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CARPOOLING AS A SUSTAINABLE TRANSPORT SOLUTION IN DEVELOPING-COUNTRY CITIES: SOCIO-DEMOGRAPHIC, ECONOMIC AND TECHNOLOGICAL PERSPECTIVES

Khansa Ali[1], Haroon Liaqat[2], Muhammad Kashif[3], Muhammad Bilal Javed[4], Hasan Zulfiqar[5]

[1]M.Phil Scholar, Institute of Agriculture and Resource economics, University of Agriculture, Faisalabad,
Email: Khansaali2346@gmail.com
[2]Lecturer, University Community College, Government College University Faisalabad,
Email: Haroonliaqat@gcuf.edu.pk
[3]Lecturer, University Community College, Government College University Faisalabad,
Email: kashifrafeeq83@gmail.com
[4]Lecturer, University Community College, Government College University Faisalabad,
Email: Mianbilal58@gmail.com
[5]Assistant Professor, Institute of Agriculture and Resource economics, University of Agriculture, Faisalabad,
Email: hasan.zulfiqar@uaf.edu.pk

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ABSTRACT

Urbanization, and the increasing number of private vehicles, has exacerbated urban transport problems in developing countries. Lack of public transport has also stimulated an interest in low cost measures, such as car pool. This research looks at the literature about carpooling and car-sharing adoption and attempts to answer two questions. It begins by inquiring about the socio-demographic, economic and technological factors related to people's willingness to use carpooling. Second, it explores the similarities and differences of these associations between developed and developing country settings, with specific focus on Pakistan. After screening, approximately 80 studies were found and 63 were included in a systematic search for review using keywords in the major academic databases. The review reveals that education level and household size are generally positive predictors of carpooling willingness and that income, commute distance, and travel cost are negative predictors, with the magnitude of these relationships being dependent on the context, and only a few studies testing for confounding or common-method bias. Results of an empirical research study undertaken in Faisalabad, Pakistan are discussed in detail and compared with the general international evidence, which is critically evaluated in terms of sample size, generalizability and measurement limitations. The review also contextualizes the concept of carpooling into the smart mobility framework and its underlying technologies such as IoT, AI and blockchain based trust systems. It ends with a consideration of the methodological shortcomings in the current evidence base and the policy directions and future research that this critically appraised evidence base informs.

Correspondence **Hasan Zulfiqar**
Email: hasan.zulfiqar@uaf.edu.pk

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Introduction

Traffic congestion, environmental degradation and increased energy consumption are among the serious urban issues brought on by the global increase in private automobile ownership. The transportation sector emits about 14% of global GHG emissions, and cities contribute disproportionately large amounts (Perboli et al., 2018). The demand for sustainable mobility is more pressing than ever: Already there are an estimated one billion passenger cars on the road and projections estimate a growth to 2.8 billion cars by 2050 (Firnkorn & Müller, 2015).

Carpooling, the sharing of a private vehicle by multiple persons traveling to work in the same direction, is one demand-side transportation management practice that has garnered renewed interest. Carpooling can also reduce the congestion on roads, in addition to the lowering of emissions and per-capita level of fuel consumption and vehicle kilometers driven. Demand-side strategies such as ride-sharing and carpooling are considered crucial for attaining equitable and sustainable mobility (World Bank, 2023) shared mobility options are estimated to be capable of cutting traffic emissions in large cities by over 30% (International Transport Forum, 2023). Notable is that such estimates tend to come from cities with a more formalized shared-mobility system, and it's an assumption that this review revisits critically later in this study: Does the same level of reduction apply to cities with more informal carpooling arrangements? In addition to ridesharing, bicycle/e-scooter sharing and carsharing, carpooling is also acknowledged as a core part of the Mobility-as-a-Service (MaaS) paradigm (Paiva et al., 2021).

These are among the challenges faced by the world in general and Pakistan in particular. Despite investment in public transport infrastructure being low, the country's urban population has grown significantly over the last 20 years and so has private vehicle ownership which has increased in line with rising incomes and increasing urban sprawl. In Pakistan, urban mobility has become one of the most salient policy issues affecting urban areas, driven by a series of factors including increasing fuel prices, deteriorating urban air quality, and the chronic congestion of peak hours, but formal transportation demand-management strategies are not as well-developed as in other more advanced markets. As this review will demonstrate, the evidence base to design an intervention with carpooling with confidence is still scant and geographically uneven, but carpooling, as one of the interventions requires relatively little investment in infrastructure, is an attractive option for resource-constrained municipal governments.

Need and Importance of Carpooling

Carpooling not only helps travelers alleviate congestion and lower their travel costs and gain mobility access, but it also offers cities an easy-to-implement instrument to manage traffic flow, improve the environment and make effective policy decisions. Figure 1 is a summary of these two-fold benefits offered by travel and to city administrations.

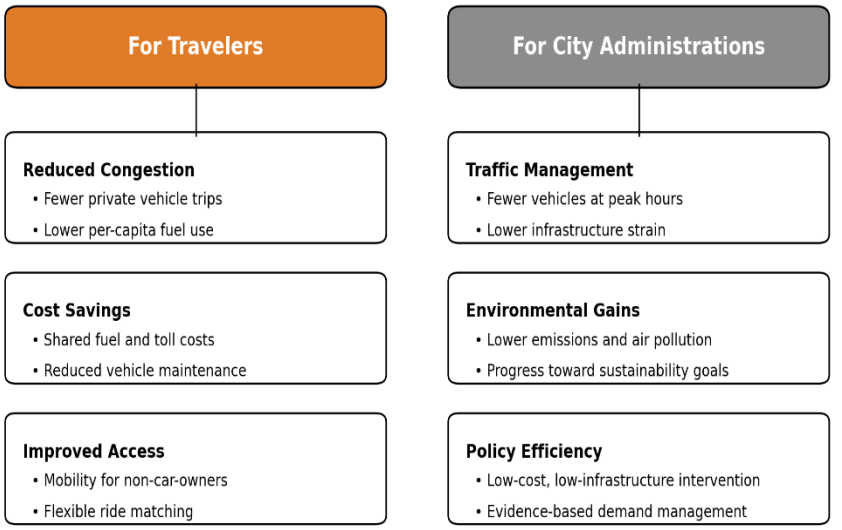

Figure 1. Need and importance of carpooling

However, there is not a great deal of empirical evidence with whom to compare in terms of the take up of carpooling in developing countries. Research on carpooling has been mainly completed in Europe, North America and East Asia. These differ significantly from South Asian cities in infrastructure, economic levels and urban planning (Min & Xing-Fu, 2020; Zhang & Li, 2020). The transportation problem in Pakistan is characterized by the rapid rate of motorization, lack of public transportation, high fuel prices, and air pollution. These challenges are highlighted in the third largest city of Pakistan, Faisalabad and industrial center with a population of around 3.2 million. Existing and general knowledge of carpooling adoption determinants is thus still limited and largely confined to high-income urban settings. There is little local evidence available for policy makers in cities like Faisalabad to base their decisions on, and even the evidence that does exist should be read with due methodological caution, as this review suggests.

To fill this void, a review of the relevant literature was conducted and critically appraised to allow the response to two questions. First, what socio-demographic, economic and technological factors are related to the willingness to carpool the strength of the evidence for each association? Second, these associations, how do they compare when taken across other international (specifically Pakistani) contexts – what does a recent empirical study conducted in Faisalabad reveal about carpooling adoption in a South Asian context, once its own limitations are taken into account?

Research Organization

This paper consists of seven sections. In section 2, the review methodology and the progress of research in the carpool adoption field were organized in a thematic manner and a critical appraisal of the methodological quality of the reviewed literature was included. The carpooling concept is placed into the smart mobility paradigm by highlighting its main characteristics, opportunities and

challenges in Section 3. Section 4 reviews the results of an empirical research on carpooling adoption in Faisalabad recently conducted, and draws comparisons with the general body of literature, while critically evaluating the study's own shortcomings. Section 5 examines and provides an overview of the enabling technologies for carpooling platforms. Section 6 critically discusses the results and points the way to future research. A statement, including this one's limitations, about the shortcomings of this review comes at the end of Section 7. An overview of the paper organization is shown in Figure 2.

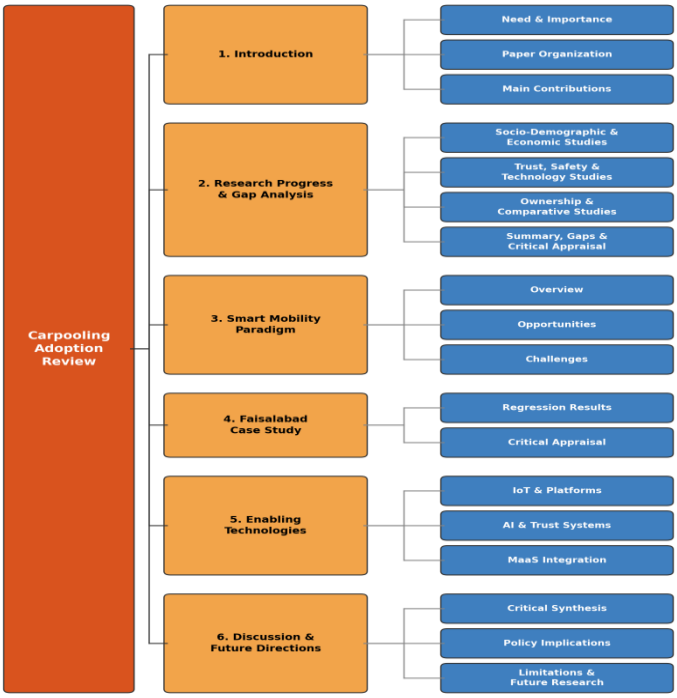

Figure 2. Overview of research organization

Main Contributions

The main contributions of this research include:

- A structured and critically appraised review of socio-demographic and economic correlates of adoption of carpooling and car sharing (trust and technology).
- A descriptive summary of the literature reviewed is not enough; it needs to be accompanied by an explicit assessment of the methodological quality, sample sizes and geographic coverage of the reviewed literature.

- Analyses of a recent empirical study on carpooling adoption determinants in Faisalabad, Pakistan in detail and critically with statistical and design limitations.
- Introduction to the concept of carpooling within the smart mobility concept, key features, opportunities and challenges.
- Enabling technologies for a carpooling platforms: IoT, AI and Blockchain.
- Policy recommendations and future research directions that are clearly identified by the extent of the evidence.

Research Progress in Carpooling Adoption and Gap Analysis

The method of review and the research advancements of carpooling adoption are described in this section, while research gaps in the existing literature are identified. To cover a wide spectrum of published literature that is relevant to carpooling and shared mobility, a literature search was carried out in the main online academic databases, such as Google Scholar, Scopus and ScienceDirect. The keywords used to search for each relevant theme are given in Table 1.

Table 1. Keywords used in literature search

Search category	Keywords used
Carpooling / cost-sharing	carpool, car-pool, cost-shar, ride-shar
Car-sharing / shared mobility	car-shar, shared mobility, vehicle shar
Sustainable & smart mobility	sustainable mobility, smart mobility, smart city, sustainable transport
Adoption & determinants	adopt, determinant, willingness, intention, behavior
Developing-country context	developing country, Pakistan, South Asia, Faisalabad, Lahore

The initial search yielded ~80 articles and reports, most of which were peer-reviewed. Three inclusion criteria were used for each item. First, it had to deal with carpooling, car-sharing, ride sharing (or similar cost sharing mode of transport). Second, it needed to provide empirical, conceptual or policy relevant results addressing determinants of adoption, barriers to adoption, benefits from adoption or governance of adoption. Third it had to be available in full text and in English. This English-language restriction is also a limitation brought back in Section 7 as it could have excluded the material relevant to Pakistan that is also published in Urdu language or in regionally. Items were removed if they were not on topic, duplicated, did not have full text available or if they were only tangentially related to shared mobility. This left a total of 63 studies as the evidentiary base of this review after applying these criteria. A summary of the steps followed in the review methodology are summarized in figure 3.

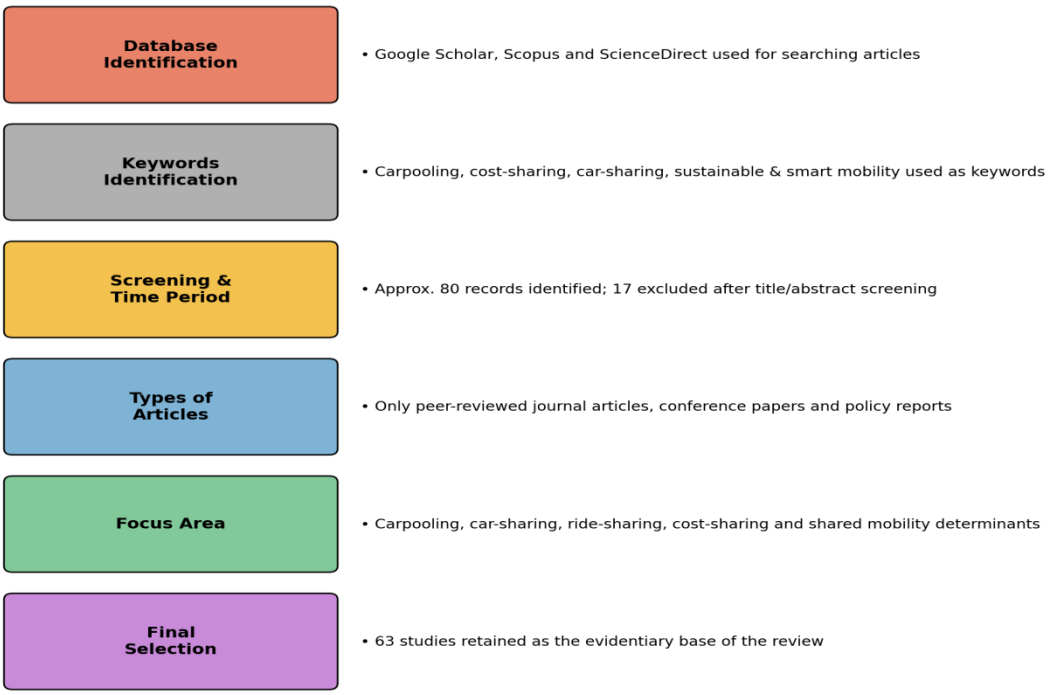

Figure 3. Steps in the review methodology adopted

After screening the articles, a detailed analysis was carried out to determine the crux, key findings and methodological quality of the articles. The details are discussed in Sections 2.1 to 2.3, respectively, with the socio-demographic and economic determinants, trust-safety-technology determinants, and ownership-and-comparative determinants, respectively. This evidence base is then critically evaluated for its quality and limitations in Section 2.5.

Studies on Socio-Demographic and Economic Determinants

Studies in the past have consistently noted socio-demographic factors as significant correlates of carpooling and car-sharing use. Amirmazmifashar and Diana (2021) conducted a systematic review of 91 studies and found the most frequently studied variables were education and age and income. The link between higher education and willingness to take advantage of shared mobility services was largely attributed to the ease of online booking platforms and acceptance of lifestyle change among educated users. Contrary to this, low-income youth were found to be more likely to carpool in Lisbon by Correia and Viegas (2011), and education and income were found to be significant factors for car-sharing adoption in Lahore, Pakistan by Safdar et al. (2022). Education is not, however, confounded in any of these three studies, nor is digital literacy or urban exposure, so the causal pathway explaining the education effect is not clear.

In contrast to family size, there has been less attention paid to family size in the literature, although it is important on a theoretical level because larger families create more travel demand, and carpooling may be a cost-effective way to meet that demand. Using data from ten countries, Molina et al. (2020) showed that the size of the household had a somewhat stronger but consistent effect on carpooling behavior. Another influential factor in carpooling adoption is economic. Smart mobility services such as sharing taxis were more appealing for non-commute trips in the Lisbon Metropolitan Area partially because of cost sensitivity, as indicated by Choudhury et al., (2018). Among the Spanish teachers, the motivation for implementing a carpooling initiative was primarily fuel savings, as identified by Fernandez et al., (2024). The likelihood of adoption of carpooling is in general inversely related to income. This aligns with the idea that affluent people value privacy and autonomy more and are more exclusive to private vehicle ownership (Ikezoe et al., 2020). Several studies have identified commute distance and travel cost as negative determinants. This seems counterintuitive, but might indicate that there are more scheduling challenges and trust barriers involved in longer, more expensive trips (Parezanovic et al., 2015); it may also be just the people who are most cost-constrained short-distance travelers who use car pooling, which is an explanation that none of the studies reviewed was designed to test.

Studies on Trust, Safety and Technology-Enabled Carpooling

The issues of trust and safety are continually appearing in the carpooling literature. Boichuk (2020) determined that people living in Polish cities knew about carpooling but had doubts about safety and social incompatibility. To overcome trust issues, Salamanis et al., (2019) introduced reputation rating systems and Afsari et al., (2025) revealed that, gender is the most significant factor influencing security perceptions in ride-sharing, with women being far more likely to perceive security concerns. Chaudhry et al., (2018), pointed out the importance of identity verification for the security of passengers. Although these findings are consistent across studies, most of the evidence supporting the mechanisms that could be used to address these issues is attitudinal or conceptual, and not based on actual outcomes from platforms, so there are limited opportunities to evaluate these systems and protocols in the field.

Carpooling platforms created and supported by technology have shown promise to address these concerns, but these are limited to a few pilot deployments instead of operational data from large numbers of platforms. The carpooling platform developed by Bruglieri et al., (2011) matched more than 90% of the trip requests, reducing the travel distance by 35% based on a sample data of one university, which has not been replicated elsewhere. While Mahapatra et al., (2023) have created a next generation of carpooling by introducing real time tracking, dynamic pricing and cashless payments, Anthopoulos and Tzimos (2021) identified, using a bibliometric analysis of carpooling platforms, the new area for development is to integrate carpooling with smart city frameworks and with IoT and blockchain technologies. The two sets of results suggest that institutional and platform design are important as well as individual willingness for the long-term viability of carpooling, though the evidence on technology adoption is more exploratory than the evidence on socio-demographics presented in Section 2.1.

Studies on Car-Sharing, Ownership and Comparative International Perspectives

The private vehicle ownership/carpooling and private vehicle ownership/car-sharing dynamic has also been the subject of a parallel stream of literature, which has considered how these dynamics are different in different national settings. There is evidence of genuine substitutive effects from Europe: Jochem et al., (2020) identified statistically significant decreases in private car ownership among urban households in Germany following the introduction of free-floating carsharing, and Kolleck (2021) reported similar trends in German cities. In a scoping review of the carsharing-ownership relationship, however, Xu et al., (2025) warn that the substitution effects are much more context-specific and less consistently documented in other cities outside Europe – this is indeed a point this review agrees with, as the evidence base outside Europe is still very limited.

Comparative studies from East Asia make the situation even more complex. The factors that distinguish Japanese consumers who choose to keep owning cars and those who do not are not just the costs associated with car sharing, but also lifestyle and convenience preferences, according to Miura and Yamamoto (2022). In a Chinese study, Li et al., (2025) also determined that more than the actual economic cost savings, the perceived usefulness and social influence facilitated shared-car adoption. The barriers perspective was used by Li and Feng (2024), who argued that even if it would be economic to participate in a car sharing scheme, private car owners are often disincentivized to do so due to a lack of control and liability concerns. Peer-to-peer carpooling has been resilient without any institutional platforms historically. A longstanding "slugging" phenomenon in Houston, an informally organized casual carpooling arrangement, is also documented by Burris and Winn (2006) and provides an instructive parallel for Pakistan, where carpooling also is largely informal. It is important to note that the literature on slugging is many decades old and primarily descriptive, and that this literature is not necessarily applicable to the digitally mediated Pakistani context, as it is merely an analogy.

A further dimension is added for research related to smart cities. Paweloszek (2022) and Popova and Fesyuk (2022) determined digital infrastructure readiness and municipal support to be key enablers of the carsharing demand in Polish smart cities. While successful schemes are reported to feature flexible operational models with strong government support (Turon, 2023), the other researchers (Rotaris and Danielis, 2018) draw attention to the fact that schemes are much less feasible in medium and small-sized towns, a finding that is relevant for potential extension of Faisalabad-style carpooling models to smaller secondary cities in Pakistan, which suggests that Forsyth and Moss' results ought not to be blindly adopted in these other contexts.

Summary and Research Gap Analysis

Table 2 summarizes the 29 core studies discussed in Sections 2.1 to 2.3, together with their principal focus.

Table 2. Summary of literature reviewed

S. No.	Study (Year)	Focus
1	Perboli et al., (2018)	Business models and tariff simulation in car-sharing services
2	Firnkorn & Müller (2015)	Free-floating electric carsharing fleets and the post-private-car era in smart cities
3	Amirmazmifashar & Diana (2021)	Systematic review of socio-demographic factors affecting car-sharing demand
4	Correia & Viegas (2011)	Carpool clubs and value-enhancement possibilities, Lisbon
5	Safdar et al., (2022)	Driving forces in car-sharing adoption, Lahore, Pakistan
6	Molina et al., (2020)	Carpooling behavior analysis using Multinational Time Use Study data
7	Choudhury et al., (2018)	Preferences for shared and personalized transport services in the developing world
8	Fernandez et al., (2024)	Efficiency of a carpooling program among teachers in Spain
9	Ikezoe et al., (2020)	Car-sharing intention of car owners and non-owners in Japan
10	Parezanovic et al., (2015)	Carpooling as a pathway toward sustainable urban mobility (CIVITAS)
11	Boichuk (2020)	Perceptions of carpooling in urban and suburban Poland
12	Salamantis et al., (2019)	Reputation systems for building trust in car-sharing
13	Afsari et al., (2025)	Security perceptions and gender differences in ride-sharing
14	Chaudhry et al., (2018)	Factors affecting ride-sharing adoption in developing countries
15	Bruglieri et al., (2011)	PoliUniPool: a university-based carpooling matching platform
16	Mahapatra et al., (2023)	Next-generation carpooling application with real-time tracking and dynamic pricing
17	Anthopoulos & Tzimos (2021)	Bibliometric analysis of carpooling platforms as smart-city plans
18	Jochem et al., (2020)	Effect of free-floating carsharing on private vehicle ownership, Germany
19	Kolleck (2021)	Influence of car-sharing on non-corporate car ownership, Germany
20	Xu et al., (2025)	Scoping review of the carsharing-private car ownership relationship
21	Miura & Yamamoto (2022)	Consumer segmentation for car-sharing adoption, Japan
22	Li, Wang & Guo (2025)	Intention to use shared cars among private car owners, China
23	Li & Feng (2024)	Barriers to car owners' participation in private car-sharing
24	Burris & Winn (2006)	Slugging informal casual carpooling, Houston
25	Paweloszek (2022)	Carsharing services research in Polish smart cities
26	Popova & Fesyuk (2022)	Elements promoting carsharing demand in smart cities
27	Turon (2023)	Compendium of knowledge on car-sharing systems in smart

		cities
28	Rotaris & Danielis (2018)	Viability of carsharing in medium and small towns
29	Paiva et al., (2021)	Enabling technologies (IoT, AI, blockchain) for urban smart mobility, including MaaS and carpooling

This review shows a number of gaps. First, almost all the research on factors driving carpooling comes from European, North American and East Asian settings. Existing evidence in South Asia is limited to a few studies including the study conducted in Lahore by Safdar et al., (2022) and the study conducted in Faisalabad which was covered in Section 4. Secondly, there is less research on the interaction between the use of car pooling and car ownership decisions in developing country cities. This aspect has been studied more in Europe (Jochem et al., 2020; Kolleck, 2021) and East Asia (Miura & Yamamoto, 2022) than in South Asia. Thirdly, the literature on trust and safety, especially the gender-specific trust and safety perception (Afsari et al., 2025) has not yet been applied to the context of carpooling in Pakistan. Fourth, there is no comparative study of cities of various sizes in the different parts of Pakistan. In other countries, there is a significant difference in the viability of car sharing between large and small towns, as demonstrated by Rotaris and Danielis (2018), so there is no reason to expect that Pakistan will be an exception.

Critical Appraisal of the Reviewed Literature

In addition to outlining gaps, it is important to critically evaluate the quality of the evidence reviewed above as a method. Because simply summarizing the evidence without critiquing its methodological quality does not provide much guidance to policy or theory.

The teacher shared the students' findings from the correlation as if they were the teacher's own findings. Most studies reviewed, such as the Faisalabad study discussed in Section 4, use a cross-sectional survey design with regression and/or logistic analysis. None uses an experimental design or quasi-experimental design that allows for the isolation of causal effects. For consistency with previous use, the term "determinant" should be interpreted as a factor that is "associated with" rather than as a causal factor in the section preceding it, this review, and throughout it.

Geographic imbalance. The vast majority of the 29 core studies in Table 2 are based on European, East Asian or North American samples, with only three studies from South Asia: from Faisalabad, and from Safdar et al., (2022) and Chaudhry et al., (2018). This is a disclaimer that should not go unnoticed in policy-oriented summary versions of this literature: the external validity of directly applying findings from Europe and/or East Asia to policy in Pakistan is limited.

Definitional inconsistency. The terms "carpooling," "car-sharing" and "ride-sharing" are not used uniformly in the studies reviewed. Some view carpooling and car-sharing as synonymous (Boichuk 2020) and others distinguish between car-sharing services run by commercial fleets and driver-owned car-sharing (Jochem et al. 2020; Kolleck 2021). This blurring makes it difficult to conduct

any formal synthesis of the data at the quantitative level and is part of the rationale for the qualitative narrative synthesis approach taken for this review rather than a meta-analysis.

Small samples and unreported power. There are several studies which have small or single site samples and samples, such as Bruglieri et al.,(2011) with one university population or Boichuk(2020) survey, which was regional in scope. When a study reports a null result, for example, no gender difference, it is not always possible to determine whether the result is due to lack of a gender difference, or whether it is due to low statistical power, because post-hoc power calculations are seldom reported.

Rather than behavior, intention. Nearly all of the papers reviewed here, including the Faisalabad study, assess self-reported willingness (or intention) to carpool, not whether people actually carpool. Some of the authors cited recognize in principle the difference between intention and behavior in the transport literature, but do not test this difference in the studies reviewed here.

Carpooling within the Smart Mobility Paradigm

Overview

Smart mobility is a concept that is emerging and is associated with sustainable urban development, which involves several modes of transport, such as on demand mobility services, electric vehicles, bicycles, rapid mass transport and walking, which are designed to offer citizens a quality mobility service and to reduce the environment's impact. (Paiva et al., 2021). In addition to ridesharing, bicycle/e-scooter sharing and carsharing collectively known as the Mobility-as-a-Service (MaaS) services – carpooling is one of the services that underpins this shift. (Paiva et al., 2021) The smart mobility attribute framework of Paiva et al., (2021) has been adapted to the specific context of carpooling in Table 3 and should not be interpreted as a list of identified attributes that have been found to benefit carpooling in practice, as only a few of the studies presented in Section 2 have explicitly tested these attributes for carpooling.

Table 3. Carpooling attributes within the smart mobility paradigm.

Attribute	Significance for carpooling
Flexibility	Allows travelers to combine carpooling with other modes through smart, dynamic ride-matching
Efficiency	Reduces per-trip fuel cost and travel time by consolidating multiple travelers into one vehicle
Integration	Enables end-to-end journeys when carpooling is coordinated with public transport schedules
Sustainability	Lowers per-capita emissions and vehicle-kilometers traveled
Security and safety	Identity verification and reputation-rating systems build rider trust
Social benefits	Extends mobility access to non-car-owning and lower-income travelers
Connectivity	Digital platforms match drivers and passengers in real time
Accessibility	Provides a low-cost alternative where public transport coverage is limited

Opportunities

Carpooling, being part of the smart mobility paradigm, provides several potential opportunities for city planners, authorities and travelers, although not all of them have been explored in the Pakistani context yet:

Strategic corridor planning: Traffic and travel data created through carpooling platforms could be used in route planning and infrastructure investment, as long as these platforms achieve a certain scale to provide useful data.

Municipal incentive programs could be targeted based on evidence on adoption determinants, although the Faisalabad evidence base for targeting is still limited to one study high occupancy vehicle (HOV) lanes, fuel rebates and fare incentives.

Opportunities for businesses: There are opportunities to create carpooling-matching apps that can meet the demand of cities in Pakistan.

Integration with public transport: by arranging timetables and ticketing systems in a coordinated way the system could increase the effective coverage of the overall transport system (Paiva et al., 2021).

Adoption determinative data: Politicians could use evidence such as from the Faisalabad study in Section 4 to help inform targeted awareness campaigns, but with an understanding of the limitations rather than as a definitive.

Challenges

Some of the problems found in the application of carpooling in cities in developing countries overlap with those reported for smart mobility in general (Paiva et al., 2021), and these are also applicable to the case of carpooling:

Infrastructure: in most cities in Pakistan, there is a lack of dedicated lanes, digital connectivity and charging stations for future electric carpooling fleets.

The first barrier is trust and safety, which includes security concerns, such as for women, which are still not directly examined in the context of Pakistan. (Afsari et al., 2025)

In addition to the other shared mobility services, there is no consistent regulation for informal ridesharing arrangements (Paiva et al., 2021).

Early adoption and awareness: like many early stage SM services, there are a high number of potential users who are not yet familiar with carpooling platforms, or who are not convinced of their benefits (Paiva et al., 2021).

Data privacy: ride-matching platforms have to gather location and personal information that should be properly safeguarded (Paiva et al., 2021).

Recommendations derived from the experience in Faisalabad should take into consideration a smaller city's viability, which was highlighted as a problem by the carpooling and car-sharing schemes in smaller cities, as they have been found to be less viable in smaller towns and less densely populated areas (Rotaris & Danielis, 2018).

Carpooling Adoption in the Faisalabad Context

The case of Faisalabad is of special interest to analyses the carpooling adoption in South Asia. It is the third largest city in Pakistan and faces a multitude of transportation problems: firstly, the number of registered vehicles has grown considerably over the last decade contributing to the major transportation congestion on the roads during peak hour periods; secondly, fuel prices have significantly increased; thirdly, poor air quality, with particulate matter levels often reaching unsafe levels; and fourthly, the existing transportation infrastructure is weak, with limited coverage and frequency of public transport services.

This empirical study was carried out in Faisalabad to explore the socio-economic and travel-related influences on carpooling adoption by conducting Binary Logistic regression on survey data of carpoolers of 100 individuals. The model was also highly predictive as the Nagelkerke R^2 was .707, which explained about 70.7% of the variance in carpooling adoption status ($\chi^2 = 72.982$, df = 8, $p < .001$). The complete regression results are shown in Table 4.

Table 4. Binary logistic regression results for determinants of carpooling adoption in Faisalabad, Pakistan.

Variable	B	S.E.	Wald	df	Sig.	Exp(B)
Gender	.694	.829	.702	1	.402 NS	2.003
Age	-.418	.321	1.694	1	.193 NS	.658
Education	2.295	.671	11.689	1	.001	9.922
Employment	.943	.753	1.568	1	.211 NS	2.568
Income	-1.210	.372	10.601	1	.001	.298
Family size	1.095	.533	4.215	1	.040	2.989
Distance	-.932	.445	4.385	1	.036	.394
Cost	-.816	.364	5.016	1	.025	.442
Constant	.099	2.670	.001	1	.970 NS	1.105

Five of the eight predictors were significantly related. The results are aligned with the socio-demographic literature reviewed in Section 2.1, which shows that education is the most important positive predictor (Exp(B) = 9.922, $p < .01$), meaning that individuals with higher levels of education are more open to new mobility concepts and are more at ease with and receptive to platform-based coordination (Amirmazmifashar & Diana, 2021; Yu et al., 2023). Family size was also positively significant (Exp(B) = 2.989, $p < .05$) - an economically rational cost-sharing in the context of above-average household sizes.

Monthly income (Exp(B) = .298, p < .01), commute distance (Exp(B) = .394, p < .05) and average intercity travel cost (Exp(B) = .442, p < .05) were significant negative predictors. The negative relationship of income is similar to the international studies that found that income is negatively associated with privacy, autonomy and flexibility (Ikezoe et al., 2020; Prettenthaler & Steininger, 1999), while the negative relationship of distance and cost pointed to the scheduling complexity and trust required with long trips which is similar to the study done in Lahore by Safdar et al., (2022).

In the Faisalabad model, age and gender were not a significant predictor, which contradicts the aforementioned international literature, such as Amirmazmifashar and Diana (2021) who found that the free-floating car-sharing in Europe had attracted a disproportionately young, male user base. But before assuming this is a true cultural difference, a more nuanced interpretation is necessary.

Critical Appraisal of the Faisalabad Study

The Faisalabad study contributes to the same end, as a regional study, but does have a number of methodological shortcomings that temper the results and should limit the extent to which they can be generalized. The number of respondents in the sample is statistically sufficient in a logistic model for eight predictors, but is still fairly small for a study in a single city, and limited by income brackets, gender or neighborhood. The Nagelkerke R^2 is relatively high for a social-behavioral logistic model of this type (n=0.707); although this within-sample explanatory power is quite high, it may also be a sign of overfitting – a pseudo-R^2 generated from a small sample size may be overestimated and could be a better estimate of explained variance if replicated or cross-validated.

Another note of caution is that neither age nor gender nor employment status is significant. However, another explanation is that they were not significant effects - a finding that is as likely as a genuine cultural difference, since similar European studies that show the same result usually involve much larger sample sizes. The two explanations cannot be separated without a reported power calculation or an independent replication; using the non-significance as confirmation of a South Asian difference is to exaggerate the extent to which the data supports this claim.

The study is also cross-sectional and assesses stated willingness to carpool, not actual uptake of carpooling, and thus associations found do not necessarily imply causal drivers of actual behavior change (as noted in Section 2.5). Lastly, it is a single-city study, so the results are only valid for Faisalabad and should not be taken as representative of all the other secondary urban settlements in Pakistan without further investigation, as Rotaris and Danielis (2018) found that the viability of car sharing is significantly different between larger and smaller urban settlements.

Enabling Technologies for Carpooling

Carpooling is one of the smart mobility solutions that is supported by the use of Internet of Things (IoT), Artificial Intelligence (AI) and blockchain technologies (Paiva et al., 2021). Through the use of sensors connected to the Internet of Things (IoT) and smartphone apps, carpooling platforms can

gather real-time data on the location and trips of both drivers and passengers, which can then be analyzed to efficiently match them and enable dynamic pricing (Mahapatra et al., 2023). These platforms can be utilized to generate data that helps make autonomous ride-matching decisions and predictions about demand patterns with the use of AI-based algorithms (Paiva et al., 2021). What is important to note is that the majority of these enabling-technology examples are taken from proof-of-concept systems, and claims of effectiveness in the field are preliminary.

Trust concerns highlighted in Section 2.2. are especially pertinent to the application of blockchain technology. Blockchain can offer a privacy-enhancing, transparent and trustless structure for mobility services – and the application for car sharing and carpooling is designed to ensure trust between all stakeholders in a shared trip, which is directly related to the overall MaaS paradigm (Paiva et al., 2021). Trust in both riders and drivers of carpooling systems is another objective that has been proposed as a feasible way in which to achieve trust and reputation, whether through blockchain or otherwise (Salamantis et al., 2019), though this again is only a theory that has not been field-tested.

In the future, the development of car-sharing technology suggests that it will evolve into a more connected, autonomous, shared, and electric vehicle (CASE), marking another step in sustainable urban mobility (Li et al., 2021). This will be determined by public receptiveness towards electrification which showed similar trends in Canada, with survey data revealing a growing trend towards positive attitudes towards EVs but concerns about cost and charging infrastructure (Waygood et al., 2026). So, the trajectory of carpooling with electric mobility in Pakistan will go hand-in-hand with investment in both EV affordability and charging infrastructure, and cannot be driven by technology alone.

Discussion and Future Research Directions

The following are drawn from the international literature reviewed in Section 2, the smart mobility framing in Section 3 and the Faisalabad evidence critically examined in Section 4, in each case qualified by the level of evidence that supports it.

The first is that education and household size are more consistently reported as positive correlates of carpooling willingness in both types of studies (developed and developing country), whereas income and commute distance and travel cost are consistently negative correlates. But because education is usually related to income in a population, and none of the reviewed studies (including the Faisalabad study) explicitly tests for this correlation, it is not clear whether education has a separate impact or is in part an indicator of income, digital literacy or urban exposure. If the policy is based upon the premise that education is the active ingredient, then it must be considered a working policy rather than a policy that has been decided.

Second, the non-significance of age, gender and employment status in the Faisalabad study as compared to the significance of these factors in some of the European and East Asian studies is commonly understood as being a cultural difference. This is one of two possible interpretations, as discussed in Section 4.1; the other is that such effects were not present in a small sample in a single

city. The distinction between these explanations would need to be further made with replication cases involving larger samples drawn from multiple cities in Pakistan and not the provision of additional narrative arguments.

Third, the environmental and economic potential of carpooling promotion, although directionally positive, is based on data like those provided by the CO2 savings example of Fernandez et al., (2024) and the International Transport Forum (2023) estimate of 30% emissions reduction from the context of formal carpooling programmers and enforced infrastructure like HOV lanes. It is an empirical question, not a fact, whether such equivalent reductions would be realized in Faisalabad given that the car pool system is informal and there is no corresponding infrastructure as in Sydney.

Fourth, from the literature reviewed in section 2.3, comparative and ownership related literature indicates that the acceptance and promotion of carpooling in Faisalabad cannot be studied and promoted separately. The readiness of digital infrastructure, the support of the regulatory framework and its integration with public transport has proven to be key enablers of accepting shared-mobility in other parts of the world (Paweloszek, 2022; Popova & Fesyuk, 2022; Turon, 2023). Trust and safety issues, especially for women (Afsari et al., 2025), are still a problem that can be solved through identity verification and reputation/trust systems based on blockchain technology (Salamantis et al., 2019; Paiva et al., 2021). Not one of these enabling conditions, however, has been directly tested in Pakistan; as such, the recommendations in Section 2.4 are extrapolations from other contexts and not necessarily conclusions that can be drawn from within Pakistan. Fifth, as a research design, the Faisalabad study provides a valuable methodological blueprint, namely, binary logistic regression using primary survey data which future work can build upon, but should not simply replicate. Future studies should validate if the determinants of carpooling willingness of Faisalabad are representative of other smaller secondary towns in Pakistan, and if they apply to the smaller, less densely populated towns in the Netherlands as in Rotaris and Danielis (2018). Future studies should confirm whether the determinants of carpooling willingness measured here apply to other smaller secondary towns in Pakistan, and whether stated willingness translates to actual carpooling behavior, moving beyond stated willingness.

Based on this important synthesis, there are several lines of further research that follow. longitudinal studies that track carpooling attitudes and behaviors as the digital infrastructure and platform ecosystem in Pakistan is developing would help differentiate between a true lack of demographic effect and one that is due to lack of statistical power. The binary logistic regression approach applied in Faisalabad could be complemented by other approaches such as stated preference or structural equation modelling, which have been used previously in the literature (Choudhury et al., 2018; Yu et al., 2023) to capture psychological and normative determinants in addition to economic ones, where the previous reported problems of collinearity between education and income flagged above can be addressed through testing. Lastly, investigations of carpooling as a part of an integrated sustainable urban mobility system, and ultimately electric and connected vehicles (Waygood et al., 2026; Li et al., 2021), would contribute to the incorporation of carpooling into a wider, evidence-based sustainable urban transport policy for rapidly urbanizing cities in Pakistan.

Conclusions

This review has collated and critically evaluated the literature on the determinants of carpooling adoption, contextualized carpooling within the smart mobility paradigm and its enabling technologies and compared the literature findings with the results of a recent empirical study on carpooling adoption determinants in Faisalabad, Pakistan. Education level is the more consistently reported positive correlate of carpooling willingness, and monthly income, commute distance and travel cost are the more consistently reported negative correlates across this evidence base. The overall results are similar to those from international studies, but as the present review has highlighted throughout, this consistency between studies with similar cross sectional, self-report designs does not equate with an established causal understanding; the apparent differences between age, gender and employment status may simply be due to failure to achieve a sufficient statistical power across studies.

This review, in turn, has its limitations that need to be recognized as much as not ignored. Only English language records were searched and retrieved from three databases, and may have overlooked relevant Urdu language or regionally published Pakistani studies. The narrative synthesis approach is suitable because of the variety of study designs and the lack of consistency in the definition of the effects as stated in Section 2.5, but it cannot provide an accurate and weighted effect size—a formal meta-analysis would be able to. Conclusions drawn here should therefore be interpreted as a qualitative synthesis of directionally consistent evidence and not as a precise estimate of the effect. First and foremost, the account of the Pakistani context in this review is based on one empirical study in one city. This is a real evidence gap and not a metaregional evidence base—so the suggestions given here are provisional and should be tested in other cities in Pakistan with more and more ethnically representative samples of children.

Promoting carpooling, with appropriate digital systems, policies, incentives and messages, is a viable and affordable intervention for the cities of Pakistan. This review's main finding, however, is that the evidence base is helpful directionally, but not sufficiently robust to provide confident, generalised policy recommendations. Thus, it is not just more literature summarizing cross-sectional findings that are similar but methodologically sound, multi-city, and properly powered studies that assess actual carpooling behavior and not only stated willingness to carpool.

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