered for this particular review. Moreover, hoverboards and Segway-type are also excluded. Hoverboards are particularly popular with children and teenagers and mostly are used for fun. Segway-related studies are almost inexistent, and they are not even allowed in several cities. Therefore, the modes included in this review are mainly e-bikes and e-scooters.

All types of study designs were included: scoping reviews, systematic reviews, meta-analysis, ecological, longitudinal, cross-sectional, case-control, intervention, and experimental study designs. Searches in all three databases resulted in a total of 10032 hits, as shown in Table 2.

During the process of selection of the papers, we followed the four phases of the PRISMA statement: identification, screening, eligibility, and inclusion (see Fig. 1). In this case, the inclusion criteria were:

- Papers providing insights into electric micromobility and including micromobility or light means of transport (i.e., scooters, bicycles, or mopeds).
- Papers reporting objective measurements of social factors, the roles of users, and/or user decision-making for electric micromobility
- Papers providing quantitative results from surveys
- Papers providing qualitative results from interviews

Out of the total 10032 papers, 6271 resulted once the duplicated were eliminated. After the title screening of these resulting non-duplicated publications, 974 qualified for abstract screening. Based on the abstract screening, 246 remained as for the full-text screening. After full-text screening, 63 articles qualified for review inclusion. Reference screening added another 4 articles. Finally, 67 articles were included in this review, as detailed in Table 3 and Fig. 1.

Table 1
Example of selected keywords for the primary literature search.

E-micromobility (vehicles)		Sociopsychological factors (Example: General factors)
(“electric bike”) OR (“e-bike”) OR (“ebike”) OR (“electric bicycle”) OR (“e-cycling”) OR (“pedelec”) OR (“pedelec bike”) OR (“pedelec mobility”)) OR ((“electric scooter”) OR (“e-scooter")) OR ((“electric micromobility”) OR (“e-micromobility”) OR (“electric two-wheelers")	*AND*	(“psychological factors”) OR (“motivations”) OR (“perceived benefits”) OR (“perceived barriers”) OR (“social factors")

Table 2
Search strategy database results.

Database	Focus	Publication date	Hits
Web of Science (WoS)	Multidisciplinary	2010–2022	968
Scopus	Multidisciplinary	2010–2022	8497
Transport Research International Documentation (TRID)	Transportation science	2010–2022	567
Total hits			**10032**

The majority of papers were excluded based on their titles as some of them followed a completely different approach (environmental, economic, industrial) and were not related to the social dimension of e-MM adoption or usage. Others clearly presented an analysis of other types of factors such as spatial, temporal, or data privacy. Of the resulting 246 papers for abstract screening, some articles were excluded for not being written in English. Also, a big part of the articles was excluded because they were not referring to e-micromobility vehicles, but to other kinds of electric vehicles such as cars or motorcycles, and some others did not specify if the micromobility mode studied was electrically powered or not. The rest of the excluded articles analyzed other factors or topics of no interest for this review (built environment, trip purpose, spatial coverage, modal shift, etc.).

3.2. Data extraction

In the analysis of the sociopsychological factors affecting the adoption intention and usage of e-MM, the factors identified were those that could either be perceived as functional or non-functional, from a private or individual point of view. Private or individual means that the beneficiary of the factor is the user of the service.

The selection of the factors was based on the factors that were objectively measured in the analyzed studies. Only the factors that were clearly described in the results of more than one publication were selected. Most of the included studies used surveys or interviews, and some complemented the research with statistics to show the results. This process resulted in a total of 17 factors: 10 within the functional category and 7 within the non-functional category.

4. Results

4.1. Study characteristics

After reviewing the 67 papers that met the selection criteria, a series of key characteristics were extracted. As shown in Table 3, the studies presented differences in terms of geography, target population, and methodology. Regarding the time of publication, most papers were published between 2018 and today. This is directly related to the recent surge of e-MM around the world and the growing interest in their impacts on society. In fact, 24 articles were published in 2021 (Teixeira et al., 2021; Glavić et al., 2021; Edel et al., 2021; Esztergár-Kiss and Lopez Lizarraga, 2021; Flores and Jansson, 1957; Huang, 2021; Kazemzadeh and Koglin, 2021; Kopplin et al., 2021; Kwiatkowski et al., 2021; Lee et al., 2021a; Melia and Bartle, 2021; Mitra and Hess, 2021; Andersson et al., 2021; Patil and Majumdar, 2021; Rejali et al., 2021; Thomas, 2021; Will et al., 2021; Abouelela et al., 2021; Bateman et al., 2021; Biegańska et al., 2021; Bielinski et al., 2021; Buehler et al., 2021; De Ceunynck et al., 2021; Eccarius et al., 2021), showing the attention academia is paying to these new modes.

In terms of geographical distribution, the majority of studies (35 articles) were from Europe (Nematchoua et al., 2020; Teixeira et al.,

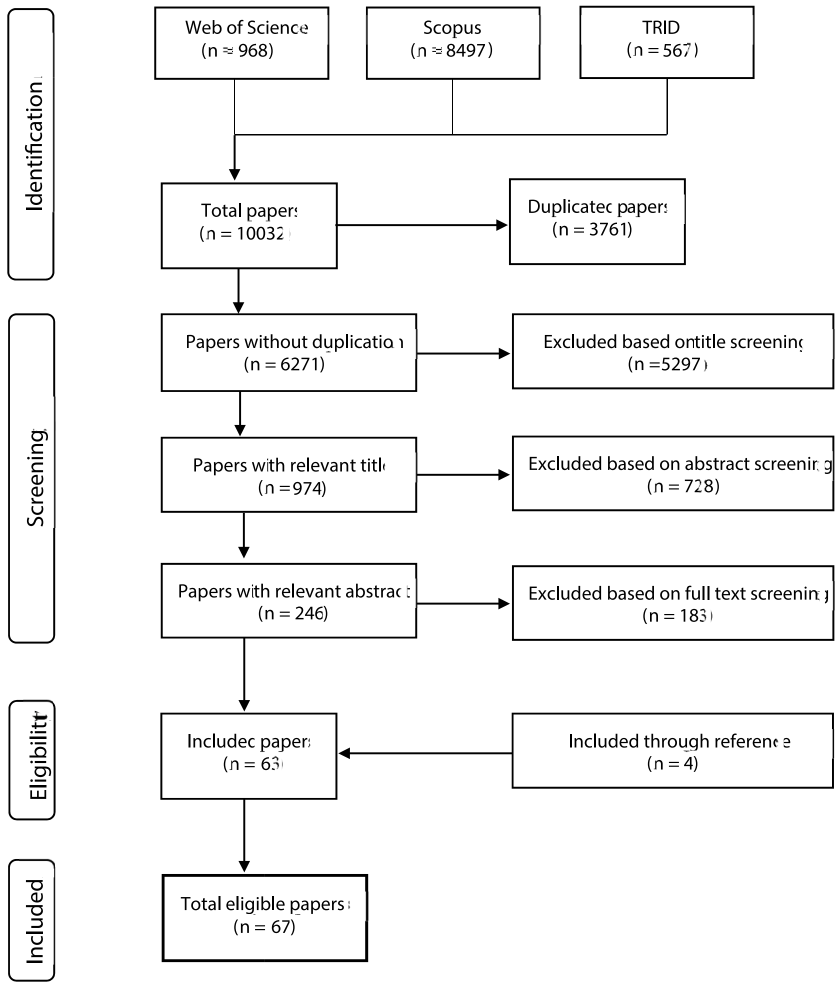

Fig. 1. PRISMA flow diagram.

2021; Biegańska et al., 2021; De Ceunynck et al., 2021; Edel et al., 2021; Esztergár-Kiss and Lopez Lizarraga, 2021; Flores and Jansson, 1957; Kazemzadeh and Koglin, 2021; Kopplin et al., 2021; Kwiatkowski et al., 2021; Melia and Bartle, 2021; Will et al., 2021; Van Cauwenberg et al., 2019; bureau de recherche 6t, 2019; Andersson AAdell et al., 2021; Arsenio et al., 2018; Bieliński et al., 2021; Hardt et al., 2019; Haustein and Møller, 2016a; Hiselius and Svenssona, 2014; Hyvönen et al., 2016; Kaplan et al., 2015; Krauss et al., 2022; Bielinski and Wazna, 2020; Munkacsy and Monzon, 2017; Plazier et al., 2017; Sellaouti et al., 2020; Simsekoglu and Klöckner, 2019b; Behrendt, 2018; Fyhri et al., 2017; Glavić et al., 2021; Jones et al., 2016; Kaplan et al., 2018; Simsekoglu and Klöckner, 2019a; Abouelela et al., 2021), where Germany (6) (Abouelela et al., 2021; Edel et al., 2021; Kopplin et al., 2021; Hardt et al., 2019; Krauss et al., 2022; Sellaouti et al., 2020), Poland (5) (Bielinski and Wazna, 2020; Kaplan et al., 2018; Biegańska et al., 2021; Kwiatkowski et al., 2021; Bieliński et al., 2021), Norway (3) (Fyhri et al., 2017; Simsekoglu and Klöckner, 2019a, 2019b), Sweden (3) (Kazemzadeh and Koglin, 2021; Andersson AAdell et al., 2021; Hiselius and Svenssona, 2014) and the United Kingdom (3) (Jones et al., 2016; Melia and Bartle, 2021; Behrendt, 2018) present most of the contributions. The rest of studies were distributed as follow: 15 publications in America (Edge et al., 2018; Dill and Rose, 2012; Mayer, 2020; Pimentel and Lowry, 2020; Popovich et al., 2014a; Rayaprolu and Venigalla, 2020; Sanders et al., 2020; Bateman et al., 2021; Buehler et al., 2021; Mitra and Hess, 2021; Thomas, 2021; Gorenflo et al., 2017a; Leger et al., 2019; Ling et al., 2017; Macarthur, 2017), mostly in the United States (11) (Dill and Rose, 2012; Bateman et al., 2021; Sanders et al., 2020; Buehler et al., 2021; Thomas, 2021; Ling et al., 2017; Macarthur, 2017; Mayer, 2020; Pimentel and Lowry, 2020; Popovich et al., 2014a; Rayaprolu and Venigalla, 2020); 11 in Asia (Huang, 2021; Patil and Majumdar, 2021; Zuev, 2018; Rejali et al., 2021; Alamelu et al., 2015; An et al., 2013; Eccarius and Lu, 2018; Elias and Gitelman, 2018; Lee et al., 2021b; Lin et al., 2018; Ye et al., 2014), mainly from China (6) (Huang, 2021; An et al., 2013; Eccarius and Lu, 2018; Lin et al., 2018; Ye et al., 2014; Zuev, 2018); and 6 in Oceania (Johnson and Rose, 2013; Eccarius et al., 2021; Dowling et al., 2015; Fitt and Curl, 2019, 2020; Washington et al., 2018), being 4 setin Australia (Johnson and Rose, 2013; Eccarius et al., 2021; Dowling et al., 2015; Washington et al., 2018).

In terms of which transport mode they focused their analysis on, 41 studies focused on e-bikes (mainly in its private form) (Nematchoua et al., 2020), (Teixeira et al., 2021), (Simsekoglu and Klöckner, 2019a), (Bateman et al., 2021; Biegańska et al., 2021; Bielinski et al., 2021), (Eccarius et al., 2021), (Kazemzadeh and Koglin, 2021), (Kwiatkowski et al., 2021), (Melia and Bartle, 2021), (Thomas, 2021), (Arsenio et al., 2018), (Johnson and Rose, 2013), (Haustein and Møller, 2016a), (Hiselius and Svenssona, 2014), (Kaplan et al., 2015), (Plazier et al., 2017), (Simsekoglu and Klöckner, 2019b; Behrendt, 2018; Gorenflo et al., 2017a; Leger et al., 2019; Ling et al., 2017; Macarthur, 2017), (Van Cauwenberg et al., 2019), (Mayer, 2020), (Popovich et al., 2014a), (Alamelu et al., 2015), (An et al., 2013), (Elias and Gitelman, 2018; Lee et al., 2021b; Lin et al., 2018; Ye et al., 2014; Zuev, 2018), (Washington et al., 2018), (Fyhri et al., 2017), (Munkácsy and Monzón, 2017), (Edge et al., 2018), (Jones et al., 2016), (Andersson et al., 2021), (Kaplan et al., 2018), (Dill and Rose, 2012), 17 focused on the e-scooter (mainly in its shared form) (Glavić et al., 2021; Abouelela et al., 2021; Krauss et al., 2022; Sellaouti et al., 2020; Sanders et al., 2020; Eccarius and Lu, 2018;

Table 3
Summary of the reviewed studies.

Author(s)	Title	Year	Publication	Type	Vehicle	Modality	Geography	Method	Sample	Target population
6t-bureau de recherche	Uses and Users of Free-floating Electric Scooters in France	2019	–	Report	E-scooter	Shared	Paris, Lyon and Marseille (France)	Survey	4382	Users
Abouelela et al.	Are young users willing to shift from carsharing to scooter-sharing?	2021	Transportation Research Part D- Transport and Environment	Journal Article	E-scooter	Shared	Munich (Germany)	Survey	503	Young individuals from 18 to 34 years old
Alamelu et al.	Preference of E-bike by women in India -a niche market for auto manufacturers	2015	Business: Theory and Practice	Journal Article	E-bike	Private	Madurai City (India)	Survey	1100	Women
An et al.	Travel Characteristics of E-bike Users: Survey and Analysis in Shanghai	2013	Procedia - Social and Behavioral Sciences	Journal Article	E-bike	Private	Shanghai (China)	Survey	470	Users
Andersson et al.	What is the substitution effect of e-bikes? A randomised controlled trial	2021	Transportation Research Part D- Transport and Environment	Journal Article	E-bike	Private	Skövde (Sweden)	Survey	65	Company employees
Arsenio et al.	Assessing the market potential of electric bicycles and ICT for low carbon school travel: a case study in the Smart City of ÁGUEDA	2018	European Transport Research Review	Journal Article	E-bike	Private/ Shared	Águeda (Portugal)	Survey	248	Students (secondary school)
Bateman et al.	Barriers and facilitators to bikeshare programs: A qualitative study in an urban environment	2021	Journal of Transport & Health	Journal Article	E-bike	Shared	Birmingham, Alabama (US)	Focus Group	27	Users
Behrendt, F	Why cycling matters for electric mobility: towards diverse, active and sustainable e-mobilities	2018	Mobilities	Journal Article	E-bike	Private	Brighton and Hove (UK)	Interview, Focus Group, Survey	80	Trial commuters
Biegańska et al.	A typology of attitudes towards the e-bike against the background of the traditional bicycle and the car	2021	Energies	Journal Article	E-bike	Private/ Shared	Poland	Survey	456	Users and non-users
Bieliński et al.	Electric bike-sharing services mode substitution for driving, public transit, and cycling	2021	Transportation Research Part D: Transport and Environment	Journal Article	E-bike	Shared	Gdansk, Gdynia, and Sopot (Poland)	Survey	488	Users and non-users
Bieliński et al.	Electric scooter sharing and bike sharing user behaviour and characteristics	2020	Sustainability	Journal Article	E-bike/E-scooter	Shared	Gdansk, Gdynia, and Sopot (Poland)	Survey	633	Users and non-users
Buehler et al.	Changes in Travel Behavior, Attitudes, and Preferences among E-Scooter Riders and Nonriders: First Look at Results from Pre and Post E-Scooter System Launch Surveys at Virginia Tech	2021	Transportation Research Record	Journal Article	E-scooter	Shared	Virginia Tech Campus, Virginia (US)	Survey	129	Members university community
De Ceunynck et al.	Assessing the Willingness to Use Personal e-Transporters (PeTs): Results from a Cross-National Survey in Nine European Cities	2021	Sustainability	Journal Article	PeTs	Private/ Shared	Ghent and Liège (Belgium), Tilburg and Groningen (The Netherlands), Trondheim and Bergen (Norway) and Düsseldorf, Dortmund and Berlin (Germany)	Survey	2159	General population >18 years
Dill & Rose	Electric Bikes and Transportation Policy: Insights from Early Adopters	2012	Transportation Research Record: Journal of the Transportation Research Board	Journal Article	E-bike	Private	Portlant, Oregon (US)	Interview	28	E-bike owners
Dowling et al.	Use of personal mobility devices for first-and-last mile travel: the Macquarie-Ryde trial	2015		Conference Proceeding	E-scooter	Private	Macquarie University, New South Wales (Australia)	Survey	17	University employees
Eccarius et al.		2021			E-bike	Shared		Survey	368	

(*continued on next page*)

Table 3 (*continued*)

Author(s)	Title	Year	Publication	Type	Vehicle	Modality	Geography	Method	Sample	Target population
	Prospects for shared electric velomobility: Profiling potential adopters at a multi-campus university		Journal of Transport Geography	Journal Article			Multi-campus university in the South East Queensland (SEQ), (Australia)			Students and staff university
Eccarius & Lu	Exploring consumer reasoning in usage intention for electric scooter sharing	2018	Transportation Planning Journal	Journal Article	E-scooter	Shared	Taiwan (China)	Survey	98	Local students
Edel & Kern	Potential analysis of E-Scooters for commuting paths	2021	World Electric Vehicle Journal	Journal Article	E-scooter	Private	Hannover (Germany)	Survey	152	Users and not-users
Edge et al.	Exploring e-bikes as a mode of sustainable transport: A temporal qualitative study of the perspectives of a sample of novice riders in a Canadian city	2018	Canadian Geographer	Journal Article	E-bike	Private	Kitchener-Waterloo (Canada)	Focus Group	10	Staff and students at the University of Waterloo (novice users)
Elias & Gitelman	Youngsters' opinions and attitudes toward the use of electric bicycles in Israel	2018	Sustainability	Journal Article	E-bike	Private	Israel (central region)	Survey	326	Young riders (students from junior high-schools and high-schools)
Esztergár-Kiss et al.	Exploring user requirements and service features of e-micromobility in five European cities	2021	CASE STUDIES ON TRANSPORT POLICY	Journal Article	E-micromobility	Private/ Shared	Munich, Barcelona, Copenhagen, Tel Aviv, and Stockholm	Survey	790	General population >18 years
Fitt & Curl	The early days of shared micromobility: A social practices approach	2020	Journal of Transport Geography	Journal Article	E-scooter	Shared	New Zealand	Survey	491	General population >18 years
Fitt & Curl	E-scooter use in New Zealand: Insights around some frequently asked questions	2019	–	Report	E-scooter	Private/ Shared	New Zealand	Survey	563	Users and non-users
Flores & Jansson	The role of consumer innovativeness and green perceptions on green innovation use: The case of shared e-bikes and e-scooters	2021	Journal of Consumer Behaviour	Journal Article	E-bike/E-scooter	Shared	Copenhagen and Stockholm	Survey	1501	General population btw 16–65 years
Fyhri et al.	A push to cycling: exploring the e-bike's role in overcoming barriers to bicycle use with a survey and an intervention study	2017	International Journal of Sustainable Transportation	Journal Article	E-bike	Private	Oslo and the Akershus County (Norway)	Survey, Intervention Study	5460/ 240	Members of the Norwegian Automobile Federation (NAF)
Glavić et al.	The e-scooter potential to change urban mobility—Belgrade case study	2021	Sustainability	Journal Article	E-scooter	Private/ Shared	Belgrade (Serbia)	Survey	1143	Users
Gorenflo et al.	Usage Patterns of Electric Bicycles: An Analysis of the WeBike Project	2017	Journal of Advanced Transportation	Journal Article	E-bike	Private	University of Waterloo (Canada)	Survey	172/ 24/24	Staff/faculty members and graduate students
Hardt & Bogenberger	Usage of e-Scooters in Urban Environments	2019	21st Euro Working Group on Transportation Meeting (Ewgt 2018)	Conference Proceeding	E-scooter	Shared	Munich (Germany)	Survey	38	General population >18 years
Haustein & Møller	Age and attitude: Changes in cycling patterns of different e-bike user segments	2016	International Journal of Sustainable Transportation	Journal Article	E-bike	Private	Denmark	Survey	427	E-bike users
Hiselius & Svenssona	Could the increased use of e-bikes (pedelecs) in Sweden contribute to a more sustainable transport system?	2014	9th International Conference on Environmental Engineering, ICEE 2014	Conference Proceeding	E-bike	Private	Sweden	Survey	321	E-bike purchasers
Huang, F.-H.	User behavioral intentions toward a scooter-sharing service: an empirical study	2021	Sustainability	Journal Article	E-scooter	Shared	Campus of Asia Eastern University of Science and Technology in New Taipei City, Taiwan (China)	Survey	99	Individuals with no previous experience of a shared two-wheeler service, possession of a driver's license, and being over 20 years
Hyvönen et al.	Light electric vehicles: substitution and future uses	2016	Transforming Urban Mobility (Tum 2016)	Conference Proceeding	Light electric vehicles	Private/ Shared	Finland	Survey	1030	Individuals aged 15–79
		2013			E-bike	Private	Australia	Survey	529	E-bike owners

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Table 3 (*continued*)

Author(s)	Title	Year	Publication	Type	Vehicle	Modality	Geography	Method	Sample	Target population
Johnson & Rose	Electric bikes - cycling in the New World City: An investigation of Australian electric bicycle owners and the decision-making process for purchase		Australasian Transport Research Forum, ATRF 2013 - Proceedings	Conference Proceeding						
Jones et al.	Motives, perceptions and experiences of electric bicycle owners and implications for health, wellbeing and mobility	2016	Journal of Transport Geography	Journal Article	E-bike	Private	Amsterdam, Utrecht and Groningen (Netherlands); Oxford (UK)	Interview	22	Adult e-bike owners
Kaplan et al.	Intentions to use bike-sharing for holiday cycling: An application of the Theory of Planned Behavior	2015	Tourism Management	Journal Article	E-bike	Shared	Copenhagen (from 35 countries, mostly European)	Survey	655	Potential tourists
Kaplan et al.	The role of human needs in the intention to use conventional and electric bicycle sharing in a driving-oriented country	2018	Transport Policy	Journal Article	E-bike	Shared	Three Polish cities (Poznan, Szczecin, Gorzow Wielkopolski)	Survey	717	General population
Kazemzadeh & Koglin	Electric bike (non)users' health and comfort concerns pre and peri a world pandemic (COVID-19): A qualitative study	2021	Journal of Transport & Health	Journal Article	E-bike	Private	Sweden	Interview	23	E-bike rider or with experience
Kopplin et al.	Consumer acceptance of shared e-scooters for urban and short-distance mobility	2021	Transportation Research Part D-Transport and Environment	Journal Article	E-scooter	Shared	Germany	Survey	749	General population
Krauss et al.	What drives the utility of shared transport services for urban travellers? A stated preference survey in German cities	2022	Travel Behaviour and Society	Journal Article	E-scooter	Shared	Germany	Survey	1779	General population with driver's license
Kwiatkowski et al.	Could it be a bike for everyone? The electric bicycle in Poland	2021	Energies	Journal Article	E-bike	Private	Poland	Survey	456	General population
Lee et al.	Public intentions to purchase electric vehicles in Pakistan	2021	Sustainability	Journal Article	E-bike	Private	Lahore City (Pakistan)	Survey	359	General population
Leger et al.	"If I had a regular bicycle, I wouldn't be out riding anymore": Perspectives on the potential of e-bikes to support active living and independent mobility among older adults in Waterloo, Canada	2019	Transportation Research Part A: Policy and Practice	Journal Article	E-bike	Private	Region of Waterloo (Canada)	Interview, Focus Group	17/37	Older adults (>55 years)
Lin et al.	The death of a transport regime? The future of electric bicycles and transportation pathways for sustainable mobility in China	2018	Technological Forecasting and Social Change	Journal Article	E-bike	Private	Nanjing City (China)	Survey	1003	General population
Ling et al.	Differences of cycling experiences and perceptions between e-bike and bicycle users in the United States?	2017	Sustainability	Journal Article	E-bike	Private	US	Survey	806	Bike owners (electric and conventional)
Macarthur, John	Evaluation of an Electric Bike Pilot Project at Three Employment Campuses in Portland, Oregon	2017	National Institute for Transportation and Communities (NITC)	Report	E-bike	Private	Three Campuses Portland, Oregon (US)	Survey	129	Campus employees
Mayer, A	Motivations and barriers to electric bike use in the U.S.: views from online forum participants	2020	International Journal of Urban Sustainable Development	Journal Article	E-bike	Private	US	Interview	47	E-bike riders
Melia & Bartle	Who uses e-bikes in the UK and why?	2021	International Journal of Sustainable Transportation	Journal Article	E-bike	Private	UK	Survey, Interview	2092	People living in the UK who had ever used or considered using an e-bike
Mitra & Hess		2021			E-scooter	Shared		Survey	1640	

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Table 3 (*continued*)

Author(s)	Title	Year	Publication	Type	Vehicle	Modality	Geography	Method	Sample	Target population
	Who are the potential users of shared e-scooters? An examination of socio-demographic, attitudinal and environmental factors		Travel Behaviour and Society	Journal Article			Greater Golden Horseshoe (GGH) region (Canada)			Residents 18 years or above
Munkácsy & Monzón	Impacts of smart configuration in pedelec-sharing: Evidence from a panel survey in Madrid	2017	Journal of Advanced Transportation	Journal Article	E-bike	Shared	Madrid (Spain)	Survey, Interview	205	Users and non-users
Nematchoua et al.	Evaluation of the potential of classic and electric bicycle commuting as an impetus for the transition towards environmentally sustainable cities: A case study of the university campuses in Liege, Belgium	2020	Renewable and Sustainable Energy Reviews	Journal Article	E-bike	Private	University of Liège (Belgium)	Survey	1206	Campus users (students, PhD students, staff members)
Patil & Majumdar	Prioritizing key attributes influencing electric two-wheeler usage: A multi criteria decision making (MCDM) approach – A case study of Hyderabad, India	2021	Case Studies on Transport Policy	Journal Article	Electric-two-wheelers	Private	Hyderabad (India)	Survey	1070	Motorized-two-wheelers users
Pimentel & Lowry	If You Provide, Will They Ride? Motivators and Deterrents to Shared Micro-Mobility	2020		Report	E-bike/E-scooter	Shared	Washington, Oregon, and Idaho (US)	Survey	1502	Users and non-users
Plazier et al.	The potential for e-biking among the younger population: A study of Dutch students	2017	Travel Behaviour and Society	Journal Article	E-bike	Private	University of Groningen (Netherlands)	Survey, Interview	37/8	University students
Popovich et al.	Experiences of Electric Bicycle Users in the Davis/Sacramento, California Area	2014	Travel Behaviour and Society	Journal Article	E-bike	Private	Sacramento, California (US)	Interview	27	E-bike owners
Rayaprolu & Venigalla	Motivations and Mode-choice Behavior of Micromobility Users in Washington, DC	2020	Journal of Modern Mobility Systems	Journal Article	E-bike/E-scooter	Shared	Washington DC (US)	Survey	440	Users and non-users
Rejali et al.	Assessing a priori acceptance of shared dockless e-scooters in Iran	2021	Transportation Research Part D: Transport and Environment	Journal Article	E-scooter	Shared	Iran	Survey	1078	General population
Sanders et al.	To scoot or not to scoot: Findings from a recent survey about the benefits and barriers of using E-scooters for riders and non-riders	2020	Transportation Research Part A: Policy and Practice	Journal Article	E-scooter	Private	Arizona State University, Tempe, Arizona (US)	Survey	1256	University staff
Sellaouti et al.	Analysis of the use or non-use of e-scooters, their integration in the city of Munich (Germany) and their potential as an additional mobility system	2020	2020 IEEE 23rd International Conference on Intelligent Transportation Systems, ITSC 2020	Conference Proceeding	E-scooter	Shared	Munich (Germany)	Survey	277	General population
Simsekoglu & Klöckner	The role of psychological and socio-demographical factors for electric bike use in Norway	2019	International Journal of Sustainable Transportation	Journal Article	E-bike	Private	Norway	Survey	910	Users and non-users
Simsekoglu & Klöckner	Factors related to the intention to buy an e-bike: A survey study from Norway	2019	Transportation Research Part F: Traffic Psychology and Behaviour	Journal Article	E-bike	Private	Norway	Survey	910	Users and non-users
Teixeira et al.	The motivations for using bike sharing during the COVID-19 pandemic: Insights from Lisbon	2021	Transportation Research Part F: Traffic Psychology and Behaviour	Journal Article	E-bike	Shared	Lisbon (Portugal)	Survey	294	Users or past users
Thomas, A	Electric bicycles and cargo bikes—Tools for parents to keep on	2021		Journal Article	E-bike/E-cargo bike	Private	San Francisco Bay Area (US)	Interview	20	E-bike users with children

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Table 3 (*continued*)

Author(s)	Title	Year	Publication	Type	Vehicle	Modality	Geography	Method	Sample	Target population
	biking in auto-centric communities? Findings from a US metropolitan area		International Journal of Sustainable Transportation							
Van Cauwenberg et al.	E-bikes among older adults: benefits, disadvantages, usage and crash characteristics	2019	Transportation	Journal Article	E-bike	Private	Flanders (Belgium)	Survey	357	E-bike users >65 years
Washington et al.	Would you consider using an electric bicycle (e-bike) to make work-related or personal trips? Report on Survey and Focus Groups with TMR employees	2018		Report	E-bike	Private	Brisbane (Australia)	Survey, Focus Group, Interview	392/31	Employees
Will et al.	Towards the future of sustainable mobility: Results from a European survey on (electric) powered-two wheelers	2021	Sustainability	Journal Article	Electric-two-wheelers	Private/ Shared	Several European countries	Survey	283	General population >16 years
Ye et al.	Characteristics of the electric bicycle: A comparative analysis with bicycles and public transit	2014	Proceedings of the 14th COTA International Conference of Transportation Professionals	Conference Proceeding	E-bike	Private	Shanghai (China)	Survey	650	Users
Zuev, D	Urban mobility in modern China: The growth of the E-bike	2018		Book	E-bike	Private	China	Interview, Focus Group	40/30	Users

Dowling et al., 2015; Fitt and Curl, 2020; Fitt and Curl, 2019; Buehler et al., 2021; Edel et al., 2021; Huang, 2021; Kopplin et al., 2021; Mitra and Hess, 2021; Rejali et al., 2021; bureau de recherche 6t, 2019; Hardt et al., 2019), 4 used both e-bikes and e-scooters (Flores and Jansson, 1957; Pimentel and Lowry, 2020; Rayaprolu and Venigalla, 2020; Bieliński and Ważna, 2020a), and the rest were not specifically using one of these vehicles, but e-micromobility, PETs and light electric two-wheelers (De Ceunynck et al., 2021; Esztergár-Kiss and Lopez Lizarraga, 2021; Patil and Majumdar, 2021; Will et al., 2021; Hyvönen et al., 2016).

Finally, regarding the methodology, a total of 51 studies collected data using surveys (Nematchoua et al., 2020), (Teixeira et al., 2021), (Bielinski et al., 2021; Buehler et al., 2021; De Ceunynck et al., 2021; Eccarius et al., 2021; Edel et al., 2021; Esztergár-Kiss and Lopez Lizarraga, 2021; Flores and Jansson, 1957; Huang, 2021), (Kopplin et al., 2021), (Kwiatkowski et al., 2021), (Johnson and Rose, 2013), (Mitra and Hess, 2021; Patil and Majumdar, 2021; Rejali et al., 2021), (Will et al., 2021), (bureau de recherche 6t, 2019), (Arsenio et al., 2018), (Hardt et al., 2019; Haustein and Møller, 2016a; Hiselius and Svenssona, 2014; Hyvönen et al., 2016), (Van Cauwenberg et al., 2019), (Kaplan et al., 2015), (Krauss et al., 2022), (Sellaouti et al., 2020), (Simsekoglu and Klöckner, 2019b), (Gorenflo et al., 2017a), (Ling et al., 2017), (Macarthur, 2017), (Pimentel and Lowry, 2020), (Rayaprolu and Venigalla, 2020), (Sanders et al., 2020), (Glavić et al., 2021), (Alamelu et al., 2015; An et al., 2013; Eccarius and Lu, 2018; Elias and Gitelman, 2018; Lee et al., 2021b; Lin et al., 2018; Ye et al., 2014), (Dowling et al., 2015; Fitt and Curl, 2019, 2020), (Andersson et al., 2021), (Bieliński and Ważna, 2020a), (Kaplan et al., 2018), (Simsekoglu and Klöckner, 2019a), (Abouelela et al., 2021), (Biegańska et al., 2021), with sample sizes varying between 17 and 4382 participants. In fact, more than half of these articles (26) present sample sizes surpassing the 500 participants (Nematchoua et al., 2020; Johnson and Rose, 2013; Mitra and Hess, 2021; Patil and Majumdar, 2021; Rejali et al., 2021; bureau de recherche 6t, 2019; Hyvönen et al., 2016; Kaplan et al., 2015; Krauss et al., 2022; Simsekoglu and Klöckner, 2019b; Ling et al., 2017; Pimentel and Lowry, 2020; Glavić et al., 2021; Sanders et al., 2020; Alamelu et al., 2015; Lin et al., 2018; Ye et al., 2014; Fitt and Curl, 2019; Bieliński and Ważna, 2020a; Kaplan et al., 2018; Simsekoglu and Klöckner, 2019a; Abouelela et al., 2021; De Ceunynck et al., 2021; Esztergár-Kiss and Lopez Lizarraga, 2021; Flores and Jansson, 1957; Kopplin et al., 2021). Qualitative interviews were used in 6 articles as their main methodology (Jones et al., 2016; Dill and Rose, 2012; Kazemzadeh and Koglin, 2021; Thomas, 2021; Mayer, 2020; Popovich et al., 2014a), with sample sizes between 20 and 47 interviewees while 2 other studies chose to use focus groups (Edge et al., 2018; Bateman et al., 2021) with sample sizes of 10 and 27 participants. The remaining 8 studies used multimethod designs, combining surveys, interviews, and focus groups (Fyhri et al., 2017; Melia and Bartle, 2021; Plazier et al., 2017; Behrendt, 2018; Leger et al., 2019; Zuev, 2018; Washington et al., 2018; Munkácsy and Monzón, 2017). The majority of the analyzed studies included both male and female subjects and included different age ranges, with some exceptions: 1 study analyzed only students from high schools (Elias and Gitelman, 2018), 2 studies focused only on older adults (Van Cauwenberg et al., 2019; Leger et al., 2019), 1 study used only younger adults between 18 and 34 years (Abouelela et al., 2021), 1 study used potential tourists (Kaplan et al., 2015), 1 study analyzed only women (Alamelu et al., 2015), and 1 study examined users with children (Thomas, 2021). Moreover, in 11 studies the sample comprised only users from university campuses, i.e., students and staff (Nematchoua et al., 2020; Edge et al., 2018; Dowling et al., 2015; Buehler et al., 2021; Eccarius et al., 2021; Arsenio et al., 2018; Plazier et al., 2017; Gorenflo et al., 2017a; Macarthur, 2017; Sanders et al., 2020; Eccarius and Lu, 2018).

Table 4
Functional and non-functional factors.

Factors	Positive association	Mixed association	Negative association
Functional			
Monetary cost	(Johnson and Rose, 2013; Van Cauwenberg et al., 2019; Mayer, 2020; Rayaprolu and Venigalla, 2020; Alamelu et al., 2015; An et al., 2013; Eccarius and Lu, 2018; Ye et al., 2014; Zuev, 2018; Haustein and Møller, 2016b; Glavić et al., 2021; Kaplan et al., 2018; Bielinski et al., 2021; Edel et al., 2021; Kopplin et al., 2021; Mitra and Hess, 2021; Rejali et al., 2021; Macarthur, 2017)	(Fyhri et al., 2017; Abouelela et al., 2021; Hyvönen et al., 2016; Kaplan et al., 2015; Krauss et al., 2022; Gorenflo et al., 2017a; Lin et al., 2018; Bateman et al., 2021; Buehler et al., 2021; Eccarius et al., 2021; Melia and Bartle, 2021; Patil and Majumdar, 2021; Thomas, 2021; bureau de recherche 6t, 2019; Arsenio et al., 2018)	(Nematchoua et al., 2020; Jones et al., 2016; Ling et al., 2017; Popovich et al., 2014a; Elias and Gitelman, 2018; Fitt and Curl, 2019; Bieliński and Ważna, 2020b; Biegańska et al., 2021; De Ceunynck et al., 2021; Esztergár-Kiss and Lopez Lizarraga, 2021; Kazemzadeh and Koglin, 2021; Kwiatkowski et al., 2021; Will et al., 2021; Sellaouti et al., 2020; Behrendt, 2018)
Practicality/ Convenience	(Edge et al., 2018; Kaplan et al., 2018; Hyvönen et al., 2016; Plazier et al., 2017; Simsekoglu and Klöckner, 2019b; Leger et al., 2019; Macarthur, 2017; Mayer, 2020; An et al., 2013; Elias and Gitelman, 2018; Ye et al., 2014; Zuev, 2018; Dill and Rose, 2012; Fitt and Curl, 2020; Fitt and Curl, 2019; Washington et al., 2018; Biegańska et al., 2021; De Ceunynck et al., 2021; Esztergár-Kiss and Lopez Lizarraga, 2021; Kwiatkowski et al., 2021; Mitra and Hess, 2021; bureau de recherche 6t, 2019; Hardt et al., 2019)	(Van Cauwenberg et al., 2019; Andersson et al., 2021; Bateman et al., 2021; Buehler et al., 2021; Eccarius et al., 2021; Rejali et al., 2021; Krauss et al., 2022; Pimentel and Lowry, 2020; Sanders et al., 2020; Eccarius and Lu, 2018)	
Ease of use/ Comfort	(Teixeira et al., 2021; Fyhri et al., 2017; Kaplan et al., 2015, 2018; Plazier et al., 2017; Simsekoglu and Klöckner, 2019a, 2019b; Gorenflo et al., 2017a; Macarthur, 2017; Popovich et al., 2014a; Rayaprolu and Venigalla, 2020; Alamelu et al., 2015; Ye et al., 2014; Dowling et al., 2015; Andersson et al., 2021; Buehler et al., 2021; Kopplin et al., 2021; Will et al., 2021; Hardt et al., 2019; Hyvönen et al., 2016)	(Kazemzadeh and Koglin, 2021; Munkacsy and Monzon, 2017)	
Accessibility/ Flexibility	(Teixeira et al., 2021; Dill and Rose, 2012; Eccarius and Lu, 2018; Lin et al., 2018; Zuev, 2018; Esztergár-Kiss and Lopez Lizarraga, 2021; Kwiatkowski et al., 2021; Melia and Bartle, 2021; Rejali et al., 2021; Thomas, 2021; bureau de recherche 6t, 2019; Mayer, 2020; Popovich et al., 2014a)	Krauss et al. (2022)	
Time savings	(Teixeira et al., 2021; Fyhri et al., 2017; Kaplan et al., 2015; Krauss et al., 2022; Plazier et al., 2017; Simsekoglu and Klöckner, 2019b; Popovich et al., 2014a; Rayaprolu and Venigalla, 2020; An et al., 2013; Lin et al., 2018; Ye et al., 2014; Zuev, 2018; Glavić et al., 2021; Kaplan et al., 2018; Bateman et al., 2021; Edel et al., 2021; Kazemzadeh and Koglin, 2021; bureau de recherche 6t, 2019; Bieliński et al., 2021; Hiselius and Svenssona, 2014)	(Andersson et al., 2021; Abouelela et al., 2021)	
Safety	(Buehler et al., 2021; Kwiatkowski et al., 2021; Behrendt, 2018)	(Dill and Rose, 2012; Abouelela et al., 2021; Plazier et al., 2017)	(Nematchoua et al., 2020), (Edge et al., 2018), (Kazemzadeh and Koglin, 2021; Kopplin et al., 2021; Kwiatkowski et al., 2021), (Mitra and Hess, 2021; Patil and Majumdar, 2021; Rejali et al., 2021; Thomas, 2021; Will et al., 2021; bureau de recherche 6t, 2019), (Hardt et al., 2019), (Glavić et al., 2021), (Kaplan et al., 2015), (Munkacsy and Monzon, 2017), (Sellaouti et al., 2020), (Gorenflo et al., 2017a; Leger et al., 2019; Ling et al., 2017; Macarthur, 2017), (Pimentel and Lowry, 2020; Popovich et al., 2014a; Rayaprolu and Venigalla, 2020), (Jones et al., 2016), (Sanders et al., 2020), (An et al., 2013; Eccarius and Lu, 2018; Elias and Gitelman, 2018), (Lin et al., 2018), (Zuev, 2018), (Fitt and Curl, 2019, 2020; Washington et al., 2018), (Bieliński and Ważna, 2020b)' (Simsekoglu and Klöckner, 2019a), (Bateman et al., 2021), (Bielinski et al., 2021), (De Ceunynck et al., 2021), (Eccarius et al., 2021), (Esztergár-Kiss and Lopez Lizarraga, 2021)
Reliability/ Security	(Kazemzadeh and Koglin, 2021; Kopplin et al., 2021)	(Arsenio et al., 2018; Lee et al., 2021b)	(Nematchoua et al., 2020; Van Cauwenberg et al., 2019; Patil and Majumdar, 2021; Thomas, 2021; Will et al., 2021; Krauss et al., 2022; Gorenflo et al., 2017a; Pimentel and Lowry, 2020; Popovich et al., 2014a; Eccarius and Lu, 2018; Elias and Gitelman, 2018; Zuev, 2018; Fyhri et al., 2017; Washington et al., 2018; Edge et al., 2018; Jones et al., 2016; Andersson et al., 2021; Dill and Rose,

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Table 4 (*continued*)

Factors	Positive association	Mixed association	Negative association
Functional			
			2012; Simsekoglu and Klöckner, 2019a; Eccarius et al., 2021; Melia and Bartle, 2021)
Non-functional			
Environmental awareness	(Teixeira et al., 2021; Johnson and Rose, 2013; Edel et al., 2021; Flores and Jansson, 1957; Huang, 2021; Kopplin et al., 2021; Kwiatkowski et al., 2021; Melia and Bartle, 2021; Mitra and Hess, 2021; Patil and Majumdar, 2021; Rejali et al., 2021; Bieliński et al., 2021; Van Cauwenberg et al., 2019; Hiselius and Svenssona, 2014; Hyvönen et al., 2016; Kaplan et al., 2015; Munkacsy and Monzon, 2017; Simsekoglu and Klöckner, 2019a, 2019b; Gorenflo et al., 2017a; Ling et al., 2017; Macarthur, 2017; Mayer, 2020; Popovich et al., 2014a; Fyhri et al., 2017; Alamelu et al., 2015; An et al., 2013; Eccarius and Lu, 2018; Lee et al., 2021b; Zuev, 2018; Haustein and Møller, 2016b; Edge et al., 2018; Glavić et al., 2021; Andersson et al., 2021; Dill and Rose, 2012; Eccarius et al., 2021)		Sellaouti et al. (2020)
Health/Well-being	(Teixeira et al., 2021; Johnson and Rose, 2013; Kwiatkowski et al., 2021; Melia and Bartle, 2021; Mitra and Hess, 2021; Patil and Majumdar, 2021; Thomas, 2021; Bieliński et al., 2021; Kaplan et al., 2015, 2018; Munkacsy and Monzon, 2017; Plazier et al., 2017; Simsekoglu and Klöckner, 2019a, 2019b; Van Cauwenberg et al., 2019; Behrendt, 2018; Gorenflo et al., 2017a; Leger et al., 2019; Ling et al., 2017; Macarthur, 2017; Popovich et al., 2014a; Rayaprolu and Venigalla, 2020; Alamelu et al., 2015; Zuev, 2018; Fitt and Curl, 2020; Fyhri et al., 2017; Washington et al., 2018; Haustein and Møller, 2016b; Edge et al., 2018; Jones et al., 2016; Andersson et al., 2021; Bateman et al., 2021)		
Social perception	(Teixeira et al., 2021; Simsekoglu and Klöckner, 2019a; Kopplin et al., 2021; Kwiatkowski et al., 2021; Rejali et al., 2021; Pimentel and Lowry, 2020; Eccarius and Lu, 2018; Fitt and Curl, 2020; Gorenflo et al., 2017b)	(Huang, 2021; Mitra and Hess, 2021; Lee et al., 2021b)	(Johnson and Rose, 2013; Bateman et al., 2021; Melia and Bartle, 2021; Thomas, 2021; Plazier et al., 2017; Leger et al., 2019; Mayer, 2020; Popovich et al., 2014a)
Riding experience	(Teixeira et al., 2021; Van Cauwenberg et al., 2019; Rejali et al., 2021; Will et al., 2021; bureau de recherche 6t, 2019; Hardt et al., 2019; Hyvönen et al., 2016; Kaplan et al., 2015; Plazier et al., 2017; Sellaouti et al., 2020; Gorenflo et al., 2017a; Leger et al., 2019; Edge et al., 2018; Ling et al., 2017; Macarthur, 2017; Pimentel and Lowry, 2020; Popovich et al., 2014a; Rayaprolu and Venigalla, 2020; Sanders et al., 2020; Elias and Gitelman, 2018; Zuev, 2018; Dowling et al., 2015; Fitt and Curl, 2019; Andersson et al., 2021; Bieliński and Ważna, 2020b; Bateman et al., 2021; Biegańska et al., 2021; De Ceunynck et al., 2021; Eccarius et al., 2021; Kopplin et al., 2021; Melia and Bartle, 2021)		
Interest in innovation/technology	(Kaplan et al., 2015, 2018; Flores and Jansson, 1957; Will et al., 2021; Hiselius and Svenssona, 2014; Simsekoglu and Klöckner, 2019b; Mayer, 2020; Alamelu et al., 2015)		

4.2. Social analysis: factors influencing the adoption of electric micromobility

In this section, the results of the social analysis are presented, listing the functional and non-functional factors most mentioned throughout the articles reviewed, and so, considered to potentially be the most relevant when determining the adoption and usage of e-MM. Table 4 includes all the factors found to be significant in the analyzed studies, categorizing them as functional or non-functional while indicating the type of association found (positive, negative, or mixed).

4.2.1. Functional factors

In general, most functional factors were found to be positively related to e-MM use, meaning that e-MM serve a practical function that makes them more competitive against other traditional modes. Among the most frequently studied functional factors we can summarize the following as the ones having the larger positive associations with e-MM use.

4.2.1.1. Monetary cost. Among the functional factors, the *monetary cost* was the most frequently mentioned factor. Some individuals seem to perceive e-MM as being economically viable, cheaper than other modes, and thus with the potential to save money in the long run (Johnson and

Rose, 2013; Van Cauwenberg et al., 2019; Mayer, 2020; Rayaprolu and Venigalla, 2020; Alamelu et al., 2015; An et al., 2013; Eccarius and Lu, 2018; Ye et al., 2014; Zuev, 2018; Glavić et al., 2021; Kaplan et al., 2018; Bielinski et al., 2021; Edel et al., 2021; Kopplin et al., 2021; Mitra and Hess, 2021; Haustein and Møller, 2016a; Macarthur, 2017). In terms of sharing systems, the pricing mechanisms of the e-MM services provided by operators are considered to be convenient and economical (Buehler et al., 2021). Also, the fact that there are no ownership and maintenance costs nor are there parking expenses contributes to this generalized perception (Eccarius and Lu, 2018). E-MM users state to perceive money savings, mainly when compared to owning a car, in terms of fuel, insurance, vehicle maintenance and parking fees (Edel et al., 2021; Will et al., 2021; Mayer, 2020; Popovich et al., 2014b). However, Mayer A. shows how among those that own an e-micromobility vehicle still some concern exists regarding future potential policy changes that may force them to license and insure these vehicles, which would lead to losing this economic benefits(Mayer, 2020).

However, not all studies reach the same positive conclusions. Some studies have found how purchasing price and operating cost (use fees) are considered the most or one of the most important attributes when choosing e-MM, but individuals seem to be uncertain regarding whether these modes are a cheaper solution than other forms of transport (Patil and Majumdar, 2021; Thomas, 2021; bureau de recherche 6t, 2019; Arsenio et al., 2018; Krauss et al., 2022; Munkácsy and Monzón, 2017). The study from Bateman et al. in Birmingham presents this dichotomy between the perception of cost as one of the main deterrents to using e-bikes, and the potential they offer to save money (Bateman et al., 2021). Similar results can be found in other studies where both expensive (high purchase price or cost of use) and inexpensive (affordable or saving money) terms are mentioned (Fyhri et al., 2017; Eccarius et al., 2021; Hyvönen et al., 2016). Also, Lin et al. state that even when individuals may perceive e-bikes as expensive, they are often willing to take on the initial investment as they expect to use them for a long time (Lin et al., 2018).

On the other end of the spectrum, several studies have found present cost and price as negatively influencing the use of e-MM (Nematchoua et al., 2020; Bielinski and Wazna, 2020; Behrendt, 2018; Ling et al., 2017; Popovich et al., 2014a; Elias and Gitelman, 2018; Fitt and Curl, 2019; Jones et al., 2016; Biegańska et al., 2021; De Ceunynck et al., 2021; Esztergár-Kiss and Lopez Lizarraga, 2021; Kazemzadeh and Koglin, 2021; Kwiatkowski et al., 2021; Will et al., 2021; Sellaouti et al., 2020), both in terms of costs associated with private ownership of the vehicles (acquisition price and maintenance cost) as well as costs required to access shared vehicles (usage or monthly fees).

4.2.1.2. Practicality and convenience. Another highly rated attribute of e-MM is *practicality* and *convenience*. In the majority of the reviewed studies, e-MM usage is perceived as practical for everyday use as a commuter vehicle, as these vehicles improve travel independence and mobility, offer better schedule predictability, and require minimal physical exertion (Edge et al., 2018; Kaplan et al., 2018; Washington et al., 2018; Biegańska et al., 2021; Mitra and Hess, 2021; Hyvönen et al., 2016; Plazier et al., 2017; Simsekoglu and Klöckner, 2019b; Leger et al., 2019; Elias and Gitelman, 2018; Zuev, 2018). Buehler et al. demonstrate how the usefulness perception of e-scooters increases once individuals try them for the first time. In this line, convenience can be conceptualized as the perception of time and effort that users invest into using a service (Buehler et al., 2021). This means that the less time and effort users have to invest in the service, the higher the level of convenience perceived by individuals (Bateman et al., 2021; De Ceunynck et al., 2021; Ye et al., 2014; Zuev, 2018; Eccarius et al., 2021; Rejali et al., 2021; Andersson AAdell et al., 2021; Hardt et al., 2019; Plazier et al., 2017; Leger et al., 2019; Sanders et al., 2020; An et al., 2013). In this context, convenience includes aspects such as distance to the service (coverage), availability of vehicles (fleet size), accident/damage handling, avoiding traffic congestions, or lack of problems with parking spaces.

Despite most of the examined studies finding positive associations between e-MM use and practicality and convenience, some studies have also found convenience issues mainly related to the access to shared vehicles. As such, e-scooter users in a university campus in Arizona reported how difficulties in finding vehicles when needed or sometimes finding them broken, made e-scooters impractical for everyday commuting (Sanders et al., 2020). Similar results were found in Eccarius and Lu (2018). An additional source of burden found also in other studies was the low carrying or baggage capacity and the heaviness of the vehicles which were mentioned as deterrents in terms of practicality (Andersson et al., 2021; Bateman et al., 2021; Rejali et al., 2021; Pimentel and Lowry, 2020).

4.2.1.3. Ease of use and comfort. One of the main selling points of e-MM is the promise of easy circulation in contrast with the inconvenience, slowness, or crowdedness of other traditional modes of transport. Thus, e-MM are seen as really *easy to drive and manage* (Teixeira et al., 2021; Andersson et al., 2021; Macarthur, 2017; Dowling et al., 2015; Kaplan et al., 2015, 2018; Kopplin et al., 2021; Will et al., 2021; Hardt et al., 2019; Hyvönen et al., 2016; Plazier et al., 2017; Simsekoglu and Klöckner, 2019b), with no training or license required, which makes them available to almost everybody. In studies such as that of Eccarius and Lu, and regarding shared services, participants seem to universally praise how easy it is to operate the App or Platform that supports the service (Eccarius and Lu, 2018). Together with ease of use, *comfort while driving* is often mentioned as a positive attribute of e-MM (Kopplin et al., 2021; Plazier et al., 2017; Macarthur, 2017; Popovich et al., 2014a; Alamelu et al., 2015; Ye et al., 2014; Dowling et al., 2015).

4.2.1.4. Accessibility and flexibility. Additionally, surveyed users from various studies commented that e-MM can ease *access* to mobility and widen transport options (Melia and Bartle, 2021; Rejali et al., 2021; Lin et al., 2018; Zuev, 2018). In one of the oldest studies included in the sample, Dill and Rose found how e-bikes made cycling accessible among some populations such as women, elderly people, or individuals that would not normally ride (i.e., with physical limitations) (Dill and Rose, 2012). This usefulness for the elderly is also mentioned by Kwiatkowski et al. (2021), as well as the potential usage when having an injury or disability (Mayer, 2020; Popovich et al., 2014a). The study conducted by Thomas, A. (Thomas, 2021) shows the potential e-bikes have to overcome the limitations that parents with children face, being these limitations the physical environment, the weight of the children, and their own physical limitations. Moreover, e-MM can be seen as a tool to mitigate the first- and last-mile problems as well as the connectivity with other modes of transport, such as public transportation (Bielinski and Wazna, 2020; Edel et al., 2021; Dowling et al., 2015). Likewise, e-MM seems to score high on *flexibility*, by offering high route and scheduling resilience in most of the studied urban areas (Teixeira et al., 2021; Esztergár-Kiss and Lopez Lizarraga, 2021; bureau de recherche 6t, 2019; Popovich et al., 2014a; Eccarius and Lu, 2018; Lin et al., 2018).

4.2.1.5. Time savings. Another recurrent topic for most e-MM users is savings in travel time. The majority of studies find users reporting their total commute *time to be reduced* thanks to using e-MM (Glavić et al., 2021; Kaplan et al., 2018; Popovich et al., 2014a; Rayaprolu and Venigalla, 2020; An et al., 2013; Ye et al., 2014; Bateman et al., 2021; Bielinski et al., 2021; Kazemzadeh and Koglin, 2021; bureau de recherche 6t, 2019; Hiselius and Svenssona, 2014; Kaplan et al., 2015; Plazier et al., 2017; Simsekoglu and Klöckner, 2019b). In fact, Ling et al. found that for both Millennials and Generation X individuals saving of travel times was among the most important factors explaining e-cycling adoption (Ling et al., 2017). Also, interviews carried out by Plazier et al. demonstrated that starting using e-bikes for commuting meant shorter travel times for almost all participants (Plazier et al., 2017). An et al. described the way e-bikes guarantee punctuality during peak times compared to the use of public transport modes such as buses (An et al., 2013). Indeed, time savings and the potential to combine several modes of transportation seem to feed into the perception of the convenience of these new modes. Users of e-MM shared services tend to appreciate time gains for intra-city trips as well as the time required to find a parking place, as indicated by the results in the work of Krauss et al. (2022).

Not all functional factors, however, were associated with positive connotations. *Safety and reliability* for instance were the two most mentioned factors with a negative association, and thus they offer two clear barriers to the adoption of e-MM.

4.2.1.6. Safety. Safety is repeatedly found as the most negatively perceived factor by both users and non-users of e-MM (Bieliński et al., 2020; Jones et al., 2016; Sellaouti et al., 2020; Simsekoglu and Klöckner, 2019b; Ling et al., 2017; Rayaprolu and Venigalla, 2020; Elias and Gitelman, 2018; Zuev, 2018; Fitt and Curl, 2019; Bateman et al., 2021; Bielinski et al., 2021; De Ceunynck et al., 2021; Eccarius et al., 2021; Esztergár-Kiss and Lopez Lizarraga, 2021; Will et al., 2021; Hardt et al., 2019; Munkacsy and Monzon, 2017). This unsafe perception is aggravated by most participants recognizing that in most cases infrastructure is not yet ready to support e-MM (i.e., not enough lanes or parking) (Nematchoua et al., 2020; Glavić et al., 2021; Bateman et al., 2021; Leger et al., 2019; Popovich et al., 2014a; Eccarius and Lu, 2018; Washington et al., 2018). The vast majority of e-MM users feel safer when dedicated and exclusive lanes are available, which are separated from motor traffic (Edge et al., 2018; Bateman et al., 2021; Leger et al., 2019; Rayaprolu and Venigalla, 2020; Sanders et al., 2020). Most participants of the reviewed studies report that the absence of infrastructure in combination with unfriendly drivers is unsettling (Bateman et al., 2021). Also, participants suggest promoting protective gear, clear and more advanced safety regulations, and training on road norms and rules of conduct, to increase overall safety perception (De Ceunynck et al., 2021; Esztergár-Kiss and Lopez Lizarraga, 2021).

Moreover, in terms of speed and according to Popovich et al. (2014a) study, e-bike users expressed feeling unsafe interacting with other road users despite the higher speed of e-bikes. In the same line, Patil and Majumdar (2021) state that in heterogeneous conditions, the lower speed associated with e-MM compared to motorized vehicles such as cars and motorcycles is posing a serious safety threat, as the other vehicles travel faster. These interaction issues with other road users such as cars and pedestrians are also mentioned by Rejali et al. (2021). Indeed, another significant safety concern related to velocity is the difficulty of distinguishing e-bikes from regular bikes, making car drivers underestimate the speed at which they approach (Popovich et al., 2014a).

Further, it is important to distinguish the safety-perception differences between users and non-users of e-MM. According to some of the reviewed studies, most potential users reported concerns with e-MM in terms of incorrect parking, speeding, and unsafe riding, including riding in sidewalks (Buehler et al., 2021; Rejali et al., 2021). Also, some studies defend that rider's familiarity with the e-MM increases perceived safety, so regular users and owners evaluate risk as being lower (Kroesen and Chorus, 2020; Flores and Jansson, 1957; Fitt and Curl, 2019).

On the other hand, the current pandemic context has created a new dimension regarding transport and safety (in terms of safety from contagion through social distancing), which positively impacted e-MM acceptance. Actually, with the impact of COVID-19, personal mobility has gained more attractiveness compared to public transport (Huang, 2021). Kazemzadeh and Koglin for example, found interviewees to be highly concerned about contagion risk when using public transport, a factor that was mitigated by increased commuting with e-bikes (Kazemzadeh and Koglin, 2021). Similarly, Eccarius et al. mention the surge of new personal mobility vehicles to avoid the use of public transport due to perceived infection risks (Eccarius et al., 2021). In the same line, the use of e-bike sharing in Lisbon skyrocketed after COVID-19 as individuals wanted to maintain social distance during trips (Teixeira et al., 2021). It is precisely this resilience of e-MM at offering a solution to specific transportation disruptions during times of crisis that Glavić et al. highlight as a potentially positive factor for the future of this transportation options(Glavić et al., 2021).

4.2.1.7. Reliability. Together with safety, *reliability* is also often mentioned as a barrier to the adoption of e-MM. The risk of theft is often stated by individuals as a big concern, especially when parking in public spaces (Nematchoua et al., 2020; Van Cauwenberg et al., 2019; Washington et al., 2018; Fyhri et al., 2017; Andersson et al., 2021; Dill and Rose, 2012; Melia and Bartle, 2021; Thomas, 2021; Popovich et al., 2014a; Elias and Gitelman, 2018; Zuev, 2018). While all e-MM vehicles seem to be affected by the risk of theft, some of them such as e-bikes are even more in danger as they look more expensive than a conventional bike (Edge et al., 2018). Another common finding regarding the reliability of these vehicles is what has been labeled as 'range anxiety'. That is the concern about battery performance in terms of range and the fear of becoming stranded right in the middle of a trip (Van Cauwenberg et al., 2019; Edge et al., 2018; Jones et al., 2016; Patil and Majumdar, 2021; Will et al., 2021; Krauss et al., 2022; Popovich et al., 2014a).

Likewise, users express concerns about maintenance and cleanliness, that is to say, they worry about the state of the vehicle they are sharing (Eccarius et al., 2021; Eccarius and Lu, 2018). This cleanliness issue has become more important after the COVID-19 pandemic due to the rise in public health awareness.

4.2.2. Non-functional factors

After all functional factors presented in the previous sections, it is time to go through the most mentioned and significant non-functional factors found in the reviewed papers.

4.2.2.1. Environmental awareness. The most frequent non-functional factor affecting e-MM use is *environmental awareness*. In more than half of the papers analyzed some of the individuals interviewed or surveyed noted that they are environmentally conscious concerning their lives, hence they try to use transport modes that do not negatively affect the environment. In that case, e-MM is considered as more environmentally friendly (Teixeira et al., 2021; Johnson and Rose, 2013; Mitra and Hess, 2021; Rejali et al., 2021; Haustein and Møller, 2016a; Hiselius and Svenssona, 2014; Hyvönen et al., 2016; Kaplan et al., 2015; Simsekoglu and Klöckner, 2019b; Ling et al., 2017; Macarthur, 2017; Popovich et al., 2014a; Edge et al., 2018; Alamelu et al., 2015; An et al., 2013; Lee et al., 2021b; Glavić et al., 2021; Andersson et al., 2021; Bielinski et al., 2021; Eccarius et al., 2021; Edel et al., 2021; Huang, 2021; Melia and Bartle, 2021). Pimentel and Lowry also found the dimension of doing 'social good' as determining the adoption and usage of e-MM[179]. However, those who frequently use active modes such as walking and cycling are more reluctant to adopt these innovative modes, as they perceive them as less environmentally friendly than their current mode of transport. Notwithstanding, prior experience with e-MM seems to awaken a perception of them as environmentally friendly and thus might reduce skepticism toward their adoption (Flores and Jansson, 1957; Eccarius and Lu, 2018).

On the other hand, some users correlate environmental friendliness with an enhanced social image. Eccarius and Lu introduce the concept of green hypocrite, as some people tend to state environmental reasons when justifying their use of e-MM, when in fact they just care about their own projected image when doing so (Eccarius and Lu, 2018).

4.2.2.2. Health and well-being benefits. E-MM (mainly e-bikes) are repeatedly considered in the articles analyzed as providing other added values such as increased well-being and health (e.g., by increasing physical activity levels), which make them more attractive for adoption

(Johnson and Rose, 2013; Jones et al., 2016; Ling et al., 2017; Popovich et al., 2014a; Washington et al., 2018; Andersson et al., 2021; Kaplan et al., 2018; Bielinski et al., 2021; Kwiatkowski et al., 2021; Melia and Bartle, 2021; Thomas, 2021; Plazier et al., 2017; Simsekoglu and Klöckner, 2019b). Additionally, e-MM is seen as a health tool, as it can address concerns about health problems related to inactivity and pollution, mainly in comparison to motorized vehicles (Teixeira et al., 2021; Edge et al., 2018; Patil and Majumdar, 2021; Behrendt, 2018; Macarthur, 2017; Alamelu et al., 2015). In fact, most of the times the perception of the health benefits depends on the mode of transportation being replaced. For instance, at Edge et al. study, e-bikes were perceived as having greater impact on physical activity when replacing sendentary modes for commuting such as car or bus (Edge et al., 2018). It is also important to mention that, for older people, to start using an e-MM vehicle may potentially allow them to continue exercising when they otherwise would not be able to (Haustein and Møller, 2016a; Popovich et al., 2014a). Bateman et al. conclude that one of the motivations of e-bike share users is to improve their health and reduce stress while riding (Bateman et al., 2021), while the study by Bieliński et al. found the positive effect on health as the top reason reported to encourage e-biking (Bieliński et al., 2021)Similarly, female participants interviewed in Washington et al. study reported to have already achieved tangible health benefits such as weight loss and strength as a result of riding an e-bike to work, (Washington et al., 2018).

4.2.2.3. Riding experience. Apart from increased health and well-being, several articles include individual perceptions of a positive and pleasant riding experience, as a motivation to adopt and use e-MM for daily commuting. Andersson et al. show how participants mention having fresh air in the morning and being fun as two factors that make them use e-bike (Andersson et al., 2021). Indeed, fun and enjoyment is emphasized in several of the reviewed articles (Teixeira et al., 2021; Van Cauwenberg et al., 2019; Sellaouti et al., 2020; Leger et al., 2019; Ling et al., 2017; Macarthur, 2017; Pimentel and Lowry, 2020; Popovich et al., 2014a; Rayaprolu and Venigalla, 2020; Sanders et al., 2020; Dowling et al., 2015; Fitt and Curl, 2019; Bielinski and Wazna, 2020; Bateman et al., 2021; Biegańska et al., 2021; Eccarius et al., 2021; Kopplin et al., 2021; Rejali et al., 2021; Hyvönen et al., 2016; Plazier et al., 2017). Will et al. study highlights how important is to experience fun and freedom as part of the riding experience when using an e-two-wheeler (Will et al., 2021). Apart from being fun to ride, interviewees from the Melia and Bartle study also seemed to value the opportunities their e-bikes offer for exploration of new places and routes (Melia and Bartle, 2021).

4.2.2.4. Social perception. *Social influence* can affect modal choice in different forms and at different stages of adoption. For once, it is well known that individuals want to be part of a group as this makes them feel socially accepted. These dynamics are also found in e-MM adoption. Kaplan et al. for instance found that the users of shared e-cycling in Poland tended to associate this mode with the feeling of being part of a community as well as with self-fulfillment (Kaplan et al., 2018). This argument supports the presence of what is called “social pull”, meaning that individuals feel a personal identification with the group of e-MM users, together with a sense of belongingness (Kaplan et al., 2015, 2018; Behrendt, 2018; Leger et al., 2019; Zuev, 2018). The study by Simsekoglu and Klöckner demonstrates that e-bike users believe that by using these vehicles they can distinguish themselves from the rest and that this usage says something positive about them (Simsekoglu and Klöckner, 2019b). The same idea of positive image and enhanced status is also found by Eccarius and Lu (2018) and Huang, F. (Huang, 2021). Moreover, the use of e-MM is sometimes considered a social activity and a way to keep up with family and friends (Kopplin et al., 2021).

On the negative side, some studies have also found a *social stigma* attached to e-MM vehicles, mainly e-bikes and especially when compared with traditional bikes (Jones et al., 2016; Melia and Bartle, 2021; Thomas, 2021; Plazier et al., 2017; Leger et al., 2019; Mayer, 2020; Popovich et al., 2014a). Jones et al. for instance found that e-bike users felt they were in some way ‘cheating’ vis-à-vis conventional cycling (Jones et al., 2016). Similarly, Mayer, A. study shows that individuals indicated that they had experienced negative comments about their electric bikes and received what they named ‘the cheating shaming’ (Mayer, 2020).

4.2.2.5. Interest in innovation and technology. Finally, another non-functional factor found in most studies is the *interest in innovation and technology*. Some individuals find the adoption of these services attractive because of the specific technical aspects and generally, because of the promises concerning these new technologies (Kaplan et al., 2015, 2018; Flores and Jansson, 1957; Will et al., 2021; Mayer, 2020; Alamelu et al., 2015). The individuals are interested in using these innovations because they value gadgetry and technological progress. As the study by Hiselius and Svenssona found, these technology enthusiasts are more likely to acquire or use these new modes of transport, especially in the earlier stages of development (Hiselius and Svenssona, 2014). In the same line, Simsekoglu and Klöckner’s study concluded that interest in innovation was the second most important predictor of e-bike usage and that the less interested in innovations and technology a person was, the less likely this person was to own an e-bike (Simsekoglu and Klöckner, 2019b).

5. Discussion

Our review found 67 studies that had included functional or non-functional sociopsychological factors in their aim to understand the adoption intention and usage of electric micro mobility (e-MM). While the examined studies used a wide range of methods and definitions, the consensus was that users will act and make travel decision based not only on a rational evaluation of the tangible attributes of the service provided, but rather on a combination of functional and non-functional factors. Our results demonstrate that non-functional factors such as environmental concerns, social perception, interest for new technologies, and the perception of increased well-being can be even more influential at determining e-MM modal choice than traditional functional factors like speed, cost, and time savings. This provides further evidence of the need to include sociopsychological factors in all travel behaviour analysis (De Witte et al., 2013; De Vos et al., 1010).

Regarding the functional factors, users seem to value the low cost-high convenience combination that most of these e-MM have to offer. Modes like electric shared bikes or electric scooters are generally perceived as practical, easy to use, accessible, and flexible. This also indicates that e-MM use is more than a fad or something just fashionable and that there are true functional benefits derived from their everyday use that are helping draw new users as well as keep current users engaged. While some debate exists on whether they are truly cost-efficient along with the real potential to offer true time-savings, a common general sense of convenience -understood as the effort and time that users may have to invest in using a particular mode-make e-MM a very attractive option. The reviewed studies suggest that one should not diminish the role of potential time savings in modal choice decision-making. On the other hand, two functional factors that were constantly mentioned as negatively affecting e-MM usage were safety and lack of reliability. These two adoption barriers are based on early reports that find a clear relationship between some of these new modes (e-scooters in particular) and a higher rate of reported accidents and injuries (James et al., 2019; Sikka et al., 2019; Badeau et al., 2019; Puzio et al., 2020). Also, noteworthy is how the COVID-19 pandemic has altered this negative view of e-MM in terms of safety, as some users now may perceive e-micromobility options as safer than other options such as public transport.

The most influential non-functional factor appears to be the belief that e-MM is environmentally friendly. More than half of the reviewed studies reported that environmental benefits were important motivations for users. In general, users tend to perceive e-MM as a step towards a greener lifestyle. Studies approaching e-MM from the environmental sustainability discipline, however, reveal two main drawbacks. On the one hand, the value-action gap (that is the gap between the attitude and actual behaviour of individuals) makes it challenging to identify whether users are adopting these modes because they care about the environment or rather because they want to improve their social image (Eccarius and Lu, 2018). On the other hand, while e-MM may bring more efficient transport, their overall environmental sustainability is under debate once the whole lifecycle of the vehicles is examined (McQueen et al., 2020; Severengiz et al., 2020; Zheng et al., 2019; Felipe-Falgas et al., 2022; de Bortoli, 2021; Hollingsworth et al., 2019b). Recent Life Cycle Analysis studies on e-MM vehicles (Moreau et al., 2020; Felipe--Falgas et al., 2022; de Bortoli, 2021; Hollingsworth et al., 2019b) demonstrate that for e-MM to be environmentally sustainable, vehicle life span needs to be significantly extended, collection and distribution distances must be reduced, and better strategies for battery charging must be implemented (Moreau et al., 2020).

The idea that e-MM may also be positive in terms of individual health has also been found to be a catalyst for e-MM use. Individuals state adopting e-MM to enhance or maintain current physical activity levels, while due to lower physical intensities and possibly shorter trip durations, e-MM need to cover longer distances or be used more frequently, to achieve the same health benefits than conventional active modes (i.e., walking and cycling). Indeed, if individuals switch from the most sedentary modes (i.e., cars and motorbikes), there will be an increase in the level of transport-related physical activity and therefore health gains (Castro et al., 2019; Glenn et al., 2020; Berntsen et al., 2017; Sanders et al., 2022). Some other studies report a desire by users to improve their well-being and enjoy the riding experience. In this sense, existing evidence suggest that e-MM can be fun and thrilling and thereby have a positive impact on mood and mental health (Milakis et al., 2020). A few studies also have found e-bike users as having lower perceived stress, better mental health and improved cognition (Leyland et al., 2019; Avila-Palencia, 2018).

Another non-functional value, such as the sense of belonging, was found to be of high significance, to the point that some studies report it can even override conflicting functional factors. Users may routinely choose a suboptimal mode of transport just for the gained status or the sense of belonging associated with using that particular mode of transport. These dynamics have been found to affect modal choice as they can express social and self-identities (Kaplan et al., 2018). Our findings suggest that adoption is also driven by the symbolism users projected towards innovation, as well as individual interests in gadgets and cutting-edge technology. On the other side, some studies have found some non-functional factors, that are discouraging e-MM adoption. Social stigma for example was found to be associated with e-bike use in some studies, as some populations felt e-bikes constituted a form of cheating when compared with traditional bikes.

In all, the present review demonstrates the complex mix of functional and non-functional factors behind the adoption and usage of e-MM. Moreover, there would be other factors, such as cultural differences and levels of support depending on the geographical location, that could be playing a role in the adoption of e-MM, and that should also be considered. For instance, in terms of e-bike, a country's "cycling culture" appears to shape e-bike use in a similar way than conventional cycling (Melia and Bartle, 2021). Therefore, perceptions might diverge, and results cannot be generalized as they would differ between cities with a strong cycling tradition and emerging cycling cities or car-dependent locations.

5.1. Implications for policy and practice

Our findings contribute to a better understanding of e-MM as a rapidly growing urban phenomenon and suggest that planners and policymakers should integrate sociopsychological factors in their attempts to manage e-MM. If city officials want to encourage e-MM use as a cleaner alternative they should emphasize the positive benefits that individuals associate with e-MM which, according to our results, are speed, convenience, easy driving, flexibility, accessibility, health, enjoyment, social status, and innovation while at the same time lowering concerns regarding safety, security, reliability, and social stigma. Given the importance of being familiar with the new technology for attracting users and the difficulty in breaking already-established travel habits, it would help to provide some type of incentive or trial period that can encourage new users to try e-MM for the first time. For instance, cities such as Christchurch (in New Zealand) and Dallas (TX) implemented trial periods before introducing e-scooters permanently (Gössling, 2020b). A study in the Netherlands that included e-bike monetary incentive programs, showed how these programs can be very effective tools when targeting specific groups such as car commuters (de Kruijf et al., 2018). The same results were found by a study in Switzerland, offering free e-bike trials for two weeks (Moser et al., 2018). Further, as monetary cost has been identified by this review to be a critical factor, policy level interventions such as tax rebates or subsidies should be considered to encourage e-MM purchase, and to highlight the affordability of these modes of transport. Economic incentives for e-bike purchase and use have been offered in numerous European countries (Austria, Belgium, France, Germany, Italy, the Netherlands, Spain), for several years (Newson and Sloman, 2019). A study in Oslo demonstrated how basic financial incentives can contribute to boost e-bike adoption even when they are not targeting any specific population group (Sundfør and Fyhri, 2022). In New Zealand, e-bike purchase incentives were launched in 2019, performing strongly and showing how individuals perceived these schemes as relevant and promising (Kotahi Transport Agency WN, 2022).

However, cities and public officials should first have a clear discussion on the benefits and threats that incorporating e-MM into a large transport system might entail. As stated by Latinopoulos, as a result of a study carried in Paris, there is a clear need for collaboration between local authorities and operators when deploying e-scooters and integrating them with public transport and other active modes (Latinopoulos et al., 2021), which can be applied to the whole e-MM system. In particular, safety concerns remain in regards to e-MM along with the potential negative impacts on health and the environment when e-MM is used to replace active commuting (De Ceunynck et al., 2021). Also, e-MM usage is supported by proper dedicated infrastructure, therefore, improvements are required including more dedicated lanes, racks, marked parking areas, and charging stations before introducing tailored e-MM-friendly policies. A report from the Institute of Transportation Studies in Berkeley summarizes some of the existent measures to support safe and correct parking of e-MM, especially e-scooters, including corrals or designated parking spaces, restricted sidewalk parking, and geofencing (virtual geographic boundary around an area)[222]. There is also the need for policies to establish a clear legal framework for e-MM use that prevent conflicts with other road users. Transparent and clear enforcement of established rules is also necessary to avoid conflicts and ensure a safe co-existence and appropriate public space allocation and usage.

On the manufacturers side, they should consider the relevance given by users to environmental concerns and product performance. Improving battery capacities and generally improving the life cycle of e-MM vehicles, and reducing the environmental footprint related to the manufacturing and disposal of vehicles and batteries should be a priority, as findings from recent studies suggest that in general e-scooters have a more negative life cycle impact on the environment that the modes they most often replace (Hollingsworth et al., 2019b). In China, government supported clustering of e-bike manufacturing, which accelerated the R&D of the innovation, which exemplifies how collaboration could result on these needed improvements (Ruan et al., 2014). From the companies' side, some are developing better software to make e-scooters last longer and to prevent safety issues such as problems with batteries (Reinhardt et al., 2020). At the institutional level, schemes for battery recycling, treatment, and disposal should also be considered. We found there exist a variety of measures with the aim to reduce this negative environmental impact that e-scooters present. In Germany, government pushes towards a system of swappable batteries for operators, with the goal to reduce pollution generated by vehicles dedicated to charging the e-scooters[222].

6. Limitations and future research

This review provided valuable results for interventions aiming to encourage e-MM adoption and usage but is not without limitations. Firstly, the review does not include communication and social media publications which may have contributed some valuable information had they been consulted, especially regarding the latest information on e-micromobility. Second, the majority of the reviewed studies were conducted in European countries, followed by the United States, Canada, and the United Kingdom, which can bias some of the observed trends. Third, the extraction data process that was followed may result in some biases, as some of the studies used more than one analysis, but only the comprehensive results aligned with the research focus were selected and summarized.

In terms of future research, it would be necessary to focus on the factors determining the adoption and usage of specific types of e-MM modes, as opposed to study them as a group, as they can present distinct characteristics that may affect these decisions. Also, these vehicles are sometimes used in combination with other modes, therefore this line of research could also provide new insights on the main social and psychological determinants affecting this mode of usage. In the same line of reasoning, other e-MM modes not included in this review such as hoverboards, segways and e-skateboards could be explored, as even today their usage is limited to some population segments and geographical contexts, they have potential to gain importance in the near future. On the other hand, cultural differences can be incorporated in future studies, as well as considering the characteristics that determine the different geographical regions where e-MM are used, and how local transport cultures affect the adoption (e.g., between driving- and cycling- oriented countries). Finally, the perceived positive and negative factors can also be affected by the destination or type of trip (e.g., commuting, leisure, care).

7. Conclusion

This review has focused on the sociopsychological determinants of e-MM use and adoption by analysing the role of functional and non-functional factors in explaining modal shift towards e-MM options. We conducted a literature search in four different databases, following the PRISMA guidelines and found a total of 67 studies. Our review demonstrates that users are motivated by a number of factors beyond just monetary costs, or other functional aspects. Rather, most of the reviewed studies highlight the importance of more symbolic factors in association with personal perceptions, self-identity, sense of belongingness, and pro-environmental attitudes. Our findings demonstrate that individuals perceive these services as being socially positive, contributing to improved liveability, equity of access, and diversity of choice. Out of all the analyzed factors, safety and the lack of reliability were the two only issues discouraging the adoption of e-MM.

CRediT authorship contribution statement

Alexandra Bretones: Conceptualization, Methodology, Validation, Investigation, Resources, Writing - Original Draft, Visualization, Oriol Marquet: Conceptualization, Methodology, Validation, Resources, Writing - Review & Editing, Supervision, Project Administration, All authors have read and agreed to the published version of the manuscript.

Data availability

No data was used for the research described in the article.

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