Determinants of Full Vaccination Coverage among Children Born in Rural Communities in Enugu State

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1.0 ABSTRACT

The WHO Immunization Agenda 2030 prioritizes equitable coverage for immunization programs in various countries, aiming to ensure that vaccines reach children in remote rural areas, urban slums, and conflict-affected communities facing multiple deprivations. This study investigates the determinants of full vaccination coverage among children born in rural communities in Enugu State to understand the factors limiting vaccine coverage in this region. A descriptive cross-sectional study design was employed, utilizing interviewer-administered questionnaires to gather information on the socio-demographic, awareness and decision-making characteristics and vaccination uptake of children from their mothers or caregivers. A multistage sampling technique was utilized in the survey to select respondents. Data collected were analyzed using the descriptive statistics and the unadjusted and adjusted Logistic regression. A total of 432 children and their caregivers participated in the survey. The prevalence of zero-dose and under-vaccinated children was found to be 1.6% (n=7) and 2.8% (n=15), respectively, with children in rural communities of Enugu South accounting for a significant portion of these zero-dose and under-vaccinated cases. The overall rate of full vaccination in the study population was 61.3%, with Enugu South recording the lowest percentage of fully vaccinated children. Only 61.1% of children received the BCG vaccine at birth in the rural Enugu South Local Government Area (LGA), compared to 100% coverage in other LGAs. The uptake of the measles-containing vaccine (MCV) was lowest in Oji-River LGA. Logistic regression analysis identified poor and strong determinants of full immunization in the study population. Strong determinants of full immunization coverage included having a father who is self-employed or a salary earner, obtaining information about immunization schedules from immunization cards and obtaining vaccination schedule information from health workers.

Keywords: Determinants, Full vaccination, Under-vaccination, Vaccine coverage, Zero-dose.

1.1 BACKGROUND

Vaccination is a proven, cost-effective intervention that significantly reduces childhood morbidity and mortality worldwide. Each year, immunization prevents over two million deaths globally. However, vaccine-preventable diseases remain the leading cause of childhood mortality, accounting for an estimated three million deaths annually, which represents 17% of all deaths among children under five (Budu *et al.,* 2020; Odusanya *et al.,* 2008; WHO, 2024). In 2020, more than 12.4 million children in lower- and middle-income countries did not receive any vaccinations, contributing to a considerable number of preventable child deaths in those regions, as reported by the WHO. The high rates of childhood mortality garnered global attention, leading to the establishment of the Expanded Programme on Immunization (EPI), now known as the Essential Programme on Immunization, in 1974 by the WHO (2025). The policies outlined by the EPI in 1977 aimed to reduce morbidity and mortality from diseases such as diphtheria, pertussis, tetanus, measles, poliomyelitis, and tuberculosis by ensuring that every child in the world had access to immunization against these diseases by 1990 (Keja and Hendersonc, 1988).

The Expanded Program on Immunization (EPI) was launched in Africa in 1978, and Nigeria joined the program in the same year. Initially, the immunization schedule in Nigeria required five visits to receive the following vaccines: one dose of Bacille Calmette-Guérin (BCG), four doses of the oral polio vaccine, three doses of the diphtheria, pertussis, and tetanus (DPT) vaccine, and one dose of the measles vaccine. In 2004, Nigeria expanded its immunization schedule to include hepatitis B and yellow fever vaccines. It recommended administering three doses of hepatitis B at birth, at six weeks, and at 14 weeks of age, while the yellow fever vaccine is given at nine months, along with the measles vaccine (Obasohan *et al.*, 2018). To further enhance its immunization efforts, Nigeria replaced the DPT vaccine with the pentavalent vaccine in June 2012. The DPT vaccine contains diphtheria, tetanus, and pertussis vaccines along with hepatitis B, while the pentavalent vaccine adds Haemophilus influenzae type b (HiB) to the same components (Olufadewa *et al.*, 2024). The current immunization schedule for Nigerian children includes the following vaccines: BCG, OPV0, and Hepatitis B0 at birth; Penta 1, PCV 1, OPV1, Rota 1, and IPV 1 at six weeks; Penta 2, PCV 2, OPV2, and Rota 2 at ten weeks; Penta 3, PCV 3, OPV3, Rota 3, and IPV 2 at 14 weeks; Vitamin A at six months; MCV1, yellow fever, and meningitis vaccines at nine months; a second dose of Vitamin A at 12 months; and MCV 2 at 15 months (UNICEF., 2025a).

Gavi defines a zero dose (ZD) child as one who has not received a single dose of a diphtheria, tetanus, and pertussis-containing vaccine. In Nigeria, the Penta vaccine is administered, which protects against diphtheria, tetanus, pertussis, hepatitis B, and Haemophilus influenzae type b (Hib). Consequently, zero dose children in Nigeria are identified as those who have not received any doses of the Penta vaccine series. This group is an important indicator of multiple deprivations (Zero Dose Learning Hub, 2023; Dadari *et al.*, 2023). Children who have received the first dose of the DPT (Diphtheria, Pertussis, and Tetanus) vaccine but have not received the third dose (DTP3) are considered under-vaccinated (Dadari *et al.*, 2023). A child is regarded as having an incomplete immunization status if they have not received at least one of the recommended childhood vaccinations. These vaccines include BCG, three doses of the pentavalent vaccine, three doses of the PCV vaccine, two doses of the Rotavirus vaccine, and three doses of both the polio and measles vaccines by the age of 12 months (Atnafu Gebeyehu *et al.*, 2022). Conversely, a fully immunized child (FIC) is defined as one who has received all the recommended basic vaccines by 12 months of age (Mutua *et al.*, 2016).

Nigeria procures vaccines through UNICEF, primarily funding them itself, while some vaccines are co-financed by Gavi, the Vaccine Alliance. In 2014, the country redesigned its vaccination supply chain system to include three national strategic cold storage facilities located in Kano, Abuja, and Lagos. From these facilities, vaccines are distributed directly to the States. Although significant progress has been made in improving vaccination coverage and reaching millions of children in Nigeria, challenges persist. These challenges disrupt access to and use of vaccines for children, resulting in continued low coverage rates in the country (Dadari *et al.*, 2023). A survey conducted across 15 sub-Saharan African countries revealed that Burkina Faso, Cameroon, and Malawi had the highest rates of full immunization coverage among children, with percentages of 81.3%, 77.5%, and 76.8%, respectively. In contrast, Nigeria and Chad had the lowest coverage rates, at 24.2% and 25.7%. The study also indicated that 40% of children in Nigeria had received no vaccinations at all (Costa *et al.*, 2020). Furthermore, the WHO reported in 2022 that 20.5 million infants did not receive the DPT-containing vaccine. Approximately 60% of these infants reside in 10 countries, including Ethiopia, Nigeria, and Indonesia (WHO, 2024). Therefore, to increase vaccination coverage, it is essential to understand the factors that influence vaccination utilization (Tekeba *et al.*, 2025).

The MICS 2021 survey in Nigeria revealed that the percentage of children aged 12–23 months who did not receive any vaccinations was higher in rural areas (22.5%) compared to urban areas (9.3%) (Adesina *et al.*, 2023). In Enugu State, a published report comparing vaccination coverage in rural and urban communities also indicated that coverage was significantly higher in urban areas (94.5%) than in rural ones (55.5%) (Eze *et al.*, 2021). Given that the Immunization Agenda 2030 prioritizes coverage and equity as one of its strategic focus areas (SP3) (Dadari *et al.*, 2023), it is essential to understand the vaccination coverage levels and the factors influencing childhood immunization in rural communities of Enugu. This understanding will contribute to the development of targeted interventions aimed at improving vaccination rates in these areas. Therefore, this study seeks to investigate the determinants of childhood vaccine coverage in rural communities of Enugu State.

1.2 METHODS

Study Area

This study was carried out in Enugu State in the South-East geopolitical zone of Nigeria. It is bordered to the north by Kogi and Benue States, to the west by Anambra State, to the south by Abia State, and the east by Ebonyi State. The state derives its name from its capital and largest city, Enugu. Enugu State covers a total area of approximately 7,625 square kilometers and is situated between latitudes 6° 32' 10.871" N and longitudes 7° 26' 8.23" E. As of the 2006 census and the 2022 population projection, the estimated

population of Enugu State is around 4,690,100. The state is divided into 17 Local Government Areas (LGAs), which contain a total of 291 wards. There are 988 health facilities in Enugu State, including both private and public institutions, with 734 of these facilities offering routine immunization services. The target population for immunization under one year of age is 215,353.

A descriptive cross-sectional study which included the use of interviewer-administered questionnaires to assess the socio-demographic, as well as maternal and child health indicators and vaccination uptake was assessed using the vaccination card and history from mothers/caregivers.

The study population were mothers/caregivers in the selected communities/or wards in Enugu State. A multistage sampling technique was utilized in the survey to select respondents. In the first stage, two Local Government Areas (LGAs) were chosen from each of the three senatorial zones in the state: Enugu East, Enugu North, and Enugu West. A total of six LGAs were selected using a simple random sampling method, employing a table of random numbers. In the second stage, two wards were randomly selected from each of the chosen LGAs, again using a table of random numbers, resulting in a total of 12 wards. The third stage involved the selection of settlements. From each ward, two settlements were randomly selected using the table of random numbers, leading to a total of 24 settlements. In each settlement, 18 respondents were surveyed. The participants for the survey were selected following the World Health Organization's (WHO) immunization coverage cluster survey design. This design employs a two-stage approach, where a random or systematic sample of households is pre-selected from the cluster, and that list is provided to field teams. All households on this list were visited, and if an eligible person resided there or had spent the previous night there, a vaccination questionnaire was completed.

Data was collected electronically using structured, pretested and semi-structured questionnaires using the Kobo Collect. Trained research assistants were used to administer the questionnaires. The questionnaire consisted of socio-demographic information, knowledge of immunization schedule, card immunization history, and knowledge about vaccine-preventable diseases. A two-days training was conducted for the six research assistants on how to administer the questionnaire. The Researcher Supervisor conducted the training. Data collection duration lasted from seven (7) to ten (10) days.

The completed survey forms were reviewed for completeness before analysis. Data was cleaned in Microsoft Excel and validated manually. IBM's SPSS version 20 was used for analysis. Descriptive statistics was applied to analyze the variables, and the result was presented in frequency, percentages, tables, and figures. The unadjusted and adjusted Logistic regression was used to determine the predictors of complete immunization. The confidence level was set at 95% two-sided, while the level of statistical significance was pre-determined at a P value of 0.05.

Approval was obtained from the Enugu State Ministry of Health following a review of the research protocol. Written consent was obtained from all the study participants.

1.3 FINDINGS

Socio-demographic Characteristics of Respondents

A total of 432 individuals participated in the survey. The distribution of male and female children was relatively even, with 49.3% being male and 50.7% female. The majority of the children were born in the third birth order or higher, and most were born in a health facility (65%). Regarding the mothers of the children, a significant portion were aged between 20 and 29 years (44.9%) and 30 to 39 years (53.0%) at the time of delivery. The fathers were predominantly in the 30 to 39 age (63%) range during the delivery. In terms of education, most parents had completed secondary education, with 52.3% of mothers and 53.5% of fathers having this level of education. Additionally, a large proportion of mothers (60.6%) and fathers (53.5%) were self-employed. The majority of the parents identified as Christians, with 97.5% of mothers and 94.4% of fathers identifying with the faith (Table 3).

Characteristics of the sample population regarding awareness and the decision to vaccinate

Caregivers of children of vaccination age in the study population were generally aware of the vaccination schedule, with 94.9% reporting this knowledge. A significant majority of mothers attended antenatal care during their pregnancy (94.9%), and nearly half of these mothers attended antenatal appointments more than five times (59.3%). Only a small percentage of mothers lived more than 5 km away from the health facility (16.2%) where they received antenatal care and took their children for immunizations. Immunization visits to health facilities were regular for 86.6% of caregivers, and vaccines were always available for 82.9% of them. The decision to vaccinate children was predominantly made by mothers (77.3%), and health workers significantly influenced these mothers at the health facility (95.6%). Furthermore, 63.9% of the communities of these children's origin strongly support vaccination, and an impressive 97.0% of caregivers are aware of the diseases that vaccinations can prevent (Table 1).

Table 1: Awareness and decision to vaccinate description of study participants

Characteristics	Frequency	Proportion (%)
Awareness of child vaccination schedule		
Yes	410	94.9
No	21	4.9
Do not know	1	0.2
Attend antenatal during pregnancy		
Yes	410	94.9
No	22	5.1
How many ANC visits		
No	32	7.4
1-4 times	144	33.3
≥5 times	256	59.3
Distance from facility		
1-5km	181	41.9
Less than 1km	181	41.9
More than 5km	70	16.2
Frequency of visits to Health facilities for immunization		
Occasionally	53	12.3
Rarely	3	0.7
Regularly	376	87.0
Availability of vaccines		
Always available	358	82.9
Rarely available	30	6.9
Sometimes available	44	10.2
The decision to vaccinate the child		
Father	90	20.8
Mother	834	77.3
Relatives	5	1.2
Traditional/religious leaders	3	0.7
Health workers influence the decision to vaccinate the child		
Yes	413	95.6
No	19	4.4
Community support vaccination		
Strongly support	276	63.9
Support	149	34.5
Neutral	7	1.6
Awareness of disease prevented by vaccination		
Yes	419	97.0
No	13	3.0
Source of information on immunization of child		
Immunization card	114	26.4
Health workers	259	60.0
Others	59	13.7

Overall Vaccination Status of Children in Rural Enugu State

In the rural communities of Enugu State, the percentage of zero-dose children—those who have not received any doses of the PENTA vaccine—was 1.6% (n=7). Additionally, 2.8% of children (n=12) were classified as under-vaccinated, having received PENTA 1 but not PENTA 3. The rates of incomplete immunization and full immunization among children were 34% (n=147) and 61.3% (n=265), respectively (see Figure 1).

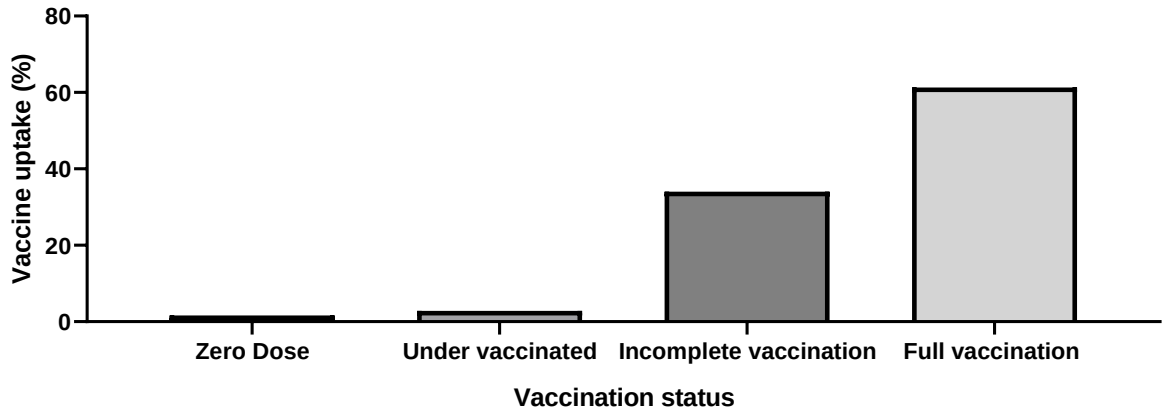

Figure 1: Vaccination status of children in rural communities, Enugu State

Zero-Dose and Under-Vaccinated Children in Rural Communities of Enugu State LGAs

Across the Local Government Areas (LGAs), only one zero-dose child was recorded in Awgu and Oji-River LGAs, representing 1.4% of the population. In contrast, Enugu-South LGA had the highest zero-dose population at 6.9% (n=5). Under-vaccinated children were reported only in Enugu-South (15.3%, n=11) and Oji-River (1.4%, n=1) LGAs (Figure 2).

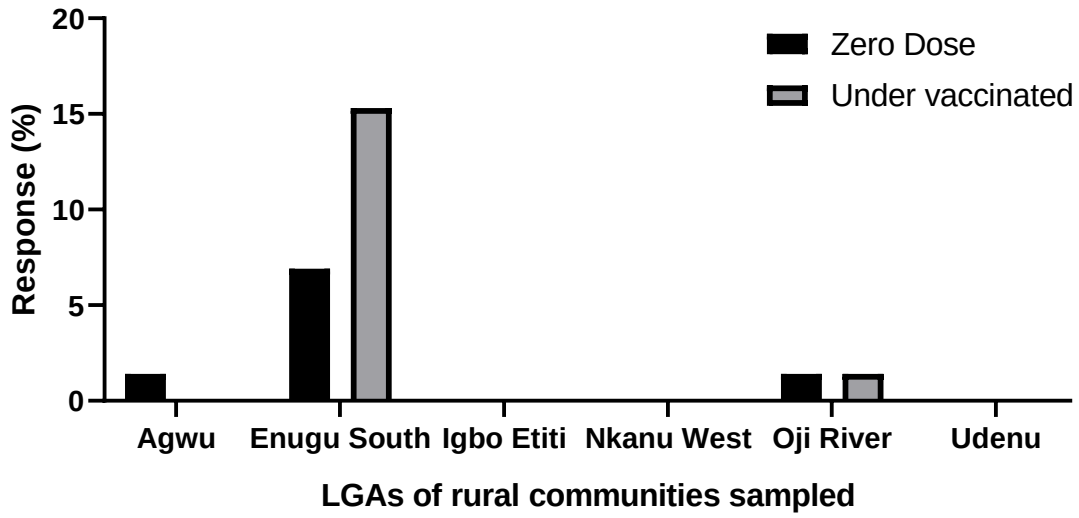

Figure 2: Zero-dose and under-vaccinated children in rural communities of Enugu State LGAs

Fully Immunized Children in Rural Communities of Enugu State LGAs

The highest percentage of fully immunized children was in Awgu LGA at 90.3% (n=65), while the lowest was in Enugu South LGA at 36.1% (n=26). Nkanu-West (59.7%), Oji-River (54.2%), and Udenu (55.6%) LGAs had moderate full immunization rates (Figure 3).

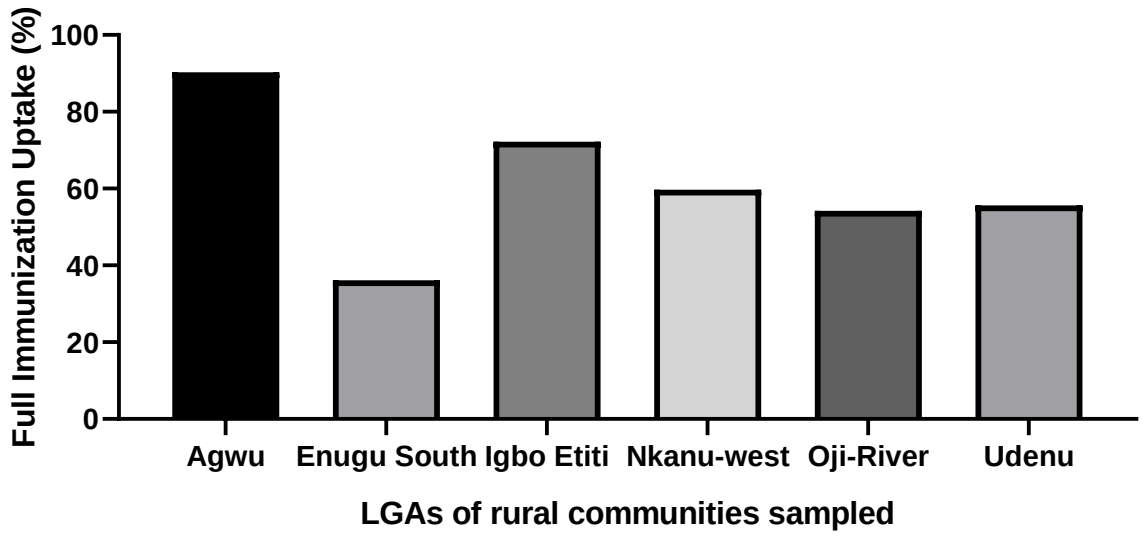

Figure 3: Full immunization uptake of children in rural communities, Enugu State

Factors Affecting Zero-Dose Status in Rural Communities of Enugu State LGAs

The influence of births in health facilities and access to routine immunization services across Local Government Areas (LGAs) on the incidence of zero-dose vaccination status was evaluated using the uptake of the BCG and MCV vaccines. All LGAs exhibited a 100% BCG uptake, except for Enugu-South LGA, where only 61.1% (n=44) of children received the BCG vaccine (Figure 4). The uptake of the measles-containing vaccine (MCV) was 100% in Awgu LGA, while it was the lowest in Oji-River LGA at 55.6% (n=40). The remaining LGAs had MCV uptake rates ranging from 72.2% to 97.2% (see Figure 5).

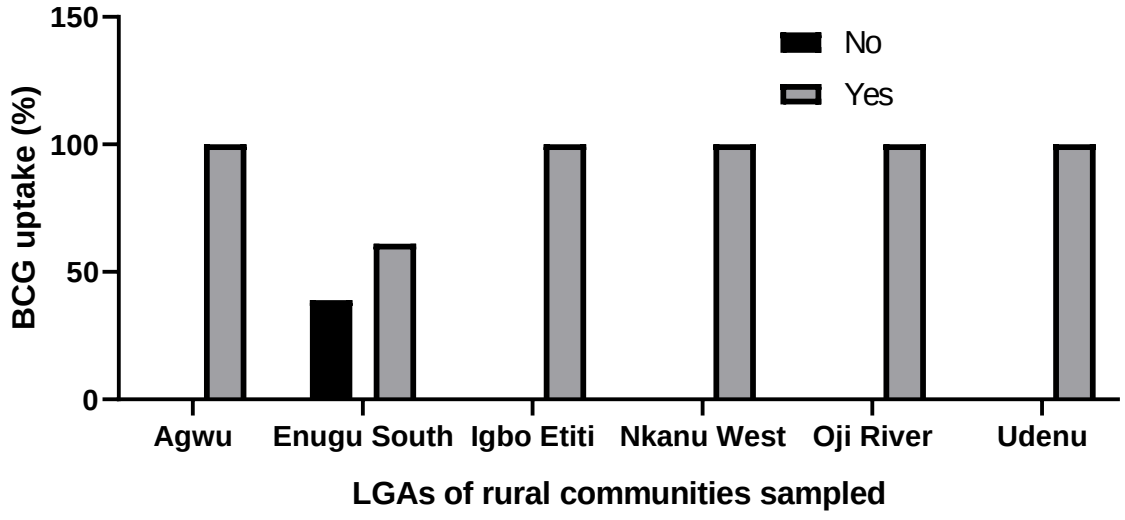

Figure 4: BCG uptake in rural communities of Enugu State LGAs

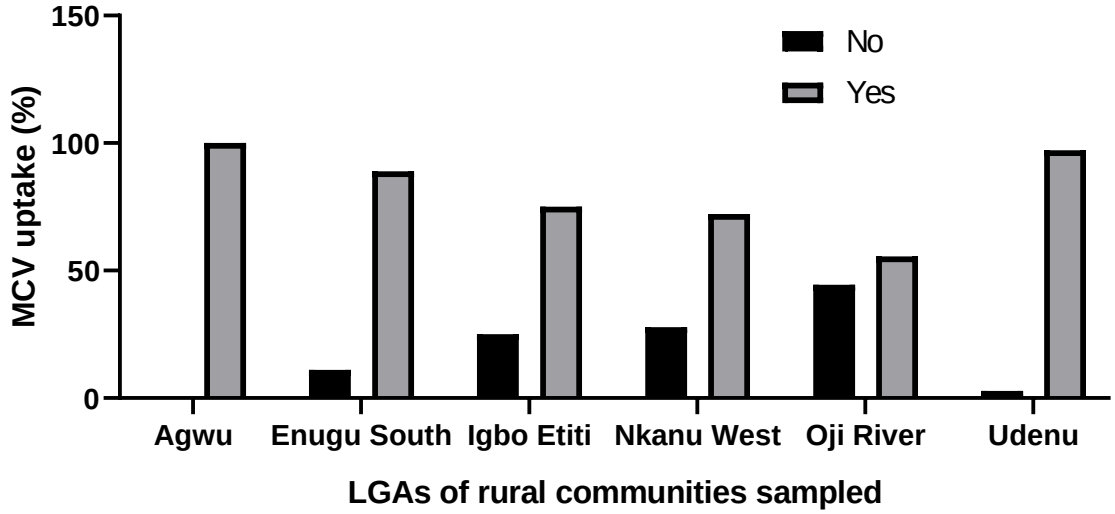

Figure 5: MCV uptake in rural communities of Enugu State LGAs

Determinants of Full Immunization Uptake in Rural Communities in Enugu State

The sociodemographic factors influencing full immunization among children aged 12-23 months in rural Enugu State, as analyzed through both unadjusted (Model 1) and adjusted (Model II) logistic regression, are presented in Table 2. In Model I, the analysis revealed that being born in a health facility (OR=0.59, 95% CI=0.37-0.94, p=0.03) and being born at home (OR=0.47, 95% CI=0.73-0.98, p=0.04), as well as being the second child in the family (OR=0.596, 95% CI=0.36-0.98, p=0.04), were associated with lower odds of full immunization in the study area. Additionally, having a father who is self-employed (OR=3.342, 95% CI=1.349-8.278, p=0.009) or a salary earner (OR=2.510, 95% CI=0.928-6.724, p=0.07) were identified as strong determinants of full immunization in rural Enugu State.

In the multivariate analysis (model II), being born in a health facility (OR=0.541, 95% CI=0.324-0.904, p=0.019), being the second child (OR=0.609, 95% CI=0.349-1.06, p=0.08), and having a mother who is a salary earner (OR=0.389, 95% CI=0.167-0.908, p=0.029) were also found to poor determinants of full immunization coverage in the study area. However, the only strong determinant of full immunization in this area was having a father who is self-employed (OR=4.486 95% CI=1.30-15.480, p=0.018).

Table 2: Sociodemographic factors associated with full immunization coverage in rural Enugu State

	Model 1		Model 2	
	Unadjusted OR	P value	Adjusted OR	P value
Sociodemographic determinants	(95% CI)			
Sex of child				
Male	1.06 (0.72-1.57)	0.746	1.165 (0.764-1.777)	0.478
Female	1		1	
Place of birth				
Health facility	0.59 (0.37-0.94)	0.03*	0.541 (0.324-0.904)	0.019*
Home	0.47 (0.23-0.98)	0.04*	0.562 (0.226-1.395)	0.214
Religious house	1.08 (0.06-17.805)	0.95	2.625 (0.094-73.529)	0.570
Traditional birth home	1			
Birth position				
1	1.16 (0.71-1.92)	0.551	1.28 (0.666-2.30)	0.50
2	0.596 (0.36-0.98)	0.041*	0.609 (0.349-1.06)	0.08*
>3	1		1	
Age of mother				
<20 yrs	1			
20-29 yrs.	0.565 (0.034-9.16)	0.68	0.548 (0.026-11.583)	0.699
30-39 yrs.	0.613 (0.038-9.92)	0.73	0.648 (0.029-14.33)	0.783
≥40 yrs.	2.50 (0.10-62.67)	0.57	4.161 (0.118-147.07)	0.433

Marital status				
Married	0.834 (0.453-1.536)	0.560	0.563 (0.272-1.162)	0.120
Widow	0.700 (0.156-3.137)	0.641	0.601 (0.117-3.077)	0.541
Separate	1		1	
Mother's employment				
Unemployed	1			
Self	0.912 (0.518-1.442)	0.695	0.782 (0.460-1.329)	0.364
Salaried	0.595 (0.305-1.162)	0.128	0.389 (0.167-0.908)	0.029*
Mother's education				
No formal education	1		1	
Primary	2.0 (0.887-4.778)	0.119	1.512 (0.505-4.526)	0.460
Secondary	2.06 (0.96-4.419)	0.064	1.831 (0.627-5.346)	0.268
Post-secondary	1.591 (0.697-3.627)	0.270	1.906 (0.555-6.552)	0.306
Father's age				
20-29 yrs	1			
30-39 yrs.	1.277 (0.629-2.595)	0.499	1.586 (0.693-3.632)	0.295
≥40 yrs.	1.143 (0.533-2.448)	0.731	1.050 (0.407-2.707)	0.920
Father's education				
Unemployed	1		1	
Primary	2.0 (0.811-4.929)	0.132	1.021 (0.307-3.396)	0.973
Secondary	1.73 (0.849-3.54)	0.131	0.772 (0.244-2.446)	0.660
Tertiary	1.534 (0.714-3.295)	0.272	0.963 (0.266-3.480)	0.954
Father's employment				
Unemployment	1		1	
Self-employed	3.342 (1.349-8.278)	0.009*	4.486 (1.30-15.480)	0.018*
Salaried	2.510 (0.928-6.724)	0.07*	3.353 (0.836-3.480)	0.088

OR- odds ratio; CI-confidence interval; *significant at p<0.05

Table 3 presents the determinants of full immunization in rural communities in Enugu State, focusing on awareness and the decision to vaccinate. In Model I, it was found that a mother's awareness of her child's vaccination schedule and traveling distances of 1-5 km and less than 5 km were identified as weak determinants of achieving full immunization in the study. In contrast, the rarity of vaccine availability and the primary sources of vaccination information—immunization cards and health workers—were recognized as strong determinants of successful immunization (see Table 4). In Model II, the traveling distances of 1-5 km and less than 5 km continued to be the only weak determinants of full immunization in the study population. Again, the regular or rare availability of vaccines, along with the information sources being immunization cards and health workers, were confirmed as strong determinants of achieving full immunization (Table 4).

Table 3: Awareness and decision to vaccinate determinants of full immunization in the study area

	Model 1		Model 2	
Variables	Unadjusted OR (95% CI)	P value	Adjusted OR	P value
Awareness of child vaccine schedule				
Yes	0.264 (0.105-0.661)	0.004*	0.342 (0.104-1.132)	0.079
No	1		1	
Attend Antenatal				
Yes	0.210 (0.08-0.547)	0.001*	0.356 (0.113-1.119)	0.077
No	1			
Distance from health centre				
1-5km	0.510 (0.290-0.897)	0.019*	0.419 (0.184-0.955)	0.038*
Less than 5km	0.444 (0.252-0.783)	0.005*	0.0407 (0.188-0.881)	0.023*
More than 5km	1		1	
Frequency of attending antenatal				
Occasionally	1		1	
Rarely	0.560 (0.048-6.557)	0.648	0.780 (0.045-13.485)	0.865
Regularly	0.642 (0.360-1.145)	0.133	0.752 (0.368-1.537)	0.434
Availability of vaccines				
Always available	1.558 (0.776-3.128)	0.213	3.254 (1.363-7.791)	0.008*
Rarely available	4.606 (1.702-12.468)	0.030*	4.502 (1.443-14.502)	0.010*
Sometimes available	1		1	

The decision to vaccinate the child				
Father	0.813 (0.071-9.353)	0.868	0.378 (0.029-4.911)	0.457
Mother	1.340 (0.120-14.9260	0.812	0.449 (0.035-5.775)	0.539
Relatives	1.333 (0.067-26.618)	1.515	1.515 (0.065-35.22)	0.796
Religious leaders	1		1	
Health workers influence to vaccinate child				
Yes	1.329 (0.495-3.567)	0.573	3.138 (0.826-11.924)	0.093
No	1		1	
Community support child vaccination				
Strongly support	0.193 (0.037-1.011)	0.052	0.145 (0.019-1.110)	0.063
Support	0.340 (0.064-1.809)	0.206	0.288 (0.038-2.185)	0.228
Neutral	1		1	
Aware of diseases prevented by vaccination				
Yes	0.969 (0.311-3.012)	0.956	0.771 (0.204-2.920)	0.702
No	1		1	
Source of information for vaccination				
Immunization card	2.133 (1.066-4.277)	0.032*	2.890 (1.160-7.198)	0.023*
Health workers	1.845 (0.996-3.489)	0.006*	2.957 (1.272-6.785)	0.012*
others	1		1	

OR- odds ratio; CI-confidence interval; *significant at p<0.05

1.4 DISCUSSION

Findings from the study indicate that the decision to vaccinate children primarily rests with mothers, who are significantly influenced by health workers. The prevalence of zero-dose vaccination was low overall; however, communities in Enugu South LGA accounted for a considerable percentage of zero-dose cases in the rural areas of Enugu State. Similarly, the prevalence of under-vaccination was also low, with under-vaccinated children mainly found in Enugu South and a few in Oji-River LGAs. Notably, Enugu South had the lowest percentage of fully immunized children. When examining the basic vaccines to identify factors contributing to zero-dose cases in rural communities of Enugu State, the study found that BCG uptake was low, specifically in Enugu South, while the uptake of the Measles Containing Vaccine (MCV) was low in Oji-River LGA. Socio-demographic factors identified as poor determinants of full immunization in the study population included births taking place at home or in health facilities, being a second-born child in the family, and the mother being a salary earner. Additional poor determinants were a lack of awareness regarding the immunization schedule, not attending antenatal care, living within 1 to 5 kilometers from a health center, and the inconsistent availability of vaccines. In contrast, strong determinants of full immunization coverage included the father being self-employed or a salary earner and obtaining information about immunization schedules from immunization cards and health workers.

The finding that the decision to vaccinate a child primarily rests with mothers in this study may be because mothers are the ones who typically attend antenatal care (ANC) visits. These visits provide vital information about vaccinations and child health, which significantly influences their decisions. This outcome aligns with findings from a study that examined vaccination decisions among mothers of children aged 0-12 months. It demonstrated that attending ANC visits and participating in health education programs led to mothers taking the lead in vaccination decisions (Adeyanju and Betsch, 2024).

The study revealed a low percentage of zero-dose and under-vaccinated children. In Nigeria, zero-dose prevalence refers to children who have not received any doses of the PENTA vaccine. The low prevalence observed in the study population suggests that most children in rural communities of Enugu State are protected against diphtheria, tetanus, pertussis, hepatitis B, and Haemophilus influenzae type b. Penta1 is often used as a proxy indicator of access to routine immunization (Zero Dose Learning Hub, 2023). Therefore, the small number of children in the rural communities of Awgu, Enugu South, and Oji-River LGAs who did not receive Penta1 indicates that their mothers faced challenges in accessing routine immunization, resulting in the omission of this vaccine. The zero-dose prevalence found in this study is lower than the rates of 8% and 46.5% reported in Bangladesh and Ethiopia, respectively (Tamir *et al*., 2024; Das *et al*., 2024).

The prevalence of under-vaccination was low in this study. Under-vaccination is defined as the number of children who missed the DPT3 vaccine in a population[10]. Since the DPT vaccine is included in the Penta vaccine in Nigeria, under-vaccination was assessed based on the Penta vaccine. Therefore, children who missed Penta 3 are considered under-vaccinated. This situation implies that the few children in Enugu South and Oji River Local Government Areas (LGAs) who missed the Penta 3 vaccine will not be fully protected against the diseases that the vaccine targets. UNICEF uses DPT3 (which corresponds to Penta 3 in Nigeria) as a measure of how effectively countries provide routine immunization services for children (UNICEF, 2025b). In this study, the coverage of Penta 3 in the

population was 98.2%, suggesting that there is an adequate provision of routine immunization in the rural communities of Enugu State. Furthermore, the WHO has set a target of 90% national coverage for DPT3 (Mahachi *et al*., 2022). Thus, the 98.2% coverage of DPT3 in the study area exceeds the WHO's 90% benchmark. The prevalence of under-vaccination reported in this study is significantly lower than the 28% prevalence found among children in Bangladesh (Das *et al*., 2024).

The study revealed a moderate prevalence of fully vaccinated children, indicating that the number of children who missed recommended routine vaccinations was significantly below average. However, a substantial percentage of those missing vaccinations were from rural communities in Enugu South. This suggests that there are issues related to access to routine immunization within this local government area. Notably, the full immunization coverage recorded in this study was higher than that reported in Papua New Guinea, which had a full immunization coverage rate of only 39% (Budu *et al*., 2020). Additionally, this coverage rate surpassed the 58% rate noted in Osun State (Adedire *et al*., 2016). Penta1, BCG, and measles vaccines are utilized to examine the factors influencing zero-dose vaccination in a locality (Zero Dose Learning Hub, 2023). In this study, BCG and MCV were specifically analyzed for their roles in zero-dose vaccination. All Local Government Areas (LGAs), except for Enugu South, reported 100% BCG coverage. Since the BCG vaccine is administered at birth in Nigeria, high coverage signifies those births occurred in health facilities, where vaccinations are accessible (Zero Dose Learning Hub, 2023). Consequently, the low BCG coverage in Enugu South suggests that a significant reason for the poor access to vaccinations in this LGA is that most births occur outside of health facilities. This finding aligns with a study conducted in a community in Lagos State, which observed that children not born in health facilities did not receive the BCG vaccine by six weeks of age due to their mothers not attending antenatal care during pregnancy (Olusanya, 2010). In this study, only Awgu LGA achieved 100% coverage for the measles vaccine (MCV). The measles vaccine is administered first at nine months and again at fifteen months in Nigeria, typically at primary healthcare facilities. The coverage rates for the measles vaccine can provide insight into access to routine immunization services (Zero Dose Learning Hub, 2023). Therefore, among the six sampled LGAs, only children from rural communities in Awgu LGA had adequate access to routine immunization services, while children from rural communities in the other LGAs experienced varying degrees of access to the provided immunization services.

In this study, certain factors were identified as poor determinants of full immunization coverage. These include being a second child, the mother earning a salary, the mother's awareness of the child's vaccination schedule, attending antenatal care during pregnancy, and the distance from home to the health facility. While these factors have been associated with full immunization coverage in other research (Adesina *et al*., 2023; Galadima *et al*., 2021; (Ayodele *et al*., 2024; Bobo *et al*., 2022) they appear to have less direct influence on a mother's decision to fully immunize her child in this particular study. Conversely, strong determinants of full immunization identified in this study included the father's employment status (whether self-employed or a salaried worker) and the use of immunization cards as a source of information regarding the child's vaccination schedule. The father's employment status was found to significantly impact full vaccination coverage, suggesting that children with employed fathers are more likely to receive complete vaccinations due to increased household income, better access to healthcare services, and a greater family awareness of the importance of immunization. This finding aligns with a study conducted in Pakistan, which also highlighted the strong odds of full vaccination associated with the father's employment status (Habib *et al*., 2024). The use of immunization cards as a source of information proved to be a strong determinant of full immunization coverage in this study. Immunization cards provide detailed records of each vaccine administered, including the dates of vaccination. Mothers who utilize these cards are more likely to ensure their children complete their routine vaccinations. A similar study conducted in Ethiopia found that mothers who use vaccination cards generally have higher rates of vaccine coverage for their children (Sako *et al*., 2023). Additionally, receiving information from health workers was identified as a strong determinant of full immunization coverage. This indicates that when caregivers receive accurate and comprehensive information about immunization from health workers, they are significantly more likely to fully vaccinate their children. This finding is consistent with research analyzing parents' and health workers' perceptions of full immunization in children, which showed that parents who obtain vaccination information from health workers are more likely to achieve full immunization coverage (Balgovind and Mohammadnezhad, 2022).

1. 5 CONCLUSIONS

In conclusion, there is a low prevalence of zero-dose and under-vaccination in the rural communities of Enugu State. However, a significant percentage of the zero-dose and under-vaccinated population comes from the Enugu South Local Government Area (LGA). Full immunization rates are moderate in rural Enugu State, and a large number of children in rural Enugu South have not received all the recommended doses of routine immunization. The lack of access to a health facility at the time of birth is a suggested factor contributing to zero-dose cases in rural communities of Enugu South LGA. Except for Awgu LGA, the other five LGAs face varying degrees of challenges related to access to immunization services. Key factors influencing the likelihood of full vaccination include the father's employment status and the availability of information about immunization schedules from immunization cards and health workers. The study recommends the implementation of robust tracking system linking birth registration with immunization follow-up, particularly in Enugu South LGA where facility births aren't translating to complete vaccination coverage. Development of targeted socioeconomic interventions including flexible scheduling for working mothers, community outreach for two-income households, and strengthening use of immunization cards and health worker communication channels. Improvement in the vaccine supply chain consistency while deploying mobile vaccination services specifically to Enugu South and Oji-River LGAs, coupled with community education campaigns about immunization importance and schedules.

Conflict of Interest

The authors declare that they have no conflicts of interest in conducting this study

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