



Original Article

Determinants of incomplete vaccination among children 12-23 months in Nigeria: An analysis of a national sample

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ABSTRACT

Objectives: The study aimed to assess the prevalence and the determinants of incomplete childhood vaccination in Nigeria. **Materials and Methods:** The data for this study was the 2018 Nigeria Demographic and Health Survey. Multivariable multilevel logistic regression analysis techniques using Stata statistical software (version 13) were used in analyzing the data of 5,384 children aged 12–23 months old. **Results:** About 69.6% of the children were incompletely vaccinated. Individual-level factors such as maternal education, household wealth were associated with incomplete vaccination. The odds of incomplete vaccination among children of mothers without education was 68% higher than those with secondary education and above (adjusted odds ratio [AOR]: (AOR = 1.68; 95% confidence intervals [CI]: 1.56–2.56). Equally children from high wealth index have reduced odds of incomplete vaccination compared to those from low wealth index (AOR = 0.58; 95% CI: 0.47–0.71). Community-level factors such as place of residence, difficulty in getting to health facility were equally associated with vaccination status. The likelihood of incomplete vaccination was 26% higher among children whose parents had difficulty reaching the health facility (AOR = 1.26; 95% CI: 1.11–1.50) than those that did not. In addition, the likelihood of been incompletely vaccinated reduced for children whose mothers live in urban areas (AOR = 0.47; 95% CI: 0.40–0.59). **Conclusions:** Incomplete childhood vaccination is prevalent in the country and associated with various individual and community factors. Program and policies aimed at improving childhood vaccination uptake should target the identified factors.

KEYWORDS: *Childhood, Determinants, Nigeria, Prevalence, Vaccination*

INTRODUCTION

Vaccination coverage is still unacceptably low in Nigeria despite the global improvement recorded in recent times. Nigeria accounts for a significant proportion of unvaccinated and incompletely vaccinated children the world over [1]. Of the 22.4 million children worldwide that were unvaccinated before 12 months, 14% are in Nigeria and remained at risk for vaccine-preventable morbidity and mortality [2]. Globally, an estimated 21.8 million eligible children did not receive three doses of the diphtheria-tetanus-pertussis (DTP) vaccine; amongst them, 9.6 million (44%) started but did not complete DTP three-dose [3,4]. Each year, about 2–3 million children's deaths from DTP, and measles are prevented through timely vaccination [5]. Every child, therefore, should benefit from complete vaccination against vaccine-preventable diseases (VPDs). Vaccination against VPDs is one of the most successful public health interventions available [6] that can

contribute extensively to achieving Sustainable Development Goal 3.2, which aims at ending preventable child deaths. The Nigeria Programme on Immunization implements the international recommendations of the World Health Organization (WHO) on childhood immunization, where a child is assumed as adequately vaccinated after receiving BCG vaccination; three doses of pentavalent vaccine and; at least three doses of polio vaccine and one dose of measles vaccine [7].

Despite being a signatory to the Global Vaccine Agenda [8], childhood vaccination uptake and coverage have not improved

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significantly in Nigeria. The Nigeria Demographic Health Survey (NDHS), a national health survey commenced in 2003, is conducted every 5 years and gives an overview of childhood vaccination coverage of the country for the period covered. It's assumed to reflect the performance of the country's immunization programs and strategies during the stated period. The most recent one was conducted in 2018, giving the same overview. Over the years, the proportion of children that completed vaccination has remained low, as reported in the various NDHS with regional variability in the coverage and vaccination rate [9]. Some region of the country appears to have better coverage and completion rate than others, which might be due to socio-demographic variability across the country's six regions. Besides, it has been observed that vaccination uptake and coverage rate are not uniform in the various local communities, with hard-to-reach rural communities reporting poorer coverage and uptake than the less rural ones. Several of these communities differ in their norms, culture, socio-economic and demographic structure. The difficulty of linking communities with health services such as routine immunization is another factor that also influences the effectiveness of vaccination programs vis-à-vis the vaccination uptake and completion. This factor among others earlier stated is contextual and impact vaccination uptake, and coverage across the country and contribute to the poor vaccination completion rate reported in the country. Earlier studies that examined the NDHS or were conducted at a smaller scale have reported maternal age and education, marital status, residence, occupation, household wealth, and place of delivery and access to media as factors contributing to low vaccination coverage [10,11]. Many of these identified factors are individual-level factors with less attention given to contextual factors that may influence vaccination uptake. Although some studies have assessed and documented the contextual factors associated with full childhood immunization [11-13], the contribution of individual and contextual factors on incomplete childhood vaccination among children 12–23 months in Nigeria had received less consideration despite the observed variations across the regions of the country. A previous study that assessed the 2013 NDHS examined individual and contextual factors associated with incomplete childhood vaccination in the country and reported access to health facilities, maternal education level, socio-economic level of community, etc., as factors contributing to incomplete vaccination [14]. We set out to examine the current prevalence of incomplete vaccination and associated factors because the country continues to strengthen its various programs targeted at improving vaccination uptake and completion rate. It is essential to identify the impediments to effective vaccination uptake and completion in the country to re-strategize and implement appropriate programs and solutions. Therefore, we aimed to assess the prevalence and determinants of incomplete childhood vaccination among children 12–23 months in Nigeria.

MATERIALS AND METHODS

Study design

The data employed for the study was the 2018 NDHS which is a population-based cross-sectional survey. The

survey was designed to provide up-to-date estimates of basic demographic and health indicators at the national level, the country's six geographical zones, the 36 states, and Federal Capital Territory (FCT).

Sampling technique

The 2018 NDHS was a two-stage stratified cluster sampling that was based on clusters and households. Stratification was done by separating each of the 36 states and the FCT into urban and rural areas. Before sample selection, all localities were classified separately into urban and rural areas based on predetermined minimum sizes of urban areas (cut-off points) with more than a minimum population size of 20,000 people and the comparative estimation of the socioeconomic status of the communities; consistent with the official definition in 2017 [9]. A total of 74 sampling strata were selected. In the first stage, 1400 enumeration areas (EAs), referred to as clusters for the 2018 NDHS, were selected with probability proportional to EA size. The EA size is the number of households in the EA. Household listing of the selected EAs was done using tablets, with the random selection of households carried out through computer programming. The household lists were used as the sampling frame for the selection of households in the second stage. At the second stage, 30 households were selected in every cluster by systematic sampling. Forty-two thousand households were selected for the survey. The interviews were conducted only in pre-selected households. The inclusion criteria for the study is the household presence of index child 12–23 months a subset of the NDHS child data that included children 0–59 months in the selected household. We excluded children <12 months >24 months. In preventing bias during the NDHS data collection, no changes or replacements of the preselected households were permitted in the implementing stages. Detailed sampling procedure is available in the 2018 NDHS [9].

Data collection

Data were collected through an interviewer-administered questionnaire. Four questionnaires were used in the survey. The model questionnaires were the Demographic and Health Survey (DHS) Program's standard DHS-7 questionnaires, modified according to the country's requirements [9]. Data on childhood vaccination were collected from health cards in which each dose of vaccine received is recorded. If the cards were not available or vaccinations were not recorded on the cards, the mother's recall of vaccination was accepted. Equally, mother's rough estimates of birth size were also accepted as birth weight sizes during the NDHS data collection [9].

Outcome variable

We used the data of children 12–23 months old in the study; this age group was expected to have completed all recommended vaccines for age. According to the National Policy on Immunization in Nigeria and as adopted in the NDHS, a child is completely vaccinated after receiving eight doses of vaccines. A dose of BCG vaccine; 3 doses of DPT-HepB-Hib vaccine; 3 doses of polio vaccine excluding polio given at birth and, one dose of measles vaccine as recommended by the WHO [7]. The definition of vaccination completion or otherwise in this study was based on the

country's national immunization schedule [Table 1]. It was measured by deriving a composite variable comprising the nine doses of the different vaccines the child was expected to have received by 12–23 months. In this study, the outcome variable-incomplete vaccination is when a child received <8 vaccines. Thus a child who received all eight doses of the vaccine was classified as completely vaccinated. A child who received anything <8 doses of the vaccine was classified as incompletely vaccinated.

Independent variable

The independent variables included in this study were grouped into individual-level characteristics: Maternal age, maternal education, marital status, sex of the child wealth index, occupation, antenatal care, place of delivery, birth order, size of child at birth, and exposure to mass media; community-level (demographic) characteristics: The place of residence, getting to health facility and region of the country. The variables were selected based on findings from previous literature for factors affecting vaccination completion [11-14]. The assumption of independence of observation was the basis for determining whether variables should be analyzed at the individual or community level. If the observations are independent at the individual level, such variables were used as individual-level factors. However, if the observations were clustered into other levels, such variables were taken as community-level factors. For example, if several people share the feature (e.g., region of the country and place of residence) that could have the same effect on incomplete vaccination, the variable was analyzed at the community level. Maternal age was regrouped into 15–24, 25–34, and ≥ 35 , maternal education level classified into no education, primary and secondary or higher [11-14]. Marital status was categorized into never married and ever married, and sex of the child as male and female. We re-grouped the wealth index into poor, middle, and high from the initial five categories done in the NDHS using principal component analysis. Occupation was recoded into not working and working; antenatal care was recoded as attended (at least one clinic visit) and never attended. The place of delivery was categorized as home delivery and health facility. Birth order was classified into 1–3, 4–6 and $\geq 7^{\text{th}}$ + order, size

of child at birth was categorized according to the national classification of birth weight of Nigerian children and the NDHS into; large (≥ 3.5 kg), average (2.5–3.4 kg) and small (≤ 2.4 kg) [15]. Exposure to mass media was classified as exposed or not exposed based on the frequency of access to newspapers, radio, and television. Those who had access to any of the three media for any number of times per week were classified as exposed. The community-level factors were the place of residence (socio-economically defined), and retained as originally grouped into urban and rural areas in the NDHS and region of the country grouped according to the country's six geographical zones. Getting to the health facility derived using distance to the health facility, and ease of transportation to the health facility was regrouped into a problem and not a big problem from the initial coding in the survey.

Statistical analysis

Descriptive analysis

Data analysis was conducted using the Stata Statistical Software: Release 13. College Station, TX: StataCorp LP. Coding and recoding of the selected variables from the 2018 NDHS were done. To assess the crude association between the independent variables and incomplete vaccination, bivariate analysis using Pearson's Chi-squared test was done with P value set at $P < 0.05$ and the distributions expressed as frequencies and percentages.

Multivariable multilevel analysis

The study used multilevel analysis techniques to account for the sampling approach and the stratified nature of the data with children nested within households and households nested within clusters (EAs). Due to the sampling approach, children within the same cluster may have more similar experiences and characteristics than the rest of the clusters and regions in the country. To address clustering, a two-stage multivariable multilevel logistic regression was used to estimate the adjusted effects of individual and community-level factors on incomplete vaccination. We constructed four models in the analysis. Model1 was fitted with no explanatory variable to evaluate random variation in the intercept and cluster variation in incomplete vaccination. The second model was fitted to estimate the effects of individual-level factors. The third model was fitted to examine the effects of community-level factors on incomplete childhood vaccination. Lastly, the fourth model provided for the individual-and community-level variables together. Measures of association (fixed effects) of individual and community-level factors and incomplete vaccination were presented as adjusted odds ratio (AOR) with their 95% confidence intervals (CIs) and a P value set at <0.05 taken as statistically significant.

The random effect was assessed using the intraclass coefficient (ICC), variance partition coefficient, and median odds ratio (MOR). ICC was estimated to determine whether the variation in incomplete vaccination is mainly within or between communities [14,16]. Variance inflation factor was used to examine Multicollinearity. In addition, we employed Schwarz's Bayesian information criteria and Akaike's information criterion to estimate the goodness of fit of the model [17].

Table 1: Nigeria routine vaccination schedule (2018) and incomplete vaccination rate for vaccines offered (n=5834)

Nigeria routine vaccination schedule		
Age	Vaccine	Incomplete vaccination for each vaccine offered, n (%)
At birth	BCG	1925 (33.0)
6 week	DPT 1 (DPT-HepB-Hib vaccine) + OPV 1	3483 (59.7)
10 weeks	DPT 2 (DPT-HepB-Hib vaccine) + OPV 2	2188 (37.5)
14 weeks	DPT 3 (DPT-HepB-Hib vaccine) + OPV 3	3004 (51.5)
9 months	Measles	3646 (62.5)

The current DTP vaccine used in the country is a pentavalent vaccine DPT-Hep-HibB (containing diphtheria, tetanus, pertussis, hepatitis B antigens and haemophilus influenzae b). BCG: Bacillus calmette-guerin, OPV: Oral polio vaccine, DPT: Diphtheria-pertussis-tetanus vaccines

Ethical approval

This study was a secondary data analysis with permission to use the 2018 NDHS data for this study sought and obtained from ICF International. The 2018 NDHS survey protocol was reviewed and approved by Nigeria's National Health Research Ethics Committee (NHREC/01/01/2007). ICF Institutional Review Board approves all DHS to ensure they follow the U.S. Department of Health and Human Services' ethical standards and regulations for the respect of human subjects. Detailed information on the ethical processes involved in the DHS program can be accessed via <https://goo.gl/ny8T6X>. Information's that could be used to identify the respondents were already removed by ICF International. No attempt was made to identify any household or individual respondent interviewed in the survey.

RESULTS

Background characteristics and prevalence of incomplete vaccination

A total of 5834 children aged 12–23 months were involved in the study [Table 2]; in all, the prevalence of incomplete childhood vaccination was 69.6%. Majority of the children born to mothers without education 75.4% of poor households 75.1% and born by young mother's 71.6% were incompletely vaccinated. In addition, children born at home (76%) and whose mothers did not receive antenatal care during pregnancy, 91.2%, and reported difficulty getting to the health facility (75.3%) were not fully vaccinated. Similarly, 73.8% of children born to mothers who did not have access to mass media did not receive complete vaccination. Similarly, 67.1% of children born in the Northeast geographic region and 80.9% born in the North West region were incompletely vaccinated. In contrast, about a little above half (57.0%) of those from the southwest region were incompletely vaccinated.

Factors associated with incomplete childhood vaccination

Table 3 expresses the multivariable multilevel logistic regression analysis results after adjusting for individual and community-level factors in the models. The odds of incomplete vaccination were reduced among children of mothers aged 35 and above (AOR = 0.75; 95% CI: 0.63–0.90); children of working mothers (AOR = 0.79; 95% CI: 0.69–0.91), and among children from high wealth index (AOR = 0.58; 95% CI: 0.47–0.71). Similarly, the likelihood of been incompletely vaccinated reduced for children whose mothers attended antenatal clinic (AOR = 0.46; 95% CI: 0.32–0.66), children whose mothers live in urban socioeconomic communities (AOR = 0.47; 95% CI: 0.40–0.59) and for children born in a health facility (AOR = 0.64; 95% CI: 0.56–0.75). However, the likelihood of incomplete vaccination was 26% higher for children whose mothers had a problem getting to health facilities (AOR = 1.26; 95% CI: 1.11–1.50). Furthermore, the odds of incomplete vaccination among children of mothers without education was 68% higher than those with secondary education and above (AOR = 1.68; 95% CI: 1.56–2.56). Equally, compared with children living in the country's Southeast region, there is a sustained higher odds of incomplete vaccination across the other regions of

Table 2: Prevalence and associated background characteristics of incomplete childhood vaccination among children aged 12–23 months in Nigeria, Nigeria demographic and health survey 2018 (n=5834)

Variables	Vaccination status		P
	Completely vaccinated, n (%)	Incompletely vaccinated, n (%)	
All children	1772 (30.4)	4062 (69.6)	
Individual level variable			
Maternal age			
15-24	379 (28.3)	960 (71.6)	0.014
25-34	914 (30.2)	2110 (69.8)	
≥35	479 (32.6)	992 (67.4)	
Marital status			
Never married	111 (32.6)	230 (67.4)	0.340
Ever married	1661 (30.2)	3832 (69.2)	
Maternal education			
No education	617 (24.6)	1893 (75.4)	<0.001
Primary	266 (29.0)	650 (71.0)	
Secondary and tertiary	889 (36.9)	1519 (63.1)	
Maternal occupation			
Not working	453 (24.4)	1406 (75.6)	<0.001
Working	1319 (33.2)	2656 (66.8)	
Wealth index			
Poor	642 (24.9)	1934 (75.1)	<0.001
Middle	355 (28.3)	899 (71.7)	
Rich	775 (38.7)	1229 (61.3)	
Place of delivery			
Home	824 (24.3)	2574 (75.7)	<0.001
Health facility	944 (38.8)	1488 (61.2)	
Antenatal clinic attendance			
Never attended	196 (8.8)	2027 (91.2)	<0.001
Attended	1221 (33.8)	2390 (66.2)	
Sex of the child			
Male	919 (31.4)	2010 (68.6)	0.095
Female	853 (29.4)	2052 (70.6)	
Exposure to media			
Not exposed	728 (26.2)	2050 (73.8)	<0.001
Exposed	1004 (34.2)	2012 (65.8)	
Size at birth**			
Large (≥3.5 kg)	677 (34.4)	1298 (65.6)	<0.001
Average (2.5 kg-3.4 kg)	898 (29.5)	2148 (70.5)	
Small (≤2.4 kg)	197 (24.0)	625 (76.0)	
Birth order			
1 st -3 rd	1028 (33.3)	2055 (66.7)	<0.001
4 th -6 th	522 (27.8)	1356 (72.2)	
7 th +	222 (25.4)	651 (74.6)	
Community level variables			
Residence			
Rural	955 (26)	2720 (76)	<0.001
Urban	683 (31.6)	1476 (68.4)	
Getting to health facility			
Not a big problem	1345 (32.7)	2763 (67.3)	<0.001
Big problem	427 (24.7)	1299 (75.3)	

Contd...

Table 2: Contd...

Variables	Vaccination status		P
	Completely vaccinated, n (%)	Incompletely vaccinated, n (%)	
Geographic region			
South West	282(43.0)	374(57.0)	<0.001
South East	409(57.0)	308(43.0)	
South South	229(41.5)	323(58.5)	
North East	297(23.9)	947(67.1)	
North West	314(19.1)	1330(80.9)	
North Central	354 (34.7)	667 (65.3)	

**Estimate of birth weight by mothers, exact birth weight not available in NDHS. NDHS: Nigeria Demographic and Health Survey

the country; the likelihood of incomplete vaccination in the Northeast region (AOR = 3.50; 95% CI: 1.12–9.08) and in the Northwest region (AOR = 4.29; 95% CI: 2.05–12.05).

Multilevel analysis (random effects) are presented in Table 3; Model 1 (empty Model) shows that there was significant variability in the proportion of children with incomplete vaccination across the region (variance = 1.73, $P < 0.001$). Equally, the intraclass correlation shows that 58.20% of the variance in odds of incomplete vaccination are related to community (region level) factors. The variation in incomplete vaccination in models Model 2, 3, and 4 remained significant [Table 3] and attributable to region-level factors. Furthermore, the proportional change in variance was 49.2%, indicating that in the Model, 49.2% in the variability in the likelihood of incomplete vaccination of a child across the region may be explained by individual-level factors. The MOR also indicate the part played by community (region-level) factors in the likelihood of a child not been completely vaccinated; thus, as Model 4 revealed, if a caregiver moved to another region with a higher likelihood of incomplete child vaccination, the probability of incomplete vaccination for that child would increase by 2.25.

DISCUSSION

This study analyzed the 2018 national sample to assess the prevalence of incomplete vaccination and its determinants in Nigeria due to the recognized importance of childhood vaccination in improving child survival and reducing childhood mortality. In this study, more than two-thirds (69.6%) of the children aged 12–23 months in the country were incompletely vaccinated. This finding demonstrates the huge burden of incomplete vaccination in the country. The study found that many children born to mothers with low education were incompletely vaccinated, as children of mothers without education had the highest likelihood of incomplete vaccination. In addition, the proportion of incompletely vaccinated children reduced as mothers' level of education improved, illustrating the importance of maternal education in the completion of vaccination. Furthermore, this finding agrees with previous studies that have established that education impacts mothers' health-seeking behavior, including obtaining vaccination services for their children [14,18-20]. An educated mother will more likely be aware of vaccination services than an uneducated one. We also found that as the

household wealth index increases, the likelihood of incomplete vaccination decreases, implying that the poorer the household, the higher the probability of incomplete vaccination. This finding is significant since it agrees with prior studies that have documented that poverty influences childhood vaccination [12,21]. Poor households are the ones unlikely to seek health care even for a free service such as immunization services. This is often due to a lack of money to get to the health facility, where there would have been an opportunity to assess the child's vaccination status to enable them to obtain missing doses. It could also be because children from poor households are more difficult to reach by health workers. Household poverty results in the inability to ensure that children are vaccinated and in poor nutritional state with associated poor natural immunity and or lack of artificial immunity due to failure to get the children vaccinated.

The study also found that children of young mothers were more likely to be incompletely vaccinated than older mothers suggesting that the probability of a child completing vaccination improves as mothers' age increases, consistent with findings from earlier studies [14,21,22]. A possible explanation for this finding is the lack of experience in child care among young mothers. Older mothers have, over time, learned and acquired essential skills and knowledge in child care and are perhaps quite informed in child health practices and utilization than younger mothers [23]. They are, therefore, more likely to make use of services that will improve their child's health. The study further found that children born to working mothers were more likely to be vaccinated completely, unlike those not working. This is because working mothers may have access to vital information as they go about their daily duty either at work or daily interaction at various forums. Similarly, the study also established delivery in health facilities as a determinant of a child's vaccination status. We found that the odds of incomplete vaccination for children born in health facilities were reduced than those born at home. This finding agrees with previous studies in the country [14,24] and elsewhere in Africa [25,26] and might be because mothers who give birth in health facilities enjoy the privilege of the first set of vaccination given at birth and the opportunity to be educated about the importance of completing vaccination for their children. Another finding of the study also revealed that the likelihood of incomplete vaccination declined among children whose mothers attended antenatal clinics than those whose mothers did not. Again, this finding is in line with reports from some prior studies [14,27,28]. Attending antenatal clinics allows mothers to obtain adequate information regarding vaccination and other child health practices for their children. During antenatal clinic attendance, individualized counseling and health education sessions sensitize mothers regarding vaccination, build confidence in the health services offered, institutional delivery, and improve childhood vaccination uptake among mothers. On assessing community-level factors, we found a significant association between incomplete childhood vaccination and mother's place of residence. The probability of incomplete vaccination dropped among children in urban areas, unlike rural areas, in keeping with Adedokun *et al.* [14] and studies from Ethiopia and India [29,30]. The

Table 3: Multivariate analysis of individual and community level factors associated with incomplete childhood vaccination among children 12–23 months in Nigeria, Nigeria demographic and health survey 2018

Variable	Total number	Incompletely vaccinated	Model 4 AOR (95%CI)
All children	5834	4062 (69.6)	
Individual-level factors			
Maternal age			
15-24	1339	960 (71.6)	1 (reference)
25-34	3024	2110 (69.8)	0.69 (0.54-0.88)***
≥35	1471	992 (67.4)	0.75 (0.63-0.90)***
Marital status			
Never married	341	230 (67.4)	1 (reference)
Ever married	5493	3832 (69.2)	1.07 (0.79-1.45)
Maternal education			
No education	2510	1893 (75.4)	1.68 (1.56-2.56)***
Primary	916	650 (71.0)	1.60 (1.53-2.64)**
Secondary/tertiary	2408	1519 (63.1)	1 (reference)
Maternal occupation			
Not working	1859	1406 (75.6)	1 (reference)
Working	3975	2656 (66.8)	0.79 (0.69-0.91)**
Wealth index			
Poor	2576	1934 (75.1)	1 (reference)
Middle	1254	899 (71.7)	0.67 (0.55-0.81)**
High	2004	1229 (61.3)	0.58 (0.47-0.71)***
Sex of child			
Male	2929	2010 (68.6)	1 (reference)
Female	2905	2052 (70.6)	1.06 (0.93-1.19)
Size of child at birth (kg)*			
Large (≥3.5)	1966	1298 (65.6)	1 (reference)
Average (2.5-3.4)	3046	2148 (70.5)	1.50 (1.23-1.84)**
Small (≤2.4)	822	625 (76.0)	1.19 (1.02-1.45)**
Birth order			
1 st -3 rd	3083	2055 (66.7)	1 (reference)
4 th -6 th	1878	1356 (72.2)	1.36 (1.27-1.85)***
7 th +	873	651 (74.6)	1.26 (1.01-2.03)**
Exposure to media			
Not exposed	2778	2050 (73.8)	1 (reference)
Exposed	3056	2012 (65.8)	0.90 (0.79-1.04)
Place of delivery			
Home	3402	2574 (75.7)	1 (reference)
Health facility	2432	1488 (61.2)	0.64 (0.56-0.75)***
Antenatal clinic attendance			
Never attended	2223	2027 (91.2)	1 (reference)
Attended	3611	2390 (66.2)	0.46 (0.32-0.66)***
Community-level factors			
Residence			
Rural	3675	2720 (76.0)	1 (reference)
Urban	2159	1476 (68.4)	0.47 (0.40-0.59)**
Getting to health facility			
Not a big problem	4108	2763 (67.3)	1 (reference)
A problem	1726	1299 (75.3)	1.26 (1.11-1.50)***
Geographic region			
South West	656	374(57.0)	1 (reference)
South East	717	308(43.0)	1.40 (1.07-1.98)**
South South	552	323(58.5)	2.53 (1.20-4.50)**
North East	1244	947(67.1)	3.50 (1.12-9.08)***
North West	1644	1330(80.9)	4.29 (2.05-12.05)***
North Central	1021	667 (65.3)	3.59 (1.94-6.22)***

Contd...

Table 3: Contd...

Variable	Total number	Incompletely vaccinated	Model 4 AOR (95%CI)	
Measures of variation for incomplete vaccination	Model 1	Model 2	Model 3	Model 4
Region variance (SE)	1.73 (1.43-2.49)	1.61 (1.46-2.01)	1.39 (1.21-1.59)	0.77 (0.67-0.89)
<i>P</i>	<0.001	<0.001	<0.001	<0.001
Explained variation (PCV) (%)	Reference	49.2	44.3	42.2
ICC (%)	58.20	42.33	36.22	35.66
MOR	2.75	2.62	2.52	2.25
Model fit statistics				
AIC	7132.33	7056.83	7050.32	7037.13
BIC	7152.34	7083.51	7077.00	7022.11

*** $P < 0.001$, ** $P < 0.05$. Model 1 is the empty model, a baseline model without any determinant variable, Model 2 is adjusted for individual factors (maternal education, occupation, wealth index, sex of child, birth order etc.), Model 3 is adjusted for community-level factors (place of residence, getting to health facility, geographic region), Model 4 is adjusted for individual and community-level factors. MOR: Median odds ratio, CI: Confidence interval, AIC: Akaike's information criterion, BIC: Bayesian information criteria, SE: Standard deviation, ICC: Intraclass coefficient, AOR: Adjusted odds ratio, PVC: Proportional change in variance

finding may not be surprising because more health facilities exist in the urban than the rural areas and are more readily accessible. Children of mothers who reported a problem getting to health facilities had a higher probability of being incompletely vaccinated. Difficulty in getting to health facilities has been reported as an obstacle to childhood vaccination and other health services. This agrees with previous study findings which has shown that socioeconomic nature of the communities impacts the health-seeking behavior of individuals within such communities [14]. The odds of incomplete vaccination are increased differentially across the geographic regions of the country and were more pronounced among children of mothers who live in the Northwest and North east region. Such children were more likely not to be completely vaccinated. This finding agrees with previous studies that have suggested community and geographic differences in childhood vaccination uptake. The background socioeconomic level of the communities influences the health-seeking behavior of individuals in such communities [11]. Previous multilevel studies that assessed the determinants of incomplete childhood vaccination in Nigeria and Ethiopia further support this finding. The studies suggest geographical and contextual factors contributing to vaccination completion [14,31]. A reasonable explanation for this finding is that the characteristics of communities where women lives influence their child care practices, including vaccination uptake, notwithstanding mothers' individual characteristics. Women from the same community tend to be similar in child care practice, different from women from other communities because of the influence of sharing the same sources of beliefs and cultures, information's, social norms, health service resources and other social infrastructures. Evidence from this study has further confirmed that there are individual and community factors that impact childhood vaccination completion.

In addressing these findings, we recommend that the government institute policies and programs at improving vaccination coverage and uptake in the country. In addition, community leaders should be incorporated into the programs to strengthen the acceptance of such programs on immunization at the community level. Furthermore, it is imperative for the government at the federal and local levels to initiate strategies to improve people's socioeconomic status, particularly in

rural communities, to enhance their access to health care. In addition to this government should also improve health services quality, coverage, and delivery. Programs to further intensify awareness about the importance of childhood vaccination, are needed than ever before. It is also essential to address inequalities between the country's geographic regions, especially regarding vaccination coverage. In doing this, the government should have policies and strategies tailored to underlying contextual barriers to vaccination.

This study is not without limitations; first, the cross-sectional nature of NDHS data collection limits inferring causal relationships between variables. Second, some respondents may also have given socially accepted responses during the survey because the data were self-reported. In addition, the data on index child's vaccination was obtained retrospectively using either the immunization card or maternal verbal response, thus prone to possible recall bias. Lastly, our findings depend on the quality of NDHS data, however, the DHS is the biggest data collection program on population and health from households in the country and most sub-Saharan African countries and largely accepted as one of the most reliable sources of maternal and child health data.

This study's strength is that it gives current insight into the enormous burden of incomplete vaccination in the country using the most recent and available nationally representative population-based data, the NDHS. In addition, the results from this study are generalizable within the country and possibly to other sub-Saharan African countries due to the similar standardized design used for DHS across the sub-continent. Aside from this, the study also revealed geographical inequalities in vaccination completion rate not well reported in previous studies, which may indicate significant gaps in the vaccination programs in these regions. This finding has implications for future research on vaccination coverage in the country. Further innovative research is needed to explore and identify factors other than those previously reported as contributing to the high incomplete vaccination rate.

CONCLUSIONS

This study has shown the high burden of incomplete vaccination in Nigeria and the influence of individual and

community-level factors. Therefore, strategies designed to improve childhood vaccination uptake and coverage in the country should address individual and community-level determinants of incomplete vaccination in addition to the existing health facility-level programs.

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Conflicts of interest

There are no conflicts of interest.

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