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Predictors of Immunization Status Among Children Aged 12-59 Months in Rural and Urban Communities of Sokoto State, Nigeria

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ABSTRACT

Background: Immunization remains a key part of child health in Nigeria, but coverage gaps persist in the Northern regions, leading to outbreaks of vaccine-preventable diseases such as measles, meningitis, and diphtheria. **Aim:** This study aims to identify and compare predictors of immunization status among children under five in rural and urban communities of Sokoto State, Nigeria. **Materials and Methods:** A comparative cross-sectional study was conducted in Sokoto State, Nigeria, among 260 mother-child pairs (130 in urban and 130 in rural areas). The participants were selected by a multi-stage sampling technique. Data were collected using an interviewer-administered questionnaire and a checklist. Data were processed using IBM® SPSS version 25 and analysed using descriptive and inferential statistics. **Results:** Only 31.5% and 20.0% of the children in urban and rural areas, respectively, were fully immunized (p=0.001). Formal education of the mothers (aOR= 3.54; 95%CI= 1.01– 10.25), social class (aOR= 3.98; 95%CI= 0.11 – 0.59), maternal TT vaccination (aOR= 0.099; 95%CI= 0.04 – 0.24), and postnatal care (aOR= 3.66; 95%CI= 1.25 – 10.67) predicted immunization status in the urban group. In the rural group, formal education of the mothers (aOR= 8.62; 95% CI= 1.76 – 16.31) and occupation of the father (aOR= 0.15; 95%CI= 0.33 – 0.66) were the predictors of the immunization status of the children. **Conclusion:** Full immunization coverage was suboptimal in both rural and urban communities, though higher in urban areas. Maternal education and immunization card retention were consistent predictors, while socioeconomic status and maternal health service utilization were particularly influential in urban settings. Strengthening female education, maternal health service engagement, record retention, and targeted rural strategies is essential to improve coverage and reduce disparities.

Keywords: Childhood Immunization, Immunization status, under-five children. Predictors, Northern Nigeria

INTRODUCTION

Despite substantial global progress in routine immunization, vaccine-preventable diseases remain a major contributor to under-five morbidity and mortality in low- and middle-income countries. In Nigeria, vaccine-preventable deaths account for a considerable proportion of under-five mortality,[1] reflecting persistent gaps in routine immunization performance. Immunization remains one of the most cost-effective public health interventions for preventing life-threatening infectious diseases and reducing childhood mortality.[2–4] However, Nigeria continues to bear a high burden of incompletely vaccinated children in sub-Saharan Africa.[5]

National data indicate persistently low and inequitable immunization coverage. According to the Multiple Indicator Cluster Survey/National Immunization Coverage Survey (MICS/NICS) 2021, only 35.6% of children received all three doses of the pentavalent vaccine, with marked regional disparities.[6] Coverage is consistently lower in the northern geopolitical zones, particularly the North-West, compared to southern regions.[6] Sokoto State has recorded some of the lowest immunization indicators nationally, with only 2.2% of children aged 12–23 months reported to be fully vaccinated in previous surveys.[6]

The Nigeria Demographic and Health Survey (NDHS) 2024 further highlights disparities by place of residence, showing that 47.7% of children aged 12–23 months were fully vaccinated in urban areas compared to 33.8% in rural areas.[7] These patterns mirror broader inequities in child survival, with higher under-five mortality rates reported in northern Nigeria.[6]

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Evidence from Nigeria and other sub-Saharan African countries demonstrates that immunization uptake is shaped by a complex interplay of socio-demographic, economic, and health system factors. Maternal education, household wealth, religion, geographic location, and health service access have consistently been associated with full immunization status. [8–10] Children residing in urban areas generally exhibit higher immunization coverage than their rural counterparts, reflecting differences in service availability, caregiver awareness, and socioeconomic conditions.[9,10] While several studies have examined determinants of immunization in Nigeria, limited research has simultaneously compared predictors across rural and urban communities within the same Northern Nigerian setting.

Understanding whether predictors operate similarly or differently across residence contexts is critical for designing context-sensitive interventions to reduce inequities and improve overall coverage.[11] Given the persistently low immunization coverage in Sokoto State and the documented rural–urban disparities in northern Nigeria, there is a need for context-specific evidence to inform targeted public health strategies. This study aims to identify and compare predictors of immunization status among children under five in rural and urban communities of Sokoto State, Nigeria.

MATERIALS AND METHODS

Study Design, Population, and Area

This study employed a comparative cross-sectional design. The study population comprised mothers or caregivers with children aged 12 to 59 months in urban and rural communities of Sokoto State. All those who gave consent to participate in the study were considered eligible and enrolled.

Sample Size Estimation and Sampling Technique

The sample size was estimated at 130 mother-child pairs per group using the formula for comparing proportions in two independent samples[12], based on the 26% and 44% basic vaccination coverage in rural and urban areas, respectively, obtained in the Nigerian Demographic and Health Survey 2018[7], and an anticipated 90% response rate.[19] A multistage sampling technique was used to select respondents for the study. In stage 1, Sokoto North LGA (urban) and Wurno LGA (rural) were selected among the urban and rural LGAs in Sokoto State using a simple random sampling technique by balloting. In stage 2, two wards were selected from each of the selected LGAs by a simple random sampling technique (balloting). In stage 3, one settlement was chosen from each of the four wards by a simple random sampling technique (balloting). Proportionate allocation (PA) of respondents to be enrolled in each settlement within each group (urban and rural) was done based on the calculated sample size per group, which was 130 per group. In stage 4, a sampling frame was obtained from the Sokoto State World Health Organization office, and systematic random sampling was used to select households for the study. In a selected household with more than one eligible mother-child pair, one of them is selected by simple random sampling using the balloting option. If the occupants of a selected household are absent, the next household is selected.

Data Collection

The socio-demographic data and other information were collected from the mothers/caregivers of all the children enrolled in the study by interview method (using an interviewer-administered questionnaire) and recorded on a structured questionnaire. The questionnaire was reviewed by senior researchers in the Department of Community Medicine at Usmanu Danfodiyo University Teaching Hospital, Sokoto, Nigeria, to assess content validity. The information included the child's biodata, antenatal care, postnatal care, and delivery history, immunization history, nutritional history, and family and social history. Each child was assigned to a socioeconomic class using Oyedeji's method, based on parents' occupations and levels of education.[13]

Information about child immunizations was collected from immunization cards and the mother's verbal report, with the verification of the presence of a BCG scar. Mothers or caregivers were asked to show the children's health record cards, which contained individual immunization data. Where the card was available, the interviewer extracted immunization information and entered it into the checklist appropriately. Where there was no specific information on the card, the mother or caregiver was then asked to confirm or otherwise whether the child had received other vaccinations that were not recorded on the card. If there was no immunization card

or the mother or caregiver was unable to present it, the child's immunization information was based on the child's recall. In case of immunization failure, they were asked to give reasons for the failure.

Data Analysis

Data were analyzed using IBM SPSS version 25. Quantitative variable (Age) was summarized using the mean and standard deviation, and categorical variables (sociodemographic and immunization status) were summarized using frequencies and percentages. The results were presented in tables and charts. Where the assumptions for Pearson's Chi-square test were violated, Fisher's Exact Test ($r \times c$ extension) was used to assess associations between categorical variables. Factors found to be statistically significant in the bivariate analysis were included in a binary logistic regression model to identify predictors of immunization status. The regression analyses were presented in tables with adjusted Odds Ratios (aORs), confidence intervals (CIs), and their p-values. All levels of significance (α) were set at $p < 0.05$.

Ethical Consideration

Institutional ethical approval for the study was obtained from the Research and Ethics Committee of the Ministry of Health, Sokoto, Nigeria. Permission for community entry was also obtained from the State Ministry of Local Government Affairs, the LGA chairmen, and the district heads of the communities before proceeding with the study. The purpose of the study was explained to the participants, and they were assured that their information would be kept confidential. A consent form was given to the literate respondents to read and sign, and was read out in the native Hausa language to the respondents with no formal education to thumbprint.

RESULTS

Sociodemographic characteristics of respondents

About one third of mothers in the urban group 45 (34.6%), compared to 3 (2.3%) in the rural group, had completed their secondary education, while 109 (83.8%) had only Quranic education in the rural group, compared to 58 (44.6%) in the urban group. The rural group had a higher proportion of unemployed mothers, 80 (61.5%), compared to the urban group, 48 (36.9%). There was a statistically significant difference in the educational attainment and occupation of the mothers of the children in both groups ($p< 0.001$). There was a statistically significant difference ($p<0.001$) in the distribution of respondents by social class, with the majority in social classes IV and V in the urban (48.5%) and rural (49.2%) groups, respectively [Table 1].

Demographic characteristics of children, place of delivery, and birth order

The highest proportion of children in both the urban 38 (29.2%) and rural 42 (32.3%) groups was in the age group 48-59months. There was no statistically significant difference in age ($\chi^2 = 0.927$, $p = 0.467$). The mean ages in the urban and rural areas were 34.70 ± 14.4 and 35.12 ± 14.8 months, respectively ($t=0.233$, $p=0.816$). There was no statistically significant difference in the gender distribution in the groups ($\chi^2 = 0.988$ p, $p = 0.384$ A higher proportion of children in the rural group 106 (81.5%) were delivered at home compared to 69 (53.1%) in the urban group; and this was statistically significant (Fisher's exact, $p<0.001$) [Table 2].

Maternal health care utilization by the mothers

The majority of the mothers in the two groups (urban: 91.5%; rural: 91.5%) attended antenatal care ($p= 1.000$). Similarly, almost half of the mothers in both groups (urban: 49.2%; rural: 48.5%) attended postnatal care ($p= 1.000$). In urban areas, 97 (74.6%) received TT immunization, compared with 105 (80.8%) in rural areas ($\chi^2 = 1.420$, $p = 0.297$) [Table 3].

Immunization status of the children by cards and mothers' recall

The immunization coverage by card and mother recall. About a third 41 (31.5%)) of the children in the urban group and 26 (20.0%) of the children in the rural group were fully immunized. Similarly, 48 (37.0%) of the children in the urban group, compared with 65 (50.0%) from the rural group, were partially immunized. About a third of the children in both groups were unimmunized: 41 (31.5%) in the urban group and 39 (30.0%) in the rural group. There was a statistically significant difference in the immunization status between the 2 groups. ($\chi^2 = 5.966$, $p = 0.047$) [Table 4].

Presentation of the child's immunization card by mothers

A higher proportion of children in urban areas (57, 76.0%) than in rural areas (50, 68.5%) have their immunization cards, but this difference was not statistically significant (p= 0.360) [Figure 1].

Availability of health facilities and provision of immunization services

A higher proportion of respondents in urban areas (99.2%) than in rural areas (82.8%) reported that immunization services were provided at a convenient place, and this difference was statistically significant (p<0.001) [Table 5].

Predictors of children's immunization status

In urban communities, children whose mothers had formal education were about 3.5 times more likely than those whose mothers had informal education to be fully immunized (aOR = 3.54; 95% CI = 1.01–10.25, p = 0.047). Children who were in the middle social class were about 6.0 times less likely than those in the upper social class to have complete immunization (aOR= 5.92; 95% CI= 0.05 – 0.54; p= 0.003). Those in the lower social class were about 4.0 times less likely to be fully immunized (aOR = 3.98; 95% CI = 0.11–0.59; p = 0.002). Children whose mothers received three or more doses of the TT vaccine were about 90.1% (10.1 times) less likely than those who received two doses or less to have incomplete immunization (aOR= 0.099; 95% CI= 0.04 – 0.24; p< 0.001). Children whose mothers attended postnatal care were 3.7 times more likely to be fully immunized (aOR= 3.66; 95% CI= 1.25 – 10.67; p= 0.017) as compared to those children whose mothers had not attended postnatal care. Children with immunization cards were about 5.2 times more likely to be fully immunized (aOR= 5.51; 95% CI= 1.87 – 14.59; p= 0.002) than those without immunization cards. In rural communities, children of mothers with formal education were about 8.6 times (aOR= 8.62; 95% CI= 1.76 – 16.31; p= 0.001) more likely to be fully immunized than those of mothers with informal education. Children of civil servants were about 7.7 times more likely to be fully immunized than children of farmers (aOR= 7.71; 95% CI= 1.32 – 45.00; p= 0.023). Those with the presence of an immunization card were 9.5 times more likely to be fully immunized (aOR= 9.53; 95% CI= 3.29 – 27.96; p= 0.001) than those without an immunization card [Table 6].

Table 1: Sociodemographic characteristics of the respondents

Variables	Urban (n=130) n (%)	Rural (n=130) n (%)	Test-statistic p-value
Age group of mothers (years)			
15-19	2 (1.5)	10 (7.7)	χ^2= 11.059
20 – 24	13 (10.0)	22 (16.9)	p=0.025*
25 – 29	63 (48.5)	44 (33.8)	
30 – 34	27 (20.8)	28 (21.6)	
≥35	25 (19.2)	26 (20.0)	
Mean ± SD (years)	32.99 ± 7.598	30.11 ± 8.348	t=2.914 p=0.004*
Religion			
Islam	125 (96.2)	130 (100)	Fischer's exact
Christianity	5 (3.8)	0	p=0.029*
Tribe			
Hausa	113 (86.9)	108 (83.1)	
Fulani	9 (6.9)	7 (5.4)	
Yoruba	5 (3.8)	1 (0.8)	Fischer's exact
Igbo	3 (2.3)	0	p<0.001*
Zabarmawa	0	14 (10.8)	
Number of children			
1 – 4	65 (50.0)	79 (60.8)	χ^2= 3.051
≥ 5	65 (50.0)	51 (39.2)	p= 0.105
Mothers' education level			
None	2 (1.5)	3 (2.3)	
Quranic only	58 (44.6)	109 (83.8)	
Primary	9 (6.9)	14 (10.8)	Fischer's exact
Secondary	45 (34.6)	3 (2.3)	p<0.001*
Tertiary	16 (12.3)	1 (0.8)	
Fathers' education level			
None	0 (0.0)	0	
Quranic only	16 (12.3)	60 (46.1)	
Primary	2 (1.5)	7 (5.4)	Fischer's exact
Secondary	56 (43.1)	46 (35.4)	p<0.001*
Tertiary	56 (43.1)	17 (13.1)	
Occupation of the mother			
Unemployed	48 (36.9)	80 (61.5)	
Farming	0 (00.0)	0 (0.0)	Fischer's exact
Trade/business	77 (59.2)	48 (36.9)	p<0.001*
Civil servant	5 (3.9)	2 (1.5)	
Occupation of father			
Unemployed	0 (0.0)	0	
Farming	6 (4.6)	39 (30.0)	χ^2 =47.070
Trade/business	66 (50.8)	74 (56.9)	p< 0.001*
Civil servant	58 (44.6)	17 (13.1)	
Social class of the parent			
SC I	2 (1.5)	0	
SC II	14 (10.8)	1 (0.8)	
SC III	41 (31.5)	7 (5.4)	Fischer's exact
SC IV	63 (48.5)	58 (44.6)	p<0.001*
SC V	10 (7.7)	64 (49.2)	

χ^2-Pearson's Chi-square test; *t*- Independent *t*-test; *Statistically significant p < 0.05

Table 2: Demographic characteristics of children, place of delivery, and birth order

Variables	Urban (n=130) n (%)	Rural (n=130) n (%)	Test-statistic p-value
Child's age group (months)			
12-23	32 (24.6)	28 (21.5)	χ^2= 0.927
24-35	30 (23.1)	30 (23.1)	p=0.467
36-47	30 (23.1)	30 (23.1)	
48-59	38 (29.2)	42 (32.3)	
Mean ± SD (months)	34.70 ± 14.4	35.12 ± 14.8	t= 0.233, p=0.816
Sex			
Male	57 (43.8)	65 (50.0)	χ^2= 0.988
Female	73 (56.2)	65 (50.0)	p=0.384
Place of delivery			
Home	69 (53.1)	106 (81.5)	
Hospital	56 (43.1)	24 (18.5)	Fischer's exact
Clinic/dispensary	4 (3.1)	0 (0.0)	p<0.001*
TBAs house	1 (0.8)	0 (0.0)	
Birth order			
1- 2	30 (23.0)	50 (38.5)	χ^2= 8.388
3 – 4	37 (28.5)	36 (27.7)	p=0.016*
≥5	63 (48.5)	44 (33.8)	

χ^2-Pearson's Chi-square test; *t*- Independent *t*-test; *Statistically significant, p < 0.05

Table 3: Antenatal and postnatal care utilization by the mothers

Variables	Urban (n=130) n (%)	Rural (n=130) n (%)	Test-statistic p-value
Attended ANC			
Yes	119 (91.5)	119 (91.5)	χ^2= 0.000
No	11 (8.5)	11 (8.5)	P= 1.000
Attended PNC			
Yes	64 (49.2)	63 (48.5)	χ^2= 0.015
No	66 (50.8)	67 (51.5)	p=1.000
Received TT immunization			
Yes	97 (74.6)	105 (80.8)	χ^2= 1.420
No	33 (25.4)	25 (19.2)	p= 0.297

χ^2-Pearson's Chi-square test ANC=antenatal care PNC=postnatal care TT=Tetanus Toxoid

Table 4: Immunization status of the children by cards and mothers' recall

Vaccine	Urban (n=130) n (%)	Rural (n=130) n (%)	Test-statistic χ^2	p-value
BCG	66 (51.2)	60 (46.5)	0.558	0.455
HBVo	69 (53.1)	66 (51.2)	0.095	0.804
OPV				
0	78 (60.0)	74 (56.9)	0.253	0.706
1	76 (58.5)	78 (60.0)	0.064	0.900
2	69 (53.1)	72 (55.4)	0.139	0.803
3	61 (46.9)	67 (52.3)	0.758	0.455
Penta				
1	67 (51.5)	57 (44.2)	1.403	0.264
2	58 (44.6)	47 (36.4)	1.798	0.206
3	51 (39.2)	45 (34.9)	0.758	0.455
PCV				
1	65 (50.0)	56 (43.1)	1.403	0.264
2	58 (44.6)	47 (36.2)	1.933	0.164
3	51 (39.2)	44 (34.4)	0.654	0.441
IPV	43 (33.1)	40 (31.0)	0.160	0.790
Measles	54 (41.5)	56 (43.1)	0.63	0.900
Yellow fever	48 (37.2)	48 (36.9)	0.002	1.000
Men A	41 (32.0)	33 (25.8)	1.217	0.335
Immunization status				
Fully immunized	41 (31.5)	26 (20.0)		
Partially immunized	48 (37.0)	65 (50.0)	5.966	0.047*
Un-immunized	41 (31.5)	39 (30.0)		

χ^2-Pearson's Chi-square test; BCG- Bacillus Calmette-Guerin; HBV-hepatitis B vaccine; OPV- oral polio vaccine; PCV- pneumococcal conjugate vaccine; IPV- inactivated polio vaccine; Men A- Meningitis A conjugate vaccine; *Statistically significant, $p < 0.05$

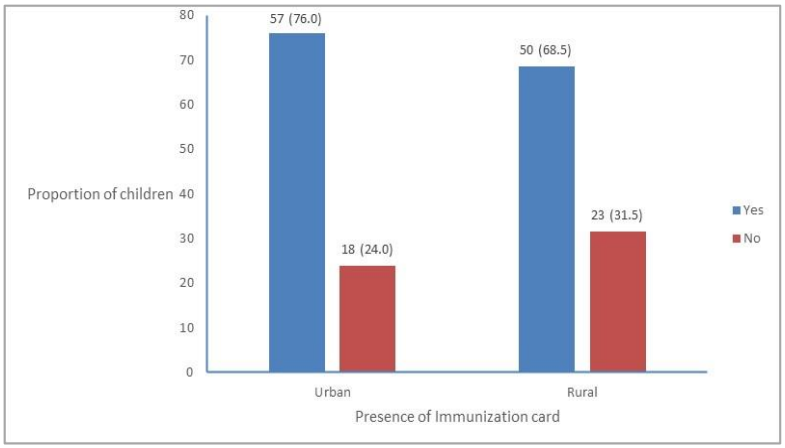

Figure 1: Presentation of the child's immunization card by mothers

Table 5: Availability of health facilities and provision of immunization services

Variables	Urban n (%)	Rural n (%)	Test statistic	p- value
Availability of health facilities in the locality	n= 130	n= 130		
Yes	130 (100)	99 (76.2)	χ^2= 32.072	<0.001*
No	0 (0.0)	31 (23.8)		
Routine immunization service is available in the health facility	n= 130	n= 99		
Yes	130 (100.0)	98 (99.1)	Fisher's exact	0.893
No	0 (0.0)	1 (0.9)		
Routine immunization is provided at a convenient place	n= 130	n= 130		
Yes	128 (99.2)	107 (82.8)	χ^2= 21.067	<0.001*
No	2 (0.8)	23 (17.2)		
Time taken to reach the health facility	n= 127	n= 99		
≤ 30 minutes	124 (97.6)	90 (90.9)		
> 30 minutes	3 (2.4)	9 (9.1)	χ^2= 5.010	0.035*

χ^2- Pearson's Chi-Square test; *Statistically significant, p < 0.05

Table 6: Predictors of children's immunization status

Variables	Urban			Rural		
	aOR	95% CI	p value	aOR	95% CI	p value
		Lower- Upper			Lower - Upper	
Education of Mother (Formal vs Nonformal*)	3.54	1.01 – 10.25	0.047**	8.62	1.76 – 16.31	0.038**
Education of the father (Formal vs Nonformal*)	3.517	0.36 – 34.81	0.282	1.087	0.02-55.273	0.967
Occupation of father (Civil servant vs farmers*)	3.551	1.60 – 7.87	0.002**	7.71	1.32 – 45.00	0.023**
(Businessmen vs Farmers*)	4.355	0.479 – 39.62	0.192	1.21	0.38 – 3.87	0.753
Social class (Middle vs Upper*)	0.169	0.05 – 0.54	0.003**	1.642	0.189-14.234	0.653
(Lower vs upper*)	0.251	0.11 – 0.59	0.002**	10.483	0.136-54.213	0.416
Mother attended ANC (Yes vs no*)	3.47	0.79 – 2.41	0.999	0.913	0.738-21.246	1.00
Mother received TT (≥3doses vs ≤2doses*)		0.04 – 0.24	<0.001**	2.923	0.235-34.169	0.999
Mother attended PNC (Yes vs no*)	3.66	1.25 – 10.67	0.017**	3.453	0.119-100.582	0.471
Place of delivery (Hospital vs home*)	0.75	0.45 – 1.25	0.269	0.332	0.042-2.625	0.296
Presence of an immunization card (Yes vs no*)	5.22	1.87 – 14.59	0.002**	9.53	3.29 – 27.96	0.001**

aOR = Adjusted Odds Ratio; **CI** = Confidence Interval; *** =** Reference group; **Statistically significant, $p < 0.05$

DISCUSSION

This study identified key determinants of immunization status among children aged 12–59 months in rural and urban communities of Sokoto State, Nigeria. By comparing predictors across residence settings, the study provides subnational evidence on both shared and context-specific drivers of immunization uptake in Northwestern Nigeria. Coverage varied across individual antigens in both urban and rural communities. Early vaccines administered at birth or shortly thereafter (BCG, OPV0, HBV0, and Penta1) recorded the highest uptake in both settings. The proximity of these vaccines to the time of delivery likely explains the relatively higher coverage, as many children have contact with health services immediately after birth. Similar patterns were reported in a comparative study conducted in Bayelsa State, Nigeria, where OPV0 and OPV1 had the highest coverage in urban and rural areas, respectively.[14] Additionally, the relatively high OPV coverage may reflect supplemental immunization activities conducted during Immunization Plus Days, which could inflate reported uptake.

In contrast, coverage for measles and yellow fever vaccines, administered in late infancy, was considerably lower. This drop-off suggests attrition along the immunization continuum, likely due to missed follow-up visits, waning caregiver motivation, or structural access barriers. Similar findings have been reported in Oyo, Bayelsa, and India.[14,15,16] However, higher coverage rates have been documented in North Central Nigeria and Imo State,[17,18,] highlighting regional heterogeneity in immunization performance. The lowest coverage was observed in both urban and rural areas for the Men-A conjugate vaccine. This is consistent with the timing of its integration into Nigeria's routine immunization schedule in August 2019,[19] by which time many children in the study cohort had already completed their primary immunization series. Approximately one-third of children in urban areas were fully immunized compared to one-fifth in rural areas. This urban advantage aligns with findings from the 2024 Nigeria Demographic and Health Survey (NDHS), conducted by the National Population Commission, which reported higher vaccination coverage among urban children than among rural counterparts.[20] Similar patterns have been documented in other Nigerian and sub-Saharan African studies.[6,18,21,22]

The disparity may reflect differences in maternal education, health literacy, access to services, and socioeconomic status. Urban mothers were more likely to have completed secondary education and to utilize maternal health services, factors known to enhance health-seeking behavior. However, a contrasting finding from Bayelsa State showed higher full immunization rates in rural areas than urban areas,[14] suggesting that urban advantage is not universal and may depend on contextual factors such as outreach intensity, community engagement, and health system performance. Despite the relative advantage of urban areas, overall coverage in both settings fell below the 80% target set by Nigeria's National Programme on Immunization (NPI). Suboptimal coverage threatens herd immunity and sustains the transmission of vaccine-preventable diseases, thereby perpetuating avoidable childhood morbidity and mortality. Encouragingly, coverage levels observed in this study were higher than those reported in the NDHS 2024 and by Raji et al. (2019) in Sokoto State.[6,20,23] While this may reflect incremental improvements attributable to strengthened routine immunization efforts and partner support, coverage remains insufficient at subnational levels.

A substantial proportion of children in both urban and rural areas had received no immunization. The most frequently cited reasons for non-immunization were spousal opposition, lack of awareness, and religious objections. These findings underscore the influence of gender dynamics and household decision-making structures on child health outcomes. In many households, women are financially dependent on their husbands, and decisions regarding child health are male-dominated. Similar sociocultural barriers have been documented in other studies.[24,25] These findings highlight the need for male-inclusive and community-engaged immunization strategies that address vaccine hesitancy, misinformation, and patriarchal constraints.

In both urban and rural settings, maternal education, paternal occupation, and the presence of an immunization card were independently associated with full immunization status. In urban areas, additional factors, including paternal education, parental social class, antenatal care attendance, place of delivery, postnatal care attendance, and maternal tetanus toxoid vaccination, were also significantly associated. Maternal education emerged as a strong and consistent predictor in both settings. Mothers with formal education were approximately 4 times (urban) and 9 times (rural) more likely to fully immunize their children than mothers with no formal education. This finding aligns with studies from Sokoto, Kaduna, Zimbabwe, and Bangladesh.[26,27,28,29] Although a study in Ghana reported contrasting findings,[35] the broader literature consistently identifies maternal education as a structural determinant of child health. Education likely enhances health literacy, autonomy, confidence in engaging with health services, and receptiveness to vaccination messages.

In the urban group, paternal education and higher social class were positively associated with full immunization. This may reflect the role of household income and decision-making authority in facilitating service utilization. Unlike several previous studies,[27,28,29] paternal education independently predicted immunization status in this urban sample, suggesting that male educational attainment may shape health investment decisions in contexts where men are primary decision-makers. Antenatal care (ANC), facility-based delivery, postnatal care (PNC), and maternal tetanus toxoid vaccination were significantly associated with full immunization in urban areas. These findings are consistent with studies

conducted in Nigeria, Kenya, Zimbabwe, and India.[28,30,31,36] ANC and PNC visits provide opportunities for health education, trust-building, and linkage to immunization services. Mothers who received three or more doses of tetanus toxoid were significantly less likely to have incompletely immunized children, a finding similar to that reported in South East Ethiopia.[33] Repeated health facility contact likely reinforces knowledge, positive attitudes, and adherence to vaccination schedules.

The presence of an immunization card was a strong predictor of full immunization in both settings. Children whose cards were available were five times as likely (urban) and ten times as likely (rural) to be fully immunized. Beyond its role as a documentation tool, card retention may reflect caregiver engagement, continuity of care, and system-level organization. This finding is consistent with studies in Ghana and Kenya.[35, 36] Improving immunization coverage in Sokoto State requires integrated strategies that address educational, sociocultural, and health system barriers. Strengthening women's education and health literacy while actively engaging men through community- and faith-based platforms is essential to reducing spousal opposition and vaccine hesitancy. Maternal health services, particularly antenatal and postnatal care and facility-based delivery, should be leveraged to reinforce immunization counseling and ensure the timely administration of birth dose vaccines. Health system efforts should also promote better retention of home-based immunization records, potentially supported by digital tracking, to minimize missed doses. In addition, targeted rural outreach programs are needed to overcome structural and informational barriers, thereby reducing urban–rural disparities in immunization uptake.

This study contributes to the limited subnational evidence from Northwestern Nigeria by simultaneously examining rural–urban disparities and identifying both shared and setting-specific predictors of immunization uptake. While maternal education and immunization card retention were consistent predictors across settings, health service utilization variables exerted a stronger influence in urban areas. These findings underscore the need for context-sensitive strategies rather than uniform policy prescriptions.

STUDY LIMITATIONS

This study has limitations. Its cross-sectional design precludes causal inference. Immunization status was partly determined by maternal recall, introducing potential recall bias. Card availability may have influenced the classification of immunization status. Additionally, findings may not be generalizable beyond similar sociocultural settings in Northwestern Nigeria.

CONCLUSION

This study reveals suboptimal full immunization coverage among children aged 12–59 months in rural and urban communities of Sokoto State, with higher uptake in urban areas. Maternal education and the presence of an immunization card were consistent predictors in both settings, while socioeconomic status and utilization of maternal health services were particularly influential in urban communities. These findings affirm that socio-demographic factors and contact with health services significantly shape immunization outcomes. Improving coverage will require integrated strategies that strengthen female education and health literacy, promote male involvement, leverage antenatal and postnatal care platforms, enhance immunization record retention, and implement targeted rural outreach interventions to reduce disparities and prevent vaccine-preventable diseases.

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Conflict of interest

None declared.

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