REGIONAL DISPARITY AND DETERMINANTS OF ZERO-DOSE VACCINATION AT BIRTH AMONG CHILDREN AGED 0-24 MONTHS IN NIGERIA

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ABSTRACT
Primary vaccination at birth is a vital precaution to ensure the early protection of children against diseases and death. There is a regional variation of birth vaccination in Nigeria, which is against the SDG goals channelled towards achieving universal health coverage and eradicating communicable and non-communicable diseases. This study examined Nigeria's regional disparity and determinants of zero-dose vaccination at birth. The study used a child-recode dataset from the Nigeria Demographic and Health Survey (NDHS, 2018). A sample of 4,634 children of women of reproductive age was considered the sample size. The outcome variable is zero-dose vaccination based on when a child does not receive a dose of HBV, OPV and BCG at birth. Frequency count, percentage and chi-square were used to analyze the data. The result showed that the northeast and northwest had the highest prevalence of zero-dose vaccination for children at birth (80.4% and 78.4%, respectively). The individual and community-based interventions needed to eliminate low birth vaccination should consider the place of delivery, number of antenatal visits, religion, education, household decision making and exposure to mass media.
Keywords: Zero-Dose Vaccination, Regional Disparity, and Health Facility.

INTRODUCTION

One of public health's most successful strategies for managing and eradicating dangerous and often fatal diseases is vaccination at birth, which has proven to be one of the most efficient preventive measures (Masters *et al*., 2019). At birth, all African children must get vaccinated against polio, hepatitis B, and the bacteria Bacillus Calmette Guerin (BCG). Some African nations continue to have dismal rates, like Nigeria (31% in 2018), Ethiopia (43% in 2019), Uganda (55% in 2016), and Ghana (57% in 2014) (Agboola *et al*., 2015; Galadima *et al*., 2021). National standards advocate giving these vaccines to newborns within 24 hours and up to 14 days post-delivery; however, BCG can be administered until 12 months of age (Ibraheem *et al*., 2019). Children from the lowest socioeconomic quintiles, those with no formal education, and those living in rural areas are disproportionately affected by the persistent regional and national gaps in Nigeria's vaccination coverage. Vaccine antigens provide the most significant protection against vaccine-preventable diseases when given at the appropriate time. Thus, children must get their shots on time (Ibraheem *et al*., 2019).

Some studies have suggested that early receipt of vaccines be a part of the assessment of immunisation programmes (David *et al*., 2020; Ibraheem *et al*., 2022; Sadoh *et al*., 2013). Investigating the regional variation of birth vaccination in Nigeria is essential for promoting child health, aligning with global health goals, identifying barriers, informing policy development, promoting equity, and facilitating data-driven decision-making. This research can significantly improve immunization coverage and, consequently, public health outcomes in Nigeria. However, the broad objective of the study is to investigate the regional disparity and determinants of zero-dose immunisation at birth in Nigeria. This study addresses the following specific objectives:

i) Examine the prevalence of zero-dose vaccination at birth across regions in Nigeria.
ii) Ascertain the background characteristics associated with zero-dose vaccination at birth across regions in Nigeria.
iii) Determine community factors associated with zero-dose vaccination at birth across regions in Nigeria.

METHODOLOGY

This study was conducted in Nigeria, which comprises 774 Local Government Areas (LGAs), distributed throughout its 36 states and the Federal Capital Territory (FCT). The sample frame for this study was drawn from Nigeria Demographic and Health Surveys (NDHS) 2018 using the 2006 Federal Republic of Nigeria Population and Housing Census conducted by the National Population Commission.

The 2006 Enumeration Area (EA) census frame makes up the principal sampling unit (PSU) for the NDHS 2018. A stratified sample was chosen in two rounds for the 2018 Nigeria Demographic and Health Survey suing stratification sampling technique. Both urban and rural areas were assigned to each state. Using a probability proportional to their size, 1,400 EAs were chosen in stage 1. A household listing operation was assigned to each EA, and the generated household lists served as the foundation for the second stage sample frame. About 42,000 households were included in the second stage's sample, with 30 households in each cluster. Tablets were used to list

the households, and a computer program randomly selected the families. According to instructions, only members of pre-selected homes were to be the subject of interviews. To prevent bias, no substitutions or adjustments were allowed during the implementation phases in the pre-selected homes.

This study focused on children between ages 0 and 24 months, using a child recode file of Nigeria Demographic and Health Surveys (NDHS) 2018; the sample size encompasses all children aged 0 to 24 months who were either permanent residents or overnight guests in their families on the night preceding the survey. After appropriate data management, the total sample size used for the study was 4,634 children.

The prevalence of zero-dose vaccination at birth was measured by asking the parents to show evidence that their child or children under 24 months received a dose of Hepatitis B (HBV), Polio (OPV 0), and Bacillus Calmette–Guérin (BCG) at birth. Those who have evidence to have received the vaccines at birth were scored 0 while those who did not receive any vaccine were scored 1 (This is because children younger than 24 months who did not receive a dose of these vaccines were our primary concern). Children older than 24 months were not considered, which served as the exclusion criteria.

While background characteristics associated with zero-dose vaccination at birth were measured were place of delivery (home, public facility), antenatal care visit (no visit, 1-3 visits, 4-7 visits, 8 visits above), birth order (1^{st}, 2^{nd}-3^{rd}, 4^{th}-5^{th}, 6 children above), mother's age (15-19 years, 20-24 years, 25-29 years, 30-34 years, 35 years above) and place of residence (urban, rural). Other factors considered were women's level of education, religion, household type (monogamous, polygamous) and exposure to mass media among other factors. Community characteristics such as education level, poverty, health decision-making, and exposure to mass media were considered as contextual variables. The community factors were derived from the cluster number (v001), the educational level among those reported secondary education was retained to denote community literacy, and those reported poorer and poorest were used to measure community poverty, when woman alone decided on the health the community decision making was derived and when women reported exposure to radio, newspaper and television the community exposure to mass media was derived.

Data were analyzed using frequency distribution, percentage, bar graphs, chi-square and multilevel binary logistics regression. The intraclass correlation coefficient (ICC) and the proportional change in variance were used to symbolize random influences. The following model explicitly explains this: $y_{ij} = \beta_0 + \beta_{1k}x_{1kij} + \beta_{2k}x_{2kj} + u_j + e_{ij}$

y_{ij}: log-odds of zero-dose vaccination at birth by child i in cluster (community) j;

β_0: intercept (average likelihood of zero-dose vaccination at birth);

β_{1k}: coefficients for the individual-level variables;

x_{1kij}: individual-level covariates (age group, education, religion, wealth; Index, etc.) for mothers i in community j;β_{2k}: coefficients for the community-level variables;

x_{2kj}: community-level covariates (education, poverty, decision-making, exposure to mass media);

u_j: community-level random effect;

e_{ij}: error terms for the individual level.

RESULTS AND DISCUSSION

Prevalence of zero-dose vaccination at birth

Figure 1 shows that North-east (80.4%) and North-west (78.4%) had the highest prevalence of zero-dose vaccination at birth. This was followed by North-central (58.6%) and the least regions to experience zero-dose vaccination at birth were South-west (23.9%) and South-east (42.0%). This prevalence of zero-dose vaccination across regions was higher than 16.5% of zero-dose among children age 12-59 months in Sub-sahara Africa (Ozigbu *et al*., 2022). According to Sato, (2023), it was reported that the prevalence of children zero-dose in Nigeria among children reduced from 61% to 40% in 2003 to 2018. The disparities in vaccination rates may indicate broader health inequities in different parts of the country. Regions with a higher prevalence of zero-dose vaccination are more vulnerable to vaccine-preventable diseases. This vulnerability can lead to outbreaks of diseases that could otherwise be prevented through timely vaccination. It emphasizes the need for urgent and targeted vaccination campaigns in these regions to protect the health of infants and the community.

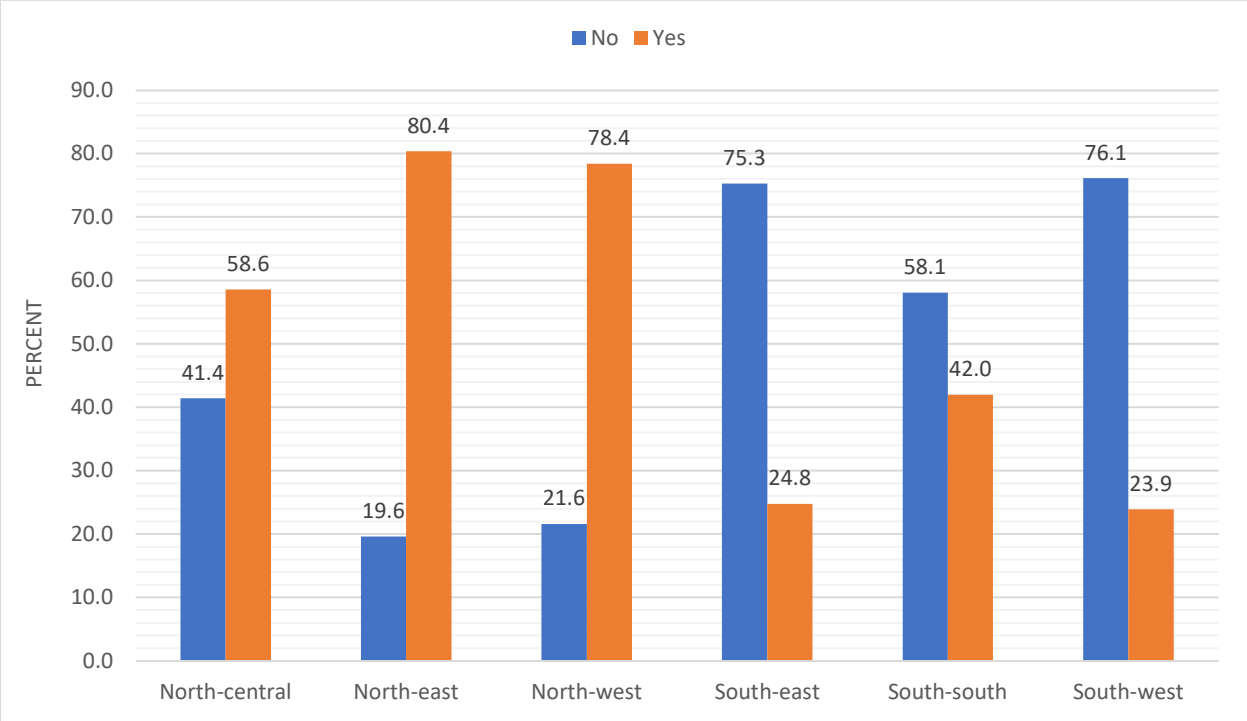

Figure 1: Regional Differential of Zero-dose Vaccination at Birth
Source: Author Construct, 2022 (NDHS 2018).

Distribution by background characteristics

Table 1 reveals the distribution by background characteristics, it was reported that children aged less than 1 year old were 32.5%, followed by those reported at 1 year (37.1%) and those reported at age 2 years were 30.4%. The majority (51.9%) of the children were male and delivered at home (66.0%). One-third reported children with no antenatal care visit (33.6%), most of the birth orders were greater or equal to 6 children (31.5%), followed by 2nd or 3rd birth order (31.3%) and the least reported first order (12.0%). Mothers aged 15-29 years were more reported (50.3%) and more than half resided in rural areas (67.4%). More than half of mothers had no formal education (55.9%) whereby only 44.7% of husband had no formal education (44.7%). This was similar to the findings by Lawal *et al*., (2023) who stated that only 7% of the respondents had tertiary education, while a larger percentage (46%) of the women had no formal education.

Furthermore, Table 1 shows that 70.2% of mothers identified as Muslims, poorest (27.6%), from a polygamous household (35.9%) and whose husband alone made the decision (61.5%), while only 40.4% were exposed to mass media.

Table 1: Distribution by background characteristics (n=4,634)

Background characteristics	Frequency	Percentage	Background characteristics	Frequency	Percentage
Age of child			**Religion**		
0	1,505	32.5	Christianity	1,341	29.0
1	1,720	37.1	Islam	3,254	70.2
2	1,408	30.4	Traditional	38	0.8
Sex of child			**Wealth index**		
Male	2,407	51.9	Poorest	1,278	27.6
Female	2,227	48.1	Poorer	1,195	25.8
Place of delivery			Middle	940	20.3
Home	3,056	66.0	Richer	713	15.4
Public facility	1,066	23.0	Richest	507	10.9
Private facility	512	11.0	**Husband Occupation**		
Number of ANC			Not working	48	1.0
No visit	1,555	33.6	Profess/managerial	474	10.2
1-3 visit	838	18.1	clerk/sales/service	1,306	28.2
4-7 visit	1,503	32.4	Agriculture	2,046	44.2
visit above	737	15.9	Manual	760	16.4
Birth order			**Wife's occupation**		
1st	554	12.0	Professional/Managerial	264	5.7
2nd or 3rd	1,452	31.3	clerk/sales/service	3,109	67.1
4th or 5th	1,167	25.2	Agriculture	1,031	22.2
Greater or equal to 6	1,460	31.5	Manual	230	5.0
Age of women			**Family type**		
15-29 yrs	2330	50.3	Monogamous	3,013	65.0
30 yrs and above	2,303	49.7	Polygamous	1,620	35.0
Place of residence			**Household decision making**		
Urban	1,509	32.6	women alone	376	8.1
Rural	3,124	67.4	Both decided	1,408	30.4
Level			Husband alone	2,850	61.5
Women level of education			**Exposure to mass media**		
No formal education	2,590	55.9	Not exposed	1,972	42.6
Primary	632	13.7	Exposed	2,662	57.5
Secondary	1,111	24.0	**Number of living children**		
Higher	300	6.5	1-3 child	2,312	49.9
Husband level of education			Above 3 children	2,322	50.1
No formal education	2,069	44.7			
Primary	644	13.9			
Secondary	1,339	28.9			
Higher	581	12.5			

ANC: Antenatal Care Visit

Distribution of respondents based on association between respondents' characteristics and prevalence of zero-dose vaccination at birth

Table 2 reveals that there was significant relationship between respondents' age of child, {North-central ($\chi2$=27.14; p=0.000); North-east ($\chi2$=16.67; p=0.001); North-west ($\chi2$=17.29; p=0.003), South-east ($\chi2$=39.69; p=0.000), South-south ($\chi2$=20.88; p=0.000) and South-west ($\chi2$=22.77; p=0.000)} and zero-dose vaccination at birth across the country, it was reported that majority of children less than 1 year do not get vaccinated at birth. There was significant association between place of delivery {North-central ($\chi2$=208.64; p=0.000); North-east ($\chi2$=160.22; p=0.001); North-west ($\chi2$=154.51; p=0.003), South-east ($\chi2$=22.03; p=0.000), South-south ($\chi2$=111.58; p=0.000) and South-west ($\chi2$=56.23; p=0.000)} and zero-dose vaccination at

birth across the country, across region it was reported majority of children were give birth to at home, followed by those reported public facility and the least reported private facility. In contrast, Farrenkopf *et al*., (2023) reported that more than one-third of zero dose children were delivered in a facility. There was significant association between number of antenatal care visit {North-central ($\chi2$=201.56; p=0.000); North-east ($\chi2$=137.60; p=0.001); North-west ($\chi2$=292.33; p=0.003), South-east ($\chi2$=17.12; p=0.000), South-south ($\chi2$=108.31; p=0.000) and South-west ($\chi2$=116.32; p=0.000)} and zero-dose vaccination at birth across the country. Lawal *et al*., (2023) reported that number of children who took zero number of vaccines was high among women with no ANC visit. There was also significant association between place of residence and zero-dose vaccination at birth {North-central ($\chi2$=14.94; p=0.0265), North-east ($\chi2$=80.58; p=0.0000), North-west ($\chi2$=63.64; p=0.0000) and South-west ($\chi2$=68.61; p=0.0000)}, it was reported that majority of children in rural areas do not get vaccinated at birth. There is significant association between mother's level of education {North-central ($\chi2$=208.38; p=0.0000); North-east ($\chi2$=117.89; p=0.0000); North-west ($\chi2$=178.93; p=0.0000), South-east ($\chi2$=17.23; p=0.0029), South-south ($\chi2$=31.57; p=0.0003) and South-west ($\chi2$=68.11; p=0.0000)} and zero-dose vaccination at birth across the country.

Similarly, there was significant relationship between respondents' wealth, {North-central ($\chi2$=131.05; p=0.000); North-east ($\chi2$=126.86; p=0.000); North-west ($\chi2$=162.70; p=0.000), South-east ($\chi2$=31.69; p=0.000), South-south ($\chi2$=36.58; p=0.000) and South-west ($\chi2$=74.82; p=0.000)} and prevalence of zero-dose vaccination at birth across the country.

Table 2: Chi-square analysis of association between background characteristics and zero-dose vaccination at birth

Characteristics	North-Central (n= 742)	North-east (n= 866)	North-west (n= 1882)	South-east (n= 324)	South-South (n= 186)	Southwest (n= 634)
Age of child	χ^2=27.14 p=0.000	χ^2=16.67 p=0.001	$\chi2$=17.29 p=0.003	$\chi2$=39.69 p=0.000	$\chi2$=20.88 p=0.000	$\chi2$=22.77 p=0.000
Number of ANC	χ^2=201.56 p=0.0000	$\chi2$=137.60 p=0.0000	$\chi2$=292.33 p=0.0000	$\chi2$=17.12 p=0.0156	$\chi2$=108.31 p=0.0000	$\chi2$=116.32 p=0.0000
Birth Order	$\chi2$=12.90 p=0.0176	$\chi2$=2.75 p=0.5837	$\chi2$=7.50 p=0.1165	$\chi2$=2.68 p=0.5214	$\chi2$=8.84 p=0.0665	$\chi2$=15.86 0.0012
Age of mothers	$\chi2$=23.81 p=0.0016	$\chi2$=8.27 p=0.1896	$\chi2$=4.33 p=0.4611	$\chi2$=4.32 p=0.4369	$\chi2$=2.14 p=0.8000	$\chi2$=1.15 p=0.8935
Mother's level of education	$\chi2$=208.38 p=0.0000	$\chi2$=117.89 p=0.0000	$\chi2$=178.93 p=0.0000	$\chi2$=17.23 p=0.0029	$\chi2$=31.57 p=0.0003	$\chi2$=68.11 p=0.0000
place of residence	$\chi2$=14.94 p=0.027	$\chi2$=80.58 p=0.000	$\chi2$=63.64 p=0.000	$\chi2$=0.80 p=0.476	$\chi2$=8.34 p=0.064	$\chi2$=68.61 p=0.000
Religion	$\chi2$=89.96 p=0.000	$\chi2$=29.59 p=0.000	$\chi2$=125.80 p=0.000	$\chi2$=2.96 p=0.461	$\chi2$=3.49 p=0.323	$\chi2$=8.23 p=0.077
Wealth index	$\chi2$=131.05 p=0.000	$\chi2$=126.86 p=0.000	$\chi2$=162.70 p=0.000	$\chi2$=31.69 p=0.000	$\chi2$=36.58 p=0.000	$\chi2$=74.82 p= 0.000
Family Type	$\chi2$=23.17 p=0.0011	$\chi2$=13.05 p=0.0045	$\chi2$=22.08 p=0.0012	$\chi2$=10.98 p=0.0019	$\chi2$=0.21 p=0.6694	$\chi2$=0.74 p=0.5299
Household Decision Making	$\chi2$=18.83 p=0.0085	$\chi2$=5.63 p=0.2814	$\chi2$=100.37 p=0.0000	$\chi2$=3.47 p=0.4680	$\chi2$=0.69 p=0.7830	$\chi2$=1.65 p=0.5511
Mass media	$\chi2$=106.36 p=0.0000	$\chi2$=52.21 p=0.0000	$\chi2$=78.02 p=0.0000	$\chi2$=12.77 p=0.0015	$\chi2$=1.24 p=0.2832	$\chi2$=6.02 p=0.0480
Number of Living Children	$\chi2$=9.67 p=0.0017	$\chi2$=0.01 p=0.9166	$\chi2$=1.92 p=0.2243	$\chi2$=2.35 p=0.1601	$\chi2$=4.70 p=0.0837	$\chi2$=17.70 p=0.0001

However, the family type and prevalence of zero-dose vaccination at birth vary across the country, significant relationships existed in the North-central (χ^2=23.17; p=0.0011); North-east ($\chi2$=13.05; p=0.0045), North-west ($\chi2$=68.61; p=0.000) and South-south ($\chi2$=10.98; p=0.0019), majority of

children from monogamous family do not get vaccinated at birth. There was significant association between mass media and prevalence of zero-dose vaccination at birth vary across the country, significant relationships existed in the North-central ($\chi2$=106.36; p=0.0000); North-east ($\chi2$=52.21; p=0.0000), North-west ($\chi2$=78.02; p=0.0000), South-south ($\chi2$=12.77; p=0.0015) and South-west ($\chi2$=6.02; p=0.0480), majority of mothers not exposed to mass media in Northern region do not get child vaccinated at birth whereby women that exposed to mass in mass media do not got child vaccinated. This was similar to the study by Farrenkopf *et al*., (2023), who stated that proportion of zero dose children among those whose mothers access TV and radio less than once a week.

Regional predictors of zero-dose vaccination at birth in Nigeria

The results in Table 3 show that women attending 1-3 antenatal care (ANC) visit, 4-7 ANC visits, and 8 ANC visits were less likely to had zero-dose vaccination for children at birth compared to those with no ANC visits (RC), this follows the same pattern in North-central (57%, 78%, 83% respectively), North-east (64%, 88%, 89% respectively) and North-west (74%, 89%, 93% respectively).

Similarly, women attending 4-7 ANC visits and 8 visits above in the South-east (83%, 82% respectively), South-south (96%, 83% respectively), and South-west (81%, 92 respectively) were less likely had zero-dose vaccination for child at birth. This were consistent with those of Etana and Deressa (2012), who found that children whose mothers had ANC were 2.1 times more likely to complete vaccination than those whose mothers did not have ANC. If women receive prenatal care, they have a greater chance of receiving sufficient information about the importance of early immunisation for their offspring. In addition, the processes performed during antenatal care prepare the mother to have a cheerful disposition toward the utilisation of health care for herself and her children.

In the northeast, those having 4^{th}-5^{th} births were 7.10 times more likely to had zero-dose vaccination for child at birth than those having their first birth (RC). This could be because mothers are taking care of more children, preventing them from having regular vaccines for their newborns at delivery time. In contrast, Gill and Devgun (2015) stated that the likelihood of a person being vaccinated was inversely proportional to their birth order. It was shown that those with birth orders of two or less had a likelihood of 2.9 times greater of being fully vaccinated than those with birth orders of three or more. The implication is that as the birth order increases, the likelihood of not vaccinating the child at birth also increases. The suggested reason is that mothers with higher birth orders may face challenges in providing regular vaccines for their newborns, possibly due to the increased responsibilities of caring for multiple children.

The older the age of women, the less likelihood of zero-dose vaccination at birth in North-central and North-east of Nigeria, those reported at age 20-24 yrs (67% and 85% respectively), 25-29yrs (77% and 86% respectively), 30-34yrs (83% and 92% respectively) and 35yrs above (87% and 80% respectively) compared to those reported at age 15-19 yrs (RC). This agrees with previous studies by Adedokun *et al*. (2017) that older women have a greater chance of immunising their children. Young mothers' lack of childcare experience may be blamed for this situation. Caring for ill children is a drain on the time and resources of older mothers who have been there. These mothers would support any effort that reduced the risk of childhood sickness. There is a positive association between the age of women and the likelihood of having their children immunised at birth.

In the South-south, women with secondary education were 95% less likely to had zero-dose vaccination for child at birth compared to women with no formal education (RC). The study by Ophori *et al*. (2014) found that mothers' post-secondary education level was a significant factor in their timely presentation for birth dosage vaccination, lending credence to the assertion that educated women are more likely to prioritise their children's health. Similarly, those reported that husbands had primary and secondary education in North-central were 0.34 times and 0.41 times less likely to had zero-dose vaccination for child at birth than those with no formal education (RC). Also, those reported husbands with higher education were 0.26 times less likely to had zero-dose vaccination for child at birth than those with no formal education (RC). This shows that education for mothers and their husbands is a significant factor in improving child vaccination rates. Promoting education, particularly at the secondary and higher levels, may contribute to a higher awareness and prioritisation of children's health, leading to increased rates of timely vaccination.

Table 3: Multi-level logistic regression of regional predictors of zero-dose vaccination at birth in Nigeria

Category	North-Central OR (95% CI)	North-East OR (95% CI)	North-West OR (95% CI)	South-East OR (95% CI)	South-South OR (95% CI)	South-West OR (95% CI)
Place of Delivery						
Home	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)
Public facility	0.36 (0.21-0.62)***	0.27 (0.13-0.54)***	0.46 (0.27-0.80)**	0.56 (0.20-1.56)	0.04 (0.01-0.31)**	0.60 (0.26-1.37)
Private facility	0.47 (0.25-0.87)*	0.25 (0.03-1.99)	0.46 (0.08-2.59)	0.82 (0.30-2.26)	NA	0.86 (0.33-2.19)
ANC Visit						
No visit	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)
1-3 visit	0.43 (0.23-0.79)**	0.36 (0.16-0.80)*	0.26 (0.14-0.46)***	0.27 (0.06-1.35)	0.37 (0.08-1.67)	0.62 (0.15-2.57)
4-7 visit	0.22 (0.13-0.37)***	0.12 (0.05-0.26)***	0.11 (0.07-0.19)***	0.17 (0.04-0.74)*	0.04 (0.01-0.18)***	0.19 (0.06-0.62)**
Eight visit above	0.17 (0.08-0.39)***	0.11 (0.03-0.43)**	0.07 (0.03-0.21)***	0.18 (0.04-0.82)*	0.17 (0.04-0.81)*	0.08 (0.03-0.27)*
Birth Order						
1st	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)
2nd - 3rd	0.53 (0.27-1.030	2.34 (0.75-7.32)	0.98 (0.41-2.33)	0.91 (0.27-3.09)	4.05 (0.75-21.94)	1.97 (0.75-5.18)
4th - 5th	0.70 (0.23-2.14)	7.10 (1.29-39.06)*	1.71 (0.57-5.13)	0.33 (0.03-3.38)	2.71 (0.12-60.36)	1.04 (0.14-7.93)
> or equal 6	1.51 (0.40-5.62)	4.28 (0.62-29.48)	2.02 (0.59-6.89)	0.31 (0.02-4.05)	1.93 (0.06-57.37)	1.53 (0.16-14.94)
Age of women						
15-19 yrs	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)
20-24 yrs	0.33 (0.13-0.88)*	0.15 (0.03-0.82)*	1.35 (0.48-3.80)	0.44 (0.02-8.82)	0.12 (0.01-2.50)	1.79 (0.12-26.58)
25-29 yrs	0.23 (0.08-0.63)**	0.14 (0.02-0.84)*	0.71 (0.23-2.18)	0.41 (0.02-7.39)	0.11 (0.00-2.68)	1.06 (0.07-16.82)
30-34 yrs	0.17 (0.05-0.51)**	0.08 (0.01-0.51)**	0.51 (0.15-1.72)	0.45 (0.02-8.70)	0.16 (0.01-4.29)	0.63 (0.04-10.25)
35+ yrs	0.13 (0.04-0.42)**	0.20 (0.03-1.40)	0.54 (0.15-1.90)	0.16 (0.01-3.45)	0.12 (0.00-3.11)	0.48 (0.03-8.07)
Women's level of education						
No formal education	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)
primary	0.68 (0.39-1.19)	1.16 (0.50-2.69)	1.04 (0.57-1.89)	1.45 (0.28-7.61)	0.15 (0.01-2.31)	0.84 (0.34-2.10)
secondary	0.55 (0.29-1.02)	0.59 (0.23-1.52)	0.55 (0.27-1.12)	0.89 (0.17-4.75)	0.05 (0.00-0.78)*	1.15 (0.44-2.99)
higher	0.22 (0.04-1.15)	0.48 (0.07-3.26)	0.70 (0.16-3.13)	0.72 (0.07-7.54)	0.22 (0.01-7.06)	0.52 (0.09-3.13)
Husband's level of education						
No formal education	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)	**1** (RC)
Primary	0.34 (0.17-0.67)**	1.87 (0.73-4.82)	0.75 (0.41-1.40)	2.10 (0.24-18.64)	0.13 (0.00-5.85)	0.52 (0.20-1.35)
Secondary	0.41 (0.22-0.78)**	0.94 (0.42-2.12)	0.58 (0.33-1.02)	1.44 (0.16-12.92)	0.09 (0.00-3.86)	0.43 (0.19-1.00)
Tertiary	0.40 (0.15-1.08)	1.29 (0.39-4.20)	0.48 (0.22-1.04)	NA	0.06 (0.00-3.91)	0.26 (0.07-0.96)*
Community Factors						
Education	0.36 (0.10-1.28)	0.54 (0.06-4.93)	0.11 (0.01-1.03)	1.28 (0.09-18.41)	0.24 (0.02-3.72)	0.18 (0.03-1.00)
Poverty	0.43 (0.14-1.34)	2.79 (0.39-19.78)	0.25 (0.07-0.98)*	0.56 (0.04-7.28)	0.66 (0.03-14.86)	0.88 (0.15-5.08)
Health decision making	2.40 (0.77-7.52)	0.08 (0.01-0.65)*	0.21 (0.04-1.12)	0.52 (0.05-5.71)	1.51 (0.10-23.28)	0.59 (0.12-2.81)
Exposed to mass media	0.32 (0.12-0.88)	8.47 (1.22-58.76)*	0.39 (0.09-1.65)	0.08 (0.01-0.99)*	2.74 (0.09-81.23)	0.38 (0.02-5.76)

Category	North-Central OR (95% CI)	North-East OR (95% CI)	North-West OR (95% CI)	South-East OR (95% CI)	South-South OR (95% CI)	South-West OR (95% CI)
/lnsig2u	-1.10 (-2.66-0.46)	0.70 (0.04-1.36)	0.23 (-0.39-0.85)	0.25(-1.25-1.75)	-9.68 (-63.07-43.70)	-11.10(-70.28-48.08)
sigma_u	0.58 (0.26-1.26)	1.42 (1.02-1.97)	1.12 (0.82-1.53)	1.13(0.54-2.39)	0.01 (0.00 - 1.00)	0.00 (0.00 - 1.00)
rho	0.09 (0.02-0.33)	0.38 (0.24-0.54)	0.28 (0.17-0.41)	0.28 (0.08-0.64)	0.00 (0.00-1.00)	0.00 (0.00-1.00)
LR test of rho=0: chibar2(01)	2.42; P>0.001	35.53; P<0.001	29.83; P<0.001	4.22; P<0.05	0.000019; P>0.05	0.000035; P>0.05
Log-likelihood	-342.00 P<0.001	-287.62; P<0.001	-476.35; P<0.001	-154.74; P>0.05	-68.60; P<0.05	-172.64; P<0.05

OR- Odds Ratio, RC- Reference Category, NA – Not Available, * P-value<0.05, **P-value<0.01, ***P-value<0.001

In the North-west, children living in a poor community were 0.25 times less likely to had zero-dose vaccination at birth. In the northeast, children born to women participating in household decision-making were 92% less likely to had zero-dose vaccination at birth. Furthermore, children born to women exposed to mass media in the northeast were 8.47 more likely to had zero-dose vaccination at birth. In contrast, those exposed to mass media in the southeast were 92% less likely to had zero-dose vaccination for child at birth.

CONCLUSION AND RECOMMENDATIONS

The study indicates that prevalence of zero-dose vaccination at birth was higher in the North-east and North-west of Nigeria. It was discovered that many of the children under 24 months are male, they were delivered at home because their mothers did not have antenatal care visit. It was also reported many of their mothers gave birth to six or more children, they resided in rural areas and had no formal education.

The findings highlighted that significant relationships existed between some characteristics (age of child and wealth index), but the relationship varied among some characteristics (place of residence, religion and age) while there were no significant relation between some characteristics (sex) and prevalence of zero-dose vaccination at birth across the country.

The study recommends the need to promote facility-based births to reduce the likelihood of zero-dose vaccination significantly. Increasing awareness and access to ANC, particularly among women with lower visit rates, is a crucial opportunity to provide information and prepare mothers for the importance of early immunisation. Interventions are proposed to target mothers with multiple children, recognising their challenges regarding childcare and vaccine accessibility. Efforts are suggested to empower and educate older mothers, leveraging their accumulated childcare experience and supportive attitudes toward healthcare utilisation. Promoting maternal and husband education is emphasised, with a call for policymakers to prioritise educational initiatives, especially at the secondary and higher levels. Tailoring community-specific strategies is identified as essential, acknowledging the diverse impacts of community factors on vaccination outcomes. Policymakers and public health professionals are encouraged to customise interventions based on unique circumstances, including economic status, women's empowerment, and the effectiveness of mass media campaigns in each region.

REFERENCES

Abadura, S. A., Lerebo, W. T., Kulkarni, U. and Mekonnen, Z.A. (2015) 'Individual and community level determinants of childhood full immunisation in Ethiopia: a multilevel analysis', *BMC public health*, 15(1), pp. 1–10.

Adedokun, S.T., Uthman, O.A., Adekanmbi, V.T. and Wiysonge, C.S. (2017) 'Incomplete childhood immunisation in Nigeria: a multilevel analysis of individual and contextual factors', *BMC public health*, 17(1), pp. 1–10.

Agboola, S.M., Busari, O.A., Segun-Agboola, B.T., Olajide, T.J., Shabi, O.M. and Elegbede, O.T. (2015) 'Knowledge, attitude, perceptions of adult males towards childhood immunisations in southwest Nigeria', *American Journal of Health Research*, 3(1), pp. 1–5.

Antai, D. (2010) 'Migration and child immunisation in Nigeria: individual-and community-level contexts', *BMC public health*, 10(1), pp. 1–12.

David, D. S., Ishaya, I. A., Shehu, N. Y., Udochukwu, D. M., Victor, P. C., and Ogbodo, C. O. (2020). At-birth vaccination timeliness: An analysis of inborns in the highlands of Jos, North-Central Nigeria. *Nigerian Postgraduate Medical Journal*, *27*(3), 209–214.

Farrenkopf, B. A., Zhou, X., Shet, A., Olayinka, F., Carr, K., Patenaude, B., Chido-Amajuoyi, O. G., and Wonodi, C. (2023). Understanding household-level risk factors for zero dose immunization in 82 low-and middle-income countries. *Plos One*, *18*(12), e0287459.

Ibraheem, R. M., Garba, B. I., Aliu, R., Ibrahim, O. R., Bello, A. O., Mohammed, S. S., Etana, B., and Deressa, W. (2012). Factors associated with complete immunisation coverage in children aged 12–23 months in Ambo Woreda, Central Ethiopia. *BMC Public Health*, *12*(1), 566. https://doi.org/10.1186/1471-2458-12-566

Galadima, A.N., Zulkefli, N.A.M., Said, SM and Ahmad, N. (2021) 'Factors influencing childhood immunisation uptake in Africa: a systematic review', *BMC public health*, 21(1), p. 1475.

Gill, K., and Devgun, P. (2015). Impact Of Socio-Demographic Factors on Age-Appropriate Immunisation of Infants in Slums of Amritsar

City (Punjab), India. *National Journal of Community Medicine*, *6*(01), 11–15.

Ibraheem, R., Abdulkadir, M., Akintola, M. and Adeboye, M. (2019b) 'Determinants of timely presentation for birth dose vaccination at an immunisation Centre in North-Central Nigeria', *Annals of global health*, 85(1).

Lawal, T. V., Atoloye, K. A., Adebowale, A. S., and Fagbamigbe, A. F. (2023). Spatio-temporal analysis of childhood vaccine uptake in Nigeria: A hierarchical Bayesian Zero-inflated Poisson approach. *BMC Pediatrics*, *23*(1), 493. https://doi.org/10.1186/s12887-023-04300-x

Masters, N.B., Wagner, A.L. and Boulton, M.L. (2019) 'Vaccination timeliness and delay in low- and middle-income countries: a systematic review of the literature, 2007-2017', *Human Vaccines and Immunotherapeutics*, 15(12), pp. 2790–2805.

Ophori, E.A., Tula, M.Y., Azih, A.V., Okojie, R. and Ikpo, P.E. (2014) 'Current trends of immunisation in Nigeria: prospect and challenges', *Tropical medicine and health*, 42(2), pp. 67–75

Ozigbu, C. E., Olatosi, B., Li, Z., Hardin, J. W., and Hair, N. L. (2022). Correlates of Zero-Dose Vaccination Status among Children Aged 12–59 Months in Sub-Saharan Africa: A Multilevel Analysis of Individual and Contextual Factors. *Vaccines*, *10*(7), 1052.

Sadoh, A. E., Sadoh, W. E., Uduebor, J., Ekpebe, P., and Iguodala, O. (2013). Factors contributing to delay in commencement of immunisation in Nigerian infants. *Tanzania Journal of Health Research*, *15*(3). https://www.ajol.info/index.php/thrb/article/view/86041

Sato, R. (2023). Zero-Dose, Under-Immunized, and Dropout Children in Nigeria: The Trend and Its Contributing Factors over Time. *Vaccines*, *1*(1), 181.

Sullivan MC, Tegegn A, Tessema F, Galea S and Hadley C. (2010). Minding Immunization Gap: Family Characteristics Associated with Completion Rates in Rural Ethiopia. *J Community Health.*35(1):53–9.