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ORIGINAL RESEARCH

Determinants of Age-appropriate vaccination among infants at a tertiary hospital in Lagos, Nigeria

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Abstract

Background: Timely vaccination is crucial for protecting infants from vaccine-preventable diseases, yet delays in receiving age-appropriate vaccines persist in many low- and middle-income countries, including Nigeria. Understanding determinants of age-appropriate vaccination is essential for improving immunization coverage. This study assessed the determinants of age-appropriate vaccination among infants at a tertiary facility in Lagos, Nigeria.

Methods: A descriptive, facility-based cross-sectional study was conducted from March to August 2016 at the Newborn and General Outpatient Clinics of Lagos State University Teaching Hospital, Ikeja. Caregivers of the infants aged 0–12 months were recruited through convenience sampling. Data on infant and caregiver characteristics, vaccination history, and health facility access were collected using structured questionnaires. Age-appropriate vaccination was defined as receipt of all vaccines recommended for the infant's age. Data were analyzed using IBM SPSS Statistics v26.

Results: Of 256 infants enrolled, 78.9% received age-appropriate vaccinations. Term birth (AOR 2.33; 95% CI 1.10–4.95), caregiver's marital status (married vs single/separated: AOR 7.74; 95% CI 1.71–34.98), and upper-class socioeconomic status (AOR 2.11; 95% CI 1.02–4.33) were independently associated with timely vaccination. Residence in a Local Council Development Area (LCDA) with a health facility showed increased odds but was not statistically significant (AOR 3.28; 95% CI 0.94–11.50).

Conclusion: Age-appropriate vaccination was suboptimal. Caregiver's marital status, term birth and higher socioeconomic status were key determinants of age-appropriate vaccination, underscoring the need for targeted interventions to address social vulnerability and support preterm infants to improve timely vaccination coverage.

Keywords: Age-appropriate, Determinants, Immunization coverage, Infants, Vaccination

Introduction

Childhood vaccination remains one of the most effective public health interventions for reducing morbidity and mortality from vaccine-preventable diseases (VPDs). Globally, immunisation prevents an estimated 4–5 million deaths annually, and timely receipt of vaccines is essential to ensuring adequate protection during periods of highest vulnerability.[1] Despite progress in many low- and middle-income countries (LMICs), delays in receiving age-appropriate vaccines continue to undermine the full benefits of national immunization programmes.[2,3] Age-appropriate vaccination—defined as receipt of recommended antigens within the nationally prescribed schedule—has gained increasing attention as a more sensitive indicator of programme performance than crude coverage alone, because delays are strongly associated with increased risk of VPD outbreaks and reduced population immunity.[4,5]

In Nigeria, childhood vaccination coverage remains suboptimal, characterised by significant geographic, socio-economic, and demographic disparities.[3,6] According to recent national surveys, a considerable proportion of Nigerian infants either do not complete the recommended vaccination schedule or receive vaccines later than scheduled, leaving critical immunity gaps in the first year of life.[7] Urban settings, including major metropolitan areas in the South-West, have shown comparatively higher vaccination coverage rates, yet vaccination timeliness remains inconsistent. Factors such as maternal education, economic status, family structure, health-system accessibility, and perinatal characteristics have repeatedly been associated with vaccination uptake and timeliness, though findings vary across contexts.[8,9]

Timely vaccination is influenced not only by healthcare access but also by broader social determinants and household circumstances. For instance, infants born preterm are frequently vaccinated later than recommended due to clinical uncertainties, caregiver anxiety, or prolonged neonatal hospitalisation.[10,11] Similarly, socio-economic disadvantage, caregiver marital instability, and long travel distances to health facilities have been associated with delays across various LMICs.[5,9] Understanding how these factors interact within specific local settings is essential for designing contextually appropriate interventions to strengthen routine immunisation services.

Despite extensive literature on general childhood immunisation coverage in Nigeria, there is limited evidence on the determinants of age-appropriate vaccination in urban areas of Lagos State, where health-seeking behaviours, mobility patterns, and socioeconomic heterogeneity differ from those in rural settings. Context-specific analyses are required to inform micro-planning, targeted vaccination outreach, and policies that address inequities in immunisation timeliness.

This study is a secondary data review of a prior cross-sectional study that assessed the factors associated with missed vaccination opportunities among infants at a tertiary hospital in Lagos.[12] This study examines the factors associated with age-appropriate

vaccination among infants at the same hospital in Lagos, Nigeria. By examining sociodemographic, perinatal, and accessibility characteristics, the study provides insights into modifiable barriers to timely childhood vaccination and highlights priority areas for strengthening routine immunisation strategies.

Methods

Study Design: A descriptive, facility–based cross-sectional study was conducted to assess the determinants of age-appropriate vaccination among infants in a tertiary hospital in Lagos, Nigeria.

Study Setting: The study was carried out at the Newborn Clinic and the General Outpatient (GOP) Clinic of Lagos State University Teaching Hospital (LASUTH), Ikeja, Lagos, located in southwest Nigeria. LASUTH is one of four tertiary hospitals in Lagos State and provides a wide range of paediatric services, including emergency care, general outpatient consultations, and various specialist clinics. The Newborn Clinic provides follow-up care for infants previously admitted to the newborn unit and operates weekly, attending to approximately 40 infants weekly. The GOP Clinic provides care for paediatric patients with minor ailments outside scheduled specialist clinic days and operates daily except on weekends, serving an estimated 200 infants per month.

Study Population: The study population comprised caregivers and the infants ~~a~~aged 0–12 months attending the Newborn and GOP Clinics.

Sample Size Determination: The minimum sample size was calculated using the standard formula for cross-sectional studies. Using a prevalence of missed opportunities for vaccination at 33%, a 5% type I error, a precision level of 6%, and an anticipated non-response rate of 10%. These assumptions yielded a minimum sample size of 256 children.[12]

Sampling Technique: A convenience sampling approach was employed. Mothers and caregivers with eligible infants presenting to the clinics during the study period were consecutively recruited following informed consent.

Study Instrument and Data Collection: Data were collected using a structured, interviewer-administered questionnaire. Five trained paediatric resident doctors obtained information on infant and caregiver demographic characteristics. Socio-economic status was determined using the Oyedeji classification, which categorises households into upper (classes I–II), middle (class III), and lower (classes IV–V) socio-economic groups.[13] Information on vaccines expected for age, previous vaccination-related complications, history of contact with other health facilities, and attempts to update vaccinations at such facilities was recorded. Immunization records (where available) were reviewed to verify reported vaccination status. Reasons for incomplete routine immunization were documented. Age-appropriate vaccination was defined as the receipt of all vaccines recommended for the child's age.

Ethical Considerations: Ethical approval was obtained from the Health Research Ethics Committee of Lagos State University Teaching Hospital (LREC/06/10/686). Written informed consent was obtained from

all participating caregivers, and confidentiality of the information provided was assured.

Data analysis: Data were analyzed using IBM SPSS Statistics version 26 (IBM Corp., Armonk, NY, USA). All statistical tests were two-tailed, with significance set at $p < 0.05$. Descriptive statistics were used to summarize participant characteristics. Categorical variables were presented as frequencies and percentages, whereas continuous variables, which were non-normally distributed, were summarized using medians and interquartile ranges (IQR). The primary outcome—receipt of age-appropriate vaccination—was coded as a binary variable (yes/no). Associations between independent variables and age-appropriate vaccination were evaluated through bivariate analyses. Pearson's Chi-square test was used for categorical variables, or Fisher's exact test where expected cell counts were <5. Variables with $p < 0.05$ in bivariate analyses were included in a multivariate logistic regression model to identify independent predictors of age-appropriate vaccination. Adjusted odds ratios (AOR) with 95% confidence intervals (CI) were reported. Model fit was assessed using the Hosmer–Lemeshow goodness-of-fit test. Multicollinearity was assessed using the variance inflation factor (VIF), with values >10 indicating multicollinearity. Confounding was evaluated by comparing crude and adjusted estimates; variables that changed effect estimates by ≥10% were retained regardless of statistical significance.

Results

A total of 256 infants were enrolled in the study. The median age was 10 weeks (IQR 4.1–31.0), and 58.2% were male (Table 1). Most infants were delivered at term (83.6%) and in a hospital setting (82.4%). The majority of caregivers were Yoruba (62.9%), married (95.7%), and resided outside the LGA where immunisation services were sought (84.8%). Approximately one-third (31.6%) used private vehicles to access vaccination services, and more than half (53.5%) travelled for longer than one hour to reach the health facilities (Table 1).

Overall, 78.9% of infants had received vaccination appropriate for their age. Vaccination uptake for individual antigens was 47.7% for BCG, 48.4% for OPV0, and 53.4%, 56.3%, and 52.6% for OPV1, OPV2, and OPV3, respectively. Uptake for other vaccines was 46.9% for HBV, 45.1% for measles, and 51.3% for yellow fever (Figure 1).

Infants who were appropriately vaccinated were slightly older than those who were not, though the difference was not statistically significant (median 11 weeks, IQR 5–32 vs 8 weeks, IQR 3–32; $p = 0.127$). Several factors demonstrated significant associations with age-appropriate vaccination in the bivariate analysis (Table II). Term infants were more likely to be vaccinated appropriately than preterm infants. A larger proportion of term infants had age-appropriate vaccines than preterm infants (82.2% vs 61.9%; $p = 0.003$). Socio-economic status was significantly associated with vaccination status ($p = 0.015$), with the highest rates observed among infants from upper-class households. Infants of married caregivers were significantly more likely to be appropriately vaccinated compared with those of single or separated caregivers (80.4% vs 45.5%; $p = 0.005$).

Table 1: Socio-demographic details of participants

Variable	n = 256	%
Gender: Female	107	41.8
Male	149	58.2
Maturity at birth: Preterm	42	16.4
Term	214	83.6
Age group (weeks) < 4	64	25.0
4 – 24	112	43.8
>24	80	31.2
	Median (IQR)10 (4.1, 31.0)	Range (0.5 – 51.5)
Place of delivery		
Home	17	6.6
Government hospital	115	44.9
TBA/ Maternity home	18	7.0
Private hospital	96	37.5
Others/ Church	10	3.9
Birth order 1	124	48.4
2	66	25.8
3	45	17.6
4	14	5.5
>4	7	2.8
Father's educational status		
Tertiary	176	68.8
Secondary	64	25.0
Primary	15	5.9
No formal education	1	0.3
Mother's educational status		
Tertiary	157	61.3
Secondary	82	32.0
Primary	15	5.9
No formal education	2	0.4
Tribe		
Yoruba	161	62.9
Igbo	53	20.7
Hausa	6	2.3
Others	36	14.1
Marital Status of caregiver		
Married	245	95.7
Single	9	3.5
Separated/ Divorced	2	0.8
Facility in LGA where respondents live		
Yes	39	15.2
No	217	84.8
Travel time to facility (hours) < 1	119	46.5
>= 1	137	53.5
Means of transport		
Private vehicle	81	31.6
Public	175	68.4
Heard vaccination messages last month: Yes	201	78.5
No	55	21.5
Sought Vaccine information: Yes	55	21.5
No	201	78.5

Table II: Factors associated with vaccination appropriate for age

Variables	Vaccination appropriate for age: Yes n = 202 (%)	No n = 54 (%)	P- value
Age group (weeks)			
<4	45 (70.3)	19 (29.7)	
4 – 24	92 (82.1)	20 (17.9)	
>24	65 (81.3)	15 (18.8)	
Median (IQR)	11 (5, 31)	8 (3, 32)	0.127
Gender			
Female	86 (80.4)	21 (19.6)	0.626
Male	116 (77.9)	33 (22.1)	
Maturity at birth			
Preterm	26 (61.9)	16 (38.1)	0.003*
Term	176 (82.2)	38 (17.8)	
Place of delivery			
Hospital	169 (80.1)	42 (19.9)	0.313
Others	33 (73.3)	12 (26.7)	
Father's educational status			
Tertiary	140 (80.5)	34 (19.5)	0.375
Others	62 (75.6)	20 (24.4)	
Mother's educational status			
Tertiary	127 (80.9)	30 (19.1)	0.327
Others	75 (75.8)	24 (24.2)	
Socio-economic status of parents			
Upper class	158 (81.9)	35 (18.1)	0.015*
Middle class	33 (64.7)	18 (35.3)	
Lower class	1 (8.3)	11 (91.7)	
Tribe			
Yoruba	125 (77.6)	36 (22.4)	0.518
Others	77 (81.1)	18 (18.9)	
Marital status of parents			
Married	197 (80.4)	48 (19.6)	0.005*
Single/Separated	5 (45.5)	6 (54.5)	
Birth order			
1	94 (75.8)	30 (24.2)	0.089
2 - 3	94 (84.7)	17 (15.3)	
>=4	14 (66.7)	7 (33.3)	
Facility in the LCDA where respondents live			
Yes	36 (92.3)	3 (7.7)	0.026*
No	166 (76.5)	51 (23.5)	
Means of transportation			
Private	64 (79.0)	17 (21.0)	0.977
Public	138 (78.9)	37 (21.1)	
Travel time to the facility			
< 1 hour	94 (79.0)	25 (21.0)	
>= 1 hour	108 (78.8)	29 (21.2)	0/975

Residence in an LCDA hosting a health facility where immunization services were sought was also positively associated with appropriate vaccination (92.3% vs 76.5%; p = 0.026). Table II shows no association between this and gender, parental education, place of delivery, means of transportation, or travel time. Multivariate logistic regression identified married caregiver, term birth, and higher socio-economic status as independent predictors of age-appropriate vaccination (Table III). Infants of married caregivers had

almost 8-fold higher odds of age-appropriate vaccination than those of single or separated caregivers (AOR 7.74; 95% CI 1.71–34.98; p = 0.008). Term infants had more than twice the odds of being appropriately vaccinated compared with preterm infants (AOR 2.33; 95% CI 1.10–4.95; p = 0.028). Upper-class socioeconomic status was also a significant predictor, with infants in this group having approximately twice the odds of appropriate vaccination relative to those in the lower class (AOR 2.11; 95% CI 1.02–4.33; p = 0.043). Although residence in an LCDA with a health facility where immunization services were sought showed increased odds of age-appropriate vaccination, it did not reach statistical significance after adjustment (AOR 3.28; 95% CI 0.94–11.50; p = 0.063).

Table III: Regression analysis of vaccination appropriate for age

Variable	AOR	95%CI	p
Facility located in LCDA where the patient lives			
No	Reference		
Yes	3.284	0.938 – 11.504	0.063
Marital status of caregiver			
Single/Separated	Reference		
Married	7.739	1.712 – 34.984	0.008*
Maturity at birth			
Preterm	Reference		
Term	2.331	1.097 – 4.953	0.028*
Socioeconomic status			
Lower Class	Reference		
Middle class	3.954	0.371 – 4.162	0.255
Upper class	2.105	1.024 – 4.329	0.043*

AOR Adjusted Odds Ratio CI Confidence interval

Discussion

This study examined determinants of age-appropriate vaccination among infants and identified a combination of sociodemographic, perinatal, and access-related factors that influenced timely immunization among the 256 infants seen at a Neonatal Outpatient Clinic and General Paediatric Outpatient Clinic. Overall, nearly four out of five infants had received vaccinations appropriate for their age, a proportion comparable to reports from several low- and middle-income countries (LMICs), although still below the universal coverage targets of 85% for the third dose of DTP and 95% of measles set by the World Health Organization.[1,14] The findings highlight household-level determinants (married caregivers, term birth and higher socioeconomic status) that remain critical for improving immunization performance in similar urban and peri-urban Nigerian settings.

Previous studies have linked marital stability to increased social support, improved health-seeking behavior, and greater household resource availability, all of which enhance adherence to childhood vaccination schedules.[15,16] Single caregivers often face competing demands and economic constraints that hinder consistent attendance at facilities.[16] The observed association in

the present study highlights vulnerable caregiver groups that may benefit from consideration in the design of supportive outreach and follow-up strategies.

Infant maturity at birth was also a significant determinant. Term infants were more likely to be appropriately vaccinated than preterm infants, consistent with global evidence that preterm infants frequently experience delays due to prolonged hospitalisation, parental hesitancy and misperceptions among healthcare workers regarding vaccine safety in this group.[10,11] Despite WHO recommendations that preterm infants should receive vaccines according to chronological age, delayed vaccination remains common in many LMIC contexts. Strengthening provider training and counselling for caregivers of preterm infants could help bridge this gap.

Socioeconomic status showed a clear gradient in vaccination outcomes, with infants from upper-class households demonstrating higher odds of receiving age-appropriate immunisation. This aligns with substantial literature indicating that economic constraints, including transportation costs, lost work time, and indirect health-care expenses, remain significant barriers to timely vaccination in resource-constrained settings. [9,17,18] Households with greater socioeconomic resources are better able to navigate these barriers, leading to more consistent engagement with routine services. The significance of this factor emphasises the need for pro-poor strategies, such as transportation stipends, community outreach, and integration of immunisation services with other primary care activities.

Although residence within an LCDA hosting a public health facility where immunisation services were sought showed a positive trend in the multivariable model, the association did not reach statistical significance. Nevertheless, the bivariate association and direction of effect suggest that geographical proximity may still play a role. Evidence across LMICs consistently demonstrates that reduced travel distance increases the probability of on-time vaccination.[19-21] The attenuation of significance after adjustment could indicate that socioeconomic status and caregiver characteristics exert stronger influences than physical access alone. However, geographic accessibility remains a relevant programmatic consideration, particularly in densely populated urban regions such as Lagos State.

Interestingly, variables such as gender, parental education, and mode of transportation were not significantly associated with vaccination status in this study, diverging somewhat from findings in other Nigerian and sub-Saharan African research.[8,22] This may reflect contextual differences or the relative uniformity of these factors in the study population. It also suggests that interventions should prioritise caregiver marital support, preterm infant follow-up, and socioeconomic barriers rather than focusing solely on general educational messaging.

In summary, caregivers' marital status, infant maturity at birth, and higher socio-economic status were consistently associated with receipt of age-appropriate vaccination. In contrast, geographical access to health

facilities showed a borderline effect after adjustment.

Limitations: This study has some limitations that should be considered when interpreting the findings. Its cross-sectional design precludes causal inference, meaning that associations observed between sociodemographic, perinatal, and access-related factors and age-appropriate vaccination cannot establish temporality. The use of convenience sampling at a single tertiary health facility may introduce selection bias and limit the generalizability of results to other urban or rural populations. Moreover, the prevalence of age-appropriate vaccination among our sample may not reflect that of the general population, as our sample was hospital-based (rather than community-based), reflecting perhaps a cluster of families with reasonable health-seeking behaviours. The study location may also introduce selection bias because the hospital cares for preterm babies and then follows them up to the clinic. This may affect the age-appropriate vaccination estimates. The relatively small sample size for subgroups, such as preterm infants or children of single caregivers, may have reduced the precision of some estimates. Finally, the absence of longitudinal follow-up prevents assessment of vaccination delays that occurred beyond the study period. Despite these limitations, the study provides valuable context-specific insights into the determinants of age-appropriate vaccination in urban Nigerian settings, which may act as potential targets for interventions aimed at improving age-appropriate vaccination.

Conclusion

Age-appropriate vaccination among infants in this urban setting remains suboptimal. Married caregivers, term birth, and higher socioeconomic status strongly influence timely immunization, while proximity to health facilities plays a lesser role. Strengthening routine vaccination requires targeted support for single caregivers, focused follow-up for preterm infants, and interventions to reduce economic and logistical barriers. Implementing context-specific strategies that address these social determinants is essential to improve immunization timeliness and minimize vulnerability to vaccine-preventable diseases.

Authors Contributions: OAK performed the conception, design, data acquisition, analysis, draft, revision. POU did the data interpretation, revision. EOA assisted in data collection and writing of the drafts. AAO assisted in data collection and writing of the drafts.
FON read and edited the final draft

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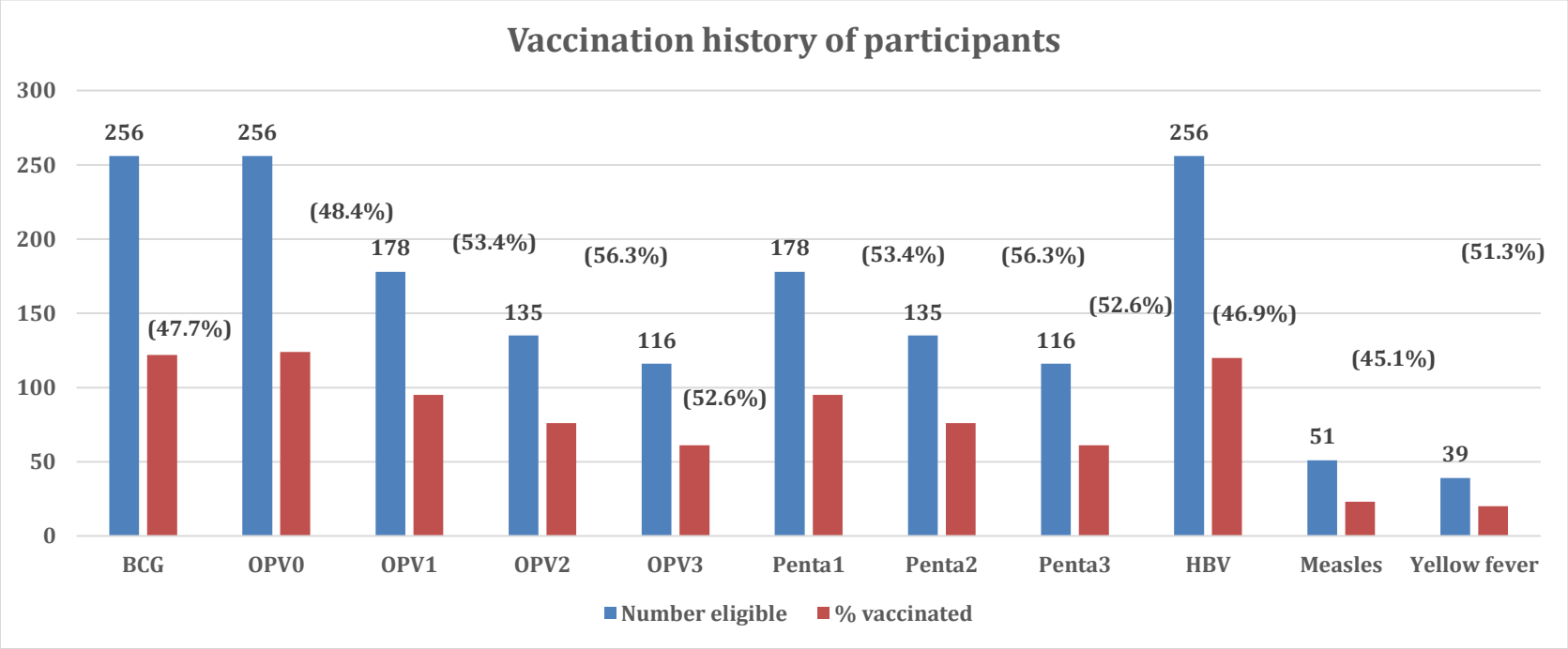


Figure 1: Proportion of participants vaccinated