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DOES SCHOOL CARPOOLING PAY OFF? PROPENSITY SCORE EVIDENCE ON HOUSEHOLD COST, TIME, AND STRESS FROM PRIVATE SCHOOLS IN LAHORE AND FAISALABAD

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Abstract

School drop-off and pick-up trips concentrate low occupancy private car travel within peak periods, imposing monetary, time, and psychological burdens on households. This study estimates the household level effects of regular, parent organized school carpooling among families of children attending elite private schools in Lahore and Faisalabad, Pakistan. Drawing on survey data from 937 parents across 52 schools, the analysis compares 106 carpooling households with 456 households relying on solo private car travel. Propensity score matching on the propensity logit, with 1:1 nearest neighbour matching without replacement, a 0.20 standard deviation calliper, and exact matching on city, yielded 85 matched pairs; inference uses two-way school clustered standard errors, Holm-adjusted p-values, and Rosenbaum bounds. Carpooling adoption is associated with a reduction of PKR 4,339 in monthly school travel expenditure (a 51.8% saving), a 0.57-point reduction in traffic related stress (four-fifths of a standard deviation), and 5.6 fewer parental driving days per month. The child's one-way travel time increases by approximately 5.5 minutes, and total monthly parental driving minutes remain statistically unchanged. Adoption is driven primarily by home school distance, dual earner status, and school level carpool readiness. The findings indicate that school facilitated carpooling delivers substantial cost and stress relief while reducing the frequency of parental escort obligations, supporting low cost, school-based coordination measures as a sustainable travel demand management strategy for urban Pakistan.

Keywords: School Travel, Carpooling, Propensity Score Matching, Travel Demand Management, Parental Escort Time, Pakistan

1. Introduction

1.1 Transport Externalities and the Social Cost of Mobility

Transport systems support access to education, employment, health care, and other essential activities. However, the prices paid by travellers rarely reflect the full social cost of mobility. Transport therefore produces substantial negative externalities. These include greenhouse gas emissions, local air pollution, traffic noise, congestion, road casualties, habitat degradation, and community severance effects. A recent multiscale assessment shows that these costs remain economically significant across regional, national, and urban

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settings (Tsoi & Loo, 2026). The burden is particularly visible in cities with rapid motorization and limited alternatives to private vehicles.

1.2 Low Vehicle Occupancy and the Case of School Travel

Low vehicle occupancy increases the environmental and social cost of road transport. This problem becomes more severe when trips are concentrated within short peak periods. School travel is an important example. Educational trips are repetitive, time sensitive, and closely aligned with morning and afternoon traffic peaks. When such trips depend on private cars, they can increase congestion, air pollution, noise, and driver discomfort (Abdullah et al., 2026). They can also create queues and unsafe traffic conditions near school entrances. These effects are experienced not only by traveling households but also by surrounding communities.

1.3 School Travel as a Component of Urban Congestion

School travel is a routine but highly concentrated component of urban travel demand because school drop-off and pick-up trips coincide with morning and afternoon peak periods. When these journeys are predominantly undertaken by private vehicles, they contribute to traffic congestion, longer travel times, fuel consumption, air and noise pollution, and driver discomfort. Similarly, an agent-based simulation in Bangkok found that removing school related trips from the road network increased average peak hour traffic speeds by approximately 8% and significantly reduced average travel time (Prakayaphun et al., 2023). These findings indicate that school travel is not merely a household mobility issue but an important component of broader urban congestion and environmental management.

1.4 School Location, School Choice, and Travel Behaviour

The spatial organization of education can reinforce car dependence. Private schools often draw students from wider geographical areas than neighbourhood schools. This increases travel distance and may reduce the practicality of walking or cycling. Recent Australian evidence illustrates this relationship. Car travel accounted for 75% of trips to private primary schools, compared with 62% for public primary schools. Active travel was also considerably lower among private school students (Kent et al., 2025). Although these estimates cannot be transferred directly to Pakistan, they demonstrate how school location and school choice can shape household travel behaviour.

1.5 School Travel Decisions in South Asian Cities

School travel decisions are especially complex in South Asian cities. Families must balance cost, distance, safety, convenience, vehicle availability, and children's needs. Evidence from Sahiwal, Pakistan, and Kandy, Sri Lanka, shows that cost-related variables are important predictors of school mode choice. However, the effects of income, distance, and school type vary between cities. The limited transferability of travel models across these locations also highlights the importance of locally grounded analysis (Abdullah et al., 2026). Findings from one city or population should therefore not be applied mechanically to another.

1.6 Carpooling as a Response to Low Occupancy School Travel

Carpooling offers a practical response to low occupancy school travel. It allows households with compatible routes and schedules to share a vehicle. This can reduce the number of separate car trips without requiring households to abandon private transport completely. A recent education sector intervention reported a 31.9% reduction in vehicle use among participants. Fuel savings were the strongest perceived benefit, followed by lower driving fatigue. However, loss of independence, schedule incompatibility, waiting time, trust, and convenience remained important barriers (Delgado-Fernández et al., 2024). These findings show that carpooling can generate benefits, but its effects depend on how shared trips are organized.

1.7 Heterogeneity in Carpooling Preferences

Recent evidence from Pakistan also reveals considerable heterogeneity in carpooling preferences. A survey of 400 travellers in Islamabad and Rawalpindi identified distinct groups based on their perceived motives, barriers, and benefits. Gender, profession, income, existing mode, driving status, trip distance, and expected cost reduction were associated with carpooling orientation. An expectation of a 50% cost reduction also increased the likelihood of belonging to carpool supportive groups (Javid et al., 2025). This evidence is

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valuable for understanding adoption. However, intentions and expected benefits do not establish whether regular users achieve actual reductions in expenditure, time burden, or stress.

1.8 Household Consequences of School Travel Beyond Monetary Cost

The household consequences of school travel extend beyond monetary cost. Parents may need to alter work schedules, undertake repeated escort trips, wait near school gates, or coordinate with other caregivers. These tasks create a time burden and may influence parental wellbeing. Evidence based on the Longitudinal Study of Australian Children indicates that parent child school travel is connected with time pressure, family relationships, physical health, and overall wellbeing (Hosseini Shoabjareh & Ghasri, 2025). Thus, school transport should be understood as both a mobility decision and a household care responsibility.

1.9 Direct Household Burdens of Private Car School Travel

The burden of private car school travel also extends directly to households. Parents may incur recurring expenditures on fuel, vehicle operation, hired drivers, parking, and other school transport arrangements, while simultaneously devoting time to driving, waiting, coordinating, and collecting their children. However, parental escorting may itself create time pressure, disrupt employment and household schedules, and affect parental wellbeing.

1.10 Psychological Strain and School Commuting

School commuting can also generate psychological strain. A cross-sectional study of 542 Spanish parents found differences in commuting stress, travel satisfaction, and life satisfaction across active, private motorized, and public transport users. The authors correctly noted that these associations were not causal (Alfaro et al., 2025). Research among adolescents further shows that distance, travel mode, road safety conditions, and traffic accidents are associated with school commute stress (Sepúlveda-Murillo et al., 2024). Together, these studies indicate that school travel stress is shaped by both the travel arrangement and the wider urban environment.

1.11 Carpooling as a Travel Demand Management Strategy

Within this context, carpooling can be considered a practical travel demand management strategy that increases vehicle occupancy by allowing children from different households to share a privately owned vehicle. In comparison with separate private car trips, carpooling has the potential to distribute fuel and operating costs among participating households, reduce the number of parental escort trips, and decrease exposure to stressful driving conditions.

1.12 Motivations for Carpool Participation

A meta-analysis of carpooling studies identified monetary savings, time related benefits, environmental concern, and congestion reduction as relevant motivations for carpool participation (Olsson et al., 2019). Carpooling may therefore retain much of the flexibility and directness associated with private car travel while reducing the duplication of vehicles making the same school journey. A recent review similarly concluded that ridesharing decisions are shaped by a combination of demographic, psychological, and situational factors, including travel cost, travel time, convenience, safety, and trust (Si et al., 2023).

1.13 Potential Drawbacks of Carpooling

The benefits of carpooling should not be assumed automatically. Pick-up detours, waiting for other children, schedule coordination, uncertainty regarding punctuality, and responsibility for children from other households may increase travel time or psychological pressure for some participants. Thus, although cost sharing is likely to reduce household expenditure, the effects on parental time and traffic related stress remain theoretically ambiguous and require empirical assessment.

1.14 Limited Evidence on School Carpooling Outcomes

One of the relatively few studies addressing carpooling for educational trips examined the effects of effort expectancy, perceived safety, hedonic motivation, and social influence on behavioural intention among university commuters in Thailand (Lowe & Piantanakulchai, 2023). Consequently, limited evidence is available on whether regular school carpooling produces measurable reductions in households' actual expenditure, parental escort time, and traffic related stress, particularly among private school families in developing country cities.

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1.15 Empirical Gap in Literature

The recent literature therefore leaves an important empirical gap. Existing studies mainly examine mode choice, behavioural intentions, perceived benefits, or associations with wellbeing. Applied carpooling studies commonly focus on workers or university populations. Few studies evaluate the realized household effects of regular, parent organized school carpooling. More importantly, the recent studies reviewed here do not jointly estimate its effects on travel expenditure, parental escort time, and school travel stress in urban Pakistan.

1.16 Methodological Challenges: Self-Selection and Bias

Estimating these effects is difficult because households self-select into carpooling. Participants may differ systematically from non-participants. They may live farther from school, have different incomes, own more vehicles, face stronger time constraints, or have better access to trusted social networks. A direct comparison between carpooling and solo driving households may therefore produce biased estimates.

1.17 Propensity Score Matching as a Solution

Maintaining a propensity score can improve comparability by balancing participants and non-participants on observed characteristics. Its recent application in transport policy evaluation demonstrates its usefulness for estimating treatment effects when random assignment is unavailable (Waldorf et al., 2025). Propensity score matching addresses this problem by matching treated and untreated observations with similar estimated probabilities of treatment based on observed pre-treatment characteristics (Austin, 2011a; Rosenbaum & Rubin, 1983). This method has also been applied in transportation research to reduce self-selection bias when estimating the effects of transport environments and interventions on travel behavior (Nasri et al., 2020).

1.18 Study Objectives and Research Questions

Against this background, the present study evaluates the household level effects of regular school carpooling among parents of children attending high-fee private schools in Lahore and Faisalabad. The analysis uses data from 937 parents across 52 schools. Regular carpool users are compared with parents who rely on individual private car trips. Propensity score matching is employed to estimate the average treatment effect on participating households. The outcomes are monthly school travel expenditure, parental escort time, and perceived school travel stress.

Based on the mechanisms identified in this discussion, the study addresses three research questions: whether regular carpooling participation reduces households' monthly school travel expenditure, whether it reduces the parental escort burden, and whether it lowers traffic related school travel stress. Three directional hypotheses are tested.

H1: Carpooling adoption reduces monthly school travel expenditure relative to solo private car use, because fuel and operating costs are shared across participating households.

H2: Carpooling adoption reduces the number of days per month on which a parent personally drives the school run, because escort duties rotate across households.

H3: Carpooling adoption reduces parents' traffic related school travel stress, because fewer stressful driving episodes are experienced.

No directional hypothesis is advanced for the child's one-way travel time or for total monthly parental driving minutes: pick-up detours and multi-stop routing may lengthen individual journeys even as their frequency falls, so these two outcomes are treated as open empirical questions.

1.19 Practical Implications and Study Contributions

This study provides practical evidence on how school carpooling affects families in urban Pakistan. Unlike earlier research that mainly examines people's willingness to carpool, it measures the actual benefits and costs experienced by participating in households. The findings show that carpooling can reduce household travel expenses, parental driving duties, and traffic-related stress. They also suggest that schools can increase participation through simple measures such as connecting nearby families, organizing driving schedules, and providing designated pick-up points.

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This study contributes in three ways. First, it shifts attention from willingness to carpool towards the realized outcomes of participation. Second, it considers economic, temporal, and psychological outcomes within one analytical framework. Third, it provides selection adjusted evidence from two major Pakistani cities. The results can inform school-based ride matching programs, parent coordination mechanisms, and policies designed to reduce low-occupancy school travel.

2. Literature Review

This This review draws together several strands of literature including school travel and the escorted school run, carpooling adoption and its outcomes, the parental escort burden and commuting stress that give those outcomes their welfare meaning, and the causal inference methods through which self-selected travel behaviours can credibly be evaluated. It concludes with the Pakistani evidence and a statement of the gaps the study addresses.

2.1 School Travel Motorization and Escorting

The motorization of children's school travel is among the most consistent findings in transport research. Bibliometric synthesis of 457 studies over 1996 to 2021 shows a field concentrated in North America, Europe, and Australia, with mode choice shaped by individual, family, built environment, and above all parental factors, and with developing economies explicitly identified as the least served frontier (Ji et al., 2022). Car escorting rises with distance, car ownership, and parental convenience (Zhang et al., 2017), and the operative decision makers are parents, whose schedules and safety concerns dominate children's preferences (He and Giuliano, 2017; Sener et al., 2019). In Southeast Queensland, private school students were significantly less likely to travel actively than public school peers after controlling for demographics and urban form, with private schools disproportionately contributing to congestion through wider catchments (Yan et al., 2022).

2.2 Barriers to Alternative School Travel

Existing studies show that families often depend on private vehicles and informal transport, especially where public transport is poor (Singh and Vasudevan, 2018). Efforts to promote alternative school travel have also faced difficulties. Walking school buses often fail because parents have problems with scheduling, coordination, and trust (Nikitas et al., 2019). Shared autonomous vehicles are still only a future possibility, and parents may not trust them (Aboutorabi Kashani et al., 2023). Similarly, a school mobility programme in Porto improved awareness but did not change travel behaviour because it lacked financial and institutional support (Teixeira et al., 2019). Overall, the main barriers are not the lack of travel alternatives, but parents' difficulties in coordinating with others and trusting them.

2.3 General Carpooling Literature: Adoption and Outcomes

The general carpooling literature is mature on who carpools and why, and strikingly thin on what carpooling does for those who practise it. Neoh et al. (2017), pooling 22 studies, found the strongest effects for external factors, workplace scale and partner matching programmes, with stated cost saving motivation exerting a surprisingly small, pooled influence. Olsson et al. (2019) found socio-demographics weak, psychological and monetary factors gaining importance, and interventions such as preferential parking measurably raising uptake. Practising casual carpoolers cite convenience, time, and money, ranking environmental motives low (Shaheen et al., 2016) whereas French drivers pool most readily for leisure and least for children's trips (Gheorghiu and Delhomme, 2018) and driver and passenger roles map onto distinct incentive structures (Park et al., 2018). Where outcomes appear at all, they are programme level or engineering quantities for example a teacher commuting scheme reduced participant vehicles by 31.9 percent with fuel savings the leading motive (Delgado-Fernández et al., 2024; Rey-Merchán et al., 2022). Similarly, trip level analysis of real ride data estimates roughly 1.2 litres of fuel saved per pooled trip (Liu et al., 2019), cost-accounting work formalizes when pooling is profitable for drivers (Čulík et al., 2021). Whereas institutional colleague-based carpooling generates quantifiable rider and congestion cost savings (Do & Jung, 2018) and optimization studies show system level matching could, under idealized assignment, cut total travel time by nearly two-thirds (Li et al., 2024). What no study provides is the household level counterfactual quantity

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policy actually needs and how much an adopting family's costs, time, driving burden, and stress change relative to what they would have been. Within school travel specifically, the gap is identical.

2.4 Parental Escort Burden and Gendered Dimensions

Two related areas of research explain why a school carpooling study should measure parents' time and daily burden. Studies on school escorting show that taking children to and from school strongly shapes parents' daily schedules, although traditional transport research often overlooks this effect (Schwanen, 2007). Parents frequently experience school escorting as time-consuming and fragmented care work that interrupts other activities throughout the day (Barker, 2011; Schouten and Heras, 2019). It also creates longer and more complicated travel chains because parents must combine school trips with work and other household responsibilities (Wang et al., 2025). This escorting has also a gendered aspect because mothers perform more than two-thirds of escorting among Parisian dual earner couples (Motte-Baumvol et al., 2017), carry a disproportionate burden in Germany moderated only in large cities (Scheiner, 2016).

2.5 Commuting Stress, Travel Satisfaction, and Wellbeing

Recent research confirms that commuting is often rated as one of the least enjoyable daily activities, mainly because of congestion and uncertainty. However, travel satisfaction may improve when people travel with others rather than alone (Chatterjee et al., 2020). Commute duration, reliability, and other travel conditions can also affect daily wellbeing and mental health (Liu et al., 2022). Overall, demanding commuting conditions are associated with greater stress and strain (Murphy et al., 2023).

2.6 Carpooling and Travel Stress in Low- and Middle-Income Countries

In low- and middle-income countries, stressful driving conditions can reduce wellbeing and also increase road safety risks (Cendales et al., 2023; Tao et al., 2024). One study directly examined the relationship between ridesharing and commuting stress. Using data from 2,591 commuters in California, Novaco and Collier (1994) found that regular ridesharers were less troubled by traffic congestion and more satisfied with their journeys than people who drove alone. However, because the study was cross-sectional and did not use matching methods, it could not establish a strong causal effect. It remains the main earlier study suggesting that carpooling may reduce travel-related stress.

2.7 Measurement of Travel Satisfaction

Travel satisfaction is now commonly measured through the Satisfaction with Travel Scale developed by Ettema et al. (2011) within the subjective wellbeing approach to travel (Ettema et al., 2010). The scale was later tested and validated by Friman et al. (2013). The present study adapts this scale to measure parents' experiences of the school journey.

2.8 Evidence from Pakistan: Willingness, Barriers, and School Travel

Recent research from Pakistan reaches a common conclusion that many people may be willing to use shared transport, but concerns about trust, privacy, safety, and gender norms limit its adoption. Willingness to share rides also varies according to travel distance, current transport mode, income, and driving licence status (Javid & Ali, 2020). Other studies suggest that a cost reduction of about 50 percent may be needed to produce a noticeable increase in carpooling willingness (Javid et al., 2025). Widespread adoption among young adults could potentially remove nearly one-third of private vehicles from Islamabad's roads (Haroon et al., 2024). Privacy concerns have also been found to influence car sharing acceptance in Lahore (Safdar et al., 2022). School travel creates an important opportunity for shared transport. Educational trips make up a substantial part of peak-hour traffic and are strongly influenced by gender. Girls hold more negative views of public transport than boys (Lodhi et al., 2022). Observations of 94 schools in Karachi also found that most schools lacked designated parking areas and faced unsafe drop-off and pick-up conditions (Ali et al., 2023).

2.9 Limitations of the Existing Pakistani Literature

However, the existing Pakistani literature has three major limitations. First, it mainly examines people's intentions and perceptions rather than their actual travel behaviour. Second, it focuses on adult commuting instead of children's school travel. Third, it identifies trust and gender concerns as major barriers. A school-based carpool may help overcome these barriers because participating families are connected through the same school community and may already know or trust one another.

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2.10 Self-Selection Bias and the Need for Causal Methods

Because people choose their own travel modes, simple comparisons between users and non-users may produce misleading results. The two groups may differ in income, distance, vehicle ownership, or other characteristics that also affect the outcomes. Transport researchers therefore commonly use propensity score matching to create more comparable treatment and control groups and to estimate the effects of travel choices more reliably.

2.11 Application of Propensity Score Matching in Transport Research

This method has been applied in several transport settings. Waldorf et al. (2025) used propensity score methods and a doubly robust estimator to assess a public transport fare innovation, with the aim of approximating a randomized experiment. Studies of new rail services found that matching substantially changed, and in some cases strengthened, the estimated effects on travel mode shares and vehicle use (Dai et al., 2020, 2022; Wang et al., 2023). Based on our literature search, propensity score matching has not yet been applied to evaluate school carpooling.

2.12 Research Gaps Addressed by the Present Study

Three important research gaps remain, and the present study addresses them together. First, no previous study has estimated how adopting school carpooling affects household outcomes such as travel cost, time, and stress. Second, no study has used a causal method that corrects for differences between families that choose carpooling and those that do not. Third, no research has examined carpooling within the elite private school sector of urban Pakistan.

3. Data and Methodology

3.1 Research design

This study employs a cross-sectional observational design analysed within the potential outcomes' framework. Because carpooling adoption is self-selected rather than assigned, a naive comparison of adopters and non-adopters confounds the effect of adoption with preexisting differences between households. Propensity score matching (PSM; Rosenbaum & Rubin, 1983) is used to construct, for each adopting household, a statistically comparable non-adopting household, so that outcome differences within matched pairs can be attributed to adoption under explicitly stated assumptions. The comparison pool is restricted to solo private car households, the mode from which adoption most plausibly occurs. Therefore, the estimand is the average treatment effect on the treated (ATT) among matched adopters within the region of common support. The analytic pool consists of the 106 households whose school journey is made by parent organized carpool and the 456 whose journey is made by solo private car (n = 562); the 375 households using school buses, vans, or other modes are excluded from the comparison for the reason given above.

The target population is parent/guardian households of children enrolled in elite English medium private schools in Lahore and Faisalabad in Punjab, Pakistan. 937 Households were sampled through 52 participating schools and one focal child per household anchors the journey items. The survey collects household socio-demographics, economic resources, spatial characteristics of the school journey, attitudinal items, travel behaviour, and the three outcome domains.

3.2 Variables: definition and formation

Tables 3.1-3.2 define the treatment and outcome variables, their measurement and formation rules, and their sources. Following common convention, a variable is labelled adopted when taken exactly from a published instrument, adapted when a published instrument was modified for context, and study developed when constructed for this study.

Table 1

Treatment variable

Variable	Definition	Measurement / formation	Source
Carpooling adoption (D)	Household currently participates in a parent-	Binary: 1 = school journey by parent-organized carpool; 0 = solo private car. Derived from the	Rafiq & Mitra (2020)

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Variable	Definition	Measurement / formation	Source
	organized rotating carpool for the school journey	primary-mode item; bus/van and other modes excluded from the analytic pool	

Table 2
Outcome variables

Variable	Definition	Measurement / formation	Source
Monthly travel cost	Total household monetary expenditure on the child school journey in an average month per child	Self-reported, open numeric, PKR/month.	Study developed item
Travel time	Child one-way, door-to-door duration of the school journey	Self-reported minutes for a typical school day.	Study developed item
Traffic-related stress	Negative affective experience of the school run journey	Composite of five 5-point Likert items adapted from the Satisfaction with Travel Scale; items reverse-coded so higher = greater stress; composite = item mean;	Adapted: Ettema et al. (2011); Friman et al. (2013); conceptual grounding Ettema et al. (2010)
Parental driving days	Days per month on which a parent personally drives the school run	Self-reported count, 0-31	Study developed item
Parental driving minutes	Total monthly minutes a parent spends driving the school run	Formed as reported driving days x reported per day driving duration	Study developed (derived)

Covariates enter the propensity model in five conceptual blocks: socio-demographic, economic, spatial, attitudinal, and behavioural. Selection follows the guidance that matching variables should be related to both treatment and outcomes and must not themselves be affected by treatment while all covariates are measured as pre-adoption or time invariant characteristics.

3.3 Model specification

3.3.1 Potential outcomes and estimand. Let D denote carpooling adoption and Y(1), Y(0) the potential outcomes under adoption and solo driving. The estimand is the average treatment effect on the treated:

$$ATT = E[\, Y(1) - Y(0) \mid D = 1 \,] \quad (3.1)$$

Identification requires (i) conditional independence, $Y(0) \perp D \mid X$, and (ii) overlap, $0 < Pr(D = 1 \mid X) < 1$, for the covariate vector X (Rosenbaum & Rubin, 1983). Both assumptions are examined empirically: overlap through the common-support diagnostic and conditional independence through sensitivity analysis (Section 3.3.6).

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3.3.2 Propensity score model. The propensity score e(X) = Pr(D = 1 | X) is estimated by logistic regression on the full covariate set:

$$ln[\ e(X) / (1 - e(X))\ ] = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k \quad (3.2)$$

Matching is performed on the linearized score (the logit of e), which is better behaved in the tails than the probability itself .

3.3.3 Matching algorithm. Each adopter is matched 1:1 without replacement to the nearest available solo-car control on the propensity logit, subject to (i) a caliper of 0.20 standard deviations of the logit, following Austin (2011b); (ii) exact matching on city; and (iii) a balance-oriented covariate distance to choose among candidate controls inside the caliper. The caliper condition for an admissible match between adopter i and control j is:

$$|\ logit(\hat{e}_i) - logit(\hat{e}_j)\ | \leq 0.20 \times SD[\ logit(\hat{e})\ ] \quad (3.3)$$

Adopters with no admissible control are excluded, and their characteristics are reported so the coverage of the estimand is explicit. Matched pairs are stored with persistent pair identifiers to eliminate matching-order ambiguity; pre-specified alternatives (1:3 ratio, caliper 0.10 and 0.25, with-replacement) are re-estimated as specification sensitivity.

3.3.4 Balance diagnostics. Balance for each covariate is assessed with the standardized mean difference before and after matching :

$$SMD = (\ \bar{x}_t - \bar{x}c\ ) / \sqrt{[\ (s_t^2 + sc^2) / 2\ ]} \quad (3.4)$$

with |SMD| < 0.10 as the balance criterion, supplemented by variance ratios. Any covariate remaining above the criterion is reported explicitly.

3.3.5 Treatment-effect estimation and inference. The primary estimator is the mean within-pair difference over the M matched pairs:

$$\hat{ATT} = (1/M)\ \Sigma_i\ (\ Y_i^T - Y_i^c\ ) \quad (3.5)$$

For monetary cost, a secondary log-scale model expresses the effect as a proportionate change:

$$\Delta_i = ln(Y_i^T) - ln(Y_i^c),\ \%\Delta = 100 \times [\ exp(\bar{\Delta}) - 1\ ] \quad (3.6)$$

As a robustness check against residual imbalance, a doubly-robust regression is estimated on the matched sample (Bang & Robins, 2005; Ho et al., 2007):

$$Y_i = \alpha + \tau D_i + X_i'\gamma + \varepsilon_i \quad (3.7)$$

Because matched pairs frequently join households from different schools, standard errors for Eq. (3.5) use two-way cluster-robust variance over the treated household's school (A) and the control household's school (B), computed as

$$\hat{V} = \hat{V}^A + \hat{V}^B - \hat{V}^{A \cap B} \quad (3.8)$$

Family-wise error across the five outcomes is controlled with the Holm (1979) step-down procedure, and paired standardized effect sizes dz = ATT / SD(Δ) accompany all estimates .

3.3.6 Sensitivity to hidden bias. Conditional independence cannot be verified from observed data. Rosenbaum (2002) bounds quantify how strong an unobserved confounder would need to be to alter conclusions: if two matched households may differ in their odds of adoption by at most a factor Γ,

$$1/\Gamma \leq [\ \pi_i(1-\pi_j)\ ] / [\ \pi_j(1-\pi_i)\ ] \leq \Gamma \quad (3.9)$$

then bounds on the Wilcoxon signed rank p-value are computed for increasing Γ; the reported Γ* is the largest value examined at which significance is retained. Γ is a sensitivity parameter and is not directly comparable with observed covariate odds ratios.

4. Results

This chapter presents the results of all the estimations in figures and tables, related to propensity score matching methodology.

4.1 Analytic sample and design

Figure 1 summarizes construction of the analytic sample. Of 937 survey respondents, the analysis was restricted to households whose school journey was made either by parent organized carpool (the treatment condition, n = 106) or by solo private car (the comparison condition, n = 456). Since the solo car

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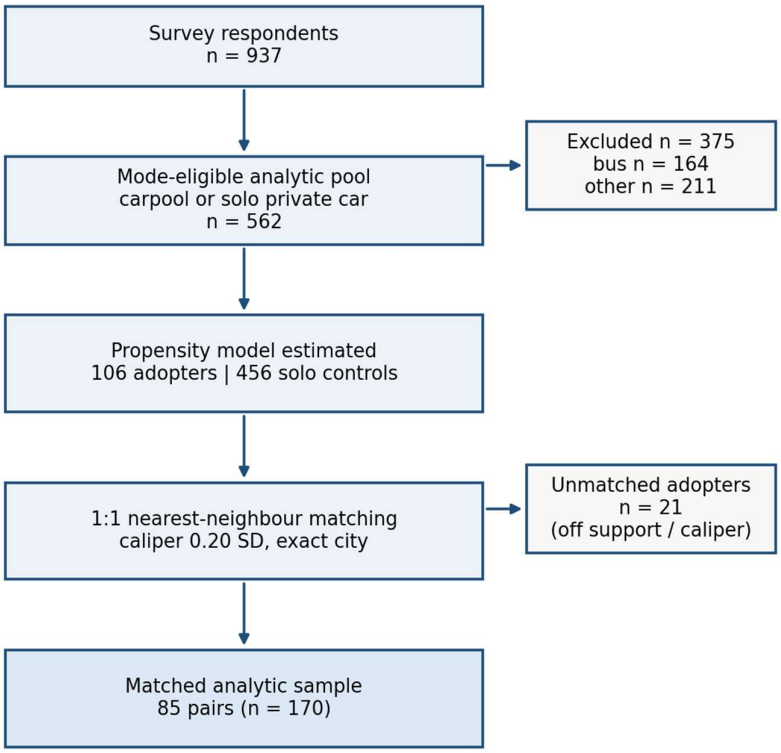
journey is the realistic counterfactual from which adopters switch, bus/van users (n = 164) and other mode users (n = 211) were excluded because their escort and cost structures are not comparable.

The estimand is the average treatment effect on the treated among matched adopters within the region of common support and it is not the effect for all adopters; a distinction developed in Section 4.4.

Figure 1

Flow of participants from the full survey sample to the matched analytic sample



The comparison group is the design decision that matters most. A carpooling parent's realistic alternative is driving their own child, not the school bus because including bus and van households in the control pool would make carpooling appear to increase driving simply because bus parents barely drive at all. Restricting the pool to solo drivers, and reporting the 21 unmatched adopters explicitly, ensures every later comparison answers the right question and that the coverage of the estimate is stated honestly.

4.2 Descriptive statistics and outcome measurement

Table 3 profiles the two groups on covariates and outcomes before any adjustment.

Table 3

Descriptive statistics of the analytic sample, by group

Variable	Adopters (n = 106)	Solo controls (n = 456)	Std. diff.
Home-school distance (km)	11.6 (6.5)	9.2 (5.4)	+0.41
Household income (PKR/month)	246,037.7 (139,860.6)	319,160.1 (176,440.6)	-0.46
Cars owned	1.7 (0.7)	1.9 (0.7)	-0.21
Work flexibility (1-5)	2.8 (1.2)	3.1 (1.2)	-0.21
School-going children	1.9 (1.0)	1.7 (0.8)	+0.25
Child age (yr)	11.1 (3.8)	10.3 (3.5)	+0.20

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Variable	Adopters (n = 106)	Solo controls (n = 456)	Std. diff.
School carpool-readiness (z)	0.5 (1.0)	-0.0 (1.0)	+0.56
Catchment dispersion (z)	-0.1 (1.0)	-0.1 (1.0)	-0.01
Household has driver (%)	27.4	54.8	-0.58
Dual-earner household (%)	54.7	33.1	+0.44
Respondent employed (%)	71.7	68.2	+0.08
School van available (%)	14.2	16.0	-0.05
City: Lahore (%)	77.4	74.6	+0.07
Fee tier: elite (%)	55.7	66.0	-0.21
Monthly travel cost (PKR)	4,028.7 (1,749.3)	7,349.5 (3,284.6)	-1.26
Child one-way travel time (min)	31.8 (13.4)	22.6 (11.3)	+0.74
Traffic-stress score (1-5)	3.2 (0.6)	3.6 (0.5)	-0.83
Parental driving days / month	10.9 (4.4)	15.8 (3.1)	-1.27
Parental driving minutes / month	828.3 (520.0)	712.4 (390.2)	+0.25

Adopters and solo drivers are not comparable groups as surveyed. Adopters live farther from school, earn less, are far more often dual earner, and are far less likely to employ a household driver, with several gaps exceeding 0.4 standard deviations. Any raw comparison of their outcomes would therefore mix the effect of carpooling with the effects of being the kind of household that carpools. This table is the evidence that matching is necessary, not optional.

4.3 Propensity model and common support

Adoption was modelled with logistic regression on the full covariate set (Table 4.2; n = 562, McFadden pseudo R-squared = 0.307). Figure 4.4.2 shows the propensity score distributions with the common support region [0.025, 0.860] shaded.

Table 4

Logistic propensity model predicting carpooling adoption

Predictor	Odds ratio	95% CI	p
(Intercept)	0.04	[0.00, 1.05]	0.053
Distance (km)	1.10	[1.05, 1.16]	< .001***
Income (per PKR 100,000)	0.72	[0.57, 0.91]	0.005**
Cars owned	0.90	[0.60, 1.36]	0.622
Work flexibility	0.91	[0.73, 1.14]	0.406
School children	1.42	[1.04, 1.92]	0.025*
Child age	0.99	[0.82, 1.20]	0.930
School size (z)	0.68	[0.51, 0.91]	0.009**
Carpool-readiness (z)	2.03	[1.52, 2.71]	< .001***
Catchment dispersion (z)	0.66	[0.47, 0.94]	0.020*
City = Lahore	1.34	[0.66, 2.72]	0.413
Fee tier = semi-elite	1.25	[0.59, 2.64]	0.564
Locale = urban	1.00	[0.52, 1.90]	0.993

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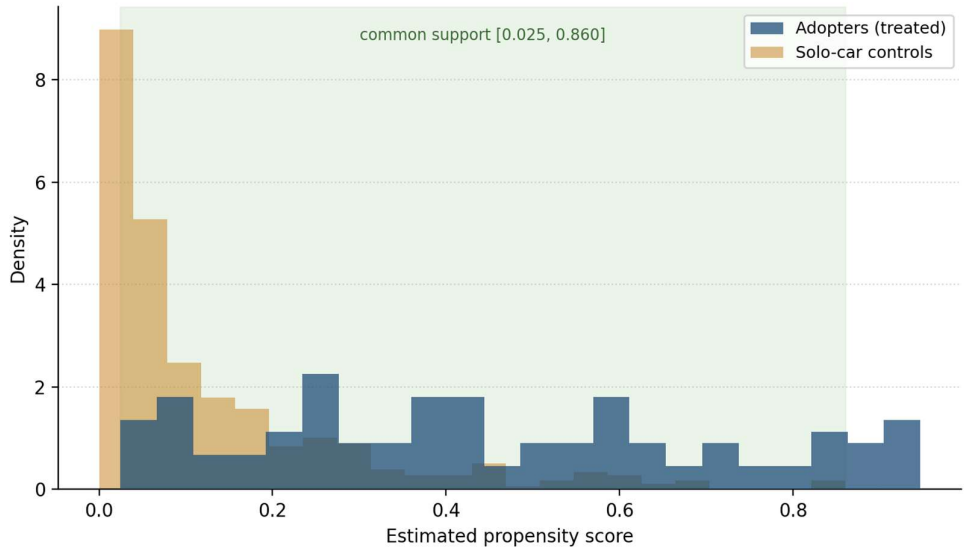
Predictor	Odds ratio	95% CI	p
education_2	2.17	[0.64, 7.41]	0.216
education_3	4.27	[1.19, 15.33]	0.026*
education_4	6.16	[1.54, 24.72]	0.010*
child_grade_primary	0.88	[0.30, 2.61]	0.821
child_grade_secondary	2.24	[0.82, 6.13]	0.117
Child male	0.37	[0.22, 0.64]	< .001***
Respondent = mother	2.03	[1.18, 3.49]	0.010*
Employed	0.27	[0.12, 0.58]	< .001***
Alternative escort available	1.02	[0.59, 1.76]	0.939
Dual-earner	5.31	[2.56, 11.02]	< .001***
Has driver	0.40	[0.22, 0.71]	0.002**
Nuclear family	2.36	[1.38, 4.06]	0.002**
Van available	1.06	[0.50, 2.28]	0.875

The model tells a coherent selection story. Each additional kilometre of distance raises the odds of adoption by about 10 percent, dual earner households have roughly five times the odds, a one SD increase in school carpool readiness doubles them, and employing a household driver cuts them by 60 percent, the driver acting as a substitute for shared escorting. Adoption is therefore driven by cost exposure, scheduling pressure, and institutional facilitation rather than by demographics alone.

Figure 4

Distribution of estimated propensity scores for adopters and solo car controls; the shaded band marks the region of common support.



For matching to work, adopters and non-adopters must overlap. This demands that for most adopters there must exist solo drivers with a similar predicted probability of adopting. The shaded band shows this holds across most of the range. The right tail, however, is dominated by adopters with no counterparts, foreshadowing that the most adoption prone households cannot be matched and will fall outside the estimate's coverage.

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4.4 Matching and covariate balance

Adopters were matched 1:1 to solo car controls without replacement, selecting for each adopter the nearest available control inside a caliper of 0.20 standard deviations of the propensity logit, with exact matching on city and a balance-oriented covariate distance used to choose among candidates within the caliper. This procedure, documented with saved pair identifiers to remove matching order ambiguity, yielded 85 matched pairs. Matched treated households span 38 schools and matched controls 34 schools (46 distinct schools in total), and 76 of the 85 pairs join households from different schools, which shapes the inference strategy in Section 4.5.

Twenty-one adopters (21/106) could not be matched within the caliper. They are systematically different from matched adopters on the basis of higher propensity scores (0.78 vs 0.36), longer commutes (13.9 vs 11.1 km), greater school carpool-readiness (1.06 vs 0.38 z), and lower incomes (PKR 179,905 vs 262,376). The estimand is therefore the ATT among adopters with solo car counterparts and it does not describe the most adoption prone households, for whom no comparable non-adopter exists.

Table 5

Covariate balance before and after matching

Covariate	SMD before	SMD after	Var. ratio	Balanced
distance_km	0.410	0.098	0.78	Yes
income	-0.459	0.070	1.47	Yes
num_cars	-0.209	0.017	1.14	Yes
work_flexibility	-0.210	-0.020	1.07	Yes
n_school_children	0.249	-0.055	1.18	Yes
child_age	0.199	0.022	1.00	Yes
school_size_z	-0.262	0.008	0.83	Yes
readiness_z	0.556	-0.016	1.26	Yes
catchment_dispersion_z	-0.013	0.121	1.04	No
city_Lahore	0.065	0.000	1.00	Yes
fee_tier_semi-elite	0.213	0.048	1.02	Yes
locale_urban	-0.025	-0.071	1.02	Yes
education_2	-0.112	-0.047	0.99	Yes
education_3	0.072	0.099	1.07	Yes
education_4	0.162	-0.060	0.91	Yes
child_grade_primary	-0.210	0.000	1.00	Yes
child_grade_secondary	0.263	0.078	1.08	Yes
child_gender_male	-0.433	0.048	1.02	Yes
relation_mother	0.279	0.096	1.05	Yes
employed_1	0.076	0.101	0.92	No
alt_escort_1	-0.048	0.141	1.03	No
dual_earner_1	0.445	0.070	1.01	Yes
has_driver_1	-0.580	-0.075	0.94	Yes
family_system_nuclear	0.358	0.071	0.98	Yes
van_service_1	-0.052	0.000	1.00	Yes

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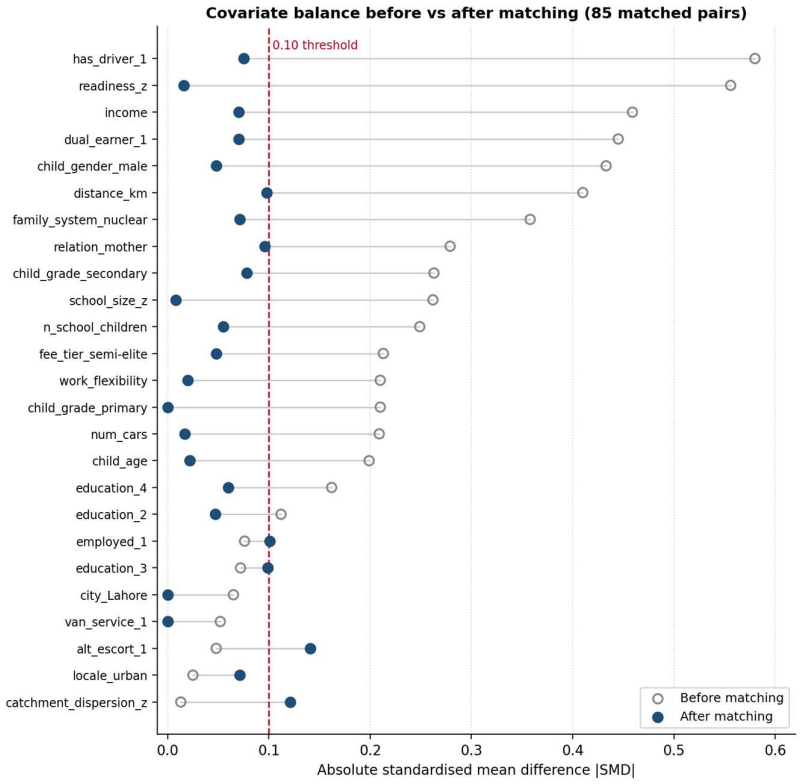
Reading the columns together: every covariate that was seriously imbalanced before matching (SMD above 0.2, and up to 0.58 for the household driver) falls below the 0.10 criterion after matching, variance ratios sit near 1, and only three terms, catchment dispersion (0.121), employment (0.101), and alternative escort (0.141), remain marginally above threshold. Balance is good but not complete, which is why the effect estimates that follow are paired with a covariate adjusted check.

Figure 3

Absolute standardized mean differences before matching (hollow markers) and after matching (filled markers); the dashed line marks the 0.10 threshold.



Matching worked where it matters most. Every large pre-matching gap, household driver (0.58 to 0.08), carpool-readiness (0.56 to 0.02), income, dual earner status, child gender, collapses to well under the 0.10 threshold, so within the 85 pairs, adopters and controls are statistically near twins on 22 of 25 characteristics. Three terms remain marginally above threshold (0.10-0.14); balance is good but not complete, which is why Table 4.4 pairs the primary estimate with a covariate adjusted check rather than relying on matching alone.

4.5 Estimated treatment effects

Table 6

Estimated treatment effects on the treated (ATT), with two-way school-clustered inference

Outcome	Treated M	Control M	ATT	Two-way cluster 95% CI	p	p (Holm)	dz
Monthly travel cost (PKR)	3,852.71	8,191.53	-4,338.82	[-5,362.18, -3,315.46]	< .001***	< .001	-0.95
Monthly travel cost (log, % change)	-	-	-51.8%	[-57.8%, -45.0%]	< .001***	-	-

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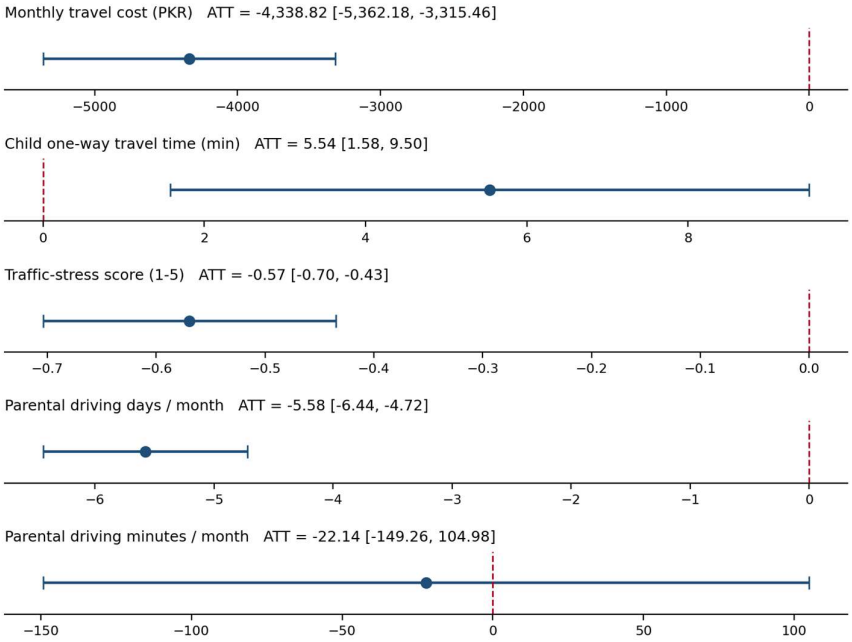
Outcome	Treated M	Control M	ATT	Two-way cluster 95% CI	p	p (Holm)	dz
Child one-way travel time (min)	30.62	25.08	5.54	[1.58, 9.50]	0.006**	0.012	0.31
Traffic-stress score (1-5)	3.19	3.76	-0.57	[-0.70, -0.43]	< .001***	< .001	-0.80
Parental driving days / month	10.99	16.57	-5.58	[-6.44, -4.72]	< .001***	< .001	-1.05
Parental driving minutes / month	798.86	821.00	-22.14	[-149.26, 104.98]	0.733	0.733	-0.03

As Table 6 shows the cost effect is PKR -4,338.82 per month, a 51.8 percent saving on the log scale, with an interval far from zero even after clustering on both households' schools. The stress and driving day effects are similarly precise and survive the Holm adjustment for testing five outcomes (all $p < .001$), with standardized effect sizes of 0.80-1.05. The travel time increase (+5.54 minutes) is smaller and only conventionally significant, and the driving minutes contrast is statistically indistinguishable from zero, its wide interval spanning roughly -150 to +105 minutes.

Figure 4

ATT point estimates with two-way cluster-robust 95% confidence intervals; the dashed line marks zero (no effect). Each panel is scaled in the outcome's own units.



Three effects are large, precise, and survive every adjustment. These include adoption associated with about PKR 4,339 less spent per month (a 51.8 percent saving, consistent with splitting costs across a two-to-three family rota), a 0.57-point lower stress score (four-fifths of a standard deviation), and 5.6 fewer days per month on which a parent drives, the largest effect in the study.

Two results tell the other side as the child's one way journey is about 5.5 minutes longer, the visible price of multi stop routing, and total monthly driving minutes do not change reliably, because parents drive on far fewer days, but each carpool run is longer. What the carpool releases, in other words, is the frequency of the obligation, not aggregate driving time.

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4.6 Sensitivity to hidden bias

Matching removes confounding only from observed covariates; Table 4.5 quantifies how much unobserved confounding each result could withstand. The cost, stress, and driving day effects remain significant at the largest hidden bias factor examined (Gamma* >= 3.0): an unmeasured characteristic would need to at least triple the odds of adoption between matched households, while simultaneously being a strong predictor of the outcome, to account for them.

Gamma is a sensitivity parameter rather than an estimate and is not directly comparable with observed covariate odds ratios. The travel time effect loses significance beyond Gamma = 1.5 and is accordingly treated as suggestive and the driving minutes null is insensitive at all values.

Table 7

Rosenbaum-bound p-values under increasing hidden bias Gamma

Outcome	Gamma = 1.00	Gamma = 1.25	Gamma = 1.50	Gamma = 1.75	Gamma = 2.00	Gamma = 2.50	Gamma = 3.00	Gamma*
Monthly travel cost	< .001	< .001	< .001	< .001	< .001	< .001	< .001	>= 3.00
Travel time	< .001	0.007	0.036	0.108	0.224	0.515	0.754	1.50
Traffic stress	< .001	< .001	< .001	< .001	< .001	< .001	0.004	>= 3.00
Driving days	< .001	< .001	< .001	< .001	< .001	< .001	< .001	>= 3.00
Driving minutes	0.455	0.782	0.936	0.984	0.997	1.000	1.000	ns at Gamma = 1

4.7 Sensitivity to the matching specification

Table 4.6 re-estimates all effects under four alternative matching designs. The cost, stress, and driving day estimates are essentially invariant to caliper width, to matching with replacement, and to a one-to-three matching ratio, behaviour characteristic of genuine signals rather than specification artefacts.

Two features of the table merit comment. First, the alternative rows were generated by greedy nearest neighbour matching under a fixed seed, whose results depend on match order; the mildly non-monotonic pair counts (81 pairs at the wider 0.25 caliper against 85 at 0.20) reflect that order dependence, whereas the primary row rests on the saved, order independent pairs.

Second, the one-to-three design retains only 58 adopters because exact city matching exhausts same city controls, which is why the one-to-one design serves as primary. The travel time estimate weakens to non-significance under with replacement matching and the driving minutes estimate is unstable in sign; consistent with the hidden bias analysis, neither is asserted as a finding.

Table 8

Sensitivity of ATT to matching specification

Specification	Treated	Cost	Time	Stress	Driving days	Driving min
Primary: 1:1, caliper 0.20, no repl. (saved pairs)	85	-4,338.8***	+5.5**	-0.57***	-5.6***	-22.1 ns
1:1, caliper 0.10, no replacement	77	-4,410.8***	+4.4*	-0.58***	-5.2***	-34.6 ns
1:1, caliper 0.25, no replacement	81	-4,321.9***	+5.2**	-0.57***	-5.3***	-17.3 ns
1:1, caliper 0.20, with replacement	94	-5,042.2***	+2.6 ns	-0.53***	-5.8***	-145.5*

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Specification	Treated	Cost	Time	Stress	Driving days	Driving min
1:3, caliper 0.20, no replacement	58	-4,352.3***	+4.0*	-0.56***	-5.2***	-33.2 ns

5. Discussion and policy implications

We get three results when we compare 85 carpooling households with observationally equivalent solo driving households. These results withstand every estimator, clustering scheme, multiplicity adjustment, hidden bias bound, and matching design. Carpooling adoption is associated with roughly half the monthly monetary cost of the school journey, a 0.57 reduction in traffic-related stress, and 5.6 fewer days per month on which a parent personally drives. As discussed in the research gap, no prior study estimates the realized monetary effect of school carpooling adoption on adopting households, so there are no direct benchmarks. In the closest Pakistani evidence, latent class analysis of Islamabad and Rawalpindi travelers found that a 50% reduction in travel cost is the incentive level at which carpooling propensity rises materially (Javid et al., 2025). A teacher commuting carpool scheme recorded fuel savings as the top ranked motive and a 31.9% reduction in participant vehicles (Delgado-Fernández et al., 2024). Similarly, cost accounting work formalizes the fixed versus variable cost structure that makes pooling arithmetically profitable for drivers (Čulík et al., 2021), with trip level fuel saving estimates from real ride data of about 1.2 liters per pooled trip (Liu et al., 2019). There is also a quantified rider and congestion cost savings in an institutional colleague carpool setting (Do & Jung, 2018). In meta-analytic evidence, however, Neoh et al. (2017) find stated cost saving motivation to be a weak predictor of who carpools. Olsson et al. (2019) stated that monetary and time benefits are important, and these rank high among revealed motives of practicing casual carpoolers (Shaheen et al., 2016). Our analysis shows that realized savings are large even though stated cost motivation predicts adoption weakly, which is precisely what one would expect if the binding constraint on adoption is coordination rather than insufficient benefit.

The reduction of 5.6 parental driving days per month has no counterpart estimates anywhere in the literature, to the best of our knowledge. Prior works measure vehicle trips, mode shares, or kilometers, not the frequency of parental obligation, whose welfare significance is established by the escort literature rather than the carpooling literature. Chauffeuring children structures parents' daily schedules as a fragmented and time-consuming care task (Schouten et al., 2019), and consequently this generates trip chains significantly longer than work-only chains (Wang et al., 2024). Its distribution is strongly gendered wherever studied. Likewise, Motte-Baumvol et al. (2015) found that mothers perform more than two-thirds of escorting among Parisian dual-earner couples, and mothers carry a disproportionate burden in Germany, moderated only in large cities (Scheiner, 2016). Escorting approaches parity in the Netherlands only where both parents work full-time with higher education (Han et al., 2019). So, keeping that in background, days released even as total minutes are conserved, identifies exactly the margin escort literature marks as welfare relevant. Mothers being at roughly twice the odds of being the adopting respondent indicates that the released days would flow to mothers.

The stress results have one direct empirical precedent. In a Southern California sample of 2,591 commuters, Novaco and Collier (1994) found full-time ride-sharers significantly less bothered by traffic congestion and more satisfied with their commutes than solo drivers. This extends the impedance framework in which congestion operates as a behavioral constraint with physiological and mood consequences (Novaco et al., 1979). Both objective and subjective impedance independently predict well-being (Novaco et al., 1990). Our estimated reduction, 0.57 scale points, and four-fifths of a standard deviation, is directionally aligned with their cross-sectional contrast. The wider commuting literature is consistent that commute satisfaction rises when traveling with company and stress is driven by congestion, crowding, and unpredictability (Chatterjee et al., 2020). According to Liu et al. (2022), objective commute characteristics affect experiential well-being and mental health. Murphy et al. (2023) stated that commuting demands are meta-analytically associated with strain. Similarly, factors that increase stress in lower and middle-income settings degrade

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welfare and road safety behavior (Cendales et al., 2023). Qualitative van pooling evidence records perceived stress relief while noting the published evidence base is thin (Robbins et al., 2015).

The 5.5-minute penalty acquires meaning against two very different literatures. Optimization studies show that system level carpool matching can, in simulation, cut total travel time dramatically, by as much as two-thirds under idealized assignment (Li et al., 2024). On the other hand, real parent organized carpools, routes around fixed homes and school bells, with no algorithmic dispatcher, and the small positive penalty estimated here is the realistic residue of that coordination. This is like a transaction cost in the sense that carpooling frameworks formalize (Julagasigorn et al., 2021). And the determinants literature explains why families accept it, because carpooling propensity rises with exactly the long distances for which a few added minutes are proportionally trivial (Rafiq & Mitra, 2020), and our adopters' average is 11.6 kilometers.

Our adoption model replicates the determinant structure of the only closely comparable school carpooling model in the literature in a new context. In California household travel data, carpooling as a child's school mode rises with home-school distance, in two-parent, two-earner households, and in neighborhoods dense with school children (Rafiq & Mitra, 2020). In our study, distance (OR = 1.10 per kilometer), dual earner (OR = 5.31), and school composition effects mirrored each finding. The dominance of school level carpool readiness parallels the strongest result in the general adoption literature, where workplace scale and partner matching programs out predict individual characteristics (Neoh et al., 2017). This echoes the Toronto evidence that carpooling is an appealing but underutilized school mode whose uptake turns on perceived convenience and coordination (Arbour-Nicitopoulos et al., 2012), and the Porto case in which soft measures without institutional support shifted awareness but not behavior (Teixeira et al., 2019). The household-driver effect (OR = 0.40), by contrast, has no counterpart in the Western literature, where domestic drivers are rare; it is a genuinely context specific substitution finding of this study.

Three features of urban Punjab give these results their local meaning. First, the trust architecture. The Pakistani carpool literature identifies privacy, security, and reluctance to share vehicles with unknown partners as the binding constraint on adult commuter carpooling in Lahore (Javid et al., 2017, 2020). In Islamabad, gender pairing norms bind sharply, with women disinclined to carpool with men regardless of marital status (Ayaz et al., 2021). Men report nearly three times women's intention to adopt ride-sharing (Hussain et al., 2025). Similarly, privacy governs the car sharing acceptance in Lahore (Safdar et al., 2022). In a Pakistani urban context, school and child carpooling is structurally positioned to relax precisely these constraints because families are known to one another through the school community and children, rather than strangers, share the vehicle. This could be a plausible reason that large private benefits estimated here can coexist with the low adult commuter uptake the intention literature documents. Second, the gendered school run. Educational travel in Pakistan is markedly gendered, with girls holding significantly more negative views of public transport (Lodhi et al., 2022). The school-run burden falls on mothers here as elsewhere. Therefore, the released driving days carry a gendered welfare interpretation in a context where mothers' alternatives are fewest. Third, the school gate environment. Systematic observations in Karachi found 88% of schools without designated parking and pervasive risky road used at drop-off (Ali et al., 2023). Educational trips are a major component of peak hour traffic (Lodhi et al., 2022). In the elite tier studied here, where vehicle ownership is near ceiling, carpooling operates as utilization sharing among car owning households, and young adult survey work suggests meaningful aggregate potential, an estimated one-third reduction in private vehicles were carpooling widely adopted in Islamabad (Haroon et al., 2024).

Some policy recommendations are forwarded on the basis of our findings. First, for schools, the strongest predictor of adoption in the propensity model is school level carpool readiness. This locates the binding constraint at the institution rather than the household. Here, the implied friction is coordination, not absence of private benefit. So, the direct lever is school level facilitation with catchment-based matching of families, rota management rules, designated pick-up points, and explicit endorsement that legitimizes the arrangement between families who are otherwise strangers. These are low-cost administrative actions rather than infrastructure investments.

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Second, for households, adoption represents a mixture of cost savings on the order of the monthly school travel outlay, lower traffic-related stress, and roughly five to six fewer days per month of personal driving obligations, with a modest trade-off of a few minutes of additional child travel time, with the total parental driving minutes roughly conserved. Third, for education authorities and urban policy in Punjab, vehicle ownership is near ceiling in the school tier sampled, so carpooling is not a substitute for car access but a utilization sharing arrangement among car-owning households. Its system level contribution is to peak-hour vehicle trips at school gates, a documented congestion points in the study cities. However, our estimates apply only at the household level. Any claim about congestion emissions or gate level traffic requires network level measurement and is not supported by this design. Fourth, the estimates describe households for whom a comparable solo driving household exists, and exclude the most eager adopters. So, within this elite school population, adopters had somewhat lower incomes, suggesting facilitation may matter most for the cost constraint end of even affluent catchments.

6. Conclusion and Limitations

This study asked whether regular, parent organized school carpooling delivers measurable benefits to the households that practice it. Using survey data from 937 parents across 52 elite private schools in Lahore and Faisalabad, and comparing 85 matched pairs of carpooling and solo driving households constructed through propensity score matching, the analysis provides the first selection-adjusted estimates of the realized household effects of school carpooling in urban Pakistan. Three findings stand out. Carpooling adoption is associated with a reduction of approximately PKR 4,339, or 51.8 percent, in monthly school travel expenditure; a 0.57-point reduction in traffic-related stress; and 5.6 fewer days per month on which a parent personally drives the school run. All three effects survive Holm adjustment, two-way school-clustered inference, alternative matching specifications, and hidden-bias factors of at least $\Gamma = 3.0$. The costs of participation are modest and clearly identifiable: the child's one-way journey lengthens by about five and a half minutes, and total monthly parental driving time is unchanged, because parents drive on fewer days but each carpool run is longer. What carpooling releases, therefore, is money and the frequency of the escort obligation rather than aggregate driving time.

These results carry a clear policy message. Because adoption tracks school level carpool readiness more strongly than any household characteristic, the binding constraint is coordination rather than insufficient private benefit. Therefore, the direct lever lies with schools by providing catchment-based matching of families, rota templates, designated pick-up points, and explicit institutional endorsement. Future research should extend this evidence with longitudinal designs that measure outcomes before and after adoption, network-level measurement of school gate congestion and emissions, and applications beyond the elite private school sector to public schools and car scarce populations.

There are some limitations that bound these claims. Outcomes and treatment are measured simultaneously, so reverse causality is possible in principle. Because cost burdened or stressed households may seek carpools, this mechanism would typically bias the stress contrast toward zero rather than create it. But only longitudinal or retrospective pre-adoption measures can resolve it. Carpooling inherently violates strict no influence assumption, as one household's adoption changes neighbours' options, and 76 of 85 pairs join households from different schools, while some controls share schools with treated households. Outcomes are self-reported and subject to measurement error. The 85-pair sample limits power for small effects. So, the driving minutes null is uninformative about modest changes. And the estimand excludes 21 unmet adopters who are systematically the longest distance, lowest income, highest readiness households. Findings pertain to elite and semi-elite private schools in two Punjab cities with near-universal car ownership. Therefore, extension to public schools, other cities, or car-scarce populations is unwarranted.

Contribution of Authors

All the authors participated in the ideation, development, and final approval of the manuscript, making significant contributions to the work reported.

Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this article.

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Data Availability

The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

References

Abdullah, M., Ali, N., Dias, C., Javid, M. A., & Sathyaprasad, I. M. S. (2026). School travel mode choice in two medium-sized South Asian cities: Cross-city transferability and explainable machine learning approaches. *Journal of Urban Mobility*, *9*, Article 100190. https://doi.org/10.1016/j.urbmob.2026.100190

Aboutorabi Kashani, M., Kamyab, S., Mamdoohi, A. R., & Sierpiński, G. (2023). What makes parents consider shared autonomous vehicles as a school travel mode? *Sustainability*, *15*(23), Article 16180. https://doi.org/10.3390/su152316180

Alfaro, E., Valle, E., Valle-Escolano, R., & Useche, S. A. (2025). Parenting 'on the move'? Active school commuting is linked to parents' well-being and children's academic performance. *Wellbeing, Space and Society*, *8*, Article 100271. https://doi.org/10.1016/j.wss.2025.100271

Ali, A., Mehry, S., Raheem, A., Bhatti, J., & Khan, U. R. (2023). Road safety hazards for children while commuting to school: Findings from a pilot study in Karachi, Pakistan. *Injury*, *54*, Article 110475. https://doi.org/10.1016/j.injury.2022.11.018

Arbour-Nicitopoulos, K., Faulkner, G. E., Buliung, R. N., Lay, J., & Stone, M. (2012). The school run: Exploring carpooling as an intervention option in the Greater Toronto and Hamilton area (GTHA), Canada. *Transport Policy*, *21*, 134-140. https://doi.org/10.1016/j.tranpol.2012.03.004

Ayaz, A., Waheed, A., Saleem, H., & Abid, M. M. (2021). Travelers' attitude towards carpooling in Islamabad. *Journal of Engineering and Applied Science*, *68*(1), Article 23. https://doi.org/10.1186/s44147-021-00023-x

Barker, J. (2011). 'Manic mums' and 'distant dads'? Gendered geographies of care and the journey to school. *Health & Place*, *17*(2), 413-421. https://doi.org/10.1016/j.healthplace.2010.04.001

Blättler, K., Wallimann, H., & von Arx, W. (2024). Free public transport to the destination: A causal analysis of tourists' travel mode choice. *Transportation Research Part A: Policy and Practice*, *187*, Article 104166. https://doi.org/10.1016/j.tra.2024.104166

Cendales, B., Llamazares, F. J., & Useche, S. A. (2023). Are subjective outcomes a "missing link" between driving stress and risky driving behaviors of commuters? Assessing the case of a LMIC. *Safety Science*, *158*, Article 105996. https://doi.org/10.1016/j.ssci.2022.105996

Chatterjee, K., Chng, S., Clark, B., Davis, A., De Vos, J., Ettema, D., Handy, S., Martin, A., & Reardon, L. (2020). Commuting and wellbeing: A critical overview of the literature with implications for policy and future research. *Transport Reviews*, *40*(1), 5-34. https://doi.org/10.1080/01441647.2019.1649317

Čulík, K., Kalašová, A., & Synák, F. (2021). Cost calculation and economic efficiency of carpooling. *Transportation Research Procedia*, *55*, 228-235. https://doi.org/10.1016/j.trpro.2021.06.026

Dai, F., Diao, M., & Sing, T. F. (2020). Effects of rail transit on individual travel mode shares: A two-dimensional propensity score matching approach. *Transportation Research Part D: Transport and Environment*, *89*, Article 102601. https://doi.org/10.1016/j.trd.2020.102601

Dai, F., Diao, M., & Sing, T. F. (2024). A two-dimensional propensity score matching approach to estimating the treatment effect of urban rail transit lines on vehicle travel. *Transportation*, *51*(3), 853-873. https://doi.org/10.1007/s11116-022-10360-2

Journal of Business Insight and Innovation
Volume 5 Issue 7, 2026
ISSN-p: 3006-2284, ISSN-e: 3006-0982
https://insightfuljournals.com/

Delgado-Fernández, V., Rey-Merchán, M. D. C., & Rosa, M. P. (2024). Development and assessment of a carpooling applied system: Perspective of users from public-education sector. *Sustainability*, *16*(23), Article 10330. https://doi.org/10.3390/su162310330

Do, M., & Jung, H. (2018). The socio-economic benefits of sharing economy: Colleague-based carpooling service in Korea. *Journal of Open Innovation: Technology, Market, and Complexity*, *4*(3), Article 40. https://doi.org/10.3390/joitmc4030040

Ettema, D., Gärling, T., Olsson, L. E., & Friman, M. (2010). Out-of-home activities, daily travel, and subjective well-being. *Transportation Research Part A: Policy and Practice*, *44*(9), 723-732. https://doi.org/10.1016/j.tra.2010.07.005

Ettema, D., Gärling, T., Eriksson, L., Friman, M., Olsson, L. E., & Fujii, S. (2011). Satisfaction with travel and subjective well-being: Development and test of a measurement tool. *Transportation Research Part F: Traffic Psychology and Behaviour*, *14*(3), 167-175. https://doi.org/10.1016/j.trf.2010.11.002

Friman, M., Fujii, S., Ettema, D., Gärling, T., & Olsson, L. E. (2013). Psychometric analysis of the Satisfaction with Travel Scale. *Transportation Research Part A: Policy and Practice*, *48*, 132-145. https://doi.org/10.1016/j.tra.2012.10.012

Gheorghiu, A., & Delhomme, P. (2018). For which types of trips do French drivers carpool? Motivations underlying carpooling for different types of trips. *Transportation Research Part A: Policy and Practice*, *113*, 460-475. https://doi.org/10.1016/j.tra.2018.05.002

Han, B., Kim, J., & Timmermans, H. (2019). Task allocation and gender roles in dual earner households: The issue of escorting children. *Travel Behaviour and Society*, *14*, 11-20. https://doi.org/10.1016/j.tbs.2018.09.001

Haroon, W., Khan, M. A., Ilyas, Z., Almujibah, H. R., Zubair, M. U., Ashfaq, M., & Hamza, M. (2024). Analyzing young adult travelers' perception and impacts of carpooling on traffic sustainability. *Sustainability*, *16*(14), Article 6098. https://doi.org/10.3390/su16146098

He, S. Y., & Giuliano, G. (2017). Factors affecting children's journeys to school: A joint escort-mode choice model. *Transportation*, *44*(1), 199-224. https://doi.org/10.1007/s11116-015-9634-x

Hosseini Shoabjareh, A., & Ghasri, M. (2025). Potential effects of parent-child joint school trips on parents' wellbeing: A conceptual framework. *Transportation Research Part A: Policy and Practice*, *191*, Article 104299. https://doi.org/10.1016/j.tra.2024.104299

Hsu, H.-P., & Saphores, J.-D. (2014). Impacts of parental gender and attitudes on children's school travel mode and parental chauffeuring behavior: Results for California based on the 2009 National Household Travel Survey. *Transportation*, *41*(3), 543-565. https://doi.org/10.1007/s11116-013-9500-7

Hussain, I., Hussain, Q., Dias, C., Bargi, W. A., Ali, N., Abdullah, M., & Cheng, L. (2025). Exploring commuter's preferences and future intentions to use ride-sharing: A case study from a developing country. *Journal of Advanced Transportation*, *2025*(1), Article 5516034. https://doi.org/10.1155/atr/5516034

Javid, M. A., Mehmood, T., Asif, H. M., Vaince, A. U., & Raza, M. (2017). Travelers' attitudes toward carpooling in Lahore: Motives and constraints. *Journal of Modern Transportation*, *25*(4), 268-278. https://doi.org/10.1007/s40534-017-0135-9

Javid, M. A., & Ali, N. (2020). Analysis of commuters' perceptions about carpooling service: A case study in Lahore. *Journal of Research in Architecture & Planning*, *29*(2), 9-16. https://doi.org/10.53700/jrap2922020_2

Javid, M. A., Farooq, A. S., & Ali, N. (2025). Latent class analysis of carpooling intentions considering the motives, barriers, and benefits: Policy insights for behavioral change. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668-025-06394-y

Ji, X., Guan, H., Lu, M., Chen, F., & Qin, W. (2022). International research progress in school travel and behavior: A literature review and bibliometric analysis. *Sustainability*, *14*(14), Article 8857. https://doi.org/10.3390/su14148857

Journal of Business Insight and Innovation
Volume 5 Issue 7, 2026
ISSN-p: 3006-2284, ISSN-e: 3006-0982
https://insightfuljournals.com/

Julagasigorn, P., Banomyong, R., Grant, D. B., & Varadejsatitwong, P. (2021). What encourages people to carpool? A conceptual framework of carpooling psychological factors and research propositions. *Transportation Research Interdisciplinary Perspectives*, *12*, Article 100493. https://doi.org/10.1016/j.trip.2021.100493

Kent, J. L., Delbosc, A., Moylan, E., Hossein-Rashidi, L., & Gilbert, H. (2025). The sector effect: Differences between public and private school travel in Australia. *Findings*. https://doi.org/10.32866/001c.143589

Li, J., Zhang, H., Liu, H., & Wang, S. (2024). Multi-objective planning of commuter carpooling under time-varying road network. *Sustainability*, *16*(2), Article 647. https://doi.org/10.3390/su16020647

Liu, X., Yan, X., Liu, F., Wang, R., & Leng, Y. (2019). A trip-specific model for fuel saving estimation and subsidy policy making of carpooling based on empirical data. *Applied Energy*, *240*, 295-311. https://doi.org/10.1016/j.apenergy.2019.02.003

Liu, J., Ettema, D., & Helbich, M. (2022). Systematic review of the association between commuting, subjective wellbeing and mental health. *Travel Behaviour and Society*, *28*, 59-74. https://doi.org/10.1016/j.tbs.2022.02.006

Lodhi, R. H., Rana, I. A., & Waheed, A. (2022). Gendered mode choice preferences and characteristics for educational trips in Abbottabad, Pakistan: An empirical investigation. *Case Studies on Transport Policy*, *10*(4), 2102-2110. https://doi.org/10.1016/j.cstp.2022.09.010

Lowe, W. U. A., & Piantanakulchai, M. (2023). Investigation of behavioral influences of carpool adoption for educational trips: A case study of Thammasat University, Thailand. *Case Studies on Transport Policy*, *12*, Article 100970. https://doi.org/10.1016/j.cstp.2023.100970

Motte-Baumvol, B., Bonin, O., & Belton-Chevallier, L. (2017). Who escort children: Mum or dad? Exploring gender differences in escorting mobility among Parisian dual-earner couples. *Transportation*, *44*(1), 139-157. https://doi.org/10.1007/s11116-015-9630-1

Murphy, L. D., Cobb, H. R., Rudolph, C. W., & Zacher, H. (2023). Commuting demands and appraisals: A systematic review and meta-analysis of strain and wellbeing outcomes. *Organizational Psychology Review*, *13*(1), 11-43. https://doi.org/10.1177/20413866221131404

Nasri, A., Carrion, C., Zhang, L., & Baghaei, B. (2020). Using propensity score matching technique to address self-selection in transit-oriented development (TOD) areas. *Transportation*, *47*(1), 359-371. https://doi.org/10.1007/s11116-018-9887-2

Neoh, J. G., Chipulu, M., & Marshall, A. (2017). What encourages people to carpool? An evaluation of factors with meta-analysis. *Transportation*, *44*(2), 423-447. https://doi.org/10.1007/s11116-015-9661-7

Nikitas, A., Wang, J. Y., & Knamiller, C. (2019). Exploring parental perceptions about school travel and walking school buses: A thematic analysis approach. *Transportation Research Part A: Policy and Practice*, *124*, 468-487. https://doi.org/10.1016/j.tra.2019.04.011

Novaco, R. W., Stokols, D., Campbell, J., & Stokols, J. (1979). Transportation, stress, and community psychology. *American Journal of Community Psychology*, *7*(4), 361-380. https://doi.org/10.1007/bf00894380

Novaco, R. W., Stokols, D., & Milanesi, L. (1990). Objective and subjective dimensions of travel impedance as determinants of commuting stress. *American Journal of Community Psychology*, *18*(2), 231-257. https://doi.org/10.1007/bf00931303

Novaco, R. W., & Collier, C. (1994). Commuting stress, ridesharing, and gender: Analyses from the 1993 State of the Commute Study in Southern California. *Transportation Research Record*, *1433*, 170-176.

Olsson, L. E., Maier, R., & Friman, M. (2019). Why do they ride with others? Meta-analysis of factors influencing travelers to carpool. *Sustainability*, *11*(8), Article 2414. https://doi.org/10.3390/su11082414

Park, K., Ewing, R., Scheer, B. C., & Ara Khan, S. S. (2018). Travel behavior in TODs vs. non-TODs: Using cluster analysis and propensity score matching. *Transportation Research Record: Journal of the Transportation Research Board*, *2672*(6), 31-39. https://doi.org/10.1177/0361198118774159

Journal of Business Insight and Innovation
Volume 5 Issue 7, 2026
ISSN-p: 3006-2284, ISSN-e: 3006-0982
https://insightfuljournals.com/

Park, Y., Chen, N., & Akar, G. (2018). Who is interested in carpooling and why: The importance of individual characteristics, role preferences and carpool markets. *Transportation Research Record: Journal of the Transportation Research Board*, *2672*(8), 708-718. https://doi.org/10.1177/0361198118756883

Prakayaphun, T., Hayashi, Y., Vichiensan, V., & Takeshita, H. (2023). Identifying impacts of school-escorted trips on traffic congestion and the countermeasures in Bangkok: An agent-based simulation approach. *Sustainability*, *15*(23), Article 16244. https://doi.org/10.3390/su152316244

Rafiq, R., & Mitra, S. K. (2020). Shared school transportation: Determinants of carpooling as children's school travel mode in California. *Transportation*, *47*(3), 1339-1357. https://doi.org/10.1007/s11116-018-9942-z

Rey-Merchán, M. D. C., López-Arquillos, A., & Pires Rosa, M. (2022). Carpooling systems for commuting among teachers: An expert panel analysis of their barriers and incentives. *International Journal of Environmental Research and Public Health*, *19*(14), Article 8533. https://doi.org/10.3390/ijerph19148533

Robbins, W. A., Berman, B. A., & Stone, D. S. (2015). Health effects of vanpooling to work. *Workplace Health & Safety*, *63*(12), 554-563. https://doi.org/10.1177/2165079915607870

Safdar, M., Jamal, A., Al-Ahmadi, H. M., Rahman, M. T., & Almoshaogeh, M. (2022). Analysis of the influential factors towards adoption of car-sharing: A case study of a megacity in a developing country. *Sustainability*, *14*(5), Article 2778. https://doi.org/10.3390/su14052778

Scheiner, J. (2016). School trips in Germany: Gendered escorting practices. *Transportation Research Part A: Policy and Practice*, *94*, 76-92. https://doi.org/10.1016/j.tra.2016.09.008

Schouten, M. J., & Heras, S. L. (2019). Chauffeuring parenthood: The everyday travel times of families. *Portuguese Journal of Social Science*, *18*(3), 283-298. https://doi.org/10.1386/pjss_00011_1

Schwanen, T. (2007). Gender differences in chauffeuring children among dual-earner families. *The Professional Geographer*, *59*(4), 447-462. https://doi.org/10.1111/j.1467-9272.2007.00634.x

Sener, I. N., Lee, R. J., & Sidharthan, R. (2019). An examination of children's school travel: A focus on active travel and parental effects. *Transportation Research Part A: Policy and Practice*, *123*, 24-34. https://doi.org/10.1016/j.tra.2018.05.023

Sepúlveda-Murillo, F. H., Lizárraga, C., & Chica-Olmo, J. (2024). Factors affecting school commute-related perceived stress in adolescents in Colombia. *SAGE Open*, *14*(4), Article 21582440241293195. https://doi.org/10.1177/21582440241293195

Shaheen, S. A., Chan, N. D., & Gaynor, T. (2016). Casual carpooling in the San Francisco Bay Area: Understanding user characteristics, behaviors, and motivations. *Transport Policy*, *51*, 165-173. https://doi.org/10.1016/j.tranpol.2016.01.003

Si, H., Shi, J., Hua, W., Cheng, L., De Vos, J., & Li, W. (2023). What influences people to choose ridesharing? An overview of the literature. *Transport Reviews*, *43*(6), 1211-1236. https://doi.org/10.1080/01441647.2023.2208290

Singh, N., & Vasudevan, V. (2018). Understanding school trip mode choice - the case of Kanpur (India). *Journal of Transport Geography*, *66*, 283-290. https://doi.org/10.1016/j.jtrangeo.2017.12.007

Tao, Y., van Ham, M., & Petrović, A. (2024). Changes in commuting mode and the relationship with psychological stress: A quasi-longitudinal analysis in urbanizing China. *Travel Behaviour and Society*, *34*, Article 100667. https://doi.org/10.1016/j.tbs.2023.100667

Teixeira, J. F., Silva, C., & Neves, J. V. (2019). School mobility management case study: German school of Oporto (Deutsche Schule zu Porto). *Case Studies on Transport Policy*, *7*(1), 13-21. https://doi.org/10.1016/j.cstp.2018.11.002

Tsoi, K. H., & Loo, B. P. (2026). A multiscale assessment on negative transport externalities: Magnitude, composition and policy implications. *Research in Transportation Economics*, *116*, Article 101732. https://doi.org/10.1016/j.retrec.2026.101732

Journal of Business Insight and Innovation
Volume 5 Issue 7, 2026
ISSN-p: 3006-2284, ISSN-e: 3006-0982
https://insightfuljournals.com/

Waldorf, I., Loder, A., Wurster, S., & Bogenberger, K. (2025). Low fare public transport as social policy? A study of Germany's 9-Euro-Ticket and Deutschlandticket via propensity score matching. *Transportation*. https://doi.org/10.1007/s11116-025-10640-7

Wang, J., Lu, Y., Yang, Y., Peng, J., Liu, Y., & Yang, L. (2023). Influence of a new rail transit line on travel behavior: Evidence from repeated cross-sectional surveys in Hong Kong. *Journal of Transport Geography*, *106*, Article 103526. https://doi.org/10.1016/j.jtrangeo.2022.103526

Wang, Y., Xiang, Z., & Li, L. (2025). Examining school escorting travel behaviors from the perspective of the trip chain. *Transportation Planning and Technology*, *48*(5), 1093-1112. https://doi.org/10.1080/03081060.2024.2402463

Yan, Y., Burke, M., Leung, A., & McBroom, J. (2022). Is private-schooling problematic for transportation? Evidence from Southeast Queensland, Australia. *Journal of Transport and Land Use*, *15*(1), 567-585. https://doi.org/10.5198/jtlu.2022.1874

Zhang, R., Yao, E., & Liu, Z. (2017). School travel mode choice in Beijing, China. *Journal of Transport Geography*, *62*, 98-110. https://doi.org/10.1016/j.jtrangeo.2017.06.001