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Routine Childhood Immunization Coverage, Vaccination Dropout, and Predictors of Schedule Completion in Benin City, Nigeria

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ABSTRACT

High initial access to childhood vaccination does not guarantee schedule completion. This study assessed antigen-specific coverage, dropout, and factors associated with completion among children in Benin City, Nigeria. A community-based cross-sectional survey included 620 mother-child pairs selected through two-stage cluster sampling. Vaccination status was determined from records and maternal recall. Coverage and individual-level dropout were estimated, and two forced-entry multivariable logistic regression models examined completion by 12 months and extended-schedule completion by 15 months. Estimates were not adjusted for survey clustering or sampling weights. Coverage was 95.8% (594/620) for bacille Calmette-Guerin and 92.1% (571/620) for pentavalent dose three. Full-schedule coverage by 12 months was 76.8% (476/620). Among 460 children aged 15-23 months, 82.2% (378/460) received measles-containing vaccine dose two and 75.4% (347/460) completed the extended schedule. Dropout was 2.9% (17/587) from pentavalent dose one to dose three and 9.7% (40/414) from measles-containing vaccine dose one to dose two among age-eligible initial-dose recipients. Antenatal-care attendance was associated with higher odds of 12-month completion (adjusted odds ratio [AOR]=4.26, 95% confidence interval [CI] 2.20-8.26) and extended completion (AOR=3.48, 95% CI 1.62-7.49). Income of at least N60,000 was associated with 12-month completion, while Ikpoba-Okha residence was associated with lower extended completion.Completion declined for later doses. The associations support evaluating antenatal counselling, reminder-recall systems, and geographically targeted follow-up in prospective or implementation studies.

KEYWORDS: childhood immunization, vaccination coverage, vaccination dropout, schedule completion, Nigeria

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1. Introduction

Vaccination is one of the most effective public health interventions, but its population benefit depends on both initiation and completion of the recommended schedule. Global coverage of the third dose of diphtheria-tetanus-pertussis-containing vaccine remained about 85% in 2025, while first-dose measles coverage was 84%; these averages conceal substantial within-country gaps (World Health Organization [WHO], 2026). The Immunization Agenda 2030 therefore emphasizes equitable access,

people-centred services, and the use of data for action (WHO, 2020).

Nigeria carries a disproportionate burden of under-immunized and zero-dose children. The 2021 Multiple Indicator Cluster Survey and National Immunization Coverage Survey showed continuing gaps in completion of recommended childhood vaccination (National Bureau of Statistics [NBS] & United Nations Children's Fund [UNICEF], 2022). An analysis of the 2018 Nigeria Demographic and Health Survey estimated basic vaccination coverage at 31% and zero-dose prevalence at 19%, with marked socioeconomic, geographic, maternal, and health-service inequalities (Williams et al., 2024). Recent national and geospatial analyses similarly demonstrate that household vulnerability and national averages can obscure marked regional and local clusters of incomplete vaccination (Ahmed et al., 2024; Baptiste et al., 2024; Kolawole et al., 2023).

Coverage for individual antigens and dropout between sequential doses answer different programme questions. Coverage describes the proportion reached at a particular point in the schedule; dropout describes failure to retain children who have already made contact with vaccination services. Low dropout in an early multidose series may coexist with substantial attrition later in the schedule, especially when caregivers have fewer routine child-health contacts after infancy. The second dose of measles-containing vaccine is particularly vulnerable because it is scheduled later than the traditional infant series and may be mistakenly perceived as optional or forgotten (Masresha et al., 2024; Melis et al., 2024; Adamu et al., 2024).

Evidence from a single urban setting that examines the entire routine schedule can reveal where retention begins to weaken and which population groups require additional support. This study therefore assessed antigen-specific vaccination coverage, full-schedule completion at 12 and 15 months, dropout across selected vaccine sequences, and predictors of schedule completion among children aged 12-23 months in Benin City, Nigeria.

2. Methodology

Study design and setting

This community-based cross-sectional study was conducted in Benin City, Edo State, in southern Nigeria, during 2023-2024. Benin City comprises Oredo, Egor, and Ikpoba-Okha Local Government Areas and includes public and private facilities that provide routine childhood immunization. The study formed the household-survey component of a broader mixed-methods assessment of factors influencing immunization coverage.

Study population and sampling

The study population comprised mothers and their resident children aged 12-23 months. Eligible mothers had lived in the study area for at least six months and provided informed consent. The minimum sample size was calculated using Cochran's formula for a single proportion and increased by 10% for potential non-response, yielding 620 mother-child pairs.

A modified two-stage cluster sampling technique adapted from the World Health Organization vaccination coverage survey approach was used (WHO, 2018). All 32 wards in the three Local Government Areas were included in the sampling frame. Settlements served as clusters and were selected with probability proportional to the routine-immunization target population. Sixty-two clusters were selected, with 10 mother-child pairs recruited per cluster. Within each selected cluster, the starting direction was chosen randomly; houses and eligible households were then sampled sequentially. One eligible mother and one eligible child were selected by simple random sampling when multiple candidates were present.

Data collection and outcome definitions

Trained research assistants administered a structured questionnaire using Open Data Kit. The authors developed the study-specific questionnaire by adapting relevant items from the publicly available World Health Organization vaccination coverage cluster survey form (WHO, 2018) and

tailoring them to the Nigerian routine-immunization schedule and study objectives. The adapted questionnaire underwent face and content validation, was pretested among 62 mother-child pairs outside the selected study clusters, and was revised before fieldwork. The complete questionnaire is supplied as Supplementary Material 1.

Antigen-specific coverage was the proportion of eligible children who had received each vaccine dose. All 620 children were eligible for vaccines scheduled within the first year. Full vaccination by 12 months required recorded or recalled receipt of BCG; birth doses of oral polio and hepatitis B vaccines; three doses each of oral polio, pentavalent, and pneumococcal conjugate vaccines; two doses of inactivated polio vaccine; and one dose each of measles-containing, yellow fever, and meningococcal A vaccines. Analyses of measles-containing vaccine dose two and extended-schedule completion were restricted to the 460 children aged 15-23 months and therefore old enough to receive the 15-month dose. Extended-schedule completion required all vaccines in the 12-month definition plus measles-containing vaccine dose two. Individual-level dropout was the proportion of recipients of the initial antigen who did not receive the specified later antigen. The prespecified sequences were BCG to measles-containing vaccine dose one, pentavalent dose one to dose three, pentavalent dose one to measles-containing vaccine dose one, and measles-containing vaccine dose one to dose two. The last sequence was restricted to children aged 15-23 months and used recipients of dose one as its denominator.

Data analysis

Data were analyzed using IBM SPSS Statistics for Windows, version 25. Frequencies and percentages summarized participant characteristics and vaccination outcomes. Wilson 95% confidence intervals were calculated for coverage proportions. Bivariate associations were assessed using Pearson's chi-square test or Fisher's exact test when expected counts were small. Two multivariable binary logistic regression models were specified: full vaccination by 12 months among all 620 children and extended-schedule completion among the 460 children aged 15-23 months. The same eight prespecified covariates - Local Government Area, maternal age, education, monthly income, health insurance, child sex, facility delivery, and antenatal-care attendance - were entered simultaneously into both models using the forced-entry method. No automated forward, backward, or stepwise selection was used. Candidate covariates reflected established public health relevance and variables considered in the bivariate analysis; the $p<0.20$ screening threshold informed consideration but did not alone determine retention. Adjusted odds ratios, 95% confidence intervals, and two-sided p-values were reported. Huber-White heteroskedasticity-consistent (HC0) standard errors were used to reduce sensitivity to model-based heteroskedasticity; they did not account for intracluster correlation. Settlement-cluster identifiers were not retained in the analytic dataset, so cluster-robust variance estimation and a design-based sensitivity analysis could not be performed. Sampling weights were also unavailable. Although 10 participants were sampled per probability-proportional-to-size cluster, the within-cluster sequential household procedure did not provide complete individual selection probabilities; weights could not be reconstructed reliably. Consequently, coverage intervals and regression inferences are non-design-adjusted, may be too precise if responses were positively correlated within clusters, and should be interpreted as sample estimates and model-based associations rather than design-weighted population parameters. Model calibration was assessed with the Hosmer-Lemeshow test and discrimination with the area under the receiver operating characteristic curve. Confidence intervals and p-values for the area under the curve were calculated using the Hanley-McNeil large-sample method. Statistical significance was set at $p<0.05$.

Ethical considerations

Ethical approval was obtained from the University of Benin Teaching Hospital Health Research Ethics Committee (protocol number ADM/E 22/A/VOL.VII/14831706). Permission was obtained from the Edo State Primary Health Care Development Agency. All participants provided informed consent and

were assured of confidentiality, voluntary participation, and the right to withdraw.

3. Results

Participant characteristics

All 620 enrolled mother-child pairs were included. Most mothers were aged 25-34 years, had secondary or tertiary education, were employed, and had attended antenatal care for the index pregnancy. Of the children, 460 (74.2%) were aged 15-23 months and 333 (53.7%) were male. Table 1 summarizes selected participant characteristics; additional variables were collected but are not presented in this descriptive table. Facility delivery denotes childbirth in a recognized public or private health facility.

Characteristic	Frequency	Percent
Maternal age 25-34 years	418	67.4
Secondary or tertiary education	545	87.9
Employed	526	84.8
Attended antenatal care	568	91.6
Child age 15-23 months	460	74.2
Male child	333	53.7
Facility delivery	584	94.2

Table 1: Selected characteristics of mothers and children (n=620). Notes: Only selected characteristics are presented. Facility delivery means childbirth in a recognized public or private health facility.

Antigen-specific and full-schedule coverage

Coverage was highest for vaccines administered at birth and during the early infant series and declined for vaccines scheduled later. More than nine in 10 children received BCG and each dose of the pentavalent series. Full vaccination by 12 months was achieved by 476 of 620 children (76.8%). Among the 460 children aged 15-23 months, 378 (82.2%) had received measles-containing vaccine dose two and 347 (75.4%) had completed the extended schedule. Table 2 presents antigen-specific coverage and both completion indicators. The denominator is 620 for vaccines due within the first year and 460 for the two 15-month indicators because only children aged 15-23 months were age-eligible.

Vaccine or completion indicator	Vaccinated, n	Coverage, %	95% CI
Bacille Calmette-Guérin	594	95.8	93.9-97.1
Oral polio vaccine, birth dose	590	95.2	93.2-96.6
Hepatitis B, birth dose	588	94.8	92.8-96.3
Pentavalent dose one	587	94.7	92.6-96.2
Pneumococcal conjugate vaccine dose one	583	94.0	91.9-95.6
Oral polio vaccine dose one	590	95.2	93.2-96.6
Pentavalent dose two	585	94.4	92.3-95.9
Pneumococcal conjugate vaccine dose two	577	93.1	90.8-94.8
Oral polio vaccine dose two	582	93.9	91.7-95.5
Pentavalent dose three	571	92.1	89.7-94.0
Pneumococcal conjugate vaccine dose three	566	91.3	88.8-93.3
Oral polio vaccine dose three	575	92.7	90.4-94.5
Inactivated polio vaccine dose one	571	92.1	89.7-94.0
Inactivated polio vaccine dose two	579	93.4	91.2-95.1
Measles-containing vaccine dose one	549	88.5	85.8-90.8
Yellow fever vaccine	532	85.8	82.8-88.3
Meningococcal A vaccine	546	88.1	85.3-90.4
Measles-containing vaccine dose two	378	82.2	78.4-85.4
Fully vaccinated by 12 months	476	76.8	73.3-79.9
Extended schedule completed by 15 months	347	75.4	71.3-79.1

Table 2: Antigen-specific and full-schedule vaccination coverage. Notes: The denominator was 620 for vaccines scheduled within the first year. The denominator was 460 for measles-containing vaccine dose two and extended-schedule completion because these analyses were restricted to children aged 15-23 months. Full vaccination by 12 months required BCG; birth doses of oral polio and hepatitis B vaccines; three doses each of oral polio, pentavalent, and pneumococcal conjugate vaccines; two doses of inactivated polio vaccine; and one dose each of measles-containing, yellow fever, and meningococcal A vaccines. Extended completion additionally required measles-containing vaccine dose two. CI, confidence interval.

Vaccination dropout

Retention through the three-dose pentavalent series was high. Among the 460 children aged 15-23 months, 414 had received measles-containing vaccine dose one; 374 of these children also had a recorded dose two, giving an individual-level dropout of 9.7% (40/414). Table 2 counts all 378 age-eligible dose-two recipients; four had no recorded dose one and were therefore excluded from the dose-one-to-dose-two dropout sequence. Table 3 presents individual-level dropout across the four prespecified sequences.

Vaccine sequence	Initial dose, n	Later dose, n	Children dropping out, n	Dropout, %
Bacille Calmette-Guérin to measles dose one	594	549	45	7.6
Pentavalent dose one to dose three	587	571	17	2.9
Pentavalent dose one to measles dose one	587	549	42	7.2
Measles dose one to dose two, age 15-23 months	414	374	40	9.7

Table 3: Individual-level vaccination dropout across selected routine-immunization sequences. Notes: For each sequence, dropout was calculated among recipients of the initial dose, so the denominator differs from the full sample. The measles dose one-to-two sequence was further restricted to the 460 children aged 15-23 months; 414 had received dose one and formed the dropout denominator. Of all 460 age-eligible children, 378 received dose two, but four had no recorded dose one and were excluded from the individual sequence, leaving 374 later-dose recipients in this table.

Bivariate analysis of schedule completion

In bivariate analysis, completion by 12 months was associated with maternal education, household income, health-insurance coverage, facility delivery, and antenatal-care attendance. Among children aged 15-23 months, extended-schedule completion was associated with Local Government Area, maternal education, facility delivery, and antenatal-care attendance. Table 4 presents the chi-square statistics and corresponding p-values for both outcomes.

Characteristic	Category	Completed by 12 months, n/N (%)	χ^2	p-value	Completed by 15 months, n/N (%)	χ^2	p-value
Local Government Area	Oredo	237/300 (79.0)	3.097	0.213	178/225 (79.1)	6.499	0.039
	Ikpoba-Okha	100/140 (71.4)			66/100 (66.0)		
	Egor	139/180 (77.2)			103/135 (76.3)		
Maternal age	<25 years	46/66 (69.7)	2.433	0.296	28/44 (63.6)	3.722	0.156
	25-34 years	327/418 (78.2)			241/313 (77.0)		
	≥35 years	103/136 (75.7)			78/103 (75.7)		
Maternal education	None/primary	48/75 (64.0)	11.325	0.003	29/48 (60.4)	9.372	0.009
	Secondary	266/350 (76.0)			192/258 (74.4)		
	Tertiary	162/195 (83.1)			126/154 (81.8)		

Monthly income	<₦60,000	316/440 (71.8)	20.876	<0.001	233/316 (73.7)	1.575	0.209
	≥₦60,000	160/180 (88.9)			114/144 (79.2)		
Health insurance	No	418/553 (75.6)	4.040	0.044	306/405 (75.6)	0.027	0.870
	Yes	58/67 (86.6)			41/55 (74.5)		
Child sex	Male	255/333 (76.6)	0.016	0.900	181/241 (75.1)	0.030	0.863
	Female	221/287 (77.0)			166/219 (75.8)		
Facility delivery	No	20/36 (55.6)	9.650	0.002	16/27 (59.3)	4.050	0.044
	Yes	456/584 (78.1)			331/433 (76.4)		
Antenatal care	No	23/52 (44.2)	33.712	<0.001	18/37 (48.6)	15.579	<0.001
	Yes	453/568 (79.8)			329/423 (77.8)		

Table 4: *Bivariate associations with full-schedule completion. Notes: Denominators differ between the outcomes because the 12-month analysis included all 620 children, whereas the 15-month analysis included only the 460 children aged 15-23 months. Within an outcome, denominators also vary by category because they reflect the number of participants in that category. χ^2, Pearson chi-square statistic.*

Multivariable predictors of schedule completion

With all eight prespecified covariates entered simultaneously, monthly income of at least N60,000 and antenatal-care attendance were associated with higher adjusted odds of completion by 12 months. For extended-schedule completion, antenatal-care attendance was associated with higher adjusted odds, whereas residence in Ikpoba-Okha was associated with lower adjusted odds than residence in Oredo. Table 5 presents the complete non-design-adjusted estimates for both models. The 12-month model showed acceptable calibration (Hosmer-Lemeshow p=0.370) and modest discrimination (AUC=0.698, 95% CI 0.653-0.742; p<0.001); Figure 1 shows its receiver operating characteristic curve. The 15-month model also showed acceptable calibration (Hosmer-Lemeshow p=0.768) and modest discrimination (AUC=0.658, 95% CI 0.604-0.713; p<0.001); Figure 2 shows its curve.

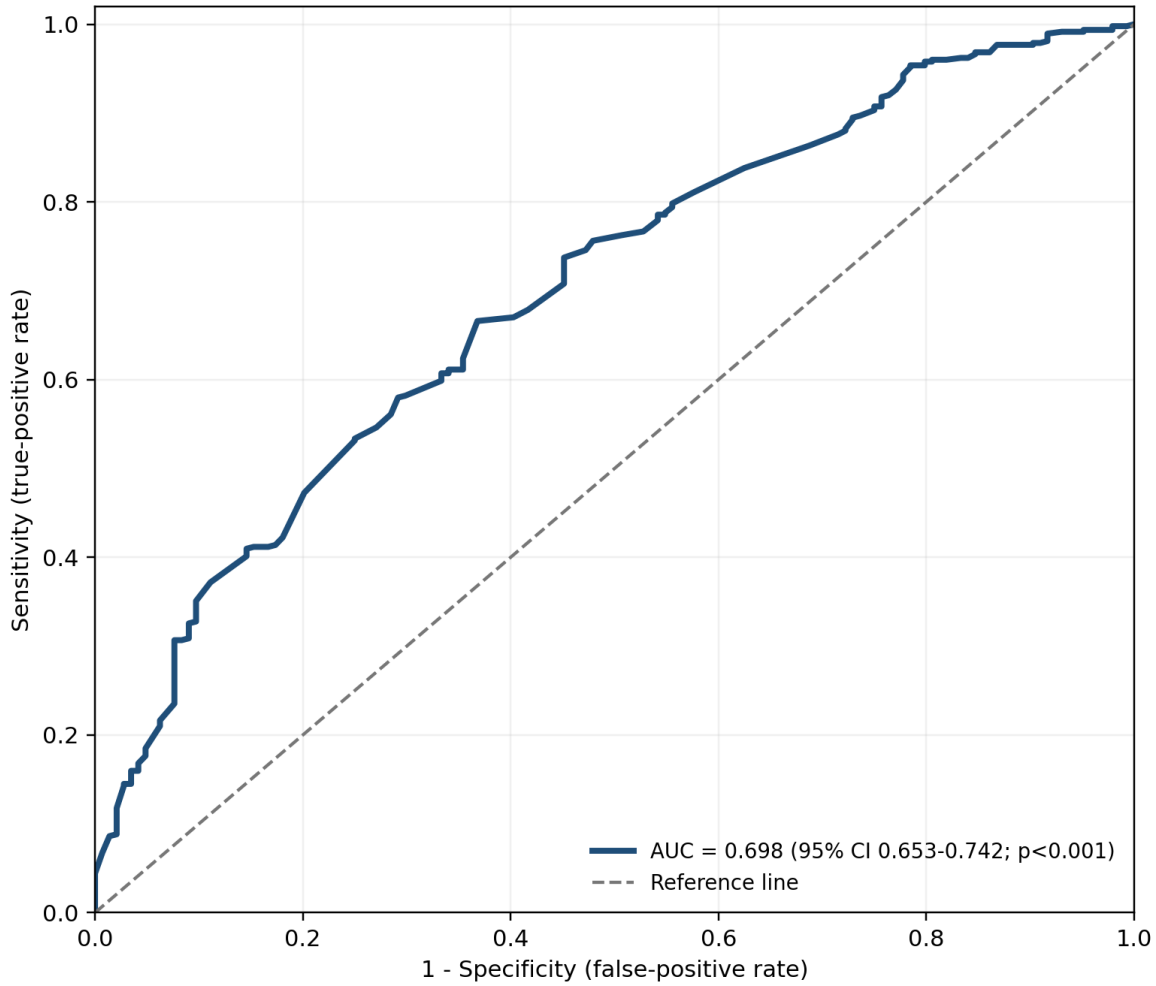


Figure 1: *Receiver operating characteristic curve for the multivariable model predicting full vaccination by 12 months. AUC=0.698 (95% CI 0.653-0.742; p<0.001). The p-value tests the null hypothesis that AUC=0.50. AUC, area under the curve; CI, confidence interval.*

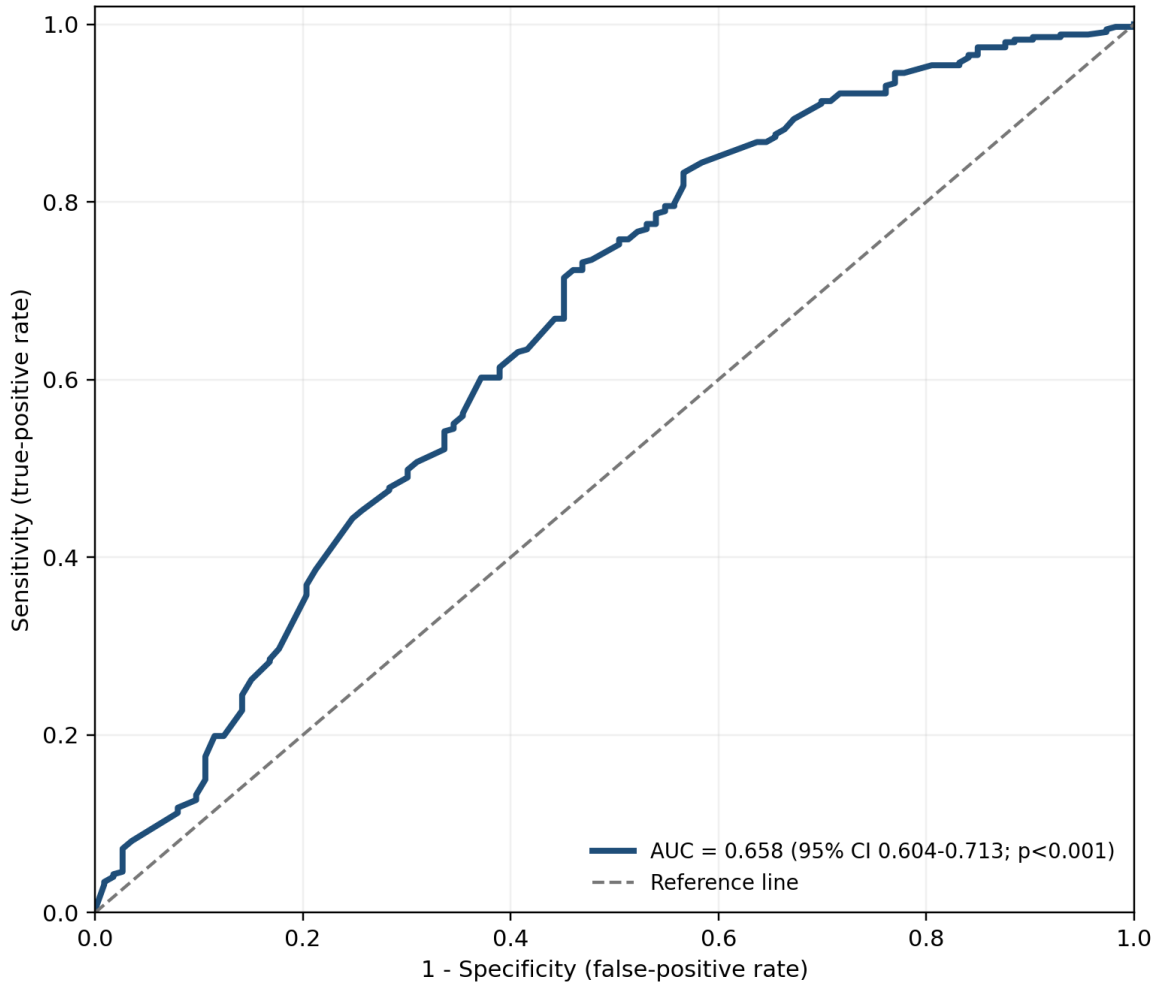


Figure 2: Receiver operating characteristic curve for the multivariable model predicting extended-schedule completion by 15 months among age-eligible children. AUC=0.658 (95% CI 0.604-0.713; p<0.001). The p-value tests the null hypothesis that AUC=0.50. AUC, area under the curve; CI, confidence interval.

Predictor	**Comparison**	**12-month AOR (95% CI)**	**p-value**	**15-month AOR (95% CI)**	**p-value**
Local Government Area	Ikpoba-Okha vs Oredo (reference)	0.63 (0.38-1.02)	0.061	0.45 (0.26-0.78)	0.004
	Egor vs Oredo (reference)	0.75 (0.46-1.23)	0.258	0.72 (0.41-1.25)	0.246
Maternal age	<25 vs 25-34 years (reference)	0.75 (0.41-1.36)	0.341	0.58 (0.30-1.13)	0.108
	≥35 vs 25-34 years (reference)	0.92 (0.57-1.49)	0.726	1.00 (0.58-1.75)	0.987
Education	None/primary vs secondary (reference)	0.70 (0.38-1.30)	0.259	0.64 (0.31-1.29)	0.211
	Tertiary vs secondary (reference)	1.19 (0.74-1.90)	0.471	1.55 (0.90-2.67)	0.112
Monthly income	≥₦60,000 vs <₦60,000 (reference)	2.83 (1.69-4.73)	<0.001	1.22 (0.73-2.03)	0.445
Health insurance	Yes vs no (reference)	1.27 (0.58-2.77)	0.548	0.59 (0.29-1.22)	0.154
Child sex	Female vs male (reference)	1.02 (0.69-1.51)	0.916	1.10 (0.71-1.71)	0.681
Facility delivery	Yes vs no (reference)	1.39 (0.65-2.96)	0.391	1.20 (0.51-2.82)	0.677
Antenatal care	Yes vs no (reference)	4.26 (2.20-8.26)	<0.001	3.48 (1.62-7.49)	0.001

Table 5: Multivariable logistic regression of full-schedule completion. Notes: All eight listed covariates

were entered simultaneously into both models using forced entry; no stepwise selection was used. Reference categories are stated in the comparison column. The 12-month model included 620 children and the 15-month model included 460 age-eligible children. Estimates are non-design-adjusted. Huber-White HC0 standard errors were used, but these were not cluster-robust because settlement-cluster identifiers were unavailable. AOR, adjusted odds ratio; CI, confidence interval.

4. Discussion

The study found high initiation of routine vaccination and strong retention through the primary infant series. This pattern may reflect the concentration of early vaccines around delivery, postnatal care, and the repeated six-, 10-, and 14-week contacts, which provide caregivers with several opportunities to enter and remain in the programme. High early-series coverage is important because it indicates that most children are reachable by routine services and that the central programme challenge is not solely first contact. The observed coverage was substantially higher than national estimates from the 2018 Nigeria Demographic and Health Survey and the 2021 Multiple Indicator Cluster Survey/National Immunization Coverage Survey (NBS & UNICEF, 2022; Williams et al., 2024; Ahmed et al., 2024), although it is comparable to the high full-immunization coverage reported in an Enugu State study (Eze et al., 2021). Benin City's urban setting, relatively high maternal education, high antenatal-care attendance, and predominance of facility delivery may partly explain this advantage. Programme managers should preserve these early contacts while using each visit to communicate the complete schedule, confirm subsequent appointments, and identify children already late for a dose.

Coverage for the extended schedule remained below the level required for optimal population protection, even after restricting the analysis to children old enough to have received the 15-month vaccines. Reduced child-health contact after infancy, competing caregiver responsibilities, and incomplete understanding that the schedule continues beyond the first year may explain the remaining gap. The public health implication is that apparently strong infant-series performance can coexist with avoidable immunity gaps in the second year of life. Similar challenges have been described across sub-Saharan Africa, where later-dose completion has lagged behind vaccine initiation (Masresha et al., 2024; Gebeyehu et al., 2022; Bobo et al., 2022). Health workers should state the 15-month return date verbally and in writing and should check vaccination status during every subsequent child-health contact.

Dropout was lowest within the closely spaced pentavalent series and higher across the longer interval between the two measles-containing vaccine doses. The increasing interval between appointments, fewer routine clinic contacts, and absence of active reminders are plausible explanations. This distinction is important because strong completion of the infant series demonstrates that families can be retained, while later dropout identifies a specific continuity-of-care weakness. The age-eligible MCV1-MCV2 dropout in this study was lower than pooled dropout estimates reported across sub-Saharan Africa (Gebeyehu et al., 2022), but two-dose measles coverage still remained below the 95% level required to interrupt sustained transmission (Masresha et al., 2024; Adamu et al., 2024). Nigerian studies have shown that SMS and telephone reminders are feasible and can improve vaccination timing and completion (Obi-Jeff et al., 2022; Ibraheem et al., 2021). Facilities should generate dose-specific defaulter lists, send reminder-recall messages, and provide catch-up vaccination through outpatient, growth-monitoring, and community outreach contacts.

Antenatal-care attendance was associated with higher adjusted odds of completing both the first-year and extended schedules. Antenatal care provides repeated opportunities for health education, birth planning, promotion of facility delivery, and early linkage to preventive child-health services, which may partly explain the association. National, Nigerian, and wider sub-Saharan African analyses similarly identify antenatal-care use as an important correlate of childhood vaccination (Williams et al., 2024; Ahmed et al., 2024; Kolawole et al., 2023; Eze et al., 2021; Adesina et al., 2023; Alabi et al., 2024; Fenta et al., 2021; Sani et al., 2025). Immunization counselling during antenatal care could include the entire childhood schedule, not only birth doses, and its effect on later completion should

be evaluated prospectively.

Higher monthly income was associated with greater adjusted odds of first-year completion but not extended-schedule completion. Household resources may reduce indirect costs of transport, time away from work, and repeated clinic attendance during infancy, although the cross-sectional data cannot establish this mechanism. Nigerian studies report similar socioeconomic gradients in vaccination completion (Williams et al., 2024; Ahmed et al., 2024; Kolawole et al., 2023; Adesina et al., 2023; Sani et al., 2025). Services could minimize waiting time and offer convenient outreach, while prospective studies assess whether these approaches reduce access barriers for lower-income households.

Residence in Ikpoba-Okha was associated with lower adjusted odds of extended-schedule completion than residence in Oredo. Differences in facility distribution, outreach, settlement characteristics, service continuity, or defaulter tracking are possible explanations, but these mechanisms were not measured. The association is programmatically relevant because citywide averages can conceal local gaps. Nigerian analyses have likewise demonstrated subnational heterogeneity in childhood vaccination (Williams et al., 2024; Ahmed et al., 2024; Baptiste et al., 2024; Kolawole et al., 2023). Local Government Area teams could disaggregate completion indicators by ward and evaluate targeted outreach and reminder strategies in low-performing areas.

Taken together, the findings indicate that coverage and dropout may reflect a continuum of programme retention associated with maternal health-service contact, household resources, and local context. Immunization programmes could complement antigen coverage with age-eligible completion, individual-level dropout, and geographically disaggregated follow-up, while implementation studies test whether these approaches improve completion. This interpretation is consistent with Immunization Agenda 2030's emphasis on people-centred, data-informed services (WHO, 2020).

5. Limitations

This study was cross-sectional and cannot establish temporal or causal relationships. Vaccination status relied partly on maternal recall when cards were unavailable or incomplete, which may have introduced recall or social-desirability bias. The analysis assessed receipt rather than timeliness. Settlement-cluster identifiers and sampling weights were unavailable, preventing cluster-robust variance estimation, design weighting, or a design-based sensitivity analysis. HC0 standard errors do not correct intracluster correlation; confidence intervals may therefore be too narrow and p-values too small if outcomes were correlated within clusters. Point estimates and regression results should be interpreted as non-design-adjusted sample estimates and model-based associations. Residual confounding may remain, and the models showed only modest discrimination. Findings from this urban setting may not generalize to rural Edo State or Nigeria. Individual-level dropout identified absence of a later recorded dose among initial-dose recipients but did not determine why the dose was missed.

6. Conclusion

Routine childhood immunization in Benin City showed high initial contact and good retention through the primary infant series, while completion was lower for later doses. Antenatal-care attendance and higher monthly income were associated with first-year completion, and antenatal-care attendance and Local Government Area were associated with extended-schedule completion. These cross-sectional associations should not be interpreted as causal effects.

Routine monitoring could use age-eligible denominators and place greater emphasis on completion beyond infancy. Prospective evaluation of antenatal counselling, geographically targeted outreach, clear appointment communication, reminder-recall systems, register-based defaulter tracking, and vaccination-status checks at child-health contacts would show whether these strategies close remaining immunity gaps.

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