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Correlates, Predictors and Cluster Analysis of Routine Vaccination Status among Infants in Ido-Osi Local Government Area, Ekiti State, Southwest Nigeria

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ABSTRACT
With low immunization coverage in Nigeria, vaccine-preventable diseases (VPDs) continue to cause significant morbidity and mortality among under 5 children. This study assessed the correlates and predictors of vaccination status among infants in Ido-Osi Local Government Area, Ekiti state. A cross-sectional survey of vaccination status among infants (0-12 months); mothers were interviewed using interviewer-administered questionnaire. Respondents were selected using multi-stage sampling. Households' GPS coordinates were plotted on GIS map and spatial distance of each household to the routine immunization facility estimated. The household wealth quintile was also established. Data were analyzed using SPSS version 21. Level of statistical significance was set at $p<0.05$. The mean age of the children was 5.6±3.6 months. While more than one-third, 116 (38.7%), of the children were 7-12 months old; 171 (57.0%) were males. About a third, 93 (31.0%), of the mothers had tertiary education. Almost three-quarters (70.0%) of the children were fully immunized for age. BCG had the highest coverage (86.3%). Age of the mother, maternal education, place of delivery and having a vaccination card were associated with vaccination status ($p<0.05$). However, maternal education was the lone significant predictor of infant vaccination. (Odds ratio=5.154; p=0.023). A sizeable number of the children were not immunized with the respective vaccines at recommended age; and some factors were found to be associated with the vaccination status of the infants in this study, but maternal education is the only significant predictor. It is recommended that government scale-up efforts at increasing awareness of the public on importance of childhood immunization, girl-child education; and put measures in place to improve accessibility and prevents missed opportunities

Keywords: Routine vaccination, infants, determinants, Nigeria

INTRODUCTION
One great achievements in global public health is the giant stride reached in reducing mortality among the Under 5 children. A number of factors are involved in this feat which include improving living conditions, improved nutrition, and breastfeeding, among other social, economic and cultural aspects. However, much more importantly is the access to vaccines, which has impacted positively in reducing deaths among children under-5 years of age group.[1]Vaccines are immuno-biological substances which produce specific protection against a given disease by stimulating immune system to protect the person, thereby producing immunization.[2,3] Immunization has proven to be a cost effective interventions worldwide through which a number of childhood diseases have been prevented or eradicated.[4] Since the introduction of the Expanded Programme on Immunization in 1974, vaccines have greatly reduced the morbidity and mortality due to vaccine preventable diseases worldwide. Despite this importance, a proportion of children, in developing countries like Nigeria, are not fully immunized with the recommended vaccines.[4]

Vaccine-preventable diseases (VPDs) cause significant morbidity and mortality among infants and children below 5 years old, particularly in developing countries; and immunization remains an important public health intervention to reduce diseases and deaths associated with infectious diseases through improved immunity.[5-8] World Health Organization (WHO)[9,10]estimate showed close to a million children under the age of five die in Nigeria yearly, which are caused by diseases like measles, meningitis, pneumonia tuberculosis among others. The seemingly endemic low uptake/coverage of immunization is a threat to the effort by the Nigerian Government which aims to significantly reduce child mortality/vaccine-preventable deaths which constitutes about 20% of childhood deaths.[8] Indeed,

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countries with low under five mortality rates have a demonstrable inverse relationship with their immunization coverage rates. Sweden, with immunization coverage rate of 98%, has an under-five morality rate of 4/1000. This is also seen in Japan, France and the United States, which have immunization coverage rate above 90%.[6] In Nigeria, while the under 5 mortality rate is 132/1000, only 31% of children 12-23 months received all required vaccines; and 21% got the vaccines at the recommended age.[11] It is essential to monitor vaccine coverage regularly and identify reasons that contribute to delay and non-vaccination at local levels in order to develop appropriate strategies in addressing the gap.[12]Identification of clusters of non-vaccinated and associated factors, by monitoring local immunization coverage, has been identified as public health challenge for outbreak mitigation; and a lack of reliable vaccination coverage data at the operational level makes it difficult to channel efforts towards program improvement.[5,13,14]

In Bangladesh, a cross sectional study found that 86% of children were fully immunized. BCG had the highest coverage rate of 97.1% followed by the oral polio vaccine 1 (97%) and Pentavalent 1 with a coverage of 96.6% while measles vaccine had the lowest coverage of 88%.[15] In Indonesia, only about a third of the children, 31.5%, were fully immunized.[16] In Myanmar, 55.4% were fully immunized; and the complete immunization coverage differs across rural (50.9%) and urban settings (67.8%).[17]Similarly, a cross-sectional study in Ethiopia, in seven hard to reach areas, found that 77.4% of the children were fully immunized, 15.5% were partially immunized; and 7.1 yet to receive any of the antigens.[18] In another study, the aggregate coverage was 38.3% and the specific vaccine coverage showed that Pentavalent3, OPV3, PCV3, Rota 2, and Measles were 56.1%, 60.4%, 51.9%, 58%, and 57.8%, respectively.[19] In Angola, more than half (52.0%) of the 1,209 under 5 children studied had no vaccination history with a full vaccination coverage of 37.1% which was higher (55.0%) in children less than 1 year; and the coverage for BCG was 90.0%, 47.0% for monovalent Measles, and 43.0% for Yellow Fever.[20] In Kakamega Central, Western Kenya, a full immunization coverage of 80.2% was obtained; but after adjusting for the stratified design, an estimated coverage value of 80.9% (95%CI: 76.9-85.3) was gotten. In the study, the vaccination coverage for BCG, OPV 3, Penta3, and Measles were 99.5%, 85.1%, 94.5% and 90.8% respectively.[21] In Malawi,72% were fully vaccinated, 26% were under vaccinated while about 2% were non-vaccinated.[22] A health-facility study conducted in Lome, Togo, among 797 children aged 12-23momths,obtained a complete vaccination coverage of 69.3%.[23]

In Nigeria, the immunization coverage rates of less than 80% and under five mortality rates above 100/1000 is an indication of the gap in routine immunization services in these countries.[8] The official estimate showed that BCG coverage was 53%, while Penta 1 and Penta 3 were 49% and 33% respectively.[24] Using WHO cluster survey, in a rural area of Southwest Nigeria, only 29.5% of the children were fully immunized, 65.7% partially immunized; and 4.8% not immunized.[6]Across rural-urban divide, OPV coverage was consistently higher in the urban areas than rural areas, sometimes coverage in the urban areas was twice that in the rural areas. OPVo coverage in urban areas was 42% in 1999, 35% in 2003, and 52% in 2008 as compared with the rural areas where coverage rates were 20% in 1999, 18% in 2003, and 25% in 2008.[25]Also, secondary data of 5.754 children aged 12-23 months cutting across 896 communities were analyzed by Adedokun *et al*[26],which showed that more than 75% were not fully immunized.

The low coverage of vaccines has been traced to a multitude of factors by several studies. In Bangladesh, full immunization coverage was significantly higher among children who lived in the urban area division ($p<0.001$), were 48–59 months old ($p=0.013$), lived in a medium size family ($p<0.001$), had parents with a higher education ($p=0.006$) and from richest families ($p<0.001$).[15]The likelihood of being partially or unimmunized was higher among children whose father is their sole healthcare decision-maker ($p<0.012$).[15] In Indonesia, children from rural areas, older children and children of mothers (aged 30-39years)were significantly more likely to be unimmunized.[16] In another study in Mysore, India, it was found that parents who obtained optional vaccinations for their children, believed in vaccines' effectiveness, and asked doctors or nurses about vaccination were significantly more likely to report complete vaccination.[27]

In Ethiopia, maternal education and health care utilization, urban city, and mothers' awareness of vaccination and perceived health care support have significant associations with immunization coverage.[28] The study also identified occupation, number of antenatal care visits and distance to vaccination sites as predictors of vaccination status in the study among children 12-23 months.[28] In another study in Ghana[29], there seems to be less evidence for an association between immunization

completeness and socio-economic status while in Ethiopia[18], birth order of the child, mothers' educational status, family size, travel distance to health facility, place of delivery and ANC follow-up were significantly associated with children's full immunization status. In Kenya[21]vaccination coverage was higher (88%) among caregivers who completed secondary school, but lower coverage (54%) was seen among caregivers who did not attend antenatal care ($p<0.001$).[21] Children delivered in a health facility had greater coverage (85%) than those who were not (71%), $P<0.001$; and coverage decreased for children born into larger families, down to 69% for children with a birth order of six or more.[21]In Mali, Zida-Campaore *et al*[23] found that vaccination coverage was higher among those who have vaccination cards ($p = 0.002$).

In Keffi, North-central Nigeria, a rural-urban comparative study of 600 women with an index child 0-12months, found that in the rural and urban areas, associations exist between respondents' age, employment status and immunization status of infants ($P<0.05$).[30] In addition, maternal education and household income were associated with immunization status of infants in the urban area specifically.[30]In similar studies in Ekiti[31] and Enugu[32],Nigeriaon the determinants of compliance of mothers towards childhood immunization, mothers' knowledge of childhood immunization, educational status and attainment of tertiary education were found to be significant determinants of mothers' compliance.

In Indonesia, it was found that parental education was a significant predictor associated with coverage and as parents' educational attainment and mother's media exposure increased, the likelihood of being unimmunized decreased ($p<0.05$).[16]The study showed that as household wealth index increased, the likelihood of being unimmunized decreased ($p<0.05$).[16] Also, the study showed that children born without antenatal care, were at least five times more likely to be unimmunized (OR 5.29; 95% CI 3.78 to 7.39) and children born in public health institutions were significantly less likely to be unimmunized compared with those born at home (OR 0.40; 95% CI 0.36 to 0.44).[16]In a study conducted in Ethiopia[19], the odds of full immunization for children whose mothers were employed, educated, had antenatal during pregnancy, delivered in the health facility and with average/rich wealth status were higher than those whose mothers whose mothers had none of the parameters. In Mali, however, being a male respondent, being not married; having primary education level, not having an immunization card and attending primary level health structure ($p<0.001$) were associated with incomplete immunization.[23]

In a study by Baguune *et al*[4]in Ghana, factors found to be significantly predictive were marital status, religion, sex of the child and having immunization card. In the study, children from married mothers ($p=0.001$) are less likely to dropout from immunization schedule than those from unmarried mothers.[4] A cross-sectional study in Ethiopia by Tefera *et al* , to identify predictors and barriers to full vaccination found mother's occupation ($p=0.0325$), number of ANC visits ($p<0.0001$), and distance to vaccination site ($p=0.0440$).[28] In another study in Ethiopia, multivariate analysis revealed that mothers' educational status, place of delivery, mothers' knowledge score; distance to a health facility, family size, and ANC follow-up were significantly associated with the child's immunization status.[18]

In Owerri, Southeast, Nigeria,younger mothers aged 25-29 years are more likely to have fully immunized children than those in other age groups. Mothers with primary and tertiary education had the highest likelihood of immunizing the children in their households. Children born in places of worship (church), home or in traditional birth attendant centres are least likely to be fully immunized than those born in orthodox settings .[33]In an urban location of Enugu, Nigeria, Tagbo *et al*[32]found that maternal occupation, particularly government employees ($p=0.043$), children born in public health facilities, the knowledge of when to start and complete vaccinations in a child are predictive of full childhood immunization. In a rural community of southwestern Nigeria,the predictors of immunization status was found to be maternal education, place of delivery, family type and the birth order of the child .[6] Similarly, in Ekiti State, Southwest Nigeria, Konwea *et al*[31], found that mothers' education status ($\beta = 0.169$; $p<0.001$) and mothers' knowledge of childhood immunization ($\beta=0.243$;$p<0.001$) were the two significant predictors. In Ilorin, North-central Nigeria, post-secondary education by mothers, antenatal care attendance, hospital delivery, and knowledge of immunization schedule ($p=0.025$), were associated with presentation for birth dose vaccinations at the right time.[34]Therefore, this study aimed to assess the routine vaccination coverage and determine the correlates and predictors of vaccination status among infants in Ido-Osi Local Government Area, Ekiti state, Southwest Nigeria.

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SCOPE OF THE STUDY

This study focused on infants aged 0-12 months and their biological mothers.

OPERATIONAL DEFINITIONS

Fully immunized for age: These are infants who have obtained the full complement of vaccines recommended for and or based on their age as at the time of this study.

Partially immunized for age: These are infants who have missed one or some of the prescribed vaccines recommended for and or based on their age as at the time of this study

Not immunized for age: These are infants who have received none of the vaccines recommended for and or based their age as at the time of this study.

Index Child: Any child included in this study from the selected household to obtain needed information on the socio-demographic and vaccination status. [35]

Cluster: A settlement of households together with the selected infants will be taken as a cluster.[36]

ASSUMPTION/LIMITATION OF THE STUDY

1. The serological conversion status of the selected infants was not assessed. The terms "vaccination and "immunization" will be used interchangeably.
2. For children with no vaccination cards, mother's recall was used to assess the routine vaccination status which therefore opens the window for potential recall bias in this study.

MATERIALS AND METHODS

Ekiti state has a land mass of 5887.890 square kilometres and population of 2,384,212 and a projected population of 3,266,945 based on an annual growth rate of 3.2%.[37]Ekiti State has three senatorial districts (Ekiti South, Ekiti central and Ekiti North) and 16 Local Government Areas.[38,39] The study area, Ido-Osi Local Government Area, Ekiti state, is in the Ekiti North senatorial zone. The LGA has a total of 11 political wards which are Ido wards 1 and 2, Ifaki wards 1 and 2, Usi, Ilogbo, Osi, Orin/Ora, Igbole/Ifisin/Aaye; and Aiyetoro wards 1 and 2. Using the 2006 population figure of 160, 001, the Local Government has a projected population of 240,968. Therefore, the projected population estimate for the under 1 children (4% of population) in the Local Government becomes 9,639. The indigenous people of Ekiti state are mainly Yoruba (and speak the Ekiti dialect) with some non-indigenes such as Hausa, Igbos, Ebira and other ethnic groups also existing in the state. Most of the people of the state are Christians with some Muslims and few traditional worshippers. The people of Ekiti are involved in various occupations such as the public service, trading, farming, and organized private business owners.

There are primary, secondary and tertiary health institutions in the Local Government Area. The tertiary public health institution is the Federal Teaching Hospital, Ido-Ekiti. These health institutions, providing routine immunization services, are widely spread in Ekiti State. However, like every other States of Nigeria, routine vaccination coverage has been sub-optimal in performance and this has been linked to missed opportunities particularly occasioned by incessant strikes by health workers especially in public health facilities.

This was a cross-sectional household survey of routine vaccination status among infants (0-12 months) in Ido-Osi Local Government Area, Ekiti State. The study population was infants (0-12months) in Ido-Osi Local Government Area, Ekiti State. Mothers of selected children were interviewed to obtain information for this study. The minimum sample size was determined using Fisher's formula for population greater than 10,000.[40,41] With P =21.0.0% (Percentage of children fully immunized before first birthday.[42]This gives 255 (approximately). As the study population of Under 1 in Ido-osi LGA is less than 10,000, using the correction factor, Nf= n/1+n/N, the sample size becomes 249 (approximately). With 10% non-response, this becomes 277. However, a total sample size of 300 was used to further improve the power, external validity and generalizability of the findings. With a zero intra-cluster correlation coefficient (ICC); m=number of subjects per cluster =10; the Design Effect becomes 1; and therefore the sample size remains 300. Design Effect= 1+ (m-1)* β.[43]

A multi-stage sampling technique was used to select respondents. In stage 1, using the delineated settlements/clusters, used for routine assessment of immunization services, 30 out of the total 115 clusters were selected using simple random sampling by balloting. In stage 2,using the WHO cluster

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sampling survey for immunization coverage, quota sample with equal number of subjects per cluster was used.[44] Consequently, "30 x 10" cluster sampling was used for this study. Ten households from each of the 30 clusters were sampled. The starting point was the first household on the numbered list of households in each cluster and sampling continued consecutively until 10 eligible and willing respondents were selected.[4] For households, where eligible respondents were not willing to participate or where there were no eligible respondent, the next household was visited to recruit subject until the desired sample size was attained. Door-to-door visits with face-face interviews were conducted with mothers/caregivers who had children 0-12 months as well as observation of the children for the presence of BCG scar. Immunization cards were sighted to verify the vaccines already received by the index child; for children with no card, mother's recall was utilized. A semi-structured, pretested, interviewer-administered questionnaire was used for data collection. For reliability, the test-retest method was used and a Cronbach's (Alpha value) co-efficient of 0.86 was obtained. Face and content validity of the tool were ensured by the researcher and other experts vast in this area of research who assessed the tool.

The GPS co-ordinates of each household was also taken using Infinix mobile hand held device with an accuracy of 4-6metres. Data were analyzed using SPSS version 21. GPS co-ordinates of the 300 households were plotted on the GIS map to demonstrate geographical accessibility of households to routine immunization facility. The wealth index analysis was done using the Principal component Analysis.[45] Thereafter the wealth quintiles were created and the households were divided into five categories: poorest, poor, average, rich and richest. Level of statistical significance was predetermined at a p-value of < 0.05.

For each outcome variable, cross tabulation was done with socio-demographic parameters to check for association and Pearson's Chi square test was used to establish such if it exists. The classification of vaccination status into fully immunized for age, partially immunized and not immunized was used as the dependent variable; and independent variables that were found to have significant association ($p<0.05$) in the bivariate analysis was selected as covariates and modelled into the ordinal regression equation to identify predictors of vaccination status. Ethical approval for this study, with protocol number ERC/2019/03/13/196A, was obtained from the Health Research and Ethics Committee of the Federal Teaching Hospital, Ido-Ekiti, Nigeria. Permission to carry out the study was also obtained from relevant community leaders and gate keepers. Informed consent was obtained from all mothers and confidentiality of findings was assured and maintained.

RESULTS

The total number of households from the selected 30 clusters was 4637; but, out of the 405 households which had infants (0-12 months), 300 mothers (with infants) consented to participate giving a response rate of 74.0%. All the respondents interviewed were biological mothers of the selected infants; and two-thirds, 67.3%, of the infants had vaccination cards. In Table 1, more than one-third, 116 (38.7%), of the children were 7-12 months old; and more than half, 171 (57.0%), were males. More than half, 164 (54.7%), of the mothers were 20-29 years old; and about a third, 93 (31.0%), of the mothers had tertiary education. Table 2 showed that more than three quarters of the mothers were Christians, 251 (83.7%) and married, 249 (83.0%). As shown in Figure 1, the proportion of children immunized with BCG vaccine, 86.3%, was the highest. In Figure 2, more than three-quarters of the children who were vaccinated with BCG (80.0%) and OPV_0 (80.0%) obtained it at the recommended age. Table 3 showed that the drop-out rate was highest for BCG/Measles with a value of 78.6%; and the least value of 25.7% was for $Penta_1$/$Penta_3$ and PCV_1/PCV_3. In Table 4, a total of 210 (70.0%) of the children were fully immunized for age; almost a tenth, 29 (9.7%) were not immunized. Some of the reasons given by the mothers of those partially/not immunized included lack of information (21.4%), health workers' strike action (14.3%), vaccine stock-out (26.2%), lack of transport fare to the health facility (26.2%), and fear of side effects (16.7%) among others. Table 5 showed that about a quarter, 71 (23.7%), of the mothers had experienced missed opportunity; and perception and attitude of mothers was found as a major cause with 29 (40.8%). In Figure 3, the co-ordinates of the households sampled were plotted on the spatial map; from the plot, using spatial analysis, the distance of the households to the facility range from 0.1-10.1km with a mean of 2.71km. In Table 6, less than a quarter 60 (20.0%) were in Quintile 5 (richest). In Table 7, younger fathers had their children fully immunized than the older fathers ($p=0.245$). In Table 8, mothers who are educated had higher proportions of children who are fully immunized than those who had no formal education ($p=0.001$). Those with institutional

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(orthodox or non-orthodox) delivery had more of their infants fully immunized for age compared with those who had home delivery (p=0.001). Table 9 showed that almost three-quarters, 194 (71.3%), of those infants with vaccination cards were fully immunized for age compared with just about half, 16 (57.1%), of those without vaccination cards (p=0.002). As shown in Figure 4, only 2 (6.6%) of the clusters (Aiyegunle and Odedele) had all the infants, 10 (100.0%), sampled who were fully immunized for age. No association was established between the cluster and vaccination status of the child (p=0.338). In Figure 5, all the sampled infants in the two clusters of Aiyegunle and Odedele, who were fully immunized for age, had vaccination cards. As shown in Figure 6, the cluster where the household selected was located and the relative household wealth index quintile of the households were found to have significant association (p<0.001). As shown in Table 10, only maternal level of education was significantly predictive of routine vaccination status of infants (odds ratio=5.154; p=0.023).

DISCUSSION

The mean age obtained for the infants was 5.6±3.6 months. This was lower than the mean age of 17.4 months obtained by Tefera *et al*[28] in an Ethiopian study among children 12-23months which has a sample size of 540 compared with this study which targeted 0-12 months and sample size of 300. Majority of the mothers in this study were in the second and third decades of life with a mean age of 28.1±5.1 years which falls within reproductive age group. This is comparable to the study in Ethiopia where majority of the women were also in second and third decades of life. It equally agreed with that obtained among urban women in a study on maternal characteristics and immunization status of infants (0-12 months) in Keffi, North-central Nigeria.[30]The mean age of mothers in this study also agreed with that found in another study in Ilorin, North-central Nigeria, where it was 28.4±4.7 years.[34] Even though, the sample sizes of 600 and 480 for the Keffi[30] and Ilorin[34] studies respectively were higher than that of this study (300), the studies were all cross-sectional and targeted infants 0-12. It was also in concordance with that of a study in Enugu, Nigeria, where majority of the mothers were between the ages 26- 30 years.[32]

In this study, about a third (31.0%) of the mothers and almost half (43.3%) of the fathers had tertiary education. This study was in Ekiti state in the southwestern part of Nigeria, which is known for high educational exposure and quest for knowledge. Similar findings were obtained in another study in Ekiti[31]and in Ilorin[34]. In another study in the southwestern state of Oyo, Nigeria, majority of the mothers were also educated with primary, secondary and post-secondary education.[6] Just like the Oyo study, Ibraheem *et al*[46] in Ilorin, Nigeria, also found that about half of the mothers had secondary and postsecondary education. However, another study in the East African country of Ethiopia found that only about a tenth, 11.8%, of the mothers had secondary education and above.[18] While the Ethiopia study was conducted in Sekota Zuria district, one of the rural hard-to-reach areas, very far from the capital city of Addis Ababa, this study was conducted in a semi-urban population with possibly better educational opportunities. More than three quarters of the household sampled practiced Christianity, a reflection of the socio-demographic characteristics of Ekiti state where majority are of the Christian faith. This agreed with the finding of Adebayo *et al*[6] in Oyo state, and in Enugu, Nigeria by Tagbo *et al*[32]. This could be because Enugu is in the southeast geopolitical zone of Nigeria where Christianity also predominates.

More than three-quarters, 83.0% of the mothers were married, a reflection of the active reproductive age group who are likely to be married. This agrees with the findings of another study in the southwestern part of Nigeria where majority of the mothers were equally married.[6] The studies were similar as both focused on immunization coverage among children and were conducted in two southwestern states of Nigeria populated by the Yorubas; and marriage at adulthood reflects the culture and traditions of the people. Indeed, more than three-quarters of the mothers were Yorubas as Ekiti state is predominantly a Yoruba-speaking state. Similarly, more than three-quarters of the households were monogamous in nature and most had between 1-5 children (2.33±1.37). This could be due to the predominant Christian religion inclination and educational exposure of the couple, particularly the mothers. Christianity preaches monogamy than polygamy and educational attainment affords exposure to information, particularly health information on family planning. With only less than a tenth of the mothers (8.3%) and fathers (6.3%) being unemployed and given the vast majority of the mothers and fathers of the infants being gainfully employed, it stands reasonable to see that almost two-thirds of the households had monthly income of more than N18,000.

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This study showed that almost three-quarters of the infants were fully immunized based on the recommended age for the different vaccines despite the fact that about a quarter (23.7%) of the mothers reported instances of missed opportunities due majorly (40.8%) to perception of mothers towards vaccination and negative attitude of health workers towards the mothers. Similar study in the North-central city of Ilorin, Nigeria also established missed opportunities to be due to child's illness (26.8%), ignorance about routine vaccines (19.5%), and mother travelling when vaccine was due (14.6%) among others.[46] Nonetheless, the high proportion of fully immunized infants in this study could be a reflection of the semi-urban location of the study area and the educational status of the parents. In addition, more than three quarters of the households were within a reasonable distance to the health facility and could easily be accessed for their child's vaccination as more than half, (53.7%), of the parents accessed these health facilities by trekking. In a study in a rural community of Oyo state[6], only 29.5% of the children were fully immunized. The lower coverage reported in the Oyo study might be due to the rural nature of the study area with hard-to reach area or clusters compared with the semi-urban location in this study. In an urban municipal area of Owerri[33] and Enugu[32], Nigeria, more than three-quarters of the children assessed were fully immunized; and this is in keeping with findings obtained in this study conducted in a semi-urban population. In a similar study in Ghana[4], a much higher proportion (89.5%) of children were fully immunized because the study was equally conducted in a central municipal region, possibly with better access to immunization services. However, in a study conducted in Ethiopia[28] in a small locality, less than two-thirds, 61%, of the children aged 12-23montths were found to be fully immunized because more than one third, 36%, of the mothers had no formal education and could possibly explain the relatively lower coverage seen. This is in contrast to the higher educational attainment seen among the mothers in this study.

On the coverage of the different antigens in this study, BCG (86.3%) and OPV_0 (84.3%) were found to have the highest proportion, higher than the national official estimate for 2017 which was 53% for BCG.[24] This disparity between the national official estimate and this survey values could be due to the fact the national estimates use a wider denominator unlike this study. However, the finding in this study is in agreement with what was obtained by Adebayo *et al*[6], Duru *et al*[33] and by Tagbo *et al*[32] where 73.6%, 96.1% and 100.0% respectively were recorded for BCG among the children studied. These are the first vaccines on the schedule and most likely the mothers (most of whom delivered in health facility in this study) might still be in the hospital and could easily be vaccinated. This is buttressed in this study going by the percentage of children immunized at the right age which also showed that 80% of the children got each of BCG and OPV_0 at the recommended age. Also, surveys conducted in Ghana and in Angola showed that almost all the children (97.5% and 90.0% respectively) assessed had BCG vaccination.[4,20] In Ethiopia, Girmay and Dadi (2019) also obtained high coverage of 90.0% for both BCG and Pentavalent1 and 91.5% for OPV1.[18] On the contrary, however, the proportion of children withmeasles and yellow fever vaccinations in this study was 18.3% each, lower than the national estimate put at 42%.[24] These are about the last vaccine on the schedule when mothers/care givers might have developed apathy towards vaccination visits to the routine immunization centres. Indeed, attitude/perception of mothers/healthcare workers accounted for the highest proportion of reasons given for missed opportunities in this study as also obtained in Ilorin, Nigeria, where ignorance, forgetfulness, fear of side effects, also contributed to the causes of missed opportunities.[46] In another study in Ilorin, North-central Nigeria, the prevalence of missed opportunities was 24.4% and yellow fever and measles vaccines were often missed compared to others.[47] This was also comparable to the findings in Oyo, Nigeria, where the two antigens also had the least in terms of coverage with 65.0% and 55.0% for measles and yellow fever respectively.[6] This was, however, at variance with the finding in Ethiopia where more than half (57.8%) of the children aged 12-23 months received measles vaccines.[19] This disparity might be due to the difference in targeted age group. While this study focused on infants, 0-12 months and collected primary data, the Ethiopia study analyzed secondary data of children 12-23 months from the 2016 Ethiopia Demographic and Health Survey. In Mali, Zida-Campaore *et al*[23] obtained a much higher coverage of 83.1% and 71.9% coverage for measles and yellow fever vaccines respectively which is much higher than the 18.3% obtained in this study. This disparity might also be traceable to the difference in the targeted age groups in the two studies and difference in sample sizes. This study targeted 300 infants, 0-12 months while the Mali study selected 797 children aged 12-59 months. Also, while more than three-quarters of the children in this study got BCG (80.0%) and OPV_0 (80.0%) at the recommended age; in the Oyo

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study[6], only about a third of the children got BCG (35.2%) and OPV_0 (34.1%) at the recommended age and vaccine stock-out accounted for the major reason in the study.

Young fathers between the 2nd and 4th decades of life had more fully immunized children than older ones (p=0.245). This is because young fathers are probably still procreating and have younger children than the older ones. Also, in this study, mothers who had ever been married with possible support from their spouses had more immunized children than those who are not (p=0.179). This is similar to what was obtained in Owerri[33], Nigeria, where even though more of the ever married had more immunized children, the observed difference was not statistically significant. In the Owerri study, majority of the mothers were students and would probably not have the time to take their children for vaccination just like in this study where most of the mothers were traders with possible tight schedules. Similarly in Oyo, Nigeria, marital status had no association with immunization status of the children as there were also more employed mothers than the unemployed/housewives.[6]

Maternal education was associated with routine vaccination status of the children in this study as mothers with higher education had higher proportion of fully immunized children than those with lower or no formal education (p=0.001). This picture was equally obtained by Adebayo *et al*[6] and Duru *et al*[33] (2016) in Oyo and Owerri respectively and by Ibraheem *et al*[34] (2019) at the General Hospital, Ilorin, North-central Nigeria, where maternal post-secondary education attainment was a significant determinant of presentation for birth dose vaccination at the right time. This finding was also in concordance with those in Ethiopia[18] and Bangladesh[15] which showed that maternal/parental educational status was significantly associated with immunization status. Educational exposure, particularly maternal education enhances women empowerment, exposes her to necessary health information and could positively impact her attitude and practice towards child immunization. Education breeds economic empowerment, though, in this study, majority of the unemployed mothers have more of their children fully immunized than those employed (p=0.434). This is similar to the study in southwest Nigeria, where a higher proportion of the unemployed also had more immunized children than the employed.[6]This could be due to the ampoule of time at their disposal and flexible schedule with opportunity to take their children for vaccination.

Parity is **a**nother factor that was found not to have association with vaccination status of the infants as mothers with $\leq$ 5 children had less immunized children than those with more than 5 children (p=0.123). Even though, those with fewer children are more likely to have younger children within the routine vaccination age than those with higher number of children, who could, possibly have grown up children and might have completed their vaccinations. This agrees with findings of a study in Ghana[4] where parity was not significantly predictive of drop-out rate for vaccination among the children studied. However, in Bangladesh[15], living in a medium family size was found to be significantly associated with full immunization coverage which corroborated the result obtained in Kenya[21]where coverage decreased for children born into larger families, down to 69% for children with a birth order of six or more. Also, in concordance with this, is the result obtained in Indonesia[16] where birth order and family size were also associated with immunization status. As child's birth order or family size increased, the likelihood of being unimmunized also increased.

Also, in this study, place of delivery of **t**he child had significant association (p=0.001) with routine vaccination status of the child as only half (50.0%) of the mothers who delivered at home had their children fully immunized for age compared with almost three-quarters of those who delivered in the health facility (70.0%) and more than three-quarters of those who delivered in religious homes (76.1%). Institutional delivery, particularly in orthodox health facility, might have exposed the mothers to health education on the importance of childhood immunization, either during antenatal care/delivery or even during post-natal visits, and could possibly have influenced mother's compliance with immunization visits for their children. Similar finding was obtained in Owerri[33], Nigeria, where more than three-quarters of mothers who delivered in the hospital had their children immunized (p<0.001); also found in Ilorin[34], North-central Nigeria and Ethiopia1[8,19], where hospital delivery was a significant determinant of compliance with birth dose vaccination and vaccination coverage. However, in Enugu, southeast Nigeria, place of delivery was not a significant (p=0.691) predictor of immunization status of the children studied. Though, in the bivariate analysis, children who were delivered in health facility were 1.1 times more likely to be fully immunized.[32] This finding from the Enugu study could be due to the fact that a number of the respondents live far away from the health

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facilities because the study also showed that those who can reach the health facility in less than an hour are 1.6 times more likely to have their children fully immunized.

More than a quarter, 28.6%, of those with no vaccination card were not immunized (p=0.002). The card serves as means of reminder for the mothers and also help to keep track of appointment for the child's vaccination ultimately impacting positively on compliance with vaccination schedule. This finding was similar to what was obtained in Mali, where among the children with no immunization card, full coverage was 62.3% whereas it was 84.6% among children who had immunization card (p=0.002).[23] Similar finding was equally obtained in Malawi, where those with no card or whose card was misplaced, had increased odds of being not vaccinated compared with those who have cards and not misplaced.[22]

Household income was not significantly associated with vaccination status of the infants because a higher proportion of those households that earn ≥18, 000 and <18,000 Naira had their children fully immunized for age (p=0.144). Even though, poverty breeds and fuels the vicious cycle of ignorance and disease, higher household income helps improve access to healthcare where health information can be obtained. Also, higher household income is a reflection of economic empowerment and could positively impact on financial accessibility to healthcare in general and immunization services in particular. However, routine vaccines are free and do not require much finance to be accessed and this could possibly explain the result of this study. Like the household income, the wealth quintiles of the household have no association with vaccination status of the infants, as majority of the households in all the quintiles have children who were fully immunized for age. This is even further buttressed in this study as there was no association (p<0.338) between the cluster where the household was selected and the vaccination status of the child, but rather between cluster and wealth quintile (p<0.001). This was not in concordance with a similar study in Malawi, where compared with children from the richest, poorest, poorer and middle wealth households had increased odds of being under-vaccinated.[22] It is equally at variance with the findings in Ethiopia[19] where women who had middle and rich wealth status had odds of full immunization of children being 1.44 and 1.65 times higher compared with those of poorer mothers. Also, while increasing socio-economic status was also found in Kenya[21] as being associated with increasing immunization coverage, the odds of being unimmunized were also significantly higher among the poorer and the poorest in Indonesia[16] and in Lao People's Democratic Republic where the areas with low immunization coverage were correlated with higher proportions of poor villages.[48] It also tallies with the finding in India where non-vaccination was associated with parental financial status among other reasons like awareness.[49]

On multivariate analysis, only maternal education was found to be a significant predictor of vaccination status of children. So, the higher the mother's educational attainment, the higher the number of immunized children, Also, mothers with formal education are five times more likely to have immunized children than those with lesser or no formal education (odds ratio=5.154; p=0.023). This goes to show the importance of mothers' educational exposure towards improvement in vaccination of children. Education enhances awareness and knowledge which might positively influence health-seeking behaviour. This similar finding was also demonstrated by studies in Oyo[6], Ekiti[31] and Ilorin[34] where maternal education was also a significant predictor of fully immunized children, but not in Enugu[32]. It is also in concordance with the finding by Oleribe *et al*[50] in a quantitative analysis of the secondary data of 27,571 under 5 children where respondent's age, maternal educational attainment, and wealth index remained significantly associated with immunization coverage in multivariate analysis.

CONCLUSION AND RECOMMENDATION

Majority of the children were fully immunized for age while almost a tenth were not immunized and about a quarter were partially immunized. Lack of information, vaccine stock-out, and lack of transport fare were some of the reasons given for default in vaccination. There are also cases of missed opportunity due to majorly to negative perception/attitude. There was no association between the cluster and routine vaccination status of the child (p=0.338). Factors identified as having significant associations (p<0.05) with the vaccination status of the infants are age of the mother, level of education of the mother, place of delivery of the child and having a vaccination card. Only maternal education was found to be a significant predictor of routine vaccination status of the children. (Odds ratio=5.154; p=0.023).

Continuous health awareness/information dissemination on the importance of childhood immunization should be sustained/scale-up by the relevant health authorities (like the Local Government Health Department, State Ministries of Health etc) to correct the negative attitude/perception, fear and apathy of parents towards vaccination. The Government should further strengthen and make compulsory girl-child/maternal education as this goes a long way to explain or influence child health outcome, particularly compliance with childhood routine immunization schedule. The importance of delivery in the health facility in the presence of skilled birth attendant should further be emphasized by Government at all levels in Nigeria to further impact on vaccination coverage. The importance of safe-guarding the child's vaccination card should further be made known tomothers during health education sessions by healthcare workers to improve compliance with the child's vaccination schedule. Identified causes of missed opportunities like health workers' strike action, vaccine-stock out should be tackled head-long by the Government through improved workers' welfare/motivation; and improved capital budgetary allocation to immunization, in order to improve access to vaccines and scale-up vaccination coverage.

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Table 1: Socio-demographic characteristics of respondents /subjects

Variable	Frequency	Percentages (%) N=300
Age group child (months)		
0-6	184	61.3
7-12	116	38.7
Sex of the child		
Male	171	57.0
Female	129	43.0
Mother's age group (years)		
10-19	12	4.0
20-29	164	54.7
30-39	112	37.3
40-49	12	4.0
Father's age group (years)		
20-29	64	21.3
30-39	152	50.7
40-49	70	23.3
50-59	12	4.0
≥60	2	0.7
Mother's level of education		
No formal education	15	5.0
Primary	28	9.3
Secondary	164	54.7
Tertiary	93	31.0
Father's level of education		
No formal education	7	2.3
Primary	19	6.3
Secondary	144	48.0
Tertiary	130	43.4
Mother's occupation		
Trading	85	28.2
House wife	76	25.3
Apprenticeship	56	19.0
Civil service	40	13.3
Unemployed	25	8.3
Artisans	13	4.3
Farming	5	1.6

Table 2: Socio-demographic characteristics of respondents /subjects… cont'd

Variable	Frequency	Percentages (%) N=300
Religion		
Christianity	251	83.7
Islam	47	15.7
Traditional	2	0.6
Marital status (biological mother)		
Married	249	83.0
Co-habiting	36	12.0
Single	13	4.3
Widowed/Separated	2	0.7
Family setting		
Monogamy	258	86.0
Polygamy	29	9.7
Single parent	13	4.3
Parity		
1-5	292	97.3
>5	8	2.7
Ethnic group		

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Yoruba	246	82.0
Ebira	38	12.7
Hausa/Fulani	8	2.7
Igbo	4	1.3
Tiv/Urobo/Idoma	4	1.3
HH* estimated monthly income (N)		
≤18,000	109	36.3
>18, 000	191	63.7
No people in the HH		
≤5	223	74.3
>5	77	25.7
Father's occupation		
Apprenticeship	82	27.4
Civil service	66	22.0
Farming	42	14.0
Artisans	37	12.0
Trading	41	14.0
Driving/bike rider (commercial)	13	4.3
Unemployed	19	6.3

*HH= Household

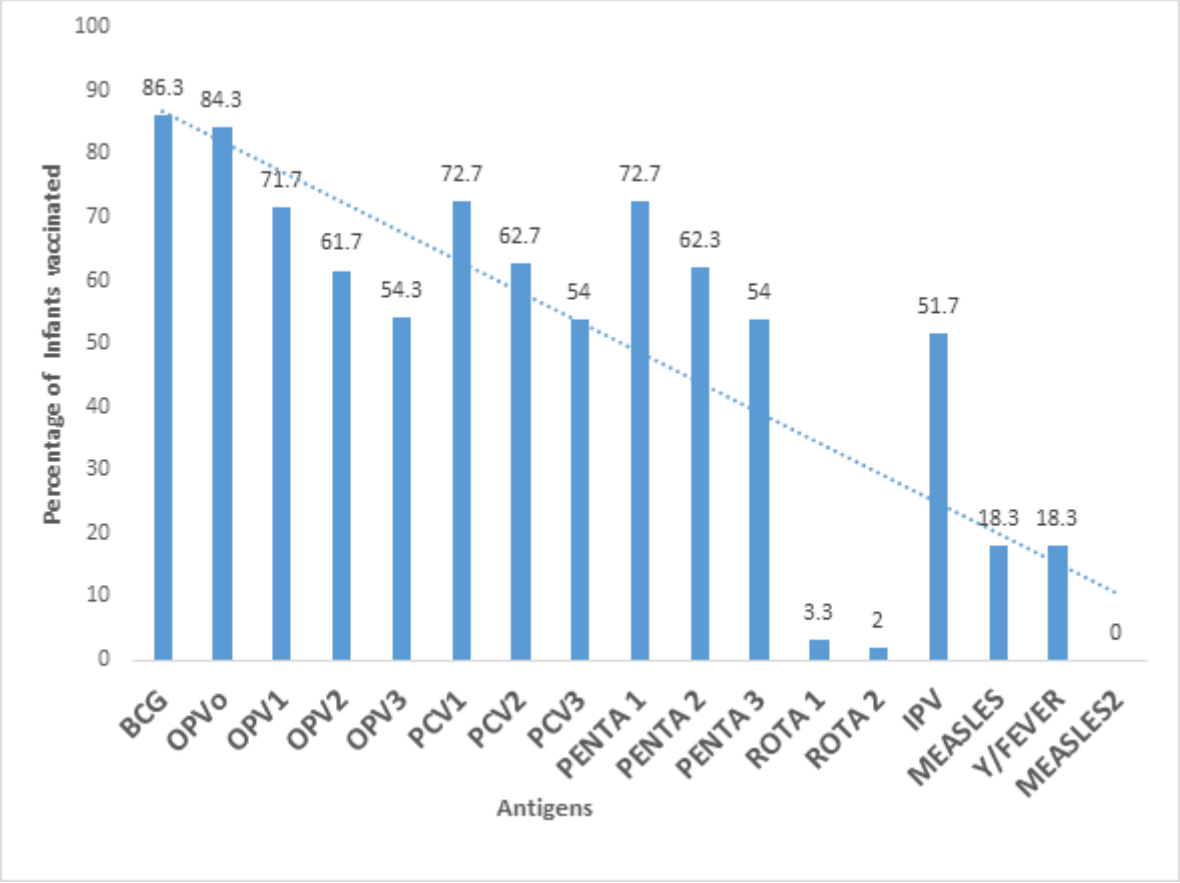

Figure 1: Percentage of Infants vaccinated with the different antigens

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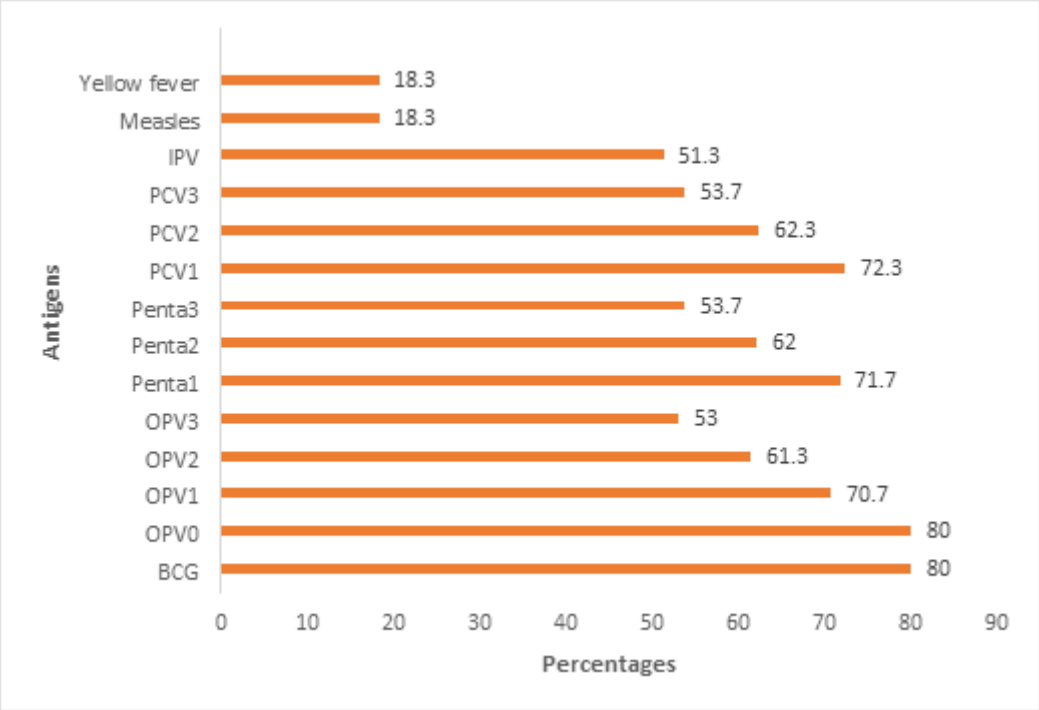

Figure 2: Percentage of children vaccinated at recommended age

Table 3: Other immunization indices among the infants

Indices	Survey Value (%)	LGA (routine) value, 2018 (%)
Drop-out rates		
BCG/Measles	78.8	-
BCG/Yellow fever	78.8	-
OPV_0/OPV_3	35.6	-
PCV_1/PCV_3	25.7	-
$Penta_1/Penta_3$	25.7	8.4
Penta3/Yellow fever	66.1	-
Overall coverage rate	90.3	79.6
*Mean coverage rate	51.9±27.0	

*Average coverage of all vaccines combined

Table 4: Routine immunization facility and vaccination status of infants

Variable	Frequency	Percentages (%) N=300
Facility where vaccinated		
Public health facility	277	92.3
Private health facility	5	1.7
None	18	6.0
Distance from HF to home		
1-5km	290	96.7
>5km	10	3.3
Time taken to reach HF		
≤10 minutes	152	50.7
>10 minutes	148	49.3
Means of accessing HF		
Trek/walk	161	53.7
Motorcycle/bike	118	39.3
Car	21	7.0
Transport Cost to HF (Naira) N=139		
<100	116	83.5
≥100	23	16.5

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Mean =59.7±21.9		
Vaccination status		
Fully immunized for age	210	70.0
Partially immunized for age	61	20.3
Not immunized	29	9.7
If not/partial, give reasons*, N=90		
Lack of information	19	21.4
Fear of side effects	15	16.7
Fear of child getting disease	9	9.5
HCWs' strike action	13	14.3
Vaccine stock-out in HF	24	26.2
Believe vaccines do not work	4	4.8
Religious reasons	6	7.1
HF too far from home	6	7.1
Lack of transport fare to facility	24	26.2
Child was sick or not around	30	33.3
Child vaccination card		
Seen	202	67.3
Not seen	98	32.7
If not seen, give reason*, N=98		
Lost	49	50.0
Misplaced at home	51	52.0
Loss during house theft	12	12.2

***Multiple response; HF= Health Facility**

Table 5: Incidence of and reasons for missed opportunity for child vaccination

Variable	Frequency	Percentages (%) N=300
Missed opportunity for child vaccinations		
Yes	71	23.7
No	229	76.3
If yes, give reasons* N=71		
Monetary	13	18.3
Perception/Attitude	29	40.8
Sickness (child/mother)	6	8.5
Health workers' strike	10	14.1
Vaccine Stock-out	14	19.7

*multiple response

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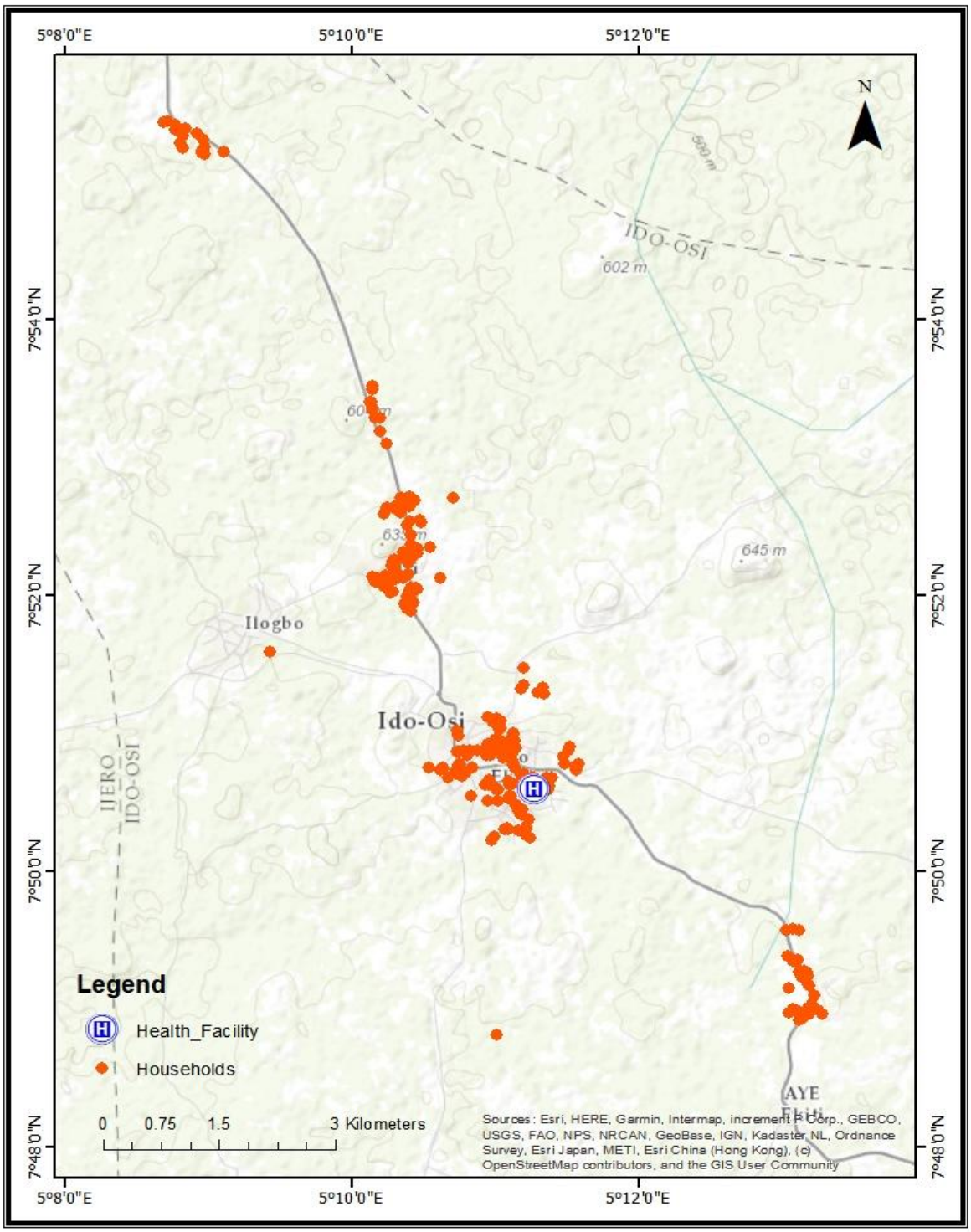

Figure 3: GIS spatial map of geographical accessibility of the households to the Routine Immunization tertiary facility in the study area.

Table 6: Relative Household Wealth Index

Variables	Yes (%)	No (%)	N-300
Ownership of household items			
Television	257 (85.7)	43 (14.3)	
Electric fan	232 (77.3)	68 (22.7)	
DVD/VCD player	208 (69.3)	92 (30.7)	
Electricity	284 (94.7)	16 (5.3)	
Refrigerator	97 (32.3)	203 (67.7)	

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Kaiser-Meyer-Olkin Measure of Sampling Adequacy 0.77	
Bartlett's test of sphericity; χ^2= 372.9; p<0.001	
*HH wealth Quintile	n (%)
Poorest	5 (1.6)
Poor	92 (30.7)
Average	102 (34.0)
Rich	41 (13.7)
Richest	60 (20.0)

***HH=Household**

Table 7: Socio-demographic variables and vaccination status of infants

Variables	Immunized for age				
	Fully (%)	Partially (%)	Not (%)	χ2	p value
Sex of the child					
Male	115 (67.3)	39 (22.7)	17 (10.0)		
Female	95 (73.6)	22 (17.1)	12 (9.3)	1.657	0.437
Age of child (months)					
0-6	134 (72.8)	30 (16.3)	20 (10.9)		
7-12	76 (65.5)	31 (26.7)	9 (7.8)	5.054	0.080
Mean = 5.6±3.6 months					
Age of Mother (years)					
10-19	4 (34.0)	7 (58.0)	1 (8.0)		
20-29	123 (75.0)	27 (16.5)	14 (8.5)		
30-39	77 (68.8)	24 (21.4)	11 (9.8)		
40-49	6 (50.0)	3 (25.0)	3 (25.0)	16.686	0.011
Mean = 28.1±5.1 years					
Age of Father (years)					
20-29	46 (71.9)	13 (20.3)	5 (7.8)		
30-39	113 (74.3)	29 (19.1)	10 (6.6)		
40-49	43 (61.4)	16 (22.9)	11 (15.7)		
50-59	7 (58.3)	2 (16.7)	3 (25.0)		
≥60	1 (50.0)	1 (50.0)	0(0.0)	10.293	0.245
Mean = 34.8±7.3 years					
Marital status (mother)					
Single/never married	8 (61.5)	1 (7.7)	4 (30.8)		
Ever Married	178 (70.9)	54 (21.5)	19 (7.6)		
Cohabiting	24 (66.0)	6 (17.0)	6 (17.0)	11.429	0.179
Family setting					
Monogamy	184 (71.0)	53 (21.0)	21 (8.0)		
Polygamy	18 (62.0)	7 (24.0)	4 (14.0)		
Single parent	8 (61.5)	1 (7.7)	4 (30.8)	8.813	0.066
Religion					
Islam	29 (61.7)	11 (23.4)	7 (14.9)		
Christianity	179 (71.3)	50 (19.9)	22 (8.8)		
Traditional	2 (100.0)	0 (0.0)	0 (0.0)	3.160	0.531

Table 8: Socio-demographic variables and vaccination status of infants…cont'd

Variables	Immunized for Age				
	Fully (%)	Partially (%)	Not (%)	χ2	p value
Level of Education (mother)					
No formal education	4 (26.7)	6 (40.0)	5 (33.3)		
Primary	21 (75.0)	2 (7.1)	5 (17.9)		
Secondary	118 (72.0)	33 (20.1)	13 (7.9)		
Tertiary	67 (72.0)	20 (21.5)	6 (6.5)	21.727	0.001

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Level of Education (father)					
No formal education	3 (43.0)	3 (43.0)	1 (14.0)		
Primary	12 (63.2)	3 (15.8)	4 (21.0)		
Secondary	99 (68.8)	28 (19.4)	17 (11.8)		
Tertiary	96 (73.8)	27 (20.8)	7 (5.4)	9.028	0.172
Ethnicity					
Yoruba	175 (70.9)	53 (21.5)	19 (7.6)		
Hausa/Fulani	1 (20.0)	3 (60.0)	1 (20.0)		
Igbo	3 (75.0)	0 (0.0)	1 (25.0)		
Ebira	27 (73.0)	4 (10.8)	6 (16.2)		
Tiv/Urobo/Idoma	4 (57.1)	1 (14.3)	2 (28.6)	15.401	0.052
Mother's occupational status					
Employed	189 (69.0)	58(21.0)	27 (10.0)		
Unemployed	21 (80.8)	3 (11.5)	2 (7.7)	1.669	0.434
Father's occupational status					
Employed	197 (70.6)	54 (19.4)	28 (10.0)		
Unemployed	13 (61.9)	7 (33.3)	1 (4.8)	2.650	0.266
Parity					
1-5	141 (66.5)	48 (22.6)	23 (10.9)		
>5	69 (78.4)	13 (14.8)	6 (6.8)	4.197	0.123
Birth order (index child)					
Last child	145 (71.8)	39 (19.3)	18 (8.9)		
First child	65 (66.3)	22 (22.5)	11 (11.2)	0.966	0.617
Place of delivery of child					
Health facility	112 (70.4)	36 (22.6)	11 (7.0)		
At Home	16 (50.0)	6 (18.8)	10 (31.2)		
Religious homes	70 (76.1)	17 (18.5)	5 (5.4)		
Traditional home	12 (70.6)	2 (11.8)	3 (17.6)	23.034	0.001
Number in Household					
≤5	159 (71.3)	43 (19.3)	21 (9.4)		
>5	51 (66.2)	18 (23.4)	8 (10.4)	0.738	0.692

Table 9: Availability of vaccination card, distance to health facility, routine immunization facility and vaccination status

Variables	Immunized for Age				
	Fully (%)	Partially (%)	Not (%)	$\chi 2$	p value
Household income (N)					
<18, 000	80 (73.4)	16 (14.7)	13 (11.9)		
≥18, 000	130 (68.1)	45 (23.6)	16 (8.3)	3.878	0.144
HH wealth Quintile					
Poorest	3 (60.0)	0 (0.0)	2 (40.0)		
Poor	60 (65.2)	26 (28.3)	6 (6.5)		
Average	74 (72.5)	19 (18.6)	9 (8.9)		
Rich	30 (73.2)	6 (14.6)	5 (12.2)		
Richest	43 (71.7)	10 (16.7)	7 (11.6)	11.902	0.156
Having vaccination card					
Yes	194 (71.3)	57 (21.0)	21 (7.7)		
No	16 (57.1)	4 (14.3)	8 (28.6)	12.072	0.002
Distance to HF (km)					
1-5	204 (69.9)	60 (20.6)	28 (9.5)		
>5	6 (75.0)	1 (12.5)	1 (12.5)	0.346	0.841
RI facility					
Public HF	197 (71.1)	57 (20.6)	23 (8.3)		
Private HF	4 (80.0)	0 (0.0)	1 (20.0)		
None	9 (50.0)	4 (22.2)	5 (27.8)	9.399	0.052

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Means of accessing RI Facility					
Trek/Walk	118 (73.3)	28 (17.4)	15 (9.3)		
Motorcycle/Bicycle	77 (65.3)	29 (24.6)	12 (10.1)		
Car	15 (71.4)	4 (19.1)	2 (9.5)	2.434	0.657
Time taken to RI facility					
≤10 minutes	114 (75.0)	25 (16.5)	13 (8.5)		
>10 minutes	96 (64.9)	36 (24.3)	16 (10.8)	3.784	0.151
Transportation cost to RI facility (Naira) N=139					
<100	78 (67.2)	25 (21.6)	13 (11.2)		
≥100	15 (65.2)	7 (30.4)	1 (4.4)	3.009	0.556

HF=Health Facility; RI=Routine Immunization; HH=Household

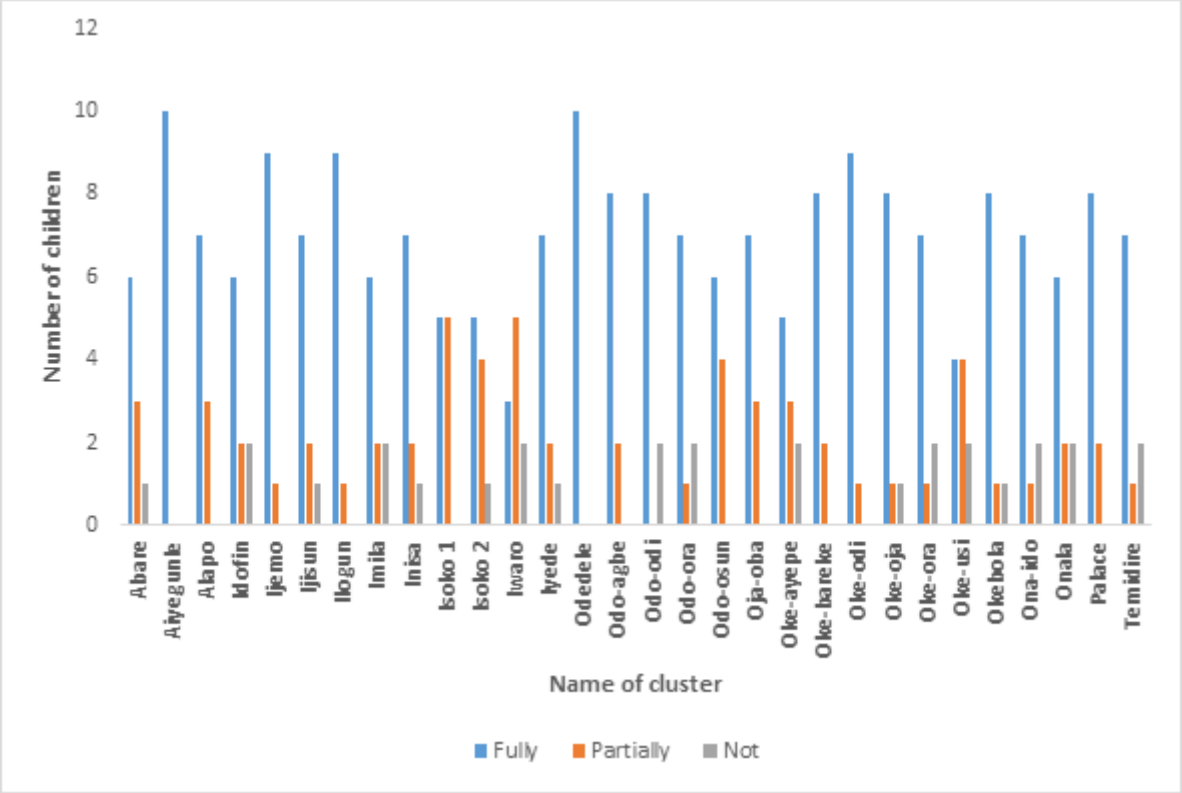

Figure 4: Distribution of vaccination status of children by Cluster (p=0.338)

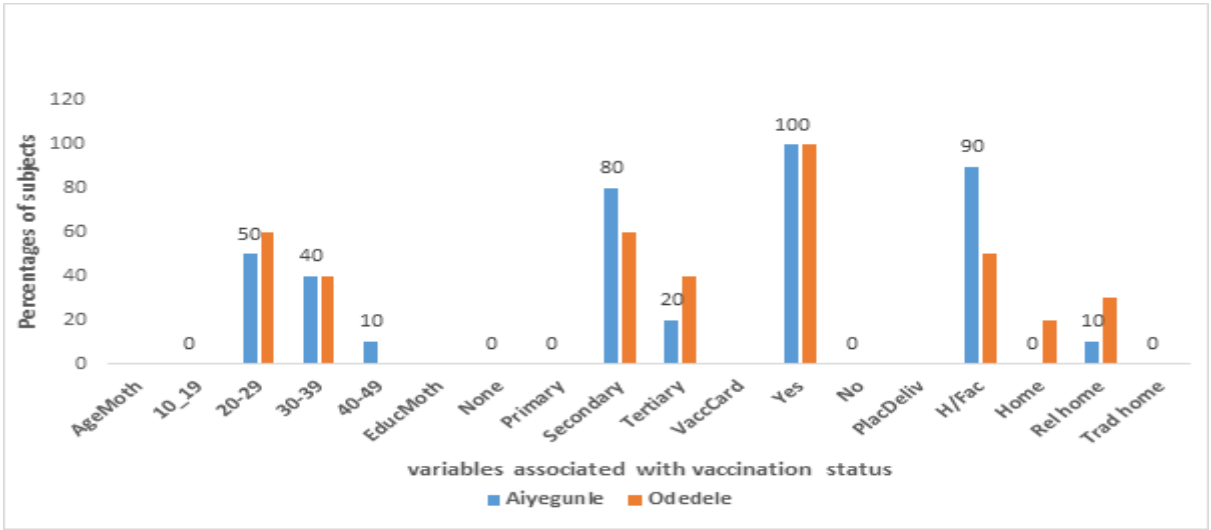

Figure 5: Analysis of variables associated with vaccination status (Aiyegunle and Odedele)

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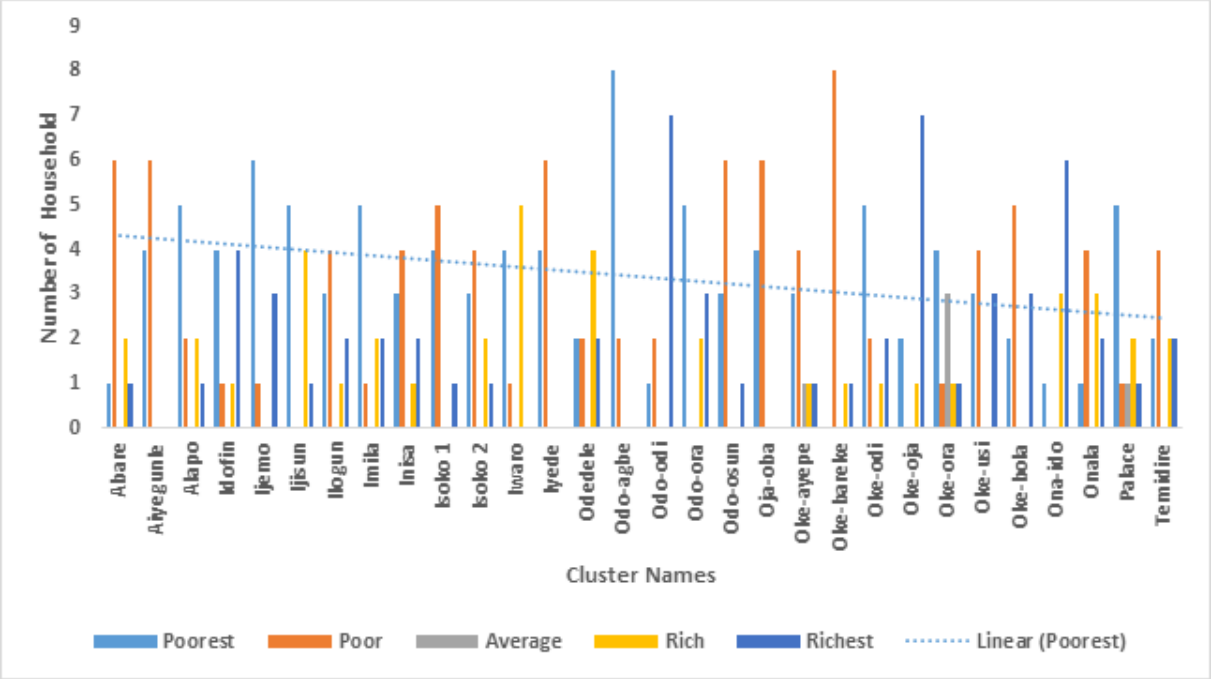

Figure 6: Distribution of household wealth quintile by Cluster ($p<0.001$)

Table 10: Ordinal Logistic regression showing the predictors of routine vaccination status of the infants

Variables in the equation	β	SE	OR	p values
Age of mother	0.228	0.196	1.344	0.246
Level of education (mother)	0.390	0.358	5.154	0.023*
Place of delivery of child	0.128	0.127	1.020	0.313
Having vaccination card	0.654	0.419	2.443	0.118

β= Regression co-efficient; SE= Standard error; *significant predictor; OR=Odds ratio