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Original Article

Assessment of Immunization Coverage Among Different Age Groups of Students in Peri-Urban Setting in Lahore

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ABSTRACT

Background: Immunization is one of the most effective public health interventions for reducing morbidity and mortality from vaccine-preventable diseases, yet disparities in vaccine uptake persist in peri-urban and underserved populations. Objective: To assess complete Expanded Programme on Immunization coverage among students aged 5-23 years in a peri-urban area of Lahore and to examine its association with age group, gender, parental education, sibling number, and distance from the nearest vaccination center. Methods: This analytical cross-sectional study was conducted from February to July 2025 in Mustafa Abad, Lahore, among 350 students enrolled in government educational institutions. Data were collected using a semi-structured questionnaire, vaccination cards where available, and caregiver verification when needed. Immunization status was classified as complete or incomplete age-appropriate EPI history. Data were analyzed in SPSS version 25 using descriptive statistics and Pearson's chi-square test. Results: Overall, 327 of 350 students were completely immunized, giving a coverage of 93.43%. The highest coverage was observed among students aged 5-10 years (96.72%), followed by those aged 16-18 years (93.18%), 11-15 years (93.02%), and 19-23 years (91.67%). Gender, parental education, and sibling number showed descriptive variation but no statistically significant association with immunization status. Distance from the nearest vaccination center was significantly associated with complete immunization ($\chi^2 = 22.24$, $p < 0.001$), with coverage declining to 76.74% among students living more than 10 km away. Conclusion: Immunization coverage in this peri-urban student population was high overall, but physical access to vaccination services remained a key determinant of complete vaccine uptake. Keywords: Immunization, vaccination, Expanded Programme on Immunization, peri-urban population, vaccine coverage, Pakistan

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INTRODUCTION

Immunization remains one of the most effective and economically efficient public health interventions for reducing childhood morbidity and mortality from vaccine-preventable diseases. By preventing infections such as tuberculosis, poliomyelitis, diphtheria, pertussis, tetanus, measles, and hepatitis B, vaccination programs have substantially improved child survival and reduced the long-term burden on health systems worldwide (1-3). Since the launch of the Expanded Programme on Immunization by the World Health Organization in 1974, routine childhood vaccination has become a central strategy for the control of infectious diseases, particularly in low- and middle-income countries where vaccine-preventable illnesses continue to contribute considerably to under-five mortality (4-6). Over time, immunization programs have expanded both in scope and public health importance, and their effectiveness is now commonly evaluated through coverage indicators, equity of access, and timeliness of vaccine uptake (7).

In Pakistan, the Expanded Programme on Immunization was initiated in 1978 and has progressively broadened its schedule to protect children against multiple vaccine-preventable diseases through routine service delivery and outreach activities (8,9). The national program remains one of the most important pillars of child health protection, particularly in settings where infectious diseases still contribute to

avoidable morbidity and mortality. Despite sustained policy attention, Pakistan continues to face challenges in achieving uniformly high immunization coverage across all communities. Geographic disparities, parental education, household socioeconomic conditions, accessibility of vaccination facilities, and variability in community-level awareness all influence vaccine uptake and completion of recommended schedules (10,11). More recent evidence from Pakistan and comparable low- and middle-income settings has shown that incomplete immunization is often concentrated in underserved populations and is strongly associated with structural barriers such as distance to health facilities, limited service access, and social disadvantage (12-14).

Although the majority of immunization research in Pakistan has focused on children aged 12-23 months, relatively little attention has been given to older children, adolescents, and young adults whose vaccination histories reflect the long-term performance of routine immunization systems. Evaluating immunization status across broader student age groups can provide useful insight into sustained vaccine coverage, missed childhood vaccination opportunities, and inequities that may persist over time. This is particularly important in peri-urban communities, where populations often experience an overlap of urban access advantages and rural service limitations. Such settings may show patterns of vaccine uptake that differ from both densely urban and remote rural populations, yet they remain underrepresented in the local literature. In addition, school- and college-enrolled populations offer an accessible framework for examining age-related gradients in immunization completion and the influence of household and access-related determinants on coverage (15-17).

Previous studies have shown that parental education is positively associated with complete childhood immunization, while larger family size, low maternal awareness, and limited proximity to vaccination services may reduce the likelihood of full coverage (13,14,18). Evidence from Pakistan further suggests that routine immunization performance can improve substantially when community-based vaccinators, female health workers, and geographically accessible vaccination services are available (11,19). However, there remains limited local evidence describing whether vaccination coverage differs meaningfully across successive educational age bands in peri-urban populations and whether factors such as parental education, sibling number, gender, and distance from vaccination centers continue to shape coverage in these groups. Addressing this gap is important for identifying population segments that may benefit from targeted catch-up strategies, school-linked immunization initiatives, or community-based awareness interventions.

The present study was therefore conducted to assess immunization coverage among students aged 5-23 years enrolled in government educational institutions in a peri-urban area of Lahore and to examine its association with selected socio-demographic and access-related factors. The study specifically aimed to compare the proportion of students with complete age-appropriate Expanded Programme on Immunization history across four age groups and to evaluate whether gender, parental education, sibling number, and distance from the nearest vaccination center were associated with immunization status.

MATERIALS AND METHODS

This analytical cross-sectional study was conducted between February and July 2025 in Mustafa Abad, a peri-urban locality situated approximately 48 km from Lahore, Punjab, Pakistan. The study population comprised students aged 5-23 years who were enrolled in government educational institutions within the study area. For analytical purposes, participants were stratified into four age categories corresponding to educational stage: 5-10 years, 11-15 years, 16-18 years, and 19-23 years. The study was designed to evaluate the proportion of students with complete age-appropriate immunization history under the Expanded Programme on Immunization and to examine its association with selected socio-demographic and healthcare access variables relevant to vaccine uptake in peri-urban populations (8,10,11).

Students were eligible for inclusion if they were currently enrolled in formal education in the selected institutions, fell within the predefined age range, and were available at the time of data collection. Students whose vaccination history could not be ascertained through any acceptable verification source, including vaccination card, parental or guardian confirmation, or visible Bacillus Calmette-Guérin scar where relevant, were not included in the final analysis. The study focused on immunization history rather than real-time routine infant program monitoring; therefore, the principal outcome variable was defined as complete age-appropriate EPI immunization status based on the participant's documented or reliably verified history of having received all routine vaccines recommended in Pakistan for the relevant age period. Participants were classified as immunized when the available record or verified history supported completion of the routine schedule and as non-immunized when this could not be confirmed.

A sample size of 350 participants was calculated using a 95% confidence level, 5% margin of error, and an anticipated vaccination coverage proportion of 50%, which was selected to yield the maximum sample size in the absence of precise local estimates for this specific student population (9). A non-probability purposive sampling approach was used to recruit participants from government primary schools, secondary schools, colleges, and universities located in the study area. This approach was selected to ensure representation from all planned educational age bands and to enable direct comparison across the study strata. Although this sampling strategy does not allow full population-level inference, it was suitable for the exploratory analytic objective of comparing coverage patterns across enrolled student groups in a defined peri-urban setting.

Data were collected using a semi-structured questionnaire developed for the study after review of the relevant literature on immunization coverage determinants in Pakistan and other comparable settings (10-14). The instrument was used to obtain information on participant age, gender, educational level, parental education, number of siblings, distance of household from the nearest vaccination center, and immunization history. Data collection was carried out in educational institutions by the research team using face-to-face administration of the questionnaire. For younger participants, information regarding immunization history and household characteristics was obtained with assistance from parents or guardians where needed. Whenever available, vaccination cards were reviewed to verify reported vaccine uptake. In the absence of documentary proof, information was cross-checked through parental or guardian recall, and visible BCG scar status was additionally considered as supportive evidence for prior vaccination where applicable. To improve data consistency, all data collectors were oriented regarding questionnaire administration, variable coding, and verification procedures before field implementation.

The primary outcome variable was immunization status, categorized dichotomously as complete or incomplete age-appropriate EPI history. Independent variables included age group, gender, maternal education, paternal education, number of siblings, and distance from the nearest vaccination center. Maternal and paternal education were recorded in ordered categories reflecting the highest completed level of formal education. Distance to vaccination center was categorized as within 5 km, 5-10 km, and more than 10 km, based on participant or guardian report. These variables were selected because prior literature has consistently identified household education, service accessibility, and family structure as important determinants of immunization uptake and completion (12-16).

Several steps were taken to reduce information bias and enhance data quality. Immunization information was preferentially verified using vaccination cards whenever available, rather than relying solely on recall. Semi-structured questionnaires were checked on the day of collection for completeness and internal consistency. A subset of completed forms was reviewed and cross-checked against entered data to reduce transcription errors. Coding categories were standardized before data entry, and data cleaning was performed prior to analysis to identify duplicate entries, inconsistencies, and missing responses. Records with unresolved discrepancies in core outcome variables were excluded from inferential analysis. The analytical framework also minimized confounding at the descriptive level by examining

immunization status in relation to each prespecified exposure variable and comparing distributions across age-group strata.

All data were entered and analyzed using SPSS version 25. Descriptive statistics were used to summarize participant characteristics and immunization coverage. Categorical variables were presented as frequencies and percentages, while continuous variables, where applicable, were summarized as mean ± standard deviation. Pearson's chi-square test was used to assess associations between immunization status and categorical explanatory variables, including age group, gender, parental education, sibling number, and distance to the nearest vaccination center. Crude proportions were compared across groups, and p-values less than 0.05 were considered statistically significant. Where cell distribution allowed meaningful interpretation, strength and direction of group differences were considered in relation to observed percentage gradients. Data analysis was performed using complete available records for each variable after consistency checking.

The study protocol was reviewed and approved by the Institutional Review Board under ethical clearance certificate number IRB/2025/12. Written informed consent was obtained from adult participants, while assent was obtained from minors alongside written consent from their parents or guardians. Participation was voluntary, and respondents were informed of their right to decline or withdraw at any stage without consequence. All collected information was kept confidential, anonymized during analysis, and used solely for research purposes. Study procedures were conducted in accordance with accepted ethical principles for human participant research, with specific attention to participant privacy, data protection, and responsible reporting of findings.

RESULTS

A total of 350 students aged 5-23 years were included in the analysis. Of these, 327 students were classified as completely immunized, giving an overall complete EPI coverage of 93.43%. Coverage remained high across all age groups, ranging from 91.67% in students aged 19-23 years to 96.72% in those aged 5-10 years. Although younger children showed the highest proportion of complete immunization, the association between age group and immunization status was not statistically significant ($\chi^2 = 6.97$, $p = 0.079$), indicating that complete immunization remained broadly similar across the four educational age bands.

Gender-wise, complete immunization was observed in 238 of 258 males (92.25%) and 89 of 92 females (96.74%). The absolute difference favored females by 4.49 percentage points, but this association did not reach statistical significance ($\chi^2 = 3.11$, $p = 0.079$). With respect to parental education, coverage tended to be higher among students whose mothers and fathers had formal schooling, with complete immunization reaching 100.0% in the small subgroups where mothers had secondary or FA-level education and where fathers had BA-level education. However, the overall associations of maternal education ($\chi^2 = 7.12$, $p = 0.715$) and paternal education ($\chi^2 = 11.87$, $p = 0.294$) with immunization status were not statistically significant in this sample. Similarly, students from households with 4-6 siblings showed the highest complete immunization proportion (93.58%), but the sibling-count association was also not significant ($\chi^2 = 3.11$, $p = 0.079$).

In contrast, distance from the nearest vaccination center showed a strong and statistically significant association with immunization status ($\chi^2 = 22.24$, $p < 0.001$). Complete immunization was documented in 222 of 232 students (95.69%) living within 5 km of a vaccination center, 72 of 75 (96.00%) among those living 5-10 km away, and only 33 of 43 (76.74%) among those living more than 10 km away. Compared with students residing more than 10 km from a vaccination center, the odds of complete immunization were markedly higher among those living within 5 km (OR 6.73; 95% CI 2.60-17.39) and 5-10 km away (OR 7.27; 95% CI 1.88-28.18). These findings indicate that physical accessibility to vaccination services was the most clearly demonstrated determinant of immunization coverage in the present study.

Table 1. Association of age group and selected socio-demographic characteristics with complete immunization status among students (n = 350)

Variable	Category	Immunized n/N	Coverage %	Pearson χ^2	p-value
Age group (years)	5-10	59/61	96.72	6.97	0.079
	11-15	120/129	93.02		
	16-18	82/88	93.18		
	19-23	66/72	91.67		
Gender	Male	238/258	92.25	3.11	0.079
	Female	89/92	96.74		
Mother's education	Uneducated	176/193	91.19	7.12	0.715
	Primary	27/28	96.43		
	Secondary	25/25	100.00		
	Matric	54/58	93.10		
	FA	22/22	100.00		
	BA	23/24	95.83		
Father's education	Uneducated	119/129	92.25	11.87	0.294
	Primary	37/39	94.87		
	Secondary	42/46	91.30		
	Matric	85/91	93.41		
	FA	18/19	94.74		
	BA	26/26	100.00		
Number of siblings	1-3	25/27	92.59	3.11	0.079
	4-6	175/187	93.58		
	7-8	127/136	93.38		

Table 2. Association between distance from nearest vaccination center and complete immunization status (n = 350)

Distance from vaccination center	Immunized n/N	Coverage %	Odds Ratio*	95% CI	Pearson χ^2	p-value
Within 5 km	222/232	95.69	6.73	2.60-17.39	22.24	<0.001
5-10 km	72/75	96.00	7.27	1.88-28.18		
>10 km	33/43	76.74	1.00	Reference		

*Odds ratios are shown relative to the >10 km category.

Table 3. Distribution of immunization status by distance from nearest vaccination center (n = 350)

Distance from vaccination center	Immunized n (%)	Not immunized n (%)	Total n (%)
Within 5 km	222 (67.89)	10 (43.48)	232 (66.29)
5-10 km	72 (22.02)	3 (13.04)	75 (21.43)
>10 km	33 (10.09)	10 (43.48)	43 (12.29)
Total	327 (93.43)	23 (6.57)	350 (100.00)

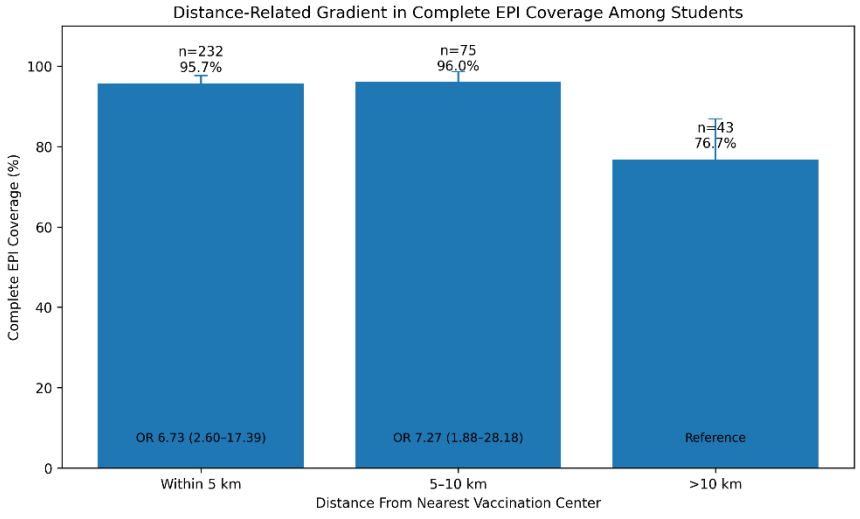

Figure 1 Distance-related gradient in complete EPI coverage among students

Complete immunization showed a clear access-related gradient. Coverage remained very high among students residing within 5 km (95.7%, 222/232) and 5-10 km (96.0%, 72/75) of a vaccination center, but dropped sharply to 76.7% (33/43) among those living more than 10 km away. Relative to the >10 km

group, the odds of complete immunization were approximately 6.7 times higher for households within 5 km and 7.3 times higher for those 5-10 km away, with confidence intervals remaining well above unity. This pattern indicates that geographic accessibility was the most influential observable determinant in the dataset, and that the principal coverage gap was concentrated among households located at greater distance from service points.

DISCUSSION

The present study found a high overall prevalence of complete EPI immunization history among students aged 5-23 years in this peri-urban community, with 327 of 350 participants (93.43%) classified as completely immunized. Although complete immunization was observed across all age groups, coverage was highest among children aged 5-10 years (96.72%) and lowest among participants aged 19-23 years (91.67%), indicating a modest declining gradient with increasing age. However, this age-group difference did not reach statistical significance ($p = 0.079$), suggesting that immunization completion remained broadly stable across the educational strata included in the study. This pattern may reflect improved routine immunization implementation over recent years, with younger cohorts benefiting from stronger outreach, improved community awareness, and better service availability than earlier birth cohorts. The high coverage observed in the youngest students is consistent with broader public health efforts to improve childhood vaccine uptake through routine immunization strengthening and enhanced service delivery in Pakistan and comparable settings (11,18).

The gender distribution in complete immunization also showed only a small difference, with females demonstrating slightly higher coverage (96.74%) than males (92.25%), although this association was not statistically significant. This finding suggests that gender-based inequity in vaccine uptake may not be a major determinant in this particular peri-urban educational population, at least within the age range studied. Previous literature from South Asia and sub-Saharan Africa has shown that gender gaps in immunization may vary by setting and are often shaped more strongly by access barriers, parental perceptions, and household decision-making than by sex alone (13,15,16). In the current sample, the relatively narrow male-female difference may indicate that once children are connected to educational systems and nearby preventive services, sex-related disparity becomes less pronounced than structural determinants such as household education and service accessibility.

Parental education demonstrated a positive descriptive relationship with vaccine completion, even though the overall associations were not statistically significant. Students whose mothers had secondary or FA-level education and those whose fathers had BA-level education showed complete immunization rates of 100.0% in their respective subgroups, while coverage was lower among children of uneducated mothers (91.19%) and uneducated fathers (92.25%). Although these differences must be interpreted cautiously because some educational strata had small sample sizes, the directional trend is epidemiologically plausible and consistent with previous research showing that educated parents are more likely to understand vaccination schedules, utilize preventive services, and respond appropriately to public health messaging (13,16,17). Maternal education, in particular, has repeatedly been associated with improved child health-seeking behavior, greater completion of immunization schedules, and better continuity of care. The present findings therefore support the view that parental literacy and health awareness remain important enabling factors for sustained vaccine uptake, even where service availability is relatively favorable.

The association between sibling number and immunization status was also limited in statistical strength, although students from households with 4-6 siblings had the highest coverage (93.58%). The absence of a strong negative relationship between higher sibling count and immunization completion in this study differs somewhat from multicountry evidence suggesting that increasing family size may reduce the likelihood of full immunization because of competing economic and caregiving demands (14). One explanation may be that this study sampled school- and college-going students in a peri-urban

community where routine health contact and social awareness may already be relatively stronger than in more deprived or highly dispersed populations. Another possibility is that sibling number in this dataset may be acting as a weak proxy for family structure rather than a direct measure of deprivation. The observed percentages therefore suggest that sibling burden alone may not explain under-immunization in this setting unless it is considered together with parental education, household resources, and access constraints.

The most important and statistically robust finding of the study was the strong association between immunization coverage and distance from the nearest vaccination center. Students living within 5 km and 5-10 km of a vaccination facility showed very high complete immunization rates (95.69% and 96.00%, respectively), whereas those living more than 10 km away had substantially lower coverage (76.74%). This association was highly significant ($\chi^2 = 22.24$, $p < 0.001$), and the odds of complete immunization were more than sixfold higher among households located closer to vaccination services than among those residing at greater distance. This finding strongly supports the interpretation that physical accessibility remains a central determinant of vaccine uptake, even in communities where general coverage is otherwise high. The result is concordant with studies from Pakistan and other low- and middle-income countries showing that distance to health facilities, travel burden, and the absence of conveniently available vaccinators reduce the likelihood of timely and complete immunization (17,20,21). It also aligns with evidence that outreach systems, female vaccinators, and community-linked service delivery mechanisms play an important role in bridging last-mile access gaps in underserved areas (22,23).

Taken together, these findings suggest that the immunization system in the studied peri-urban setting is performing relatively well in terms of overall coverage, but not uniformly so across all access conditions. The data indicate that the principal coverage gap is concentrated among students from households located farther from vaccination centers rather than among specific age, sex, or family-size categories. This has practical implications for local public health planning. In such peri-urban communities, improvements in immunization indicators may depend less on universal messaging alone and more on geographically targeted service delivery, including mobile vaccination teams, outreach sessions, school-linked follow-up mechanisms, and community-based awareness efforts directed toward households with lower educational attainment and poorer physical access. Because the present study was conducted in one peri-urban locality using purposive sampling, the findings should not be generalized to all student populations in Lahore or Pakistan. Nevertheless, the study provides useful local evidence that can guide context-specific immunization strengthening strategies and highlights the importance of access-sensitive planning in routine vaccination programs.

CONCLUSION

This study found a high overall prevalence of complete EPI immunization history among students aged 5-23 years in a peri-urban community of Lahore, with the highest coverage observed in the 5-10-year age group. Although age, gender, parental education, and sibling number showed descriptive variation in vaccine completion, the most important determinant identified was distance from the nearest vaccination center, with markedly lower coverage among students living more than 10 km away. These findings suggest that while routine immunization performance in the study area is encouraging, further gains are likely to depend on improving physical access to vaccination services and strengthening targeted awareness strategies for households that remain underserved.

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