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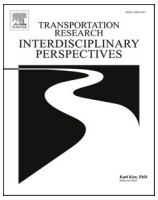
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A review of the socio-demographic characteristics affecting the demand for different car-sharing operational schemes

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ABSTRACT

In this paper, socio-demographic factors influencing the demand for different car-sharing forms are examined. An in-depth review of such factors is provided based on the type of shared car service, geographic area, and specific travel demand aspect being considered. Conclusions highlight the differences between car sharing operational schemes. The number of males, young individuals, and people with above-average income among free-floating members is higher than in other car-sharing services. Also, although round-trip car-sharing users appear to be less educated than other car-sharing services users, car-sharing members may follow a more efficient and sustainable lifestyle than the one-way shared car system members. Besides, some suggestions are recommended for future studies. A research gap has been identified regarding the direction of causation between vehicle ownership levels and car-sharing demand. Most studies have worked on the impact of vehicle ownership on car-sharing or simply noted a correlation between the two. However, clarifying any reverse effect would help in better assessing the sustainability of car-sharing services. This overview can guide policymakers, planners, and other stakeholders to enhance the car-sharing program's effectiveness and opt for the best kind of service according to their goals.

Introduction

Attitudes toward urban transportation have changed in recent times. Initially, the rising personal vehicles usage in developed countries provided more access. However, it has led to negative externalities, like pollution and excessive consumption of time and energy because of traffic congestion in the long run. This is significantly more likely to occur in cities where usage is concentrated during rush hours (Jorge and Correia, 2013). The transportation market is, however, changing. It provides new opportunities to offer more flexible, efficient, and responsive solutions, such as shared mobility modes. In particular, car-sharing consists of a medium or small fleet of cars offered in a number of locations that a relatively large group of individuals can use. According to Shaheen et al. (2015), a car-sharing service offers short-term accessibility to a car for users since a third-party organization maintains, operates, and ensures the vehicles. In a car-sharing system, users can book a car with their smartphones or easily pick it up on the street.

Car-sharing is a mode of transport, and it combines the affordable cost of traditional public transit and the freedom of a private vehicle (Uteng et al., 2019). It can also offer privacy and flexibility as a private car without the disadvantages of public transportation (Clewlow, 2016; Zhou and Kockelman, 2011), and it occurs without incurring direct costs such as maintenance and repair costs (Hua et al., 2019; Jones and Leibowicz, 2019). Car-sharing can decrease car ownership (Lempert et al., 2019) and the personal cars needed to meet the demand for the entire trip (Morency et al., 2015). Therefore, it increases public space availability (Lagadic et al., 2019). Also, it reduces urban traffic jams (Lee et al., 2016). Furthermore, shared car fleets have lower than average emission levels (Catalano et al., 2008).

One element that is sometimes not enough considered by researchers in this area is that the car-sharing concept encompasses a range of different services, each one with different impacts on transport systems and different implications from a policy viewpoint. Car-sharing business models can include four groups: Peer-to-Peer (P2P), Business-to-Business (B2B), Business-to-Customer (B2C), and Business to Government (B2G) (Shaheen et al., 2019). In P2P service, people can rent their vehicles to other people if they do not use them (Balac et al., 2015; Li et al., 2018; Shaheen and Cohen, 2020). As of 2017, In North America, 2.9 million people shared 131,336 cars within the framework of a P2P service (Shaheen et al., 2019). B2B is another type of car-sharing in which the companies' employees are service members. The company or a third-party operator owns and/or manages the fleet.

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In B2C systems, the operators offer it to the people (Lagadic et al., 2019). This service can be one-way or round-trip (Le Vine et al., 2014; Lempert et al., 2019; Namazu and Dowlatabadi, 2018). In 2016, there were around 4.7 million one-way and 10.3 million round-trip service members worldwide (Shaheen et al., 2019). The round-trip or Two-way system encompasses home zone-based and station-based (Efthymiou and Antoniou, 2016). In round-trip station-based services, people pick-up the car and return it to the same parking lot (Del Mar Alonso-Almeida, 2019; Ferrero et al., 2018); whereas, in the round-trip Home Zone-based system, users pick-up the car and drop-off it in the same urban zone (Firnkorn and Shaheen, 2016). The point-to-point or one-way shared car is either a free-floating service or a station-based one (Martin and Shaheen, 2016). The one-way station-based service allows people to return the car to another car-sharing station different from where the car was picked up (Guirao et al., 2018; Shaheen and Cohen, 2013). In free-floating programs, people can pick up the vehicle and drop it off at any place in the service zone (Becker et al., 2017a, 2017b, 2018).

Finally, in a B2G model, car-sharing operators provide transportation services to a government agency. Pricing may include different pricing models, such as the per-transaction cost or a fee-for-service contract. It is important to note that B2G car-sharing services are usually offered by B2C service operators (Shaheen et al., 2019). Also, since the B2G model is rarely considered in the literature compared to other business models, it is not reviewed in this study.

This article reviews research on car-sharing and investigates socio-demographic characteristics' impacts on car-sharing demand. Socio-demographics refer to a combination of social and demographic factors that define individuals in a particular group or population. These different social and demographic characteristics can help understand group members' commonalities (Burghard and Dütschke, 2019). The importance of sociodemographic factors is that they can be considered key drivers of mobility patterns and travel modes and can ascertain the diffusion of car-sharing services in the urban population (Prieto et al., 2017). Generally, a proper understanding of key demographic factors may help increase the diffusion of car-sharing services (Millard-Ball, 2005). Focusing on the effect of users' sociodemographic factors on the choices of different car-sharing operational schemes can help offer suggestions for the planning and increasing demand for car-sharing operational schemes.

The main socio-demographic factors mentioned in the literature and considered in this study include gender, age, educational level, occupation and economic status, household size, marital status, presence of children, and vehicle ownership status. These are, in fact, the most frequently investigated characteristics in the reviewed literature. Factors influencing the demand for car-sharing according to geographical areas and car-sharing service type are presented in tables in the related sections with a comparative assessment. This paper aims to compile the socio-demographic factors influencing the travel demand in car-sharing to provide suggestions to researchers and planners that can be utilized in their research and contribute to car-sharing literature.

Previous work and methodology of the review

This paper proposes a review of the socio-demographic factors that can affect the demand for different car-sharing forms. Previous work has already reviewed these factors. Jorge and Correia (2013) examined research that developed models to describe car-sharing demand, and they also focused on solving the problem of vehicle imbalance. Ferrero et al. (2018) categorized the research, identified mainstream, and studied trends and perspectives. Illgen and Höck (2019) reviewed the papers that had provided solutions to car-sharing relocation problems in the networks. Besides, Liao and Correia (2020) reviewed the publications that focused on demand estimation, use patterns, and potential impacts of Electric Car-Sharing (E-Car-Sharing). Unlike many previous studies that often did not explicitly consider different car-sharing variants, it is explicitly acknowledged that the operational scheme can profoundly impact the targeted travel demand segment. Therefore, an effort is made in the following analysis to distinguish the impacts of passengers' socio-demographic characteristics on different shared car schemes.

The following are the steps taken in this study to complete the review, mainly based on the method presented in similar studies (Akter et al., 2021; Eren and Uz, 2020; Nguyen et al., 2021; Rand and Fleming, 2019; Sadri et al., 2021). For a review, four databases, including Google Scholar, TRID (https://trid.trb.org/), Scopus, and Web of Science, were used to evaluate recent papers on the car-sharing system according to a keywords-based process. During this process, no lower bounds on the publication date of reviewed papers are considered. The upper bound is December 22, 2020.

Several searches are performed in the mentioned databases by combining the keywords related to shared car systems like socio-demographic characteristics, demand for car-sharing, and car-sharing programs. These keywords were combined to form the set of strings used in the search, as listed by rows in Table 1.

For each keyword, the title of the first 100 articles (if any) of each database was reviewed, totaling 1979 articles. As indicated in Table 1, 499 articles were selected based on titles that, at first glance, seemed relevant to the purpose of the study. After eliminating duplicates (354 articles), 145 articles remained. An additional set of 23 articles was reviewed, including articles cited in the articles obtained by keywords, articles selected based on the authors' knowledge, and articles used to explain the methodology of this article. These additional articles were not among the 499 articles because they did not contain the above-mentioned keywords. Therefore, this initial pool of published papers consisted of $145 + 23 = 168$ articles.

This pool was then scanned to select those focusing on different car-sharing systems' features and important factors influencing the service demand. Hence, 64 articles were not considered in this study since they mainly covered topics such as the benefits of the shared car, history and car-sharing trends, car-sharing classification, interaction with other modes of transport, and re-balancing issues. Therefore, 104 articles were left. Additionally, 13 articles not significantly dealing with the socio-demographic effects on demand for car-sharing services were discarded. These features included the trip purpose (2 articles), trip distance (2 articles), travel time (1 article), travel distance (1 article), Provision of Electric Vehicles (1 article), land use (2 articles), accessibility, and fleet size (3 articles), travel cost (1 article) that were omitted. Out of these 13 discarded articles, six focused on more than one non-socio-demographic feature.

In total, 91 articles have then been considered in this review paper coming from 25 different journals, two different conference proceedings, and four from research or educational reports. Among these articles, 59 articles directly mentioned the socio-demographic characteristics influencing the demand for car-sharing. The other 32 articles

Table 1
Number of selected articles by each keyword in each database.

String of Keywords	Google Scholar	TRID	Scopus	Web of Science	Total (With Duplicates)
Impacts of carsharing	44	9	4	31	88
Carsharing demand	43	3	13	30	89
Carsharing use	54	7	8	28	97
Gender effect on carsharing use	52	1	–	1	54
Sociodemographic factors' effects on carsharing	33	–	–	–	33
Users' behavior of a carsharing	31	10	–	26	67
Carsharing attraction	28	–	–	1	29
Carsharing adoption	19	6	6	11	42
Total (with duplicates)	304	36	31	128	499

were not discarded and were used to cover other sections of the article, such as the introduction and method.

Given the uneven attention that previous research has paid to different characteristics, the conclusions or claims of the present review are based on only a few studies in some cases, while several studies have been reviewed for other claims. Fig. 1 illustrates the number of studies examined for each of the eight socio-demographic characteristics according to the type of car-sharing services. Therefore, it helps to analyze and understand the degree of support for some of the results. It should be noted that the "station-based (type is not specified)" in Fig. 1 refers to articles that did not explicitly state whether the authors worked on round-trip station-based car-sharing or one-way station-based car-sharing. It is only mentioned that they have worked on station-based car-sharing. "round-trip" in Fig. 1 refers to articles working on home zone-based round-trip car-sharing or station-based round-trip car-sharing. Obviously, also differences in findings among studies on the same issue should be considered to assess if such findings are well established, as discussed in the following.

Socio-demographic characteristics influencing the demand for different car-sharing systems

Car-sharing users appear to be a particular group concerning socio-demographics (Burghard and Dütschke, 2019). People's features, such as age and gender, can impact member behavior (Morency et al., 2012). The impact of the main socio-demographic characteristics on choosing different shared car systems is examined in the following subheads.

Some tables show the impact of the socio-demographic characteristics on the membership of shared cars, usage, or attitudes in each section. Also, the type of car-sharing services and any study-specific conditions are shown in the tables to identify the relationship between socio-economic characteristics and car-sharing demand. Besides, in some tables, the percentage of members belonging to a particular group or level in each study is specified, as the definitions in studies are different.

The tables are arranged according to the types of car-sharing services to make them easier to read. In the row of tables, first, studies on free-floating car-sharing are listed. Then, studies that have reviewed more than one type of car-sharing service are listed. Finally, studies examined other car-sharing services, including station-based (service type is not specified), one-way station-based, P2P, and round-trip station-based are listed.

Gender

One of the important factors that have been stressed in the previous literature is the gender factor. Table 2 lists the studies that concluded that either males or females tend to choose car-sharing more consistently.

It can be seen that different studies led to different conclusions. It indicates that the gender dimension is intertwined with other elements that need to be considered to clarify how gender affects car-sharing demand. The first group of studies showed that car-sharing members are predominantly male (Ciari et al., 2015; Firnkorn and Müller, 2012; Kawgan-Kagan, 2015; Kopp et al., 2015; Shaheen et al., 2018). Males are more likely to change from their existed mode of transportation to car-sharing (Acheampong and Siiba, 2020; Cartenì et al., 2016; Ceccato and Diana, 2021; Hu et al., 2018). Males are more receptive to shared car services, especially free-floating shared car schemes (Becker et al., 2017a). About 79% of free-floating service members were male in Turin, Italy (Perboli et al., 2017). In general, males are more interested in cars, technology, and innovation, of which the car-sharing system is an example (Kawgan-Kagan, 2020).

Similarly, in Zurich, Switzerland, males accounted for 80% of the free-floating service members (Ciari et al., 2015). Although males have a higher frequency of use, their trips are shorter (Habib et al., 2012). Moving from considering actual behaviors to attitudes, 84% of male users expressed interest in using car-sharing in a stated preferences survey conducted in Salerno, Italy. In addition, they raised their utility of switching from personal cars to shared cars (Cartenì et al., 2016). Morency et al. (2012) indicated that males are more inclined to choose station-based car-sharing than females in monthly usage. However, although the gender variable was significant in their study, this parameter's coefficient was somewhat minor. This reflects the significant but small impact of gender on station-based car-sharing demand. In Beijing, although males were more inclined to replace their existing mode of transport with car-sharing for round-trips, males and females did not exhibit markedly different behavior on the car-sharing choice for one-way trips (Yoon et al., 2017).

On the other hand, a handful of papers from North America reported higher membership rates for females. However, the observed gap was minimal in Martin and Shaheen (2011a). They focus on round-trip

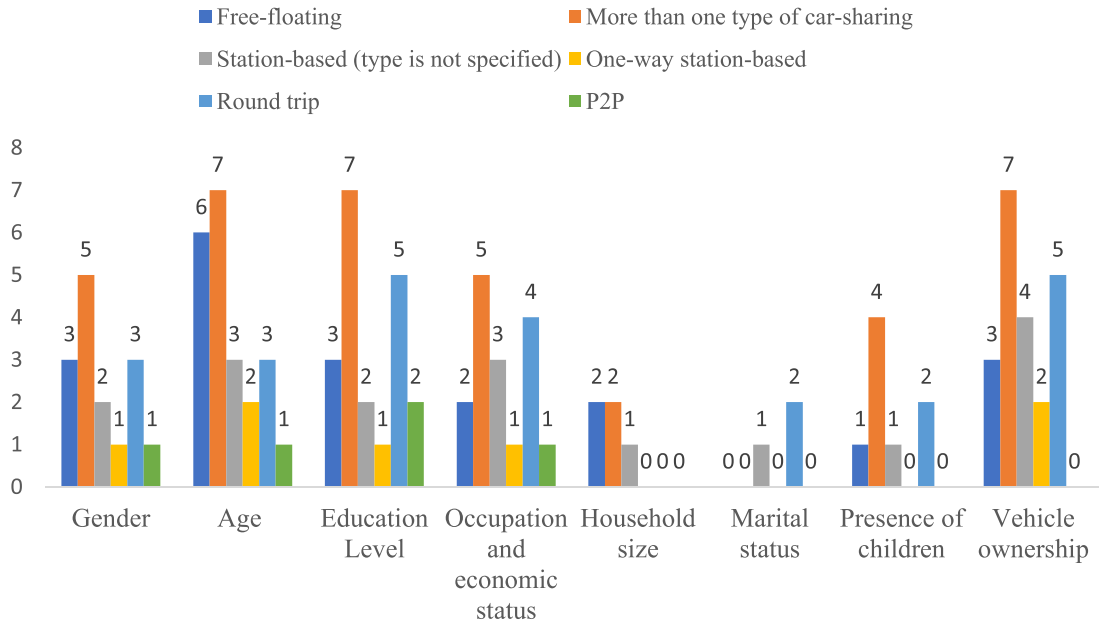


Fig. 1. The number of studies reviewed for each socio-demographic characteristic according to the type of car-sharing service.

Table 2
The positive relationship of being a man or a woman with car membership, usage, or attitude.

Gender Groups	% of Members in This Group	Car-Sharing Service Type	Studied Impact	Specific Conditions	Geographic Area	References
Male	63.6	Free-floating	Membership	–	Germany	Firnkorn and Müller, 2012
	70.0	Free-floating	Membership	–	Munich and Berlin, Germany	Kopp et al., 2015
	80.0	Free-floating	Membership		Zurich, Switzerland	Ciari et al., 2015
	70.0	Free- floating	Adoption	–	Based, Switzerland	Becker et al., 2017a
	60.0	Station-based				
	58.1	One-way station-based and free-floating	Switch from existing transport mode to car-sharing	–	Turin, Italy	Ceccato and Diana, 2021
	Unspecified	Station-based and free-floating	Switch from existing transport mode to car-sharing	–	Ghana, Sub-Saharan Africa.	Acheampong and Siiba, 2020
	84.6	Round-trip, free-floating	Membership	–	Berlin, Germany	Kawgan-Kagan, 2015
	Unspecified	Station-based	Frequency of use	–	North America	Morency et al., 2012
	74.2	Station-Based	Switch from existing transport mode to car-sharing	–	Shanghai, China	Hu et al., 2018
	Unspecified	One-way Station-based	Usage	–	Salerno, Italy	Cartenì et al., 2016
	55.7	Round-trip	Switch from existing transport mode to car-sharing	–	Beijing, China	Yoon et al., 2017
	About 55.0%	P2P	Membership	–	Portland, USA	Shaheen et al., 2018
Female	63.0	Free-floating	Membership	–	Montreal, Canada	Wielinski et al., 2015
	51.0	Station-based				
	57.0	Round-trip	Membership	–	North America	Martin and Shaheen, 2011a
	Unspecified	Round-trip	Membership	New service	San Francisco, USA	Cervero, 2003

services only, compared to most previously mentioned studies, which often focused on the correlation between being male and larger free-floating services use. In this regard, a study on the willingness to join the round-trip system found no gender differences (Kim et al., 2017). Cervero (2003) reported a much larger membership rate of females for a round-trip service in San Francisco, but this could result from the survey being conducted only one month after the service launch. In addition, this study is significantly older than the average and therefore refers to services whose features are somewhat different from the contemporary standard practice.

Only one study (Wielinski et al., 2015) reported an over-representation of female members of the free-floating system in Montreal, which is even more surprising since the gender distribution in the same city is usually almost the same for different services. Apart from this exception, about 75% of females chose free-floating services in Berlin, while about 80% of males. However, there is a significant gap between females and males for round-trip car-sharing usage, while 35% of females chose round-trip car-sharing; this figure was almost 60% of males. Also, males and females have a similar interest in using e-car sharing. Approximately 80% of females chose Battery Electric Vehicles (BEVs), while 65% chose Internal Combustion Engine Vehicles (ICEVs) (Kawgan-Kagan, 2015). It indicates that females who chose car-sharing are more likely to use BEVs instead of ICEVs. However, males chose ICEVs slightly more than BEVs (Kawgan-Kagan, 2015). Therefore, females seem more attracted to the more specific BEV systems than the ICEV system (Kawgan-Kagan, 2015; Kim et al., 2015). Del Mar Alonso-Almeida (2019) offered additional insights into the perceived value role in increasing car-sharing demand for females.

To sum up, being male seems positively correlated with the demand for car-sharing, especially the free-floating variant, while results are more mixed for round-trip services. However, females seem keener to choose e-car-sharing systems. Besides, female car-sharing members in North American countries appear to be more inclined to choose car-sharing than female members in Europe.

Age

Many studies stated that car-sharing attracted more attention from younger members (Burkhardt and Millard-Ball, 2006; Ceccato and Diana, 2021; Ceccato, 2020; Firnkorn and Müller, 2012; Martin and Shaheen, 2011a; Vinayak et al., 2018). Table 3 lists studies stating that youngsters are more inclined to choose shared cars. Because different articles consider different definitions of youth, for each study, the age range with the highest percentage of membership distribution is presented in the first column of Table 3.

Having a personal car is no longer a priority for adults, which can be considered a reason to attract young members to shared cars (Ceccato and Diana, 2021). This shift from car ownership to "cars as demand" is reinforced by the preference for more sustainable mobility practices (Ceccato and Diana, 2021; Kortum and Machemehl, 2012). For instance, in North America, 67% of car-sharing members were between 20 and 40 years old (Martin et al., 2010). Also, in the San Francisco Bay Area, USA, the car-sharing system members are significantly younger than non-members. About 50% of members are in the age group of 31 to 50 years. However, this figure is around 37% for non-members (Clewlow, 2016). This may be because the employment rate among members is higher than among non-members, associated with a lower average age (Becker et al., 2017a). This is more the case in free-floating car-sharing than station-based car-sharing (Becker et al., 2017a; Wielinski et al., 2015). For example, 73.8% of free-floating members were between 25 and 44 years old in Montreal, Canada. However, the 25 to 49 age group accounted for 71.1% of the members of station-based car-sharing, slightly less than free-floating. Approximately 93% of the members of free-floating car-sharing were between 18 and 34 years old in Turin, Italy (Perboli et al., 2017). Similarly, half of the free-floating car-sharing members in Basel, Switzerland, and 56% of members of the system in Germany were under 36 and 35 years old, respectively (Becker et al., 2017a; Firnkorn and Müller, 2012).

Car-sharing with Evs has a special added attraction for young couples with no private car. The same is true for young people who start a family and use car-sharing to complement their private car trips (Burghard and Dütschke, 2019). In rural areas, similar to urban areas, car-sharing users are young (Rotaris and Danielis, 2018). In Beijing, China, people encouraged to use car-sharing belonged to the younger age group of 20 to 35 years (Shaheen and Martin, 2010). Furthermore, 85% of 25–45-year-old people were satisfied using the car-sharing system in Salerno, Italy (Cartenì et al., 2016). Analogously, some research has shown that members of shared cars are in their late 20 s and mid-30 s (Brook, 2004; Lane, 2005) or are 20 to 39 years old (Kortum and Machemehl, 2012; Sioui et al., 2013) or in their 30 s or 40 s (Millard-Ball, 2005), or are 25

Table 3
The positive correlation between young age groups and car-sharing membership, usage, or attitudes.

Age Groups (Brackets Or Mean)	% of Members in This Group	Car-Sharing Service Type	Studied Impact	Specific Conditions	Geographic Area	References
25–54	77.0	Free-floating	Membership	–	Turin, Italy	Ceccato, 2020
18–34	93.0	Free-floating	Membership	New Service	Turin, Italy	Perboli et al., 2017
Mean age of 38.7	–	Free-floating	Usage	E-car-sharing	Germany	Burghard and Dütschke, 2019
Under 35	56.0	Free-floating	Membership	–	Germany	Firnkorn and Müller, 2012
Under 36	60.0	Free-floating	Membership	–	Austin, USA	Kortum and Machemehl, 2012
Under 36	50.0	Free-floating	Membership	–	Based, Switzerland	Becker et al., 2017a
25–44	73.8	Free-floating	Membership	–	Montreal, Canada	Wielinski et al., 2015
25–49	71.1	Station-based				
35–44	25.4	One-way station-based and free-floating	Membership, switch from existing transport mode to car-sharing	–	Turin, Italy	Ceccato and Diana, 2021
18–24	Unspecified	One-way station-based and free-floating	Membership	–	Seattle. USA	Vinayak et al., 2018
20–39	About 62.0	Station-based and free-floating	Membership	–	Montreal, Canada	Sioui et al., 2013
The 30 s or 40 s	Unspecified	Round-trip, one-way station-based	Membership	–	North America	Millard-Ball, 2005
18–25	Unspecified	Round-trip, one-way station-based, free-floating, P2P	Usage	In rural areas	Friuli-Venezia Giulia, Italy	Rotaris and Danielis, 2018
The Mid-30 s	Unspecified	Round-trip and one-way station-based, B2B	Membership	–	North America	Brook, 2004
31–50	50.0	Station-based	Membership	–	San Francisco Bay Area, USA	Clewlow, 2016
25–39	55.0	Station-based	Membership	–	Philadelphia, USA	Lane, 2005
The 20 s and 30 s	77.9	Station-based	Membership, willingness to continue membership	BEV service	Seoul, South Korea	Kim et al., 2015
25–45	Unspecified	One-way station-based	Switch from existing transport mode to car-sharing	E-car-sharing	Salerno, Italy	Cartenì et al., 2016
20–35	56.0	One-way station-based	Interested in car-sharing	–	Beijing, China	Shaheen and Martin, 2010
20–40	67.0	Round-trip	Membership	–	North America	Martin et al., 2010
30–60	55.0	Round-trip	Membership	–	North American	Martin and Shaheen, 2011a
Mean age of 37.7	–	Round-trip	Membership	–	USA and Canada	Burkhardt and Millard-Ball, 2006
25–34	55.0	P2P	Membership	–	Portland, USA	Shaheen et al., 2018

to 45 years old (Kopp et al., 2015). In Portland, USA, P2P service members are between 25 and 34 years old. In Switzerland, the effect of age in increasing car-sharing demand is maximized at age 35 (Juschten et al., 2017). Besides, the older age (55 years or older) in households without high income negatively affects the willingness to join a car-sharing program (Dias et al., 2017).

However, Cervero et al. (2007) mentioned that round-trip car-sharing usage increased with age in San Francisco, USA. Nevertheless, it is significant to stress that this study used the age factor as a numerical variable. However, in most other studies, age has been used as a class variable, making it possible to identify potential non-linear relationships. In a study by Kim et al. (2015), it was found that 77.9% of e-car-sharing members were within the age group of the 20 s and 30 s in Seoul. Interestingly, the probability of switching from private cars to e-shared-cars among elders is higher than among younger ones. However, this seems to have happened because the survey is aimed at members of the electric vehicle sharing program who have a strong will to change their transportation mode, not the general public. In essence, it can be indicated that most car-sharing users are young people, typically in their mid-20 s to mid-30 s. In addition, free-floating members appear to be slightly younger than station-based members. Also, it appears that in North America, the age of car-sharing members is a little older than the age of car-sharing members in other countries.

Education level

The most prominent feature of car-sharing members is their high education level (Burkhardt and Millard-Ball, 2006; Becker et al., 2017a; Ceccato, 2020; Firnkorn and Müller, 2012; Juschten et al., 2017; Kawgan-Kagan, 2015; Shaheen et al., 2018; Shaheen and Martin, 2010). Table 4 lists the papers that showed that well-educated background raises car-sharing demand. Different articles have different definitions of well-educated people. For each study, the educational background of the well-educated people with the highest percentage of membership distribution is specified in the first column of Table 4.

A typical figure is that more than sixty-seven percent of members had a bachelor's or advanced degree in North America. This rate is remarkably above the average education level of people living in the neighborhoods where the services are provided (Brook, 2004). Also, more than 80% of round-trip car-sharing members had a four-year college or advanced degree, while around 28% of all US citizens had a bachelor's degree (Martin and Shaheen, 2011a). Similarly, about 87% of station-based car-sharing members had a bachelor's degree or higher, while only 31% of Portlanders had a bachelor's degree (Cooper et al., 2000). This significant gap in education levels may be since educated people are more adapted to using the internet, such as booking car-sharing, than others. In addition, these people are usually more prepared to adapt to the new lifestyle. It is also essential to state that well-educated individuals are associated with environmental awareness and calculate the car's actual costs rather than car-sharing (Coll et al., 2014). Besides, the education level is higher among frequent users of shared transport (Vinayak et al., 2018). The reason may be that educated decision-makers are more environmentally friendly and favor a new urban lifestyle. Millard-Ball (2005) suggested that in North America,

Table 4
The positive correlation between well-educated background and car-sharing membership, usage, or attitudes.

Education Level	% Distribution of The Members	Car-Sharing Service Type	Studied Impact	Specific Conditions	Geographic Area	References
Master's degree or PhD	52.9	Free-floating	Membership	–	Turin, Italy	Ceccato, 2020
University degree or PhD	70.0	Free-floating	Usage	–	Munich and Berlin, Germany	Kopp et al., 2015
University or technical college	46.3	Free-floating	Membership	–	Germany	Firnkorn and Müller, 2012
Graduate degree	Unspecified	One-way station-based and free-floating	Frequency of use	–	Seattle. USA	Vinayak et al., 2018
Bachelor's degree or higher	Unspecified	One-way station-based and free-floating	Usage	–	Seattle. USA	Dias et al., 2017
University degree (or equivalent)	75.0 70.0	Station-based Free-floating	Membership	–	Based, Switzerland	Becker et al., 2017a
Graduated from a university or technical college	66.7	Round-trip, free-floating	Membership, trip frequency	–	Berlin, Germany	Kawgan-Kagan, 2015
Bachelor's degree	35.0	Round-trip one-way station-based	Membership	–	North America	Millard-Ball, 2005
Postgraduate or advanced degree	48.0					
Upper secondary education or higher	71.1	Round-trip, free-floating, and P2P	Membership	–	Switzerland	Juschten et al., 2017
Four-year or advanced college graduates	66.7	Round-trip and one-way station-based, B2B	Membership	–	North America	Brook, 2004
Bachelor's degree or higher	87.0	Station-based	Membership	–	Portland, USA	Cooper et al., 2000
Bachelor's degree or higher	Unspecified	Station-based	Membership	–	Quebec City, Canada	Coll et al., 2014
Above high school diploma	60.0	One-way station-based	Membership	–	Beijing, China	Shaheen and Martin, 2010
University education	Unspecified	Round-trip	Interested in car-sharing	–	Dublin, Ireland	Carroll et al., 2017
Bachelor's degree or higher	84.0	Round-trip	Membership	–	North America	Martin et al., 2010
Bachelor's Degree	43.0	Round-trip	Membership	–	North America	Martin and Shaheen, 2011a
Graduate or Professional Degree	41.0					
Bachelor's degree	35.0	Round-trip	Membership	–	USA and Canada	Burkhardt and Millard-Ball, 2006
Postgraduate or advanced degree	48.0					
Bachelor's degree or higher	Unspecified	Round-trip	Interested in car-sharing	–	Shanghai, China	Wang et al., 2012
Postgraduate degree	Unspecified	P2P	Adoption	–	Paris, France, Madrid, Spain; Tokyo, Japan; and London, England	Prieto et al., 2017
Bachelor's degree or higher	86.0	P2P	Membership	–	Portland, USA	Shaheen et al., 2018

more than one-third of members have a four-year college degree, and about half possess a postgraduate or advanced degree. It is noteworthy that an online survey of shared cars members was employed in this study. This survey results primarily represented well-educated members because they are more likely to use a personal computer. Round-trip car-sharing members are mostly highly educated (84% have four-year college or advanced degree) in North America (Martin et al., 2010).

Beyond car-sharing membership, a high level of education can also increase the demand for car-sharing (Coll et al., 2014; Dias et al., 2017; Kopp et al., 2015). It is likely that highly educated people are more aware of this service and can leverage it through technology (Dias et al., 2017). This may show that being attracted to car-sharing may be based on a certain level of social awareness, not strictly an economic decision. Wang et al. (2012) noted that the tendency to use shared cars is directly related to the level of education. However, this study's distribution of academic achievement indicates that this sample had a higher level of education than the Shanghai population. This may be because the head of the household had filled out the mail survey, and they probably have the highest education in the household.

Shaheen et al., 2018 found that 86% of the P2P members had bachelor's degrees or higher. This may be because P2P car-sharing, like other shared mobilities, operates mainly in urban areas and larger cities where people with higher education live. However, surprisingly, Prieto et al. (2017) mentioned that having a higher education level, such as a postgraduate degree, had no impact on joining P2P car-sharing. This study noted that this is normal because P2P car-sharing is more compatible with a wide range of users. However, it should be noted that the education factor in this research is insignificant. Overall, most people looking to choose car-sharing seem to have a four-year college degree or higher, especially a postgraduate or advanced degree. Also, it appears that the education level of round-trip shared car users is less than that of other shared cars service users.

Occupation and economic status

People's economic and social views can be an important factor influencing their attitudes in choosing a car-sharing program (Becker et al., 2017a). Most car-sharing members earn more than non-members, and most are employed. This may mean that the employee may choose car-sharing for work-related activities (Ceccato and Diana, 2021; Ceccato, 2020; Clewlow, 2016; Dias et al., 2017; Juschten et al., 2017; Kawgan-Kagan, 2015; Vinayak et al., 2018; Winter et al., 2017; Yoon et al., 2017). Table 5 lists studies that examined the impact of income levels on the membership and usage of car-sharing. It should be stated that there is a different perceptions of low, middle, or high income, and there are subgroups with distinct behaviors/preferences. Therefore, for

Table 5
The positive relationship of occupation and economic status groups on car-sharing membership, usage, or attitudes.

Occupation and Economic Status Groups	Average Household Income) (Euro/Year)	% Distribution of The Members	Car-Sharing Service Type	Studied Impact	Specific Conditions	Geographic Area	References
Above-average or high-income level	≥30000.0	77.0	Free-floating	Membership	–	Netherlands	Winter et al., 2017
	≥30000.0	About 48.0	Free-floating	Membership	–	Turin, Italy	Ceccato, 2020
	≥30000.0	About 48.0	One-way station-based and Free-floating	Membership	–	Turin, Italy	Ceccato and Diana, 2021
	≥82836.0	Unspecified	One-way station-based and free-floating	Membership	–	Seattle. USA	Vinayak et al., 2018
	≥82836.0	Unspecified	One-way station-based and free-floating	Membership	–	Seattle. USA	Dias et al., 2017
	Net household income ≥ 24000.0	About 50.0	Round-trip and free-floating	Membership	–	Berlin, Germany	Kawgan-Kagan, 2015
	Canada: ≥ 39767.0 USA: ≥ 82836.0	50.0	Round-trip, one-way station-based	Membership	–	North America	Millard-Ball, 2005
	≥ 82836.0	59.0	Station-based	Membership	–	San Francisco Bay Area, USA	Clewlow, 2016
	15000.0–25000.0	Unspecified	One-way station-based	Willingness to join	–	Greece	Efthymiou et al., 2013
	13255.0–26512.0	19.0	Round-trip	Membership	–	North America	Martin et al., 2010
	≥ 12240.0	About 16.0	Round-trip	Membership	–	Beijing, China	Yoon et al., 2017
	41420.0–62130.0	18.0	P2P	Membership	–	Portland, USA	Shaheen et al., 2018
Low- or Moderate-Income Level	17800.0–44520.0	58.2	Station-based	Willingness to continue membership	BEV service	Seoul, South Korea	Kim et al., 2015
	15000.0–25000.0	Unspecified	Station-based	Willingness to join	–	Athens, Greece	Efthymiou and Antoniou, 2014
	Median Household income: 42420.0	Unspecified	Round-trip	Membership	–	San Francisco, USA	Cervero et al., 2007
	≤ 82840.0	68.0	Round-trip	Membership	–	North America	Martin and Shaheen, 2011a

each study, the income range for the designated income level (Low- or Moderate and Above-average or high), which has the largest share in the distribution of members, is specified in the second column of Table 5. The unit currencies of the countries listed in Table 5 have been converted to Euros per year for comparative purposes, although incomes in different countries have different purchasing powers.

Results from previous studies are somewhat mixed. In Salerno, Italy, nearly 80% of employed users were inclined to use the e-car-sharing service (Cartenì et al., 2016). Car-sharing members generally are from families where the number of employed people is above average, and they are from high-income households in Turin, Italy (Ceccato and Diana, 2021). Nonetheless, Martin and Shaheen (2011a) figured out that shared cars primarily served the middle class in North America. Nevertheless, it should be pointed out that more than 20% of the members of the shared cars earned $100,000 or more in the latter study. In San Francisco, the USA, the average annual income of round-trip car-sharing members was $ 57,000, higher than the city average, especially since more than 90% worked in professional fields (Cervero and Tsai, 2004).

Similarly, some studies showed that members are mostly middle-to-higher-income in North America (Brook, 2004; Martin et al., 2010; Millard-Ball, 2005). However, it should be noted that Millard-Ball (2005) conducted an online survey of shared cars members. The results of this survey are likely to over-represent the individuals who have a high-income level because these people are more inclined to use their personal computers. Shaheen et al. (2018) mentioned that P2P shared cars members generally earned slightly more than the US population. For the most part, this result is generally since P2P car-sharing, like many shared mobility systems, is built in large, higher-income cities. Similarly, in a study by Winter et al. (2017), this sample shows more educated people than the national average. The geographical limitations of this study could explain this problem in a sample of selected cities located in the metropolis of the Randstad region, which is more prosperous.

On the other hand, Kortum and Machemehl (2012) mentioned that families with higher income levels are less inclined to choose shared cars. They probably prefer their vehicles. Importantly, in this study income variable is insignificant. Hence, the direct relationship between membership and income may not be between the mode share and income.

The probability of using e-car-sharing is higher among lower-income groups than high-income individuals in Seoul. It may imply that the current economic advantages are not satisfactory for this group (Kim et al., 2015). Also, in San Francisco, car-sharing trips declined as income levels raised (Cervero et al., 2007). It is significant to highlight that this study used the income factor as a numerical variable. Nevertheless, in most other studies, income has been used as a categorical variable to make it more informative. This can help us identify which income group most members belong to, make comparisons between income groups, and discover potential non-linear relationships.

Similarly, Efthymiou and Antoniou (2014) suggested that low-to-middle-income individuals are more willing to join the car-sharing program in Greece. In this study, median-income respondents earning between € 15,000 and € 25,000 per year are more inclined to join the car. This may show that individuals with lower incomes find station-based car-sharing more expensive and prefer to use public transport or walk. Also, high-income individuals prefer to use their vehicles. It should be noted that the presence of children seems to decrease car-sharing use among families with low and middle levels of earnings (Dias et al., 2017). This could be due to financial hardship and the complexity of children's activities and travel patterns.

Overall, the income of people who want to use a car subscription is

above-average, especially in a free-floating system. Indeed, it may not be easy to offer shared vehicles such as free-floating car-sharing in low-income neighborhoods because it may not be profitable for commercial operators. However, for people with lower than average incomes, car-sharing is attractive. It seems to these people that purchasing and maintaining a personal car is pricy. However, they do require it for their causal travels. It is likely that certain local circumstances, such as the availability and attractiveness of other travel means like public transport, may determine which social group tends to use shared cars.

Furthermore, it should be noted that the reasons why high-income people are attracted to car-sharing can be different from low-income people. In this regard, Millard-Ball (2005) noted that individuals with various earnings stated various causes to utilize shared cars. For instance, people who earned between $ 10,000 and $ 20,000 a year (4% of the sample) looked for trip comfort. People with income between $20,000 and $30,000 a year (7.7% of the sample) demanded acceptable trip costs, needed to carry their belongings, and were reluctant to use public transportation. People with income between $30,000 and $40,000 a year (11.3% of the sample) looked for acceptable trip costs. People earning more than $ 75,000 a year (35% of the sample) need a car for their destination and are looking for a low-cost means of transport. This shows that members with middle to upper-income levels can also be cost-sensitive people. Further, it is necessary to emphasize that their neighborhood's shared car system may not be conveniently provided.

Household size

Car-sharing users are in smaller households than the average (Ceccato and Diana, 2021; Ceccato, 2020; Kortum and Machemehl, 2012; Millard-Ball, 2005). Table 6 indicates a list of studies that showed a positive correlation between small household size and car-sharing use. In order to clarify the meaning of small household size, for each study, the household size that is considered to be small is specified in the first column of Table 6.

It is worth mentioning that if household income rises, the likelihood of buying a car-sharing subscription increases (Clewlow, 2016; Dias et al., 2017); this is associated with the number of employees in the house, a similar trend. However, the number of household members negatively impacts shared car use (Ceccato and Diana, 2021). This can indicate that shared car is utilized by employees living in low-size families. For example, in Portland, Oregon, the household size of station-based car-sharing members was 1.8 people per household, while the average city household was 2.23 people per household (Cooper et al., 2000). In Canada, the probability of car-sharing members living with someone else was 71%. However, that figure was 61% for US car-sharing members. Also, in North America, about 64% of members live with at least another individual, with a household mean of 2.02. In addition, about a quarter of families have children (Millard-Ball, 2005). Therefore, it seems that the decline in car-sharing due to the average increase in household size is probably because of the larger number of children in larger families (Kortum and Machemehl, 2012). Because sometimes, the presence of children, especially among low- and middle-income households, can be accompanied by a decrease in shared car membership.

It is worth noting that these results are based on only a few articles. Therefore, more research is required to add strength to the results.

Marital status

Many single-person households use car-sharing systems in Austin, USA (Celsor and Millard-Ball, 2007). Generally, the shared car is more appealing in places where the ratio of single-parent households is high (Carroll et al., 2017; Coll et al., 2014).

Generally, married people are less inclined to utilize shared cars in Athens, Greece (Efthymiou and Antoniou, 2014). This may be because a married couple may commute to different workplaces, and both may use a personal car. Because using two shared cars or a private car and car-sharing can be very costly for them. For example, the husband/wife can take the wife/husband to the nearest public transport or workplace instead of the shared car.

It should be noticed that only a few articles examine the impact of marital status on car-sharing demand. Therefore, more studies are needed to better understand its effects on car-sharing demand, especially in free-floating and P2P services.

Presence of children

Some studies suggest that families with children are more inclined to opt for shared car schemes (Carroll et al., 2017; Coll et al., 2014; Rotaris and Danielis, 2018; Sioui et al., 2013). This could be due to child seats in car-sharing vehicles, depending on local conditions. Indeed, some other studies have suggested that the presence of children may be associated with reduced car-sharing use (Kim et al., 2017; Kopp et al., 2015; Vinayak et al., 2018), especially among low- and middle-income households (Dias et al., 2017). This may occur because of the more complex travel-activity patterns created by children and also budget constraints. For instance, in Munich and Berlin, Germany, most car-sharing members did not have children (Kopp et al., 2015). Table 7 indicates a list of studies on the effect of the presence of children on car-sharing use.

Namazu et al. (2018) reported that the probability of being in the early stages of family formation among the early users of one-way car-sharing is higher than among round-trip car-sharing users. However, the survey data from this study is not enough to clarify whether users of one-way shared cars become round-trip shared car users when they have children.

Vehicle ownership

In most cases, the mean number of cars in each family among the members of the car-sharing systems is less than among non-members (Becker et al., 2017a; Catalano et al., 2008; Ceccato and Diana, 2021; Ceccato, 2020; Cervero et al., 2007; Clewlow, 2016; De Luca and Di Pace, 2015; Efthymiou and Antoniou, 2014; Habib et al., 2012; Juschten et al., 2017; Namazu et al., 2018; Nobis, 2006; Wang et al., 2012; Wang et al., 2017). Table 8 shows a list of studies showing the positive correlation between the low level of vehicle ownership and the use of shared cars.

To clarify the low ownership level meaning, for each study, the vehicle ownership range considered as a low level of vehicle ownership is specified in the first column of Table 8. It is important to note that

Table 6
The positive correlation between small household size and car-sharing membership, usage, or attitudes.

Average Household Size	Car-Sharing Service Type	Studied Impact	Specific Conditions	Geographic Area	References
About 2.5	Free-floating	Usage	–	Austin, USA	Kortum and Machemehl, 2012
About 2.4	Free-floating	Membership		Turin, Italy	Ceccato, 2020
Around 2.5	One-way station-based and free-floating	Membership	–	Turin, Italy	Ceccato and Diana, 2021
About 2.0	Round-trip, one-way Station-based	Membership	–	North America	Millard-Ball, 2005
1.8	Station-based	Membership	–	Portland, USA	Cooper et al., 2000

Table 7
Effect of the presence of children on car-sharing membership, usage, or attitudes.

Presence of Children	Car-Sharing Service Type	Studied Impact	Specific Conditions	Geographic Area	References
Positive	Round-trip, one-way station-based, free-floating, P2P	Interested in car-sharing	In rural areas	Friuli-Venezia Giulia, Italy	Rotaris and Danielis, 2018
	Station-based and free-floating	Membership	–	Montreal, Canada	Sioui et al., 2013
	Station-based	Membership	–	Quebec City, Canada	Coll et al., 2014
	Round-trip	Interested in car-sharing	–	Dublin, Ireland	Carroll et al., 2017
Negative	Free-floating	Membership	–	Munich and Berlin, Germany	Kopp et al., 2015
	One-way station-based and free-floating	Usage	–	Seattle. USA	Dias et al., 2017
	One-way station-based and free-floating	Usage	–	Seattle. USA	Vinayak et al., 2018
	Round-trip	Usage	–	Netherlands	Kim et al., 2017

vehicle ownership, unlike the previously reviewed socio-economic factors, can be seen as an exogenous variable (thus impacting car-sharing demand) and an endogenous variable (since car-sharing might impact vehicle ownership levels). It is important to distinguish the two opposite directions of causation from a transport policy viewpoint, although the literature does not focus adequately on such aspects. Therefore, the fourth column in Table 8 indicates whether vehicle ownership levels are considered exogenous, endogenous, or (perhaps more realistically) a mix.

Some studies have shown that vehicle ownership affects car-sharing demand. For example, in San Francisco in 2010, the average vehicle ownership for station-based car-sharing members was 0.47 vehicles per household, and for non-members, 1.22 vehicles per household (Ter Schure et al., 2012). The explanation that can be given is that most of the decline in vehicle ownership seems to be related to shifting to walking, cycling, and transit and shortening the average daily travel distance. Similarly, in Montreal, Canada, car-sharing members own fewer private cars than average (Sioui et al., 2013). Besides, in the US, households without vehicles or one vehicle have the highest rate of shared cars use (Celsor and Millard-Ball, 2007). Regardless of residential density, the high level of vehicle ownership adversely influences one-way station-based and free-floating shared car usage (Dias et al., 2017). Probably, it is more comfortable and cost-effective for individuals to use personal cars than shared cars.

In general, the mobility behavior of car-sharing system members is more sustainable, and they are more multimodal than non-members (Becker et al., 2017a; Clewlow, 2016; Costain et al., 2012; Wang et al., 2017). Car-sharing is generally accepted by people who reside in families that have fewer personal vehicles than non-members (Chicco et al., 2020). In this regard, Clewlow (2016) figure out that in city regions, members of station-based car-sharing own fewer cars (0.58) than non-members (0.96). It was shown that car-sharing system members have only made 41.5% of their private cars' travels, but this figure is 61.8% for non-members. Also, car-sharing members have carried out about 15% of their travels in transit and around 35% of their travels on foot. However, these figures for non-members are 10.3% and 23.0%, respectively. Hence, car-sharing is linked to multimodal travel behavior. This effect looks greater for the station-based shared systems members (Namazu et al., 2018). Also, shared car members are more inclined to own cars with low carbon footprints (Kawgan-Kagan, 2015). Also, they are more inclined to have more sustainable car technologies. The portion of Evs is remarkably more significant among car-sharing members. Besides, about one-fifth of cars owned by car sharing members were hybrid, plugin hybrid, or BEVs, while the diffusion rate of such vehicles among non-members is halved (Clewlow, 2016). This may indicate a possible link between membership in car-sharing and environmental attitudes.

In a study by Chicco et al. (2020), it was noted that in Frankfurt, Germany, people who chose both free-floating and station-based programs had less private car ownership than people who utilized only the free-floating service. Further, it was stated that in the Brussels Capital Region, the round-trip service members have five times fewer private cars than free-floating service members. Around 62% of round-trip car-sharing system members in the USA are from households that did not have a private car when joining car-sharing, and 31% of members had only one car. Therefore, more than 90% of them did not have more than one car (Martin and Shaheen, 2011a).

Some studies have indicated the effects of shared cars on car ownership. For example, in Montreal, Canada, the car usage by people, who did not have a vehicle and used shared cars more than 1.5 times a week, was 25% lower than vehicle owners. This difference raises with a reduction in the frequency of car-sharing services usage (Sioui et al., 2013). This confirms the remarkable effect of car-sharing usage. Further, round-trip car-sharing service usage sometimes decreases car ownership and car use (Celsor and Millard-Ball, 2007). In North America, around one-third decline in the mean car kilometers traveled before and after joining the round-trip car-sharing program was observed. This figure was 6468 km per year for the former and 4729 km per year for the latter (Martin and Shaheen, 2011b). This reduction of about 1740 km per year means a 27% reduction in the driving distance before and after. In North America, round-trip car-sharing members' vehicle ownership dropped dramatically from a mean of around 0.47 cars per household to about 0.24 cars per household (Martin et al., 2010). Hence, the car-sharing service can facilitate a reduction in ownership of household vehicles as this service dramatically eliminates the need for a personal vehicle to complete travel. That way, car-sharing can only provide a car to a member if needed. Out of every 25 households joining round-trip car-sharing, six would shed off their private car within two years in San Francisco (Cervero and Tsai, 2004). Maybe the comfort of having access to a fleet of cars on demand encourages some car owners to dispose of their second vehicles and give up car ownership altogether.

Similarly, Becker et al. (2017a) indicated that half of the comparison group members used their vehicles at least once a week. However, it is 14% for free-floating shared car system members and 4% for station-based shared system members. It seems that members of different shared car systems types belong to different kinds of households. Moreover, the motivation of the round-trip members is more for financial and environmental reasons. On the other hand, one-way shared car members are more motivated with more convenience and safety. In addition, members of the one-way car-sharing consider car-sharing as an alternative to ride-hailing systems like Uber or Lyft. Round-trip members, however, see the shared car as a substitute for car ownership and a way to travel out of the city (Lempert et al., 2019).

Looking at different geographic areas, if station-based car-sharing programs were available in China, a small percentage (11%) of households with a private car would tend to shed one. This ratio is lower than

Table 8
Positive correlation between low vehicle ownership level and car-sharing membership, usage, or attitudes.

Average Household Vehicle Ownership (Vehicle/Household)	Car-Sharing Service Type	Studied Impact	Direction of Causation	Specific Conditions	Geographic Area	References
1.4	Free-floating	Membership	Exogenous	–	Turin, Italy	Ceccato, 2020
1.0	Free-floating	Usage	Exogenous	E-car-sharing	Germany	Burghard and Dütschke, 2019
Average car per adult: about 0.4	Free-floating	Membership	Exogenous, Endogenous	–	Munich and Berlin, Germany	Kopp et al., 2015
1.1	Station-based and free-floating	Membership	Exogenous, Endogenous	–	California, USA	Mishra et al., 2019
0.1	Station-based and free-floating	Membership	Exogenous, Endogenous	–	Montreal, Canada	Sioui et al., 2013
Households with one or two vehicles	One-way station-based and free-floating	Membership	Exogenous	–	Turin, Italy	Ceccato and Diana, 2021
Households with zero or one vehicle	One-way station-based and free-floating	Usage	Exogenous	–	Seattle. USA	Dias et al., 2017
0.4 1	Round-trip- Free-floating	Membership	Endogenous	–	Vancouver, Canada	Lempert et al., 2019
About 0.8 0.9	Round-trip One-way (Mainly free-floating, partially station-based)	Membership	Exogenous	–	Vancouver, Canada	Namazu et al., 2018
About 1.2	Round-trip, free-floating, and P2P	Membership	Exogenous	–	Switzerland	Juschten et al., 2017
Unspecified	Station-based	Membership	Exogenous	–	Athens, Greece	Efthymiou and Antoniou, 2014
About 0.6	Station-based	Membership	Exogenous	–	San Francisco Bay Area, USA	Clewlow, 2016
About 0.5	Station-based	Membership	Exogenous	–	San Francisco, USA	Ter Schure et al., 2012
About 0.7	Station-based	Membership	Exogenous	–	Montreal, Canada	Habib et al., 2012
About 0.2	One-way station-based	Membership	Exogenous	–	California, USA	Mishra et al., 2015
Less than about 0.8	One-way station-based	Membership	Exogenous	–	Salerno, Italy	De Luca and Di Pace, 2015
About 0.7	Round-trip	Usage	Exogenous, Endogenous	–	USA	Celsor and Millard-Ball, 2007
about 0.2	Round-trip	Membership	Exogenous, Endogenous	–	North America	Martin et al., 2010
Households with zero or one vehicle	Round-trip	Membership	Exogenous	–	North America	Martin and Shaheen, 2011a
Households with zero or one vehicle	Round-trip	Membership	Exogenous, Endogenous	–	San Francisco, USA	Cervero et al., 2007
0.3	Round-trip	Membership	Endogenous	–	San Francisco, USA	Cervero and Tsai, 2004

the one found in previous research in European and North American countries. However, those who want to buy a private car in the short term, within one year to three years, consider car-sharing because the majority of them tend to give up their purchase plans (Wang et al., 2012). Car-sharing in China seems to be more effective in preventing the purchase of vehicles than car-shedding. Car-sharing, especially free-floating services, may significantly influence postponing the purchase of additional private cars in Italy. However, in the Brussels Capital Region, members of free-floating car-sharing services did not necessarily see the service as a replacement for their private car but as a supplement (Chicco et al., 2020). In this regard, it can be stated that free-floating shared car members are more likely to agree that the personal vehicle is a symbol of status (Burghard and Dütschke, 2019).

The free-floating shared car program influenced the car ownership of 37% of users in London. Of this 37%, most users (83%) reported that they desired not to purchase a private vehicle after using car-sharing. Furthermore, 11% stated that they had not used their vehicle in the previous three months, and 6% indicated that they would sell their vehicle within the next three months (Le Vine and Polak, 2019). However, 63% of members stated that the car-sharing system did not influence their car ownership status. Some concerns can be raised because Le Vine and Polak (2019) surveyed users only three months after introducing the free-floating system in London. Users may change their minds after a while. Hence, these results may not reflect their actual long-term behavior. Also, most of that 37% of users probably did not own a private car.

In general, there seems to be a complex two-way relationship between shared car membership and owning a car. For instance, in a survey conducted by Martin et al. (2010), approximately 30% of respondents noted that they had joined car-sharing to throw away their cars or avoid purchasing an extra car. This highlights the influence of shared cars on vehicle ownership status. This group can be extended to suburban residents who do not access shared cars in their neighborhoods but utilize car-sharing when visiting city centers or workplaces. On the other hand, about 50% of respondents stated that they did not have a vehicle and had joined a shared car program to access the vehicles. This determines that the strength of the relationship is in the opposite direction. There may be a hypothesis that car-sharing affects increased driving and travel but does not reduce vehicle ownership. The second group of members joins the shared cars to reduce car ownership; however, further research is required to address such heterogeneity.

Some studies, such as Martin et al. (2010) and Firnkorn and Müller (2012) on the impact of car-sharing causality, have been conducted according to surveys of shared car members. The research addressed the two-way relationship between car ownership and car-sharing. Therefore, by examining the number of people's cars before registering in the shared car program and then also the number of their cars after registration, they try to control the reverse causality bias. The research did not evaluate impacts by comparing the changes with a comparison group. They assessed the impacts by asking respondents to describe their decision to car-shed and sign-up for car-sharing. For instance, in a study by Firnkorn and Müller (2012), car-sharing members were asked to explain whether their decision to eliminate or ignore future car purchases was taken because of using shared car programs or other reasons.

Some studies have inferred causal impacts with the comparison of the trip behavior of members with non-members (Kopp et al., 2015; Sioui et al., 2013).

Moreover, in order to draw causal inferences, Cervero et al. (2007) compared the trip behavior of the members of shared car programs with those of individuals who requested to be part of a car sharing scheme but were not yet (control group). It turned out that members of round-trip car-sharing avoid using personal cars almost 12% more than non-members. It seems that a decrease in car possession can accompany membership and a decline in car possession with more shared car travels.

Mishra et al. (2015) applied a survey to investigate the effects of shared cars on trip behavior. Propensity score matching was utilized to control the self-selection bias resulting from the observed differences. Each member has matched non-members with the same person and family demographics and lives vicinities with an analogous built environment. Vehicle ownership of members is significantly less than that of non-members. This difference also rises with the increase in the desire to register a car-sharing. However, there is simultaneity bias in this study. Also, there is possibly the self-selection bias which differences in unobserved features may cause it. Hence, this study cannot claim that car-sharing can cause the observed differences in trip behavior between matched pairs.

Mishra et al. (2019) estimated the car-sharing impact on car ownership and current members' trip behavior using the California household travel survey database. However, in this study, the surveys have not explored the features of trip behavior, in particular the chronology of events which might result in inverse causation.

To sum up, round-trip shared car service members may follow a more efficient and sustainable lifestyle than members of the one-way shared car system. Sometimes, this difference can be significant, especially in China, where the effect of choosing car-sharing is more to prevent the purchase of a new car than to reduce car ownership. For instance, a study conducted in Beijing, China, indicated that car ownership positively affects the number of one-way trips and negatively influences the round-trip travels numbers (Yoon et al., 2017). Generally, it appears that people attracted to the station-based shared car program have less vehicle ownership than those attracted to the free-floating shared car program. Besides, station-based shared car members can decrease their vehicle ownership more than free-floating shared car members. Also, it should be stressed that the mean number of cars per family for car-sharing members in North America seems lower than in Europe.

Generally, most studies have focused on the effect of vehicle ownership on shared cars. However, in order to have a deep insight into the direction of causation between shared cars and car ownership and consequently assess the sustainability of shared cars, further research on this two-way relationship is needed.

Conclusions

This paper aims to provide an overview that assesses the socio-demographic factors influencing car-sharing use, membership, and attitudes to evaluate shared car services' performance. According to the shared cars service type and geographic area, the factors affecting the demand for all car-sharing systems were reviewed. Therefore, this paper can offer decision-makers or planners an overview of the key socio-demographic elements influencing car-sharing demand. The conclusion section includes key conclusions on the effect of different factors, a summary of their implications for car sharing demand, limitations, and suggestions for future research.

The effect of different sociodemographic factors is summarised in the following list. Besides, the number of articles used to claim each result is mentioned to assess its corresponding level of support in the literature.

- Gender: car-sharing seems to be accepted by both males and females (4 articles), even if there is much attraction for potential female members (3 articles); males are more likely to travel shorter distances and more frequently (1 article).
- Age: the majority of car-sharing members/users are young people (23 articles), typically in their mid-20 s to mid-30 s (12 articles).
- Education level: being attracted to car-sharing may be based on a certain level of social awareness, not strictly an economic decision (5 articles); most people looking to choose car-sharing seem to have a four-year college degree or higher (14 articles), especially a post-graduate or advanced degree (4 articles); beyond car-sharing membership, a high level of education can also increase the utilization of car-sharing (20 articles).
- Occupation and economic status: most shared car members earn more than non-members, and most are employed (12 articles); car-sharing members with middle to upper-income levels can also be cost-sensitive people (1 article).
- Marital status: car-sharing is attractive in places where the proportion of single-parent households is high (5 articles).
- Car ownership: the mean number of cars per family for car-sharing system members is lower than for non-members (21 articles); there is a complex two-way relationship between car ownership status and shared car demand (6 articles); car-sharing in China seems to be more effective in preventing the purchase of vehicles than car-shedding (1 article).

However, several interaction effects between different socio-demographic factors have been detected. The most important ones are the following:

- Between age and economic status: an older age (55 years or older) of people living in households without high income negatively affects the propensity to join a car-sharing scheme (1 article).
- Between age, marital status, and car-ownership status: car-sharing with Evs has a special added attraction for young couples with no private car (1 article). The same is true for young people who start a family and use car-sharing to complement their private car trips (1 article).
- Between occupation status and household size: shared cars are more utilized by employees living in low-size families (1 article).
- Between the presence of children status and economic status: the presence of children may increase the desire to choose car-sharing (4 articles). However, it appears that the children's presence can reduce shared car demand in low-and-middle-income households (1 article).

On the basis of the above findings, the following policy implications and suggestions to expand the demand for different car sharing schemes can be formulated.

At the outset, it is important to note that the rate of young members and people with above-average income are higher among free-floating members. Also, males' adoption of this service is more elevated than station-based service. Also, the rate of female members in free-floating services is higher than in station-based services. Besides, as females seem to be more eager to opt for E-car-sharing services, free-floating services can attract females by offering this type of car, especially in Europe, where females are less attracted to car-sharing than females in North American countries. Also, since an older age (55 years or older) of people living in households without high income negatively affects the propensity to join a car-sharing scheme, free-floating operators should target this group through specific actions.

It is also interesting to mention that although round-trip car-sharing users appear to be less educated than other car-sharing services users, car-sharing members may follow a more efficient and sustainable lifestyle than the one-way shared car system members. As an example, round-trip service members have significantly fewer private cars than free-floating service members. However, the rate of young members in the free-floating services is more elevated than in station-based services. Since car-sharing with EVs has a special added attraction for young

couples with no private car, round-trip operators can offer this kind of service to attract younger members. Furthermore, the probability of decreasing vehicle ownership by members of station-based shared cars is more than free-floating car-sharing members. It may be because members of free-floating shared car services do not necessarily see the service as a replacement for their private car but as a supplement. It is important to note that car-sharing with EVs has a special added attraction for young people who start a family and choose car-sharing to complement their private car trips. Concerning developing e-car-sharing, some articles identified the factors affecting the development or downturn of e-car-sharing services in the entire e-car-sharing industry concerning stakeholders. (Turoń et al., 2020). Also, Turoń et al. (2021) showed the main factors affecting the operation of the e-car-sharing market in the COVID-19 and post-quarantine periods.

It should be noted that this study has some limitations. First, the results and claims related to the effect of marital status and household size characteristics on car-sharing demand are based on only a few articles. Therefore, more research needs to be done to increase the robustness of the results, especially for free-floating and P2P services. In addition, more studies should be done on the impacts of child presence and vehicle ownership characteristics on demand for P2P services.

It is worth pointing out that although car-sharing has spread to the global markets, most research on shared car systems has been investigated in China, the USA, Canada, and some European countries. Hence, more studies need to be implemented in other countries, especially in developing countries, to understand better the socio-demographic factors that affect car-sharing demand according to the geographical area. For example, differences in education levels between developed and underdeveloped countries may lead to different proportions of car-sharing because there may be a relationship between education level and country. In addition, other factors such as residence status (permanent residence or not, or tourist effect) could be worth investigating to broaden the view.

Last but not least, another research gap is the direction of causation between private car ownership levels and car-sharing demand. There appears to be a complex two-way relationship between car ownership and shared car demand. However, most studies have worked on the vehicle ownership impacts on shared cars. Therefore, to clarify the direction of causality more realistically and better assess the shared car systems' sustainability, more research is required to work on vehicle ownership as exogenous and endogenous variables.

Declaration of Competing Interest

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

References

Acheampong, R.A., Siiba, A., 2020. Modelling the determinants of car-sharing adoption intentions among young adults: the role of attitude, perceived benefits, travel expectations and socio-demographic factors. Transportation 47 (5), 2557–2580.

Akter, S., Mamun, M.M.H., Mwakalonge, J.L., Comert, G., Siuhi, S., 2021. A policy review of electric personal assistive mobility devices. Transp. Res. Interdiscip. Perspect. 11, 100426.

Balac, M., Ciari, F., Axhausen, K.W., 2015. Car-sharing demand estimation: Zurich, Switzerland, area case study. Transp. Res. Rec. 2563 (1), 10–18.

Becker, H., Ciari, F., Axhausen, K.W., 2017a. Comparing car-sharing schemes in Switzerland: User groups and usage patterns. Transp. Res. Part A: Policy Pract. 97, 17–29.

Becker, H., Ciari, F., Axhausen, K.W., 2017b. Modeling Free-floating car-sharing use in Switzerland: A spatial regression and conditional logit approach. Transp. Res. Part C: Emerg. Technol. 81, 286–299.

Becker, H., Ciari, F., Axhausen, K.W., 2018. Measuring the car ownership impact of Free-floating car-sharing–A case study in Basel, Switzerland. Transp. Res. Part D: Transp. Environ. 65, 51–62.

Brook, D., 2004. Carsharing–start up issues and new operational models. Transportation Research Board Annual Meeting.

Burghard, U., Dütschke, E., 2019. Who wants shared mobility? Lessons from early adopters and mainstream drivers on electric carsharing in ermany. Transp. Res. Part D: Transp. Environ. 71, 96–109.

Burkhardt, J.E., Millard-Ball, A., 2006. Who is attracted to carsharing? Transp. Res. Rec. 1986 (1), 98–105.

Carroll, P., Caulfield, B., Ahern, A., 2017. Examining the potential for car-shedding in the Greater Dublin Area. Transp. Res. Part A: Policy Pract. 106, 440–452.

Cartenì, A., Cascetta, E., de Luca, S., 2016. A random utility model for park & carsharing services and the pure preference for electric vehicles. Transp. Policy 48, 49–59.

Catalano, M., Lo Casto, B., Migliore, M., 2008. Car-sharing demand estimation and urban transport demand modelling using stated preference techniques. Eur. Transp. / Trasporti Europei.

Ceccato, R., Diana, M., 2021. Substitution and complementarity patterns between traditional transport means and car-sharing: a person and trip level analysis. Transportation 48 (4), 1523–1540.

Ceccato, R., 2020. Switching intentions towards car-sharing (Doctoral dissertation, Politecnico di Torino).

Celsor, C., Millard-Ball, A., 2007. Where does carsharing work? Using geographic information systems to assess market potential. Transp. Res. Rec. 1992 (1), 61–69.

Cervero, R., 2003. City carshare: First-year travel demand impacts. Transp. Res. Rec. 1839 (1), 159–166.

Cervero, R., Golub, A., Nee, B., 2007. City carshare: longer-term travel demand and car ownership impacts. Transp. Res. Rec. 1992 (1), 70–80.

Cervero, R., Tsai, Y., 2004. City carshare in San Francisco, California: second-year travel demand and car ownership impacts. Transp. Res. Rec. 1887 (1), 117–127.

Chicco, A., Diana, M., Rodenbach, J., Matthijs, J., Nehrke, G., Ziesak, M., Horvat, M., 2020. STARS shared mobility opportunities and challenges for European cities: Deliverable D5.1 - Mobility scenarios of car-sharing: gap analysis and impacts in the cities of tomorrow.

Ciari, F., Balac, M., Balmer, M., 2015. Modelling the effect of different pricing schemes on Free-floating car-sharing travel demand: a test case for Zurich, Switzerland. Transportation 42 (3), 413–433.

Clewlow, R.R., 2016. Carsharing and sustainable travel behavior: Results from the San Francisco Bay Area. Transp. Policy 51, 158–164.

Coll, M.H., Vandersmissen, M.H., Thériault, M., 2014. Modeling spatio-temporal diffusion of carsharing membership in Québec City. J. Transp. Geogr. 38, 22–37.

Cooper, G., Howe, D. A., & Mye, P., 2000. The Missing Link: An Evaluation of carsharing Portland Inc. Portland, Oregon. Master of Urban and Regional Planning Workshop Projects. 74.

Costain, C., Ardron, C., Habib, K.N., 2012. Synopsis of users' behaviour of a carsharing program: A case study in Toronto. Transp. Res. Part A: Policy Pract. 46 (3), 421–434.

De Luca, S., Di Pace, R., 2015. Modelling users' behaviour in inter-urban carsharing program: A stated preference approach. Transp. Res. Part A: Policy Pract. 71, 59–76.

Del Mar Alonso-Almeida, M., 2019. Carsharing: Another gender issue? Drivers of carsharing usage among women and relationship to perceived value. Travel Behav. Society 17, 36–45.

Dias, F.F., Lavieri, P.S., Garikapati, V.M., Astroza, S., Pendyala, R.M., Bhat, C.R., 2017. A behavioral choice model of the use of car-sharing and ride-sourcing services. Transportation 44 (6), 1307–1323.

Efthymiou, D., Antoniou, C., Waddell, P., 2013. Factors affecting the adoption of vehicle sharing systems by young drivers. Transp. Policy 29, 64–73.

Efthymiou, D., Antoniou, C., 2014. Modeling the propensity to join carsharing using hybrid choice and latent variable models 2 and mixed internet/paper survey data 3 (no. 14–2512). Transp. Res. Rec.

Efthymiou, D., Antoniou, C., 2016. Modeling the propensity to join carsharing using hybrid choice models and mixed survey data. Transp. Policy 51, 143–149.

Eren, E., Uz, V.E., 2020. A review on bike-sharing: The factors affecting bike-sharing demand. Sustain. Cities Society 54, 101882.

Ferrero, F., Perboli, G., Rosano, M., Vesco, A., 2018. Car-sharing services: An annotated review. Sustain. Cities Society 37 (501–518).

Firnkorn, J., Müller, M., 2012. Selling mobility instead of cars: new business strategies of automakers and the impact on private vehicle holding. Bus. Strategy Environ. 21 (4), 264–280.

Firnkorn, J., Shaheen, S., 2016. Generic time-and method-interdependencies of empirical impact-measurements: A generalizable model of adaptation-processes of carsharing-users' mobility-behavior over time. J. Cleaner Prod. 113, 897–909.

Guirao, B., Ampudia, M., Molina, R., García-Valdecasas, J., 2018. Student behaviour towards Free-floating Carsharing: First evidences of the experience in Madrid. Transp. Res. Procedia 33, 243–250.

Habib, K.M.N., Morency, C., Islam, M.T., Grasset, V., 2012. Modelling users' behaviour of a carsharing program: Application of a joint hazard and zero inflated dynamic ordered probability model. Transp. Res. Part A: Policy Pract. 46 (2), 241–254.

Hu, S., Chen, P., Lin, H., Xie, C., Chen, X., 2018. Promoting carsharing attractiveness and efficiency: An exploratory analysis. Transp. Res. Part D: Transp. Environ. 65, 229–243.

Hua, Y., Zhao, D., Wang, X., Li, X., 2019. Joint infrastructure planning and fleet management for One-wayelectric car-sharing under time-varying uncertain demand. Transp. Res. Part B: Methodol. 128, 185–206.

Illgen, S., Höck, M., 2019. Literature review of the vehicle relocation problem in one-way car sharing networks. Transp. Res. Part B: Methodol. 120, 193–204.

Jones, E.C., Leibowicz, B.D., 2019. Contributions of shared autonomous vehicles to climate change mitigation. Transp. Res. Part D: Transp. Environ. 72, 279–298.

Jorge, D., Correia, G., 2013. Carsharing systems demand estimation and defined operations: a literature review. Eur. J. Transp. Infrastruct. Res. 13 (3).

Juschten, M., Ohnmacht, T., Thao, V.T., Gerike, R., Hössinger, R., 2017. Carsharing in Switzerland: identifying new markets by predicting membership based on data on supply and demand. Transportation 46 (4), 1171–1194.
Kawgan-Kagan, I., 2015. Early adopters of carsharing with and without bevs with respect to gender preferences. Eur. Transp. Res. Rev. 7 (4), 33.
Kawgan-Kagan, I., 2020. Are women greener than men? A preference analysis of women and men from major German cities over sustainable urban mobility. Transp. Res. Interdiscip. Perspect. 8, 100236.
Kim, D., Ko, J., Park, Y., 2015. Factors affecting electric vehicle sharing program participants' attitudes about car ownership and program participation. Transp. Res. Part D: Transp. Environ. 36, 96–106.
Kim, J., Rasouli, S., Timmermans, H.J., 2017. Satisfaction and uncertainty in car-sharing decisions: An integration of hybrid choice and random regret-based models. Transp. Res. Part A: Policy Pract. 95, 13–33.
Kopp, J., Gerike, R., Axhausen, K.W., 2015. Do sharing people behave differently? An empirical evaluation of the distinctive mobility patterns of Free-floating car-sharing members. Transportation 42 (3), 449–469.
Kortum, K., & Machemehl, R. B., 2012. Free-floating carsharing systems: innovations in membership prediction, mode share, and vehicle allocation optimization methodologies (No. SWUTC/12/476660-00079-1). Southwest Region University Transportation Center, Center for Transportation Research, University of Texas at Austin.
Lagadic, M., Verloes, A., Louvet, N., 2019. Can carsharing services be profitable? A critical review of established and developing business models. Transp. Policy 77 (C), 68–78.
Lane, C., 2005. PhillyCarShare: First-year social and mobility impacts of carsharing in Philadelphia, Pennsylvania. Transp. Res. Rec. 1927 (1), 158–166.
Le Vine, S., Polak, J., 2019. The impact of Free-floating carsharing on car ownership: Early-stage findings from London. Transp. Policy 75, 119–127.
Le Vine, S., Adamou, O., Polak, J., 2014. Predicting new forms of activity/mobility patterns enabled by shared-mobility services through a needs-based stated-response method: Case study of grocery shopping. Transp. Policy 32, 60–68.
Lee, D., Quadrifoglio, L., Teulada, E.S.d., Meloni, I., 2016. Discovering relationships between factors of Round-trip car-sharing by using association rules approach. Procedia Eng. 161, 1282–1288.
Lempert, R., Zhao, J., Dowlatabadi, H., 2019. Convenience, savings, or lifestyle? Distinct motivations and travel patterns of One-way and two-way carsharing members in Vancouver, Canada. Transp. Res. Part D: Transp. Environ. 71, 141–152.
Li, Q., Liao, F., Timmermans, H.J., Huang, H., Zhou, J., 2018. Incorporating Free-floating car-sharing into an activity-based dynamic user equilibrium model: A demand-side model. Transp. Res. Part B: Methodol. 107, 102–123.
Liao, F., Correia, G., 2020. Electric carsharing and micromobility: A literature review on their usage pattern, demand, and potential impacts. Int. J. Sustain. Transp. 1–30.
Martin, E., Shaheen, S.A., Lidicker, J., 2010. Impact of carsharing on household vehicle holdings: Results from North American shared-use vehicle survey. Transp. Res. Rec. 2143 (1), 150–158.
Martin, E.W., Shaheen, S.A., 2011a. The impact of carsharing on public transit and non-motorized travel: an exploration of North American carsharing survey data. Energies 4 (11), 2094–2114.
Martin, E.W., Shaheen, S.A., 2011b. Greenhouse gas emission impacts of carsharing in North America. IEEE Trans. Intell. Transp. Syst. 12 (4), 1074–1086.
Martin, E., Shaheen, S., 2016. Impacts of car2go on vehicle ownership, modal shift, vehicle miles traveled, and greenhouse gas emissions: An analysis of five North American cities. Transportation Sustainability Research Center, UC Berkeley, p. 3.
Millard-Ball, A., 2005. Car-sharing: Where and how it succeeds. Transp. Res. Board 60.
Mishra, G.S., Clewlow, R.R., Mokhtarian, P.L., Widaman, K.F., 2015. The effect of carsharing on vehicle holdings and travel behavior: A propensity score and causal mediation analysis of the San Francisco Bay Area. Res. Transp. Econ. 52, 46–55.
Mishra, G.S., Mokhtarian, P.L., Clewlow, R.R., Widaman, K.F., 2019. Addressing the joint occurrence of self-selection and simultaneity biases in the estimation of program effects based on cross-sectional observational surveys: case study of travel behavior effects in carsharing. Transportation 46 (1), 95–123.
Morency, C., Habib, K.M.N., Grasset, V., Islam, M.T., 2012. Understanding members' carsharing (activity) persistency by using econometric model. J. Adv. Transp. 46 (1), 26–38.
Morency, C., Verreault, H., Demers, M., 2015. Identification of the minimum size of the shared-car fleet required to satisfy car-driving trips in Montreal. Transportation 42 (3), 435–447.
Namazu, M., Dowlatabadi, H., 2018. Vehicle ownership reduction: A comparison of One-way and two-way carsharing systems. Transp. Policy 64, 38–50.
Namazu, M., MacKenzie, D., Zerriffi, H., Dowlatabadi, H., 2018. Is carsharing for everyone? Understanding the diffusion of carsharing services. Transp. Policy 63, 189–199.
Nguyen, J., Powers, S.T., Urquhart, N., Farrenkopf, T., Guckert, M., 2021. An overview of agent-based traffic simulators. Transp. Res. Interdiscip. Perspect. 12, 100486.
Nobis, C., 2006. Carsharing as key contribution to multimodal and sustainable mobility behavior: Carsharing in Germany. Transp. Res. Rec. 1986 (1), 89–97.
Perboli, G., Caroleo, B., Musso, S., 2017. Car-Sharing: Current and Potential Members Behavior Analysis after the Introduction of the Service. Proc. – Int. Comput. Software Appl. Conf. 2, 771–776.
Prieto, M., Baltas, G., Stan, V., 2017. Car sharing adoption intention in urban areas: What are the key sociodemographic drivers? Transp. Res. Part A: Policy Pract. 101, 218–227.
Rand, K., Fleming, C.H., 2019. An interdisciplinary review to develop guidelines for modeling population displacement as a function of infrastructure reconstruction decisions. Transp. Res. Interdiscip. Perspect. 3, 100072.
Rotaris, L., Danielis, R., 2018. The role for carsharing in medium to small-sized towns and in less-densely populated rural areas. Transp. Res. Part A: Policy Pract. 115, 49–62.
Sadri, A.M., Ukkusuri, S.V., Ahmed, M.A., 2021. Review of social influence in crisis communications and evacuation decision-making. Transp. Res. Interdiscip. Perspect. 9, 100325.
Shaheen, S., & Cohen, A., 2020. Innovative mobility: carsharing outlook carsharing market overview, analysis, and trends.
Shaheen, S.A., Martin, E., 2010. Demand for carsharing systems in Beijing, China: an exploratory study. Int. J. Sustain. Transp. 4 (1), 41–55.
Shaheen, S.A., Chan, N.D., Micheaux, H., 2015. One-way carsharing's evolution and operator perspectives from the Americas. Transportation 42 (3), 519–536.
Shaheen, S.A., Cohen, A.P., 2013. Carsharing and personal vehicle services: worldwide market developments and emerging trends. Int. J. Sustain. Transp. 7 (1), 5–34.
Shaheen, S., Cohen, A., Farrar, E., 2019. Carsharing's impact and future. Adv. Transp. Policy Plann. 4, 87–120.
Shaheen, S., Martin, E., & Bansal, A., 2018. Peer-to-Peer (P2P) carsharing: Understanding early markets, social dynamics, and behavioral impacts.
Sioui, L., Morency, C., Trépanier, M., 2013. How carsharing affects the travel behavior of households: a case study of Montréal, Canada. Int. J. Sustain. Transp. 7 (1), 52–69.
Ter Schure, J., Napolitan, F., Hutchinson, R., 2012. Cumulative impacts of carsharing and unbundled parking on vehicle ownership and mode choice. Transp. Res. Rec. 2319 (1), 96–104.
Turoń, K., Kubik, A., Chen, F., Wang, H., Łazarz, B., 2020. A holistic approach to electric shared mobility systems development—Modelling and optimization aspects. Energies 13 (21), 5810.
Turoń, K., Kubik, A., Chen, F., 2021. Electric Shared Mobility Services during the Pandemic: Modeling Aspects of Transportation. Energies 14 (9), 2622.
Uteng, T.P., Julsrud, T.E., George, C., 2019. The role of life events and context in type of car share uptake: Comparing users of Peer-to-Peer and cooperative programs in Oslo, Norway. Transp. Res. Part D: Transp. Environ. 71, 186–206.
Vinayak, P., Dias, F.F., Astroza, S., Bhat, C.R., Pendyala, R.M., Garikapati, V.M., 2018. Accounting for multi-dimensional dependencies among decision-makers within a generalized model framework: An application to understanding shared mobility service usage levels. Transp. Policy 72, 129–137.
Wang, M., Martin, E.W., Shaheen, S.A., 2012. Carsharing in Shanghai, China: analysis of behavioral response to local survey and potential competition. Transp. Res. Rec. 2319 (1), 86–95.
Wang, Y., Yan, X., Zhou, Y., Xue, Q., Sun, L., 2017. Individuals' acceptance to Free-floating electric carsharing mode: A web-based survey in China. Int. J. Environ. Res. Public Health 14 (5), 476.
Wielinski, G., Trépanier, M., Morency, C., 2015. What about Free-floating carsharing? A look at the Montreal, Canada, case. Transp. Res. Rec. 2563 (1), 28–36.
Winter, K., Cats, O., Martens, K., van Arem, B., 2017. A stated-choice experiment on mode choice in an era of Free-floating carsharing and shared autonomous vehicles (No. 17–01321). Transp. Res. Rec.
Yoon, T., Cherry, C.R., Jones, L.R., 2017. One-way and Round-trip carsharing: A stated preference experiment in Beijing. Transp. Res. Part D: Transp. Environ. 53, 102–114.
Zhou, B., Kockelman, K.M., 2011. Opportunities for and impacts of carsharing: A survey of the Austin, Texas market. Int. J. Sustain. Transp. 5 (3), 135–152.