



Institutional Readiness and Parental Carpooling Adoption: Multilevel Evidence from Private Schools in Urban Punjab, Pakistan

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ABSTRACT

Parental carpooling for the school commute is a low-cost demand-side response to congestion and air pollution, yet the institutional role of schools in enabling it remains empirically unexplored, particularly in the developing world. Against the backdrop of Punjab's recurring smog emergencies and judicial orders targeting school-related vehicle trips, this study examines whether school-level institutional readiness is associated with parents' adoption of carpooling. Primary data were collected from 937 parents (Level 1) nested within 52 elite/high fee private schools (Level 2) in Lahore and Faisalabad through a structured parent survey, paired with a school-administration survey completed by principals or transport coordinators at every sampled school. A two-level random-intercept logistic regression was estimated with carpooling adoption as the binary outcome. At the parent level, commute distance, the number of the household's children at the school, parent education, and having a secondary-grade child were positively associated with adoption, while household income was negatively associated. At the school level, the Carpool Readiness Index compiled from a formative composite of route-matching support, a parent communication channel, coordinated dismissal, child-handover and safety protocols, supervised pickup and drop-off, and a written carpool policy was the strongest predictor, whereas catchment dispersion and school size were negatively associated. Predicted adoption rises from 3% at the lowest observed readiness to 27% at the highest, a 24 percentage-point difference. The null-model intraclass correlation of 0.126 indicates that one-eighth of the latent variation in adoption lies between schools. The study provides among the first multilevel evidence on the school-as-institution association with parental carpooling in the Global South and identifies concrete, low-cost institutional levers for schools, regulators, and urban transport planners.

1. Introduction

The daily school commute is a large recurring part of urban peak hour traffic at elite and high-fee English-medium private schools in the metropolitan cities like Lahore and Faisalabad. A large number of children are transported by private car or hired drivers with single occupancy. School gate congestion concentrates vehicle trips at fixed times. This directly adds to congestion, fuel use, and tailpipe emissions. Distance is the dominant determinant of how children get to school (AlQuhtani, 2023; Rafiq & Mitra, 2020). In low-density car-oriented affluent neighborhoods, walking and cycling are not feasible and, therefore, motorized escort is seen near schools. Children's daily travel to school as a part of urban mobility impacts traffic congestion, environmental sustainability, and public health. The decision-making process related to children's transportation is different from those of adults because children depend on adults to decide where, when, and how they will travel (Tristram et al., 2023).

Lahore and Faisalabad have been repeatedly ranked as the world's most polluted cities (Ali & Rana, 2024). Especially in November 2024, Lahore recorded its highest ever reading of around an air quality index (AQI) of 1,900, with PM2.5 approaching hazardous levels. Schoolchildren and children under five are among the most exposed and an environmental emergency was declared in Punjab. Emergency green lockdown measures, including cancelling schools across multiple districts, moving universities online, closing parks, museums, zoos, and monuments were taken to mitigate smog impacts (Nasar-u-Minallah et al., 2024a). The Lahore High Court has repeatedly ordered action on vehicular emissions. As vehicular emission is a major part of the smog crisis, the court extended enforcement and ordered schools to provide school buses so that individual occupancy vehicles can be reduced. The city's rapid urbanization has led to deforestation and the loss of green spaces, exacerbating the urban heat island effect and contributing to rising temperatures, urban air pollution and smog phenomenon (Nasar-u-Minallah et al., [2024b](#))

A timely and sustainable solution is organized carpooling for the school run that directly cuts the number of vehicle trips, easing congestion, fuel costs, and emissions. Carpooling is defined as a shared ride from home to school with at least one other child (Rafiq & Mitra, 2020). Carpooling has been repeatedly identified as an underused component of school travel demand management (Arbour-Nicitopoulos et al., 2012). Neoh et al. (2017) show in their meta-analytic evidence that institutional/structural facilitation, especially partner matching, is among the strongest correlates of carpooling. Yet, school trip carpooling is low and poorly understood, especially in developing country settings (Rafiq & Mitra, 2020).

Schools are a natural organizing unit for carpooling, similar to workplaces, which the literature treats as effective contexts for carpool programs (Bachmann et al., 2018). Vanoutrive et al. (2012) modelled carpooling across Belgian workplaces with the multilevel design and showed that organizational and promotional factors are helpful in carpooling adoption. Schools can lower the practical and trust barriers by matching families on common routes, running parent communication channels. Schools can facilitate coordinating pick-up and drop-off at school gates, regulating child handover, and providing safety protocols. Priority drop-off, awareness campaigns, and written carpool policy, all are steps that schools can take to make parents trust carpooling.

Trust and safety are decisive barriers to ride-sharing in Pakistan (Ayaz et al., 2021; Dias et al., 2022). Therefore, school-facilitated carpools can provide institutional facilitation development of interpersonal trust among parents. This will also address security and gender sensitivity concerns, particularly for girl students. The success of school carpooling and bus schemes rests on community initiatives and cooperation (Kelly & Fu, 2014). Schools are a natural place to mobilize these initiatives and cooperation.

The elite, high-fee private schools in Lahore and Faisalabad have organized socially homogeneous parent communities and also active WhatsApp and Facebook groups. They also have institutional resources to facilitate carpooling. Some private schools in Lahore initiated carpooling programs in the wake of smog crises and orders of Lahore High Court considering it as a sustainable and green solution and it coincides with their social responsibility slogans. One example of a school-led initiative to encourage sustainable commuting in Pakistan is the introduction of a carpooling feature in the parents' portal of Aitchison College, designed to facilitate ride-sharing among families, reduce traffic congestion, and lower carbon emissions (Aitchison College, 2024).

Some distinctive local dynamics, like hired driver culture, security and general norms, and acute smog exposure, will make school-level facilitation both relevant and potentially high-impact. Existing Pakistani carpool research is attitudinal, stated preference, and single-level for work related trips, and no study examined the institutional role of schools or used a multilevel design (Farooq et al., 2025; Ayaz et al., 2021).

School-level institutional support has rarely been operationalized or tested as a predictor of carpooling adoption in sustainable school travel literature. Multilevel (parents nested in schools) logistic modelling of carpooling is also absent. The school travel literature is dominated by single-level discrete choice models, and no study addresses this in a developing country elite, high-fee private school context such as urban Punjab.

The objective of this study is to examine whether institutional readiness of schools supports carpooling and is associated with parents' adoption of organized carpooling, keeping household characteristics constant.

This study makes three contributions. First, it provides, to the best of our knowledge, the first multilevel (parents-nested-in-schools) analysis of carpooling as a school travel mode in any country, complementing the single-level evidence from North America (Arbour-Nicitopoulos et al., 2012; Rafiq & Mitra, 2020) and the workplace multilevel tradition (Vanoutrive et al., 2012). Second, it introduces and tests a measured construct of institutional behavior the Carpool Readiness Index, reported by school administrators rather than parents. This separates what schools do from what parents perceive and avoiding same source bias between the focal predictor and the outcome. Third, it supplies developing country evidence directly aligned with an active policy process related to the smog-driven judicial and administrative push for shared school transport in Punjab. These school-level levers identified here are immediately actionable.

The remainder of this paper is structured as follows. Section 2 reviews the theoretical foundations and empirical literature. Section 3 describes the research design, data collection, variable operationalization, and econometric methodology. Section 4 presents the results across all analytical components. Section 5 discusses findings and implications. Section 6 concludes with policy recommendations.

2. Literature Review

Families are choosing larger schools over smaller and more dispersed schools. This increases the reliance on motorized vehicles (Ji et al., 2022; Liu et al., 2024). Resultantly, problems such as air pollution, energy consumption, and traffic congestion during peak urban hours get deteriorated (Prakayaphun et al., 2023). Children's school travel modes choice, including carpooling, have been studied in the literature, but most of the studies are related to active school travel and cycling and bike use as sustainable travel modes. Carpooling as a sustainable school travel mode has not received due importance and is understudied, especially in developing countries' context. Travel

mode selection is a complex process influenced by socioeconomic factors, demographic characteristics, and modal characteristics (Jeong et al., 2022; Yose et al., 2020).

Distance from home to school is the single biggest factor that determines the school travel mode (Li et al., 2023; Liu et al., 2024). The farther away the school, the less children walk and the more they use cars, school buses, and public transport (Zhang et al., 2017; Stark et al., 2018). And due to road safety, and security concerns, most of the students end up in escorted by parents (Mandic et al., 2020). But “how far is too far?” depends on the country and its culture (Scheiner et al., 2019). Children in China and the U.S. tend to walk up to about 500 m (Kontou et al., 2020; Han et al., 2022).

Household resources matter a lot for school mode choice including income (Ranjan & Sinha, 2025), the number of cars (Ozen et al., 2025), how many licensed drivers there are (Mehdizadeh et al. (2018)), and the parents’ work and travel habits (Sukmayasa et al., 2025). As a rule, more money plus more cars means the child is more likely to be driven (Dias et al., 2022; Ermagun & Samimi, 2015). In the U.S., low-income families lean on the school bus (Lidbe et al., 2020). But in China, Lin & He (2020) found income did not really change whether children walked, a useful reminder that context matters.

If an adult is home at school-run time, the child is more likely to be driven (Mitra & Buliung, 2014). Bigger families also tend to drive their children more (Li & Zhao, 2015). Parents with flexible working hours are more likely to walk their kids to school (He & Giuliano, 2017). Father’s commute does not change much, but if the mother works in the morning, the child is less likely to walk (McDonald, 2008a). And children with unemployed parents walk more (AlQuhtani, 2023) because somebody is free to walk along with them.

Both age and gender also matter although Lin & He (2020) found no link at all. Generally, older children become more independent as they need less hand-holding from parents and more walking, biking, or taking the bus on their own (Müller et al., 2020; Li et al., 2022). Boys tend to use active and independent modes more (AlQuhtani, 2023; Li et al., 2022; Guliani et al., 2015), while girls are driven more often (Lidbe et al., 2020; Zwerts et al., 2010).

Parental education is another factor linked to school-travel choices, but the evidence is mixed. Some studies find that children of more educated parents walk and use public transport less for example, Martin et al. (2007) reported this in the United States and AlQuhtani (2023) in Najran, Saudi Arabia. Others report the reverse, with Ozbil et al. (2020) linking higher parental education to more active travel. More recent work shows the effect depends on the household characteristics (Ozen et al., 2025) and Mehdizadeh et al. (2018) found that parental education and socio-economic status shape parents' mode choices differently across groups and settings, so it cannot be assumed to work the same way everywhere.

Carpooling means one household’s car carrying its own kids plus kids from other households to school (Rafiq & Mitra, 2020). Carpooling is useful for three reasons. First, schools are getting farther away, so fewer kids can walk or bike and for those longer trips, sharing a ride is a sensible green option (Kelly & Fu, 2014). Second, carpooling suits busy dual-earner parents multitasking rush-hour schedules. On top of that, it cuts congestion and vehicle-miles travelled (Olsson et al., 2019).

Only a handful of studies look at carpooling for education trips for schools and universities. Staunton et al. (2003) were first to study a Safe Routes to School success story in Marin County, California, where a community program promoted carpooling and cut the number of solo-car school trips. Later, Arbour-Nicitopoulos et al. (2012) studied parents in Toronto and found carpooling was seen as eco-friendly and low-hassle, with convenience and safety the top reasons

people used carpooling. Rafiq & Mitra (2020) is the latest study available conducted in the US for studying carpooling as a sustainable school travel mode.

As far as school-level and institutional support is concerned, school travel plans studies show that travel behavior can shift when schools coordinate parents, municipal agencies, and route safety interventions (Mammen et al., 2014). These studies focus mostly on active travel rather than carpooling, but the same institutional logic applies to school-based parent matching, pay timing, and communication. Mammen et al. (2015) conclude that modal shift away from driving depends on characteristics at the child, family, and school levels. The success of active school programs depends on school champions, stakeholders buy-in, and resource availability coupled with community mobilization for community resources to encourage safer, more sustainable school transportation (Buliung et al., 2011; Mammen et al., 2015).

Javid et al. (2025) explored different factors which affect the intentions of university students to adopt carpooling for university trips and found 60% with positive intentions provided that some incentives and barriers are kept in place.

After detailed review of the literature, we found significant gaps in literature especially about carpooling for commuting school kids. Even though some studies have been conducted in Western contexts, but for developing country and especially Pakistan, we found not a single study which specifically analyzed determinants of carpooling. So our study is the first to investigate and explore the school carpooling as a sustainable transport strategy. The nesting of parents within schools is a textbook two-level structure; reporting an intraclass correlation (ICC) and between-school variance is the expected practice, yet school-travel mode-choice studies overwhelmingly use single-level MNL/logit. And the third gap we found in literature is the non-existence of schools as institutions in promotion of carpooling among parents in developing-country context. There is a clear and exploitable gap as almost no study has modelled school-level institutional support as a driver of carpool adoption using multilevel (parents nested in schools) logistic regression, especially in a developing-country, elite/high fee private-school setting.

3. Research Design, Data and Methodology

3.1 Study Design and Target Population

We collected primary data through a cross-sectional survey at multi-level. The study population consisted two levels, (a) parents or primary guardians of children enrolled in grades 1–10 at high-fee and medium-fee schools in Lahore and Faisalabad, Punjab, Pakistan, and (b) school administrators (principals, transport coordinators) at the same school. This dual survey helped us simultaneously measure the parent-level decision variables and school-level institutional characteristics.

3.2 Sampling and Data Collection

A stratified multi-stage sampling procedure was implemented. In the first stage, 52 schools were selected across two cities (37 schools from Lahore, 15 from Faisalabad). Then these schools were stratified by fee-tier, as high versus very high. And in the second stage, parents were approached within each school through different channels. Some parents were distributed online questionnaires via Google Forms. Some parents were contacted through school and class WhatsApp groups. And at some schools, physical forms were distributed at parent-teacher meetings. The data collection took place from July to November 2025. As parents are very sensitive about providing information about their kids, so at early stage the response rate was very low. Subsequently, City Traffic Police were approached and with the help of Education Department that regularly conducts seminars and awareness programs in the schools about road safety, traffic awareness, and deploy personnel at

pick-up and drop-off times at schools, reminders and quick response was requested from school administrations.

A total of 985 responses were received, but after excluding responses with incomplete answers, missing values, 937 responses were retained and used for the analysis. The average school-level sample size was 15 to 40 parents per school.

At the same time, school administration questionnaires were completed from the relevant persons from schools and we received 52 school-level observations. This survey contained information are institutional policies about carpooling, what kind of infrastructure is available in the schools, and what are their attitudes and barriers related to carpooling facilitation.

3.3 Variable Operationalization

3.3.1 Dependent Variable

The outcome variable for the multilevel model is carpooling adoption, coded as a binary indicator: 1 if the parent currently carpools (or has carpooled in the current academic year) for their child's school commute, and 0 otherwise.

Table 1. Definition and Measurement of Study Variables

Variable	Level	Definition	Coding/Measurement
Outcome			
Carpool adoption	Parent	Whether the parent currently participates in organized carpooling to school	1 = adopts, 0 = does not
School-level predictors (focal — Level 2)			
Carpool Readiness Index	School	Institutional support for carpooling:	Additive index 0–6
Catchment dispersion	School	Within-school variability of home-to-school distance of families	Within-school SD of distance (km)
School size	School	Total student enrollment	Count
Location	School	City in which the school is located	1 = Lahore, 0 = Faisalabad
Transport availability	School	Whether the school operates its own van/bus service (in-house or outsourced)	1 = yes, 0 = no
Parent-level controls (Level 1)			
Distance to school	Parent	Home-to-school distance for the family	Continuous (km);
Number of cars	Parent	Number of cars owned by the household	Count
Alternative escort availability	Parent	Whether a non-parent (hired driver or extended-family member) is available to do the school run	1 = yes, 0 = no
Parent employment status	Parent	Whether the responding parent is employed	1 = employed, 0 = not employed
Household income	Parent	Total monthly household income	Continuous (PKR)
Parent education	Parent	Highest education level of the responding parent	Ordinal: 1 (up to secondary) to 4

			(postgraduate)
Child grade	Parent	Grade stage of the child the survey concerns	Categorical: primary / middle / secondary (primary = reference)
Children in same school	Parent	Number of the parent's own children enrolled at the school	Count
Descriptive context (not entered in the model)			
Fee tier	School / Parent	Very high fee vs. high fee classification based on monthly fee	Very high fee $\geq$ PKR 30,000/month; high fee PKR 20,000–30,000
Locale	School / Parent	Urban-core vs peripheral/suburban setting of the school	Urban core / periphery
Work-schedule flexibility	School / Parent	Self-rated flexibility of the parent's work schedule	Ordinal 1–5

School-level support is important because school travel behavior is shaped not only by household characteristics but also by institutional coordination and school travel policies (Vasey et al., 2022).

The Carpool Readiness Index is a formative, additive index. It was built on six binary survey items. Each item asked a specific institutional support measure school is providing. A school administrator answered yes, 1, or no, 0, to each of the following:

1. Route matching support: Does the school help connect parents who live on the same route? 2. Child safety protocol: Is there a formal procedure for handing over children during carpool pickup/drop-off? 3. Staggered or coordinated dismissal: Does the school stagger dismissal time to ease carpool logistics? 4. Parent Communication Channel: Is there a WhatsApp group or similar system dedicated to connecting carpool families? 5. Awareness Campaign: Has the school issued a formal carpool policy or run an awareness campaign? 6. Infrastructure and logistic support. Has school dedicated parking space and designated staff for facilitating carpoolers. Then these six items were simply added together. A school scoring zero has none of these measures in place, and a school scoring six has all six. It tells us how many institutional support mechanisms the school has adopted.

3.3.3 Model Specification

Two-level, multilevel hierarchical logistic regression was appropriate because the outcome is binary, and our observations were clustered within schools. Multilevel modeling is appropriate when individuals are nested within institutions such as schools, because observations within the same school may be correlated (Maas & Hox, 2005; McNeish & Stapleton, 2016).

Model 1. Parent Level

$$\text{logit}(p_{ij}) = \gamma_{00} + \gamma_{10}(\text{Distance}_{ij}) + \gamma_{20}(\text{Cars}_{ij}) + \gamma_{30}(\text{Escort}_{ij}) + \gamma_{40}(\text{Employment}_{ij}) + \gamma_{50}(\text{Income}_{ij}) + \gamma_{60}(\text{ChildAgeGrade}_{ij}) + \gamma_{70}(\text{ChildrenSameSchool}_{ij}) + u_{0j}$$

Model 2. School Level

$$\text{logit}(p_{ij}) = \gamma_{00} + \gamma_{01}(\text{Readiness}_j) + \gamma_{02}(\text{CatchmentDispersion}_j) + \gamma_{03}(\text{SchoolSize}_j) + \gamma_{04}(\text{Location}_j) + \gamma_{05}(\text{TransportAvailability}_j) + u_{0j}$$

Model 3. Full Two-Level Hierarchical Logistic Model

$$\begin{aligned} \text{logit}(p_{ij}) = & \gamma_{00} + \gamma_{10}(\text{Distance}_{ij}) + \gamma_{20}(\text{Cars}_{ij}) + \gamma_{30}(\text{Escort}_{ij}) + \gamma_{40}(\text{Employment}_{ij}) \\ & + \gamma_{50}(\text{Income}_{ij}) + \gamma_{60}(\text{ChildAgeGrade}_{ij}) + \gamma_{70}(\text{ChildrenSameSchool}_{ij}) \\ & + \gamma_{01}(\text{Readiness}_{ij}) + \gamma_{02}(\text{CatchmentDispersion}_{ij}) + \gamma_{03}(\text{SchoolSize}_{ij}) \\ & + \gamma_{04}(\text{Location}_{ij}) + \gamma_{05}(\text{TransportAvailability}_{ij}) + u_{0j} \end{aligned}$$

Continuous predictors were standardized so odds ratios are per one standard deviation.

4. Results

Table 1 describes the parent-level descriptive statistics. Overall sample size was 937. Average one-way distance from home to school was 10.15 km, whereas the maximum distance is 36 kilometers. It shows that some parents travel farther enough to attend some prestigious schools, even though they would have available schools near around. Number of cars ranges from 1 to 3, showing that at least one car is available in all households in our targeted population, and therefore, carpooling specific policies are focused to this group. Household mean income is 272,590, again showing that these elite schools attract affluent families. Some families have children in the same school that ranges from 1 to 4.

Table 2. Parent-Level Descriptive Statistics (n = 937 parents)

Variable	N	Mean/%	SD	Min	Max
Continuous and count measures					
Distance to school (km)	937	10.15	5.79	1.50	36.00
Number of cars	937	1.80	0.72	1.00	3.00
Work flexibility (1–5)	937	3.04	1.23	1.00	5.00
Household income (PKR/month)	937	272,590	159,616	80,000	1,200,000
Parent education (1-4)	937	2.52	0.85	1.00	4.00
Children in same school	937	1.67	0.84	1.00	4.00
Binary measures (% = yes)					
Carpool adoption	937	11.3%	—	0	1
Alternative escort availability	937	49.9%	—	0	1
Employed	937	69.8%	—	0	1

Overall carpooling adoption is 11.3%, which seems to be high as compared to international references (Rafiq & Mitra, 2020; Arbour-Nicitopoulos et al., 2012). Reason for this high carpooling adoption rate is that some schools in Lahore, especially the Aitchison College and schools with big chains, had already initiated carpooling as a sustainable and environmental initiative. The most affected sector with smog crisis was school sector that have to be closed for several weeks in November 2024. This smog crisis and poor air quality index has direct impact on children's health. Therefore, Lahore High Court intervened in this matter and called for emergency steps that included promotion of carpooling and provision of school buses to at least 50% students. As a result, carpooling awareness and facilitation was the first step because this requires little investment in infrastructure and logistics, whereas buying buses for school is a hefty investment and schools were reluctant to provision of school buses. 69.8% of the sample are employed in the government or private sector and the remaining 30.2% are either self-employed or running their own business. Nearly 50% of the sample have either hired driver or some person in extended family available for pick-up and drop-off, which is very common in Pakistan that someone in the family will escort children to schools.

Table 3. School-Level Descriptive Statistics (k = 52 schools)

Variable	N	Mean/%	SD	Min	Max
Continuous and count measures					
Carpool Readiness Index (0–6)	52	2.50	1.57	0.00	6.00
Catchment dispersion (km SD)	52	4.34	2.15	1.04	10.25
School size (enrollment)	52	1275.00	453.45	400.00	2200.00
Observed adoption rate (%)	52	11.4	6.5	5	21
Binary measures (% = yes)					
Location (Lahore)	52	71.2%	—	0	1
Transport availability (van/bus)	52	15.4%	—	0	1

Carpool readiness index has mean value of 2.50, which shows that most of the schools are not still ready for carpool initiatives. They have some modalities going on, but there is a need to increase the steps at school level. School size with a mean of 1275 students is enough to make arrangement for carpool at school level.

Table 4. Categorical Descriptive Statistics

Variable	Category	n	%
Child grade (parent)			
	Primary	429	45.8%
	Middle	274	29.2%
	Secondary	234	25.0%
Fee tier (school)			
	Elite	29	55.8%
	Semi-elite	23	44.2%
Locale (school)			
	Periphery	27	51.9%
	Urban	25	48.1%
City (school)			
	Lahore	37	71.2%
	Faisalabad	15	28.8%

Carpooling adoption was analysed with a two-level multilevel logistic regression, fitting a parent-level (Level 1) model with a school-level (Level 2) random intercept by maximum likelihood (adaptive Gauss–Hermite quadrature). The sample comprised 937 parents nested in 52 elite and semi-elite private schools in Lahore and Faisalabad. Overall adoption was 11.3% which is reasonably good as compared to international references. School-level readiness variables were the focal predictors and parent variables entered as controls. Results are reported as log-odds coefficients (b), standard errors, odds ratios (OR), 95% confidence intervals, and p-values; the cross-sectional design means relationships are associational.

Hierarchical Logistic Regression Results

Firstly, we ran an empty model and it gave us intraclass correlation (ICC) = 0.126. This shows that about 13% of latent variation lies in adoption between schools and justifies our multilevel logistic regression. Between-school residual variance approached zero after adding school predictors. Figure 1 shows adoption rising across schools' group by readiness.

Figure 1. Carpool Adoption by City and School Readiness

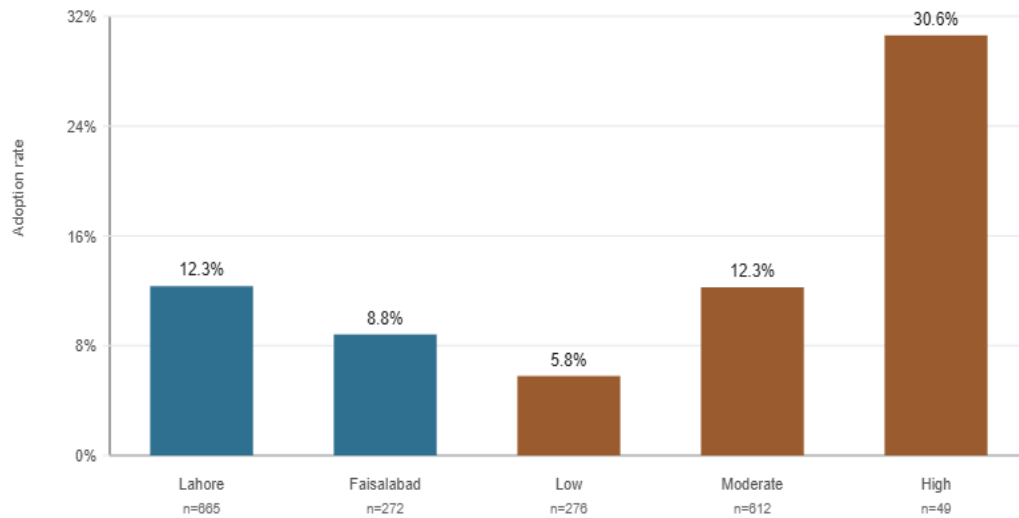


Figure 1. Carpool Adoption by City and School Readiness

In figure 1, we see that adoption rate in Lahore is 12.3% and in Faisalabad, it is 8.8%. So overall, it is consistent with our observation that Lahore, being most affected by smoke crisis, schools already have some carpooling initiatives and overall carpool adoption is greater in Lahore than Faisalabad. Most of the schools are at moderate level of school readiness index and we see a skewed representation here as only 49 schools are placed in high readiness level.

Table 5. Two-Level Logistic Regression Predicting Carpooling Adoption (Full Model)

Predictor	Level	b (SE)	OR	95% CI	p
Intercept	—	-2.70 (0.33)	0.07	0.03–0.13	< .001
School-level predictors (focal — Level 2)					
Carpool Readiness Index	School	0.65 (0.12)	1.91	1.51–2.41	< .001
Catchment dispersion	School	-0.31 (0.13)	0.73	0.56–0.96	.022
School size	School	-0.33 (0.12)	0.72	0.57–0.90	.004
Location (Lahore)	School	0.49 (0.27)	1.63	0.95–2.78	.074
Transport availability	School	0.13 (0.31)	1.14	0.62–2.11	.665
Parent-level controls (Level 1)					
Distance to school	Parent	0.44 (0.12)	1.56	1.24–1.95	< .001
Number of cars	Parent	-0.13 (0.16)	0.88	0.64–1.20	.411
Alternative escort availability	Parent	-0.24 (0.22)	0.78	0.51–1.21	.271
Parent employment status	Parent	-0.17	0.84	0.52–1.36	.489

		(0.24)			
Household income	Parent	-0.41 (0.14)	0.67	0.50–0.88	.004
Parent education	Parent	0.28 (0.11)	1.33	1.07–1.65	.010
Child grade: middle	Parent	0.03 (0.27)	1.03	0.61–1.74	.916
Child grade: secondary	Parent	0.52 (0.26)	1.69	1.01–2.82	.046
Children in same school	Parent	0.27 (0.10)	1.31	1.07–1.60	.008

School-Level Predictors

The strongest school-level finding was the Carpool Readiness Index. A one-standard-deviation increase in school readiness was associated with 89% higher odds of parent carpool adoption. This means that schools with route-matching systems, safety/handover protocols, pickup/drop-off support, coordinated dismissal, communication groups, and written carpool awareness had significantly higher adoption. Catchment dispersion was negative and significant. It implies that schools where families were more geographically spread out were less willing to adopt. It is because carpooling requires route compatibility, and if parents live in very different directions, matching and finding carpooling partners become more difficult. School size was also negative and significant. It may sound weird because theoretically, larger schools may provide larger pool for matching, but this suggests that size alone is not enough. In Pakistani high-fee private school context, may also mean larger school have more private car-dependent parents. There is gate congestion at pick-and-drop time and there is weaker coordination among the parents. So we can infer that organized readiness matters more than size alone. The Lahore indicator was positive but not statistically significant. School van/bus service was also not significant, so the expected substitution effect was not supported in this dataset. Parents in elite Pakistani schools don't consider carpooling and school-provided bus/van as substitutes.

Table 6. Model Comparison: Null, Parent-Only, School-Only, and Full Models

Statistic	Null	Parent-only	School-only	Full
Predictors (fixed)	0	9	5	14
Log-likelihood	-325.4	-309.6	-309.2	-289.4
AIC	654.9	641.2	632.4	610.8
Between-school var. (τ^2)	0.475	0.603	0.326	0.176
ICC	0.126	0.155	0.09	0.051

In multilevel logistic models the Level-1 residual variance is fixed at $\pi^2/3$, so adding Level-1 predictors rescales the latent outcome and can increase the estimated between-school variance even as fit improves; the rise from 0.475 to 0.603 reflects this rescaling rather than added heterogeneity (Snijders & Bosker, 2012).

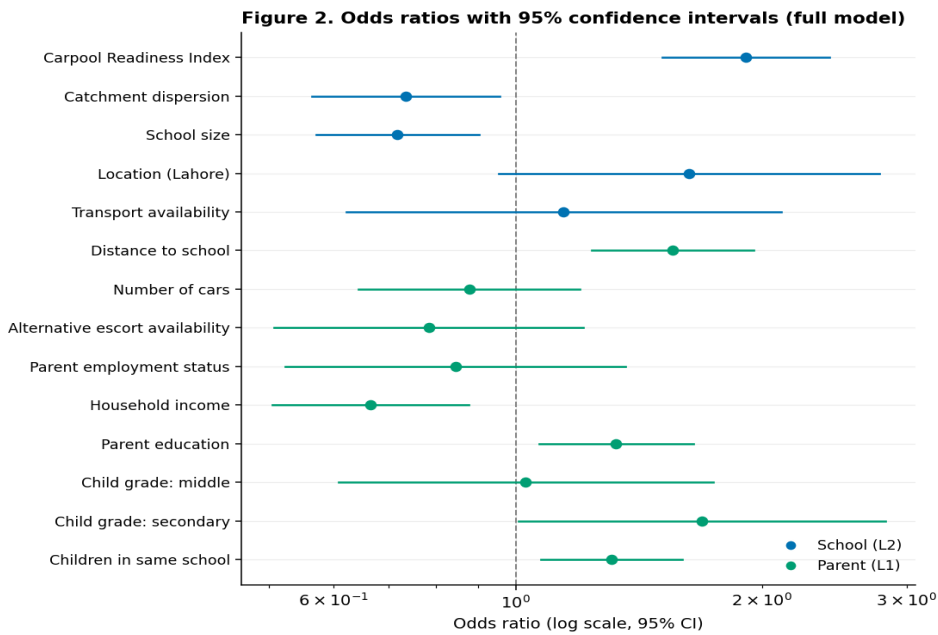


Figure 2. Odds Ratios with 95% Confidence Intervals (Full Model)

The figure.2 shows which factors increase or decrease the chances of carpooling adoption. Values on the right side of 1 mean the factor increases the odds of carpooling, while values on the left side of 1 mean it reduces the odds. The strongest positive factor is Carpool Readiness Index, meaning schools that are more ready to support carpooling have higher carpooling chances. At the parent level, longer distance to school, secondary-grade children, more children in the same school, and higher parent education also increase the likelihood of carpooling. On the other hand, household income, alternative escort availability, number of cars, school size, and catchment dispersion mostly reduce carpooling chances. If the confidence interval line crosses 1, the effect is weaker or not clearly significant

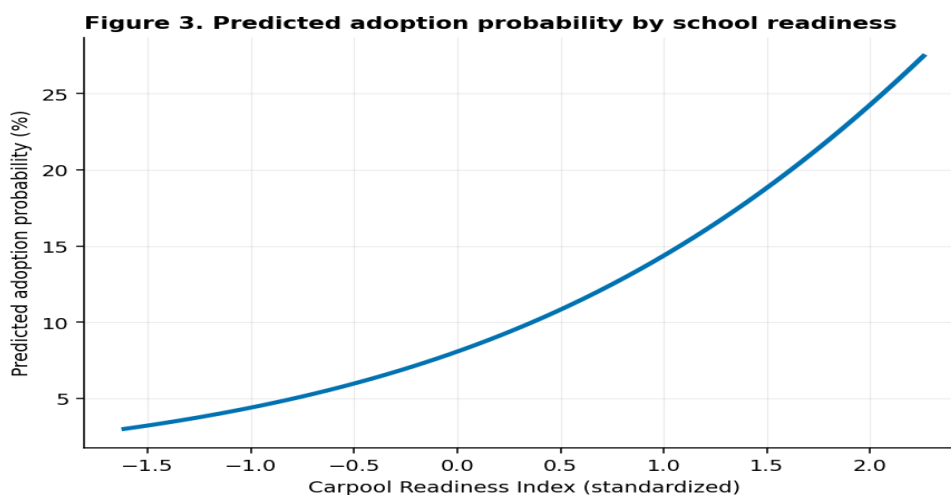


Figure 3. Predicted Adoption Probability by School Readiness

This figure.3 shows that when the Carpool Readiness Index of a school increases, the predicted probability of parents adopting carpooling also increases. At low readiness levels, the chance of carpooling is very small, around 3–5%. At average readiness, it rises to about 8–10%. When school readiness becomes high, the probability increases sharply and reaches around 25–28%. In

simple words, schools that provide better support, planning, communication, and facilities for carpooling are much more likely to have parents adopting carpooling.

In summary, the Carpool Readiness Index was the strongest school-level correlate of adoption (OR = 1.91, $p < .001$), and two further school-level factors were significant and negative: catchment dispersion (OR = 0.73, $p = .022$) and school size (OR = 0.72, $p = .004$). Among parent controls, distance (OR = 1.56), parent education (OR = 1.33), secondary-grade children (OR = 1.69) and having more children at the school (OR = 1.31) were positively associated, while household income (OR = 0.67) was negatively associated. Location (borderline, $p = .074$), transport availability, number of cars, alternative escort, parent employment and the middle-grade contrast were not statistically significant.

5. Discussion

In this study, we asked whether what schools do to enable carpooling is associated with whether parents adopt it by controlling other household variables. We get three main findings from this analysis. First, between-school clustering was justified to require a multilevel model. This shows that carpooling rates vary systematically across schools rather than being purely individual choices (Vanoutrive et al., 2012). Second, institutional readiness was the dominant school-level correlate of adoption. Third, the measured school factors explained virtually all of the between-school variance. This shows that observable institutional and contextual features account for why adoption differs across schools.

The positive association between the Carpool Readiness Index and adoption (OR = 1.91) is the study's core contribution and is consistent with the workplace-commuting literature. Vanoutrive et al. (2012), using a multilevel approach for Belgian workplaces, found that organizational characteristics and measures to increase carpool-oriented mobility were significant factors. They found that explicit organizational support was meaningful in increasing carpooling adoption. The same logic applies to schools where route matching, communication channels, and a written policy lower the coordination and matching costs. Kelly and Fu (2014) similarly found that school carpooling and bus schemes succeed only where there is community initiative and cooperation. Correia and Viegas (2011) show that carpool clubs and formal matching mechanisms enhance the value parents derive from carpooling. Neoh et al. (2017) stated that readiness operates largely through the situational channel by reducing the practical frictions of organizing shared trips. It also aligns with school travel planning literature, which emphasizes the role of schools, parents, and administrators in organizing travel behavior change (Buliung et al., 2011).

Along with readiness, geographical spread and school size were also significantly and negatively associated with adoption. Catchment dispersion shows that schools having families from a large geographically dispersed area have low carpooling. This is because when households are scattered, the search for a compatible route is harder. This will increase the matching cost. Schools have readiness measures to lower these frictions. This is analogous to the individual-level role of distance that is studied in carpooling and school travel literature (McDonald, 2008a; Neoh et al., 2017). This is helpful for dispersed families to have an active route matching support.

School size was also negatively associated; this means large schools have lower adoption. Although it is against common expectation that families in large schools will have more matches, but this could be due to gate congestion and weak interpersonal trust in large schools. Elite schools also have stronger private car dependence. This negative sign should be read cautiously and as contextual rather than causal.

Distance to school was positively associated with adoption. This is in line with the school travel literature where distance is the single strongest determinant of mode. Longer trips make sharing more beneficial. Household income was negatively associated. This showed that affluent families are more inclined towards private single-household transport. Rafiq and Mitra (2020) found that distance is an important determinant of school carpooling. Longer school commutes increase time and cost burden, making shared travel more attractive. Also consistent with evidence in the literature that higher income and car ownership reduce shared or active school travel (McDonald, 2008b; McMillan, 2007). Parent education was positively associated with adoption, consistent with greater awareness of and openness to organized and environmentally favorable options. Dias et al. (2017) also found shared mobility users to be better educated. Older children carpooled more than primary-age children. This creates evidence that younger children are escorted more closely by parents, while older children require travel independence (McDonald et al., 2011). Parents appear more willing to place older children in shared rides with other families, whereas primary-age children are more often escorted personally. Having more of one's own children at the same school was also positively associated (OR = 1.31), plausibly because shared arrangements become more convenient and valuable for larger sibling groups.

Several expected factors were not statistically significant. School-provided transport (van/bus) showed no association (OR = 1.14, $p = .665$). The anticipated substitution of formal transport for carpooling was not supported. The reason could be that few schools operate their own service or because the two coexist for different families. Location (Lahore vs Faisalabad) was positive but only borderline ($p = .074$) once readiness and the other covariates were controlled. This suggests that institutional readiness and the structural school factors drive the observed differences instead of city factors. Number of cars, alternative escort availability and parent employment were also non-significant. This is in contrast to workplace studies where car ownership and schedule flexibility feature prominently (McMillan, 2007; Neoh et al., 2017), most likely because this affluent, car-owning private-school sample compresses variation in these controls.

Based on our study, institutional readiness is not only the strongest correlate but also fully accounts for between-school differences. Therefore, schools can be a practical unit of intervention. Schools that establish group matching support, a parent communication channel, for example, a WhatsApp group, and a clear carpool policy and awareness programs can increase adoption more efficiently than individual-level appeals. This is exactly what Vanoutrive et al. (2012) found for employer-based mobility management. The same was found in community initiatives for school travel (Kelly & Fu, 2014). This represents a low-cost, scalable response to rising car dependence and school gate congestion in Pakistani cities.

6. Conclusion and Policy Recommendations

This study asked whether what schools do to enable carpooling is associated with whether parents adopt it. Using primary two-level data from 937 parents in 52 elite and semi-elite private schools in Lahore and Faisalabad, a random-intercept logistic model showed that a one-standard-deviation increase in a school's Carpool Readiness Index corresponds to 91% higher odds of parental adoption. This study also predicted adoption rises from 3% at the lowest observed readiness to 27% at the highest. Enabling factors for carpool adoption at parent level are distance, sibling groups, parent education, and older children whereas income stands out as barrier. The measured school variables account for the detectable between-school variance. This makes the schools and not the individual household as the efficient unit of intervention.

Some policy recommendations drawn from the study here are that regulators implementing Punjab's shared school transport agenda should focus on low-cost readiness components measured in this analysis. They should prioritize route-matching assistance, a dedicated parent

communication channel, a written carpool policy, child-handover and safety protocols, supervised pickup–drop-off, and coordinated dismissal. Schools can easily meet these steps within one term at negligible capital cost, in contrast to bus fleets. District Education Authorities and school regulators can adopt the Carpool Readiness Index itself as a monitoring and accreditation instrument, scoring schools 0–6 annually and publishing results, which converts a vague mandate into an auditable standard. Because catchment dispersion lowers adoption therefore matching support should be route-based rather than class-based. Some safety protocols like formal handover procedures, verified driver lists, and gender-sensitive arrangements needed to be adopted as these address the trust and security concerns that distinguish child escort sharing from adult commuting.

Data are collected at a single point in time, so the study establishes associations, not causal effects. A longitudinal or quasi-experimental design would be needed to establish direction. Schools that agreed to participate and parents who responded may differ systematically from those who did not, which can bias estimates. Our sample was restricted to elite and high-fee private schools in selected cities of urban Punjab. Findings may not transfer to government schools, rural schools, or lower-income households. With a relatively small number of schools, statistical power to track school-level effects and cross-level interaction is limited. Because carpool adoption is a relatively rare outcome, the number of carpooling cases per estimated parameter is low, which can reduce the stability and precision of coefficient estimates, especially for the school level block. The carpool readiness index is a formative composite summarizing the presence of support measures but not their intensity, quality, or actual use. Parent level variables rely on self-report and may be subject to recall or reporting error. So, future research could use a longitudinal design and sample a wide range of school types.

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