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Gender and Mobility – A Literature Review on Women's (Non-)Use of Shared Mobility Services

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Gender and Mobility – A Literature Review on Women's (Non-)Use of Shared Mobility Services

Research Paper

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Abstract. In the context of the development of smart cities, the number and types of shared mobility solutions, such as carsharing and bikesharing, have increased in recent years. While the services are generally becoming more popular, there are comparatively few women among the users. With a view to gender-equitable mobility, this literature review explores gender-specific reasons for this low use of shared mobility solutions. Based on 35 relevant studies from multiple databases and disciplines, we identified four overarching barriers related to: security, availability, simplicity, and costs. By identifying these barriers and the reasons for them, and by linking them in a self-developed conceptual model with starting points for potential actions to address these issues, this literature review contributes to gender-equitable mobility.

Keywords: shared mobility, smart cities, gender differences, gender equity, literature review

1 Introduction

The development of smart cities is revolutionizing urban planning by using technology and data-driven approaches to improve many aspects of urban life in an efficient and sustainable way, including transportation (Benevolo et al., 2016; Nikitas et al., 2017; Singh, 2019). The integration of advanced information and communication technologies in transportation has given rise to innovative 'smart' mobility solutions, which are recognized as a crucial component in improving the quality of services for all citizens (Giffinger et al., 2007; Orlowski & Romanowska, 2019; Singh, 2019). One of the main smart mobility innovations is shared mobility services (Butler et al., 2020) such as bikesharing, e-scooters, carsharing, and ridesharing, where multiple users share the same transportation options on a pay-per-use basis (Nikitas et al., 2017). Despite the associated potential benefits of creating more sustainable and accessible transportation systems, studies have revealed a considerable gender gap in the adoption and usage of these services. User data shows that across different types of shared mobility, country

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contexts, and providers, the proportion of female users remains consistently low, typically ranging from 20% to 40% (Ramboll Smart Mobility, 2021; Reidl, 2021; Valentiner, 2021).

Previous research on mobility and transportation has shown that gender is an influential variable, affecting transportation mode choice, with significant differences prevailing between women and men (Duchène, 2011; Ramboll Smart Mobility, 2021). Women often have more complex travel patterns, combining multiple routes with short stops in between, for example, to take children to daycare on the way to work or to run other errands. Men are more likely to move linearly from A to B, e.g., to and from work (Gerecht Mobil, n.d.; Ramboll Smart Mobility, 2021). However, due to the fact that decision-making in this sector is conducted almost exclusively by men for decades (Stanković & Nikolić, 2021) with only 22% of workers in the transport sector in Europe being women today (Hortelano et al., 2021), transportation systems and mobility solutions tend to be geared toward the average man and his needs and travel patterns (Ramboll, 2021), not taking gender differences in travel needs and patterns into account (ITF, 2021; Ramboll Smart Mobility, 2021; Women in Mobility, 2022). As a consequence, feminist urban planning has developed as a research field that aims to address the limitations of traditional urban planning. It recognizes the importance of considering the diverse needs and experiences of all individuals regardless of gender, age, and origin and challenges the male-oriented "one size fits all" approach (Majdoub, 2023).

In line with this perspective and in order to design a truly gender-neutral transport sector that is equally accessible to all genders, it is important to examine the reasons for the above-mentioned gap, which may be rooted in different mobility behaviors and needs, as well as gender-specific barriers. Identifying and addressing these points will help to design and enable more equal transportation systems in the present and future. Thus, the goal of this paper is to identify possible causes for the low female usage rate of shared mobility services and to answer the following research question (RQ) and two sub-questions (SQ):

- RQ: Why are women less likely to use shared mobility services?
  - SQ 1: Which gender-specific differences exist in mobility behavior?
  - SQ 2: What barriers do women face when using shared mobility services?

To answer these research questions, a systematic literature review was conducted. Considering the increasing number of publications in past years, this method allows us to thoroughly examine previous research, consequently gaining a broad perspective and valuable insights into our area of interest. Therefore, relevant literature was identified and reviewed according to the works of vom Brocke et al. (2009) and Webster & Watson (2002). The current state of knowledge will be explored to find correlations between mobility use and gender in order to identify possible starting points for bridging the gender mobility gap in shared mobility services.

This paper is structured as follows: Section two establishes a theoretical basis, explaining relevant key terms related to shared mobility. Section three addresses the research methodology and its process. Section four presents the research findings and section five interprets them, pointing out possible links for future research. Finally, in the conclusion, the most important findings are briefly summarized.

2 Theoretical Background

Transportation is a key factor in determining the quality of life (Jiao, 2021). The digital age has created new business models that integrate mobility with technology (Jiao, 2021), starting in the late 1990s with websites that helped drivers and passengers to connect and organize joint trips (Guyader et al., 2021). Driven by the advancement of information and communication technologies and an increased environmental orientation, shared mobility services were developed, which belong to the "sharing economies" and encompass business models that focus on collaborative or shared consumption providing access to goods or services without the costs and environmental impacts associated with personal ownership (Karbaumer & Metz, 2022; Krämer & Bongaerts, 2019). "Shared mobility", the sharing of a vehicle, bicycle, or other modes of transportation, is a growing sector of the sharing economy, where smartphone interactions and intermediary platforms create innovative services and bring user groups together (Jie et al., 2021; Mourey & Köhler, 2017), providing short-term access to transportation on demand (Shaheen, Bansal et al., 2017).

Shared mobility is often found in the context of smart cities as one important topic among other "smart mobility" solutions, such as intelligent transport systems, alternate fuel systems, or driving automation systems (Butler et al., 2020). The smart city concept describes a concept where communication and information technology are used in cities in an intelligent and sustainable way (Wawer et al., 2022), with the overarching goal to improve various sectors such as economy, governance, and mobility, and to enhance citizens' quality of life (Benevolo et al., 2016, Giffinger et al., 2007). However, not all of these smart solutions seem to reach women to the same extent as men (Singh, 2019), considering the gender usage gap mentioned above and the often applied "one size fits all" approach in the mobility sector. This issue has already been recognized by previous research which tries to address these inequalities and promote gender equality within urban environments (e.g. Hudson & Rönnblom, 2020; Ortiz Escalante & Gutiérrez Valdivia, 2015, Singh, 2019), including transportation. By adopting a feminist, gender-neutral, perspective on urban planning, smart cities should be designed in an inclusive, safe, and accessible way for everyone (Hudson & Rönnblom, 2020; Majdoub, 2023; Singh, 2019).

Smart mobility, as one of the most important aspects of smart cities (Benevolo et al., 2016), and shared mobility, as one aspect of smart mobility, thus play a fundamental role in improving the lives of women and other underrepresented groups in the context of feminist urban planning (Singh, 2019; Zehba & Firoz, 2022), but the use of these transportation options is still limited compared to men (Reidl, 2021; Valentiner, 2021; Ramboll Smart Mobility, 2021). In order to explore the reasons for women's lower use of shared mobility services, it is important to first have an understanding of the different forms of shared mobility.

Two overarching forms of shared mobility can be distinguished: "vehicle sharing" and "trip sharing" (Karbaumer & Metz, 2022; Shaheen, Bansal et al., 2017). "Vehicle sharing" includes carsharing and shared micromobility (Karbaumer & Metz, 2022). Ridesharing and on-demand ride services fall under the umbrella term "trip sharing"

(Karbaumer & Metz, 2022). There are numerous forms and characteristics for the respective forms of shared mobility. To facilitate understanding, the different forms of shared mobility solutions have been summarized in Figure 1, with the shared mobility types focused on in the analysis marked in bold.

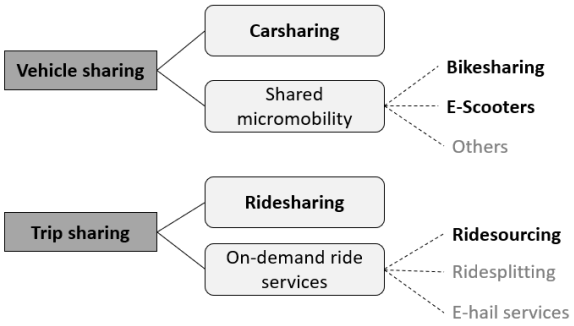

Figure 1: Forms of shared mobility [based on Karbaumer & Metz, 2022]

Carsharing allows the use of locally available cars for any period of time (Karbaumer & Metz, 2022). The vehicles are owned by a provider and payment is usually per hour and per kilometer (Karbaumer & Metz, 2022; Krauss et al., 2021). The use of small vehicles, such as bicycles, scooters, and mopeds, powered by muscle power or electricity, falls under "*shared micromobility*" (Karbaumer & Metz, 2022). Such offerings include for example bikesharing, scootersharing, and mopedsharing (Karbaumer & Metz, 2022). They are freely accessible in public spaces, can be unlocked and locked via smartphone at the beginning and the end of the ride, and billing is usually per minute (Krauss et al., 2021). For vehicle sharing, further distinctions can be made regarding the usage specifications, e.g., whether the vehicles have to be picked up and returned at the same place (roundtrip) or whether the return location expands to a specific operating zone defined by the provider (one-way) (Karbaumer & Metz, 2022; Shaheen, Bansal et al., 2017).

Through *Ridesharing*, several people share a single vehicle. The start and end destinations are recorded within the intermediary platform or app and passengers agree on a pick-up location before the trip begins (Karbaumer & Metz, 2022). In contrast to such formal ridesharing models that connect services and user groups via a platform, ridesharing services can also be created through own networks (informal ridesharing model). The latter ones are, however, not part of our analysis. *On-demand ride services* differ from ridesharing in that the driver acts as the chauffeur; the driver and passenger do not share a common start and end destination (Shaheen, Bansal et al., 2017; Weber, 2020). This includes the following models: ridesourcing, ridesplitting, and e-hail services (Karbaumer & Metz, 2022; Shaheen, Bansal et al., 2017). *Ridesourcing* providers, also called "ride hailing" and "ride booking", use online platforms to match passengers in need of a ride with a private driver (Shaheen, Bansal et al., 2017). Drivers typically work on a freelance basis, they are not directly employed by the service provider and are not licensed cab drivers (Karbaumer & Metz, 2022). Compared to traditional cabs, operators of ridesourcing companies are not bound to regulated fares and payments are

cashless via an app (Weber, 2020). Ridesourcing services offer various vehicles, such as vehicles with car seats, wheelchair-accessible vehicles, SUVs, etc. (Shaheen, Bansal et al., 2017). These include providers such as "Uber" and "Lyft". *Ridesplitting* is a further development of the ridesourcing concept, where users with similar origins and destinations are assigned a ride in real-time (Karbaumer & Metz, 2022). The trip and trip costs are shared amongst the users (Shaheen, Bansal et al., 2017). Ridesplitting services are operated by ridesourcing companies, such as "Uber-POOL" and "Lyft Line". Due to competition from ridesourcing providers, cab services have developed so-called "*e-hail services*" (Shaheen, Bansal et al., 2017), which are operated either by a cab company or a third party. This allows travelers to book a cab electronically through a service app (Shaheen, Bansal et al., 2017), such as "taxi.eu" and "Bolt" (Karbaumer & Metz, 2022).

3 Methodology

As the aim of this paper is to identify possible causes for the low female usage rate of shared mobility services, a systematic literature review was conducted to summarize the current state of research on this topic and to find possible starting points for gender equitable mobility. We followed the approach of vom Brocke et al. (2009), which requires rigorous documentation and presentation of the literature review and search process by applying five sequential steps.

In the first step, the scope of the literature review was defined. In our study, the focus of this paper was on empirical findings (research outcomes) and concepts. The aim of the literature analysis was to analyze the results of various studies on gender-specific differences in mobility behavior and gender-specific mobility requirements and to synthesize the existing results and theoretical approaches to the given research question. The selection of literature was based on predefined selection criteria. The literature to be examined was presented conceptually and viewed from a neutral position. This work can be relevant for general scholars as well as for practitioners. The conceptualization of the topic (step two) was conducted as part of the theoretical background section by providing an overview of shared mobility and thus enabling a common understanding of the relevant concepts. The approach to the literature search and analysis (steps three & four) is explained within this section. The results were then classified and presented using a concept matrix according to Webster & Watson (2002), which ensures reusability. Possible starting points or questions for future research (step five) are discussed in the fifth section.

To optimize the search process and find sources containing all specified search terms, we used the advanced search function and the boolean operators "AND" and "OR". Key terms were enclosed in quotation marks to search for groups of words and exact matches. Depending on the database, the search strings had to be partially adjusted. The literature search was limited to the period 2017-2022 in order to collect the most recent data in a rapidly evolving sector, but at the same time not to limit the results too much. Due to the background of the authors, English and German literature was

considered. Thus, we searched the selected databases (see Figure 2) for the following two search strings that should appear in the abstract:

- "shared mobility" OR "transport" AND "gender" for English literature
- "shared mobility" OR "geteilte mobilität" AND "geschlecht" for German literature

The literature databases and the selection of relevant publications are presented in Figure 2.

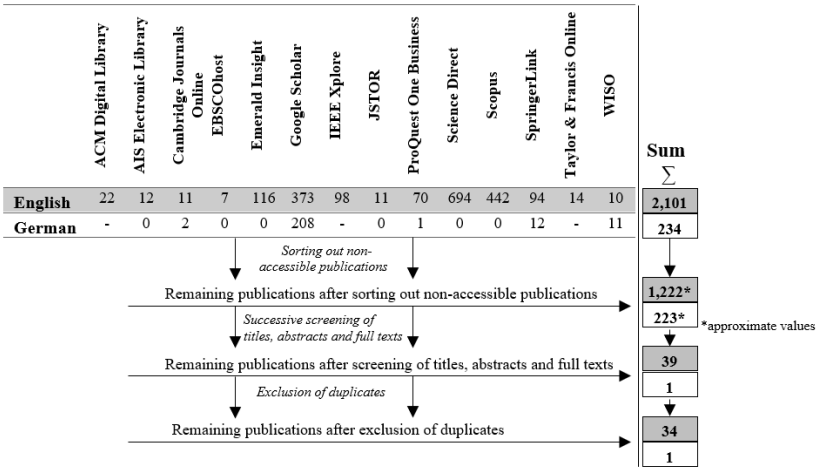

Figure 2: Selection of relevant publications [own representation]

Three of the examined databases did not support German literature (see databases with "-"). Some results had to be excluded due to a lack of accessibility, which reduced the number of sources that we analyzed for content. In two databases this restriction was not clearly determinable, so the values with the * can only be understood as approximate values. The total number of the remaining literature decreased due to the lack of relevance to the research question. Search results were sorted out sequentially, first based on the title, then by reading the abstract. In the English search string, "transport" was included as a search term to ensure that literature where the authors may not explicitly use the term "shared mobility", but (in part) discuss this type of mobility, could be found. As expected, this also resulted in many irrelevant search hits, which were therefore excluded (e.g., men and women were asked about mobility, e.g., women's opinion on using public transportation during Covid-19). All papers with relevant abstracts were subjected to a full-text screening, leaving 40 sources. After removing five duplicates, a total of 34 English sources and one German source remained. Some of the identified sources did not specifically focus on shared mobility, but their concepts could nevertheless still be applied to shared mobility (e.g., the lack of bicycle infrastructure or street lights in public spaces also affects the use of bikesharing services). Our final dataset includes studies from different countries and continents, as there were no cultural or country-based exclusion criteria. In the next step, the relevant sources were analyzed for their content and structured using a concept matrix (see Table 1) based on their answers to the research questions.

4 Results

Our systematic literature review shows that gender differences in shared mobility are already being recognized and studied. Of the 35 references considered, 27 were published within the last three years and only 8 are from 2017 and 2019, highlighting the growing importance of this research field. The results of the literature review are presented in an overarching concept matrix (see Table 1). The 35 sources are numbered as in the reference list. The first major column 'Focus' shows which types of shared mobility and/or whether general shared mobility was discussed in the paper. In addition, the specific types of shared mobility were numbered with superscripts (Carsharing[1], Bikesharing[2], E-Scooters[3], Ridesharing[4], Ridesourcing[5]) to enable a more precise analysis with regard to SQ2. The second column refers to SQ1, i.e., an examination of the female-specific characteristics in mobility behavior found in the literature. Here, an 'x' has been inserted, when a specific category is mentioned by a reference. The third column shows the barriers preventing women from using shared mobility services (SQ2), which are also marked with an 'x'. In order to provide a more detailed overview and to be able to better derive practical implications in the discussion, we additionally marked when certain barriers were mentioned in relation to a specific type of shared mobility (e.g. for reference 5, the barrier 'transport choice' was mentioned in relation to bikesharing and the barrier 'affordability' in relation to ridesourcing). The last row of the concept matrix shows the sum of how many references are mentioned in each of the categories.

The differences found in the mobility behavior of men and women are mainly ascribed to the prevailing gender roles and lead to different travel patterns (e.g., Oviedo et al., 2020; Singh, 2019). Almost half of the publications highlighted the still rather traditional role distribution, with women more often taking on domestic or caring roles, as opposed to men taking on the role of the breadwinner (Oviedo et al., 2020). The prevalence of feminine constructions was also evident in the literature, where cultural expectations of women and "feminine" behavior were mentioned (Carboni et al., 2021, p. 3; Wild et al., 2021, p. 7). These distinct gender roles seem to shape the mobility behavior between men and women (Lecompte & Bocarejo S., 2017; Singh, 2019), making women's travel behavior more complex due to different responsibilities and work roles (AitBihiOuali & Klingen, 2022). Women are more likely to work part-time due to family obligations or responsibilities and are more likely to be responsible for housework, children, and elderly relatives (Hortelano et al., 2021; Ramboll Smart Mobility, 2021). As a result, they are also more likely to have luggage, children, or other passengers with them (Ramboll Smart Mobility, 2021). One study shows that women make twice as many trips for domestic tasks, such as taking children to school, compared to men (Hortelano et al., 2021).

The imbalance of domestic tasks puts a strain on women's time budgets: They travel shorter distances, drive less, use public transportation more often, walk more often, travel during off-peak hours, and resort to trip chaining (adding several short stops along their journey) (Ramboll Smart Mobility, 2021; Singh, 2019).

Table 1: Concept Matrix: State of research on gender differences in shared mobility services [own representation]

	Focus						**Mobility behavior (SQ1)**						**Barriers (SQ2)**										
							Travel characteristics			**Role characteristics**			**Security**				**Availability**			**Simplicity**		**Costs**	
	Carsharing[1]	Bikesharing[2]	E-Scooters[3]	Ridesharing[4]	Ridesourcing[5]	General shared mobility	Short distances	Trip chaining	Walking	Caregiver	Part-time	Feminine constructions	Transport options	Street lighting	Ergonomics	Gender preferences	Lacking infrastructure	Parking zone	Coverage	Registration	Digital skills	High costs for families	Affordability
[1]		x					x	x		x			x^{2}				x^{2}						
[2]		x										x	x^{2}		x^{2}		x^{2}						
[3]						x																	
[4]						x	x							x									
[5]		x			x	x				x			x^{2}										x^{5}
[6]						x															x		x
[7]		x	x										$x^{2,3}$		$x^{2,3}$		$x^{2,3}$						
[8]		x															x^{2}			x^{2}			
[9]						x															x		
[10]			x							x		x	x^{3}	x^{3}	x^{3}		x^{3}	x^{3}	x^{3}	x^{3}	x^{3}		
[11]		x				x	x	x			x		x^{2}							x	x		x
[12]						x																	
[13]		x				x	x	x		x			x^{2}										
[14]						x	x	x		x	x												x
[15]		x				x	x	x		x						x^{5}			x^{2}				
[16]				x												x^{4}							
[17]						x				x				x			x		x		x		
[18]	x	x	x	x													$x^{1,2,3,4}$						
[19]		x				x		x		x			x^{2}									x^{2}	x^{2}
[20]	x					x				x			x^{1}						x^{1}			x^{1}	
[21]						x		x	x	x													
[22]		x								x				x^{2}									
[23]	x	x		x	x											$x^{1,4,5}$							
[24]						x	x	x	x	x				x								x	x
[25]			x			x								x			x^{3}						
[26]						x	x	x	x	x													
[27]		x				x	x	x		x		x		x^{2}	x^{2}		x^{2}						
[28]	x	x	x	x	x	x	x	x	x	x	x		x^{2}	x		x^{2}	$x^{1,2}$					$x^{1,4,5}$	x^{1}
[29]						x	x		x														
[30]			x										x^{3}		x^{3}		x^{3}			x^{3}			
[31]	x	x				x											$x^{2,5}$	x^{2}	x		x^{1}		$x^{1,5}$
[32]	x	x				x	x	x	x	x	x		$x^{1,2}$										$x^{1,2}$
[33]			x											x^{3}			x^{3}						x^{3}
[34]	x	x																$x^{1,2}$	$x^{1,2}$				
[35]		x										x					x^{2}						
∑	**7**	**18**	**7**	**4**	**5**	**22**	**12**	**12**	**6**	**16**	**4**	**4**	**12**	**9**	**5**	**4**	**14**	**3**	**6**	**4**	**7**	**4**	**10**

Men, on the other hand, tend to travel longer distances and primarily travel for work-related activities (Lenz et al., 2019), and are more likely to exhibit a linear travel pattern from A to B (Ramboll Smart Mobility, 2021). Research shows that women are more likely to work closer to home and thus travel shorter distances to work (Nasrin & Bunker, 2021; Singh, 2019). For example, women were found to be twice as likely to walk to work (28%) as men (14%) (Singh, 2019).

In a second step, the publications were examined for gender-specific barriers that (may) lead to a gender imbalance in the use of shared mobility services. During the analysis of the relevant literature, four factors emerged that influence people's mobility decisions and behavior, namely: security (i.e., how safe one feels when using the vehicle), availability (i.e., how accessible and flexible the mode of transportation is at the time of need), simplicity (i.e., the ease of use), and costs (i.e., what costs incur). For this reason, it seemed useful to analyze the literature with regard to these four factors and to classify the barriers mentioned in this way. Therefore, the barriers were first recorded individually and then grouped into the four overarching categories (see Table 1).

Women tend to be more concerned about security than men (Levin, 2019; Meyer & Shaheen, 2017). Security is a high priority when choosing a mode of transportation, especially at night or in remote locations (Haddad et al., 2022). Fear of assault and harassment strongly influences the route and transportation choices: For example, women often opt for longer routes if they perceive them to be safer or better lit at night (Cassitas Hino & Cunha, 2021; Parnell et al., 2022). Considering this, and the sometimes long time it takes to unlock bikesharing bikes and e-scooters, the lack of street lighting at their stations is considered a barrier resulting in the non-use of such services (Haddad et al., 2022; Meyer & Shaheen, 2017). While one of the main security-related barriers of micromobility solutions tends to relate to the fact that women are alone when using them, further barriers arise even in a more social setting, as seen with ridesourcing and ridesharing. Here, in both cases, women are in an enclosed vehicle with another person, typically a stranger (Nagy & Csiszár, 2022). Particularly, the lack of the option to specify gender preferences was identified as a reason for the low female usage rate. Women prefer female drivers, however, only 5% of ridesourcing drivers are women (ITF, 2021).

One barrier that has been mentioned in relation to all types of shared mobility services is the limited transportation and carrying capacity (12 mentions). While bikesharing and e-scooters are generally not suitable for carrying children, additional passengers, strollers, or luggage/food (Ramboll Smart Mobility, 2021), shared mobility services as a whole typically lack child seats and there is no way to check via the app whether the vehicles are equipped with them (lack of availability and convenience) (Carboni et al., 2021; Lenz et al., 2019; Ramboll Smart Mobility, 2021). Lastly, the rather masculine-oriented design of the transport services was mentioned, especially in relation to bikesharing and e-scooters. For example, women perceive the weight of the vehicle as very heavy, thus making it difficult to move and maneuver, resulting in a lack of security (Haddad et al., 2022). In addition, parts of the female wardrobe (e.g., dresses or high heels) are rather impractical and risky for the use of certain shared mobility solutions (Haddad et al., 2022).

A second type of barrier is the availability and convenience of transport services and it is in part connected to security issues. Women are more risk averse; they perceive a significantly higher risk of being run over by a car while cycling (AitBihiOuali & Klingen, 2022) and express fear of running over pedestrians or being hit by other drivers when riding e-scooters (Nathanail et al., 2021). The high speed of e-scooters, coupled with the lack of helmets, and riding on the sidewalk or sharing traffic with cars and bikes, is viewed negatively (Nathanail et al., 2021). As can be seen in Table 1, the lack of infrastructure was the most frequently mentioned issue (14 mentions), especially for bikesharing. Women are less likely than men to bike when there is no or poor bike infrastructure (Ramboll Smart Mobility, 2021). The limitation of carsharing and micromobility in zoned areas is another barrier. If stations are full at the end of the trip, users must travel to more distant stations to drop off the vehicle (Shaheen, Bell et al., 2017; Wang et al., 2020). In addition, such mobility services are largely limited to central urban areas (lack of availability) (Lenz et al., 2019). These two aspects lead users to rely on other modes of transportation for the first and last mile, if necessary (Shaheen, Bell et al., 2017), making the trips less convenient.

A third type of barrier is related to the perceived simplicity of using shared mobility, which was the least frequently mentioned. First, the complex and time-consuming registration process for micromobility solutions is seen as a barrier. Registration usually takes three to five minutes and requires a lot of information such as name, address, phone number, and bank details (Fan et al., 2019). Technical problems, such as system errors and failures, require re-registration (Fan et al., 2019). Also, the multitude of operators, all running their own app, creates confusion and can be overwhelming (Shaheen, Bell et al., 2017). Overall, the use of car sharing and micromobility solutions requires digital skills, such as extensive knowledge of how to use a smartphone and location-based services (Durand et al., 2022) and knowledge regarding cashless payment systems with access to bank and credit cards (Golub et al., 2022). This primarily excludes people with low incomes and lower digital literacy (Golub et al., 2022), which comparatively affects women more often than men (Singh, 2019).

Lastly, the cost of technology and shared mobility solutions can be seen as a barrier. Since women are more likely to work part-time, they are more dependent on the affordability of transportation (Hail & McQuaid, 2021), and research shows that women primarily use low-cost modes of transportation such as walking or public transit (Ramboll Smart Mobility, 2021; Singh, 2019). However, micromobility, carsharing, and ridesourcing services are not considered easily affordable modes of transportation (Chowdhury, 2019; Ramboll Smart Mobility, 2021), which is reflected in the fact that this barrier is mentioned 10 times. Ridesharing services are especially costly for families since they charge per person and do not offer family tickets (Ramboll Smart Mobility, 2021). This aspect is mainly prevalent for households with many children.

5 Discussion

From our literature review, we derived a conceptual model (see Figure 3) that provides an overview of the conditions and barriers found as explained in section four. However,

understanding and recognizing the gender-specific barriers and requirements is only the first step toward gender-equitable mobility. A logical next step would now be to put this knowledge into practice by developing and testing possible solutions. Therefore, the third building block of our conceptual model is *Actions*.

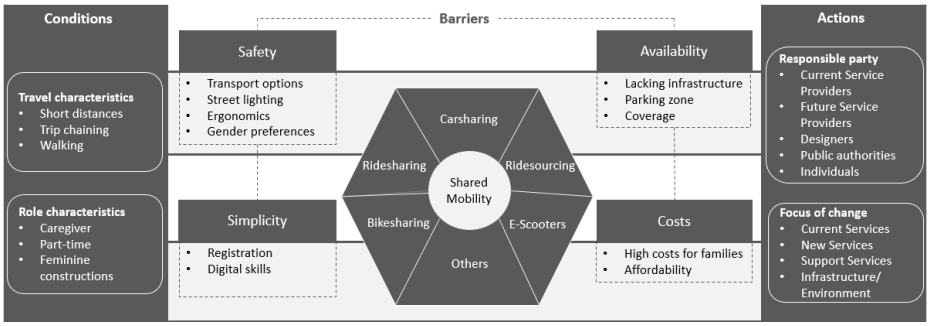

Figure 3: Conceptual model for achieving gender-equitable shared mobility services [own representation]

Based on our findings, it is now up to various parties in the transportation sector to develop solutions to the existing and perceived barriers in order to make shared mobility more inclusive and the smart city concept more equitable. Clearly, some issues are easier to address than others, and the responsibility is distributed among service providers, developers, public authorities, individual users, and so forth. Involving women in the design and development of shared mobility solutions, as well as early attempts and initiatives by service providers, can already be seen in practice. They show that the approaches can differ in nature by either making existing solutions more gender-equitable for women or by creating new gender-specific solutions. In the case of e-scooters, for example, the provider TIER found that women would feel more comfortable riding at night if certain product features and vehicle adaptations were provided (e.g., alarms on the vehicle or in the app, the ability to share their route with family and friends, etc.) (TIER, 2022). In contrast, the North American ridesourcing company "Wilma"[1] has only female drivers, thus directly addressing a second security-related barrier. An additional approach would be to make the job of a driver more attractive to women and, from the user's perspective, to be able to select a female driver in the app (ITF, 2021).

With regard to the often-mentioned barriers lacking infrastructure and street lighting (see Table 1), the municipality or local government plays an important role, as it is responsible for a city's infrastructure, transportation planning, and parking policy (Shaheen et al., 2016). Here, a collaboration with the service providers could be useful to jointly address some of the security and infrastructural barriers. Another possible solution would be the implementation of car-free spaces, as non-users wish for separate paths and the opportunity to familiarize themselves with the modes of transport before using them (Haddad et al., 2022). Other barriers are related to the characteristics of the transport mode, such as the limited carrying capacity of shared bikes. Here, providers

[1] Company website: https://getwilma.app/

could try to develop special offers (e.g., tandems) with extra space for objects or a second seat for children, for example.

Limitations to the validity of our findings result from the restriction of the literature search to 14 databases in the years 2017-2022, as well as the restriction by the selected search words in the two languages German and English. Furthermore, our findings regarding 'gender-specific' barriers and 'feminine' mobility behavior must be viewed with caution, as women are not a homogeneous group. For example, the lack of child seats is unlikely to be a barrier for women without young children, and the complex registration process may be more of a barrier for older women than for younger tech-savvy women. In addition, the country and cultural context also needs to be taken into account in a more in-depth analysis, as the various barriers that we identified based on papers across different continents may be weighted differently in different countries (e.g. Nasrin & Bunker (2021) highlighting harassment – i.e., a security barrier – specifically for India), which will influence the actions to be derived. A more differentiated approach is therefore needed, taking into account different mobility patterns and usage requirements and identifying and addressing the specific barriers for different groups of potential female users across the globe. Therefore, we encourage researchers to use, validate and expand our conceptual model in its entirety including conditions, barriers, and actions in different (cultural) contexts for other sociodemographic groups beyond women, such as the older generation. Furthermore, our detailed breakdown in the concept matrix shows that some types of shared mobility solutions have been studied differently in the literature and that barriers seem to be more or less important for each type. Further research is needed to assess these differences in more detail. Since our literature review primarily yielded results for the first two aspects of our conceptual model (i.e., conditions and barriers), focusing on the implementation of certain solutions might provide interesting insights. In this sense, the model can also be used by practitioners to gain in-depth knowledge and to create a more (gender-)inclusive mobility sector.

6 Conclusion

The aim of this systematic literature review was to identify barriers to the low female usage rate of shared mobility services. Our literature search in 14 databases yielded 35 relevant papers that were published between 2017-2022. Our literature analysis identified gender-specific differences in mobility behavior and four different types of barriers that prevent women from using shared mobility solutions. These barriers are related to security (e.g., sharing a car with strangers), availability (e.g., restricted drop-off zones), simplicity (e.g., complex registration processes), and costs (e.g., high costs of use). In part, the limiting effects of these barriers can be attributed to differences in travel behavior between men and women, which in turn can be attributed to prevailing gender roles and the unequal distribution of household responsibilities that still exist to some extent. Understanding and recognizing these barriers can be a starting point for making shared mobility services more gender equitable and increasing their usage amongst women.

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