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MODELLING OF ACCESS TO MOSQUITO TREATED NET IN NIGERIA: USING MULTILEVEL LOGISTIC REGRESSION APPROACH

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ABSTRACT

This research examined the current status of access to Mosquito Treated Net (MTN) for children under five years in Nigeria. Despite the National malaria elimination programme recommendation of long-lasting insecticide treated net as the cornerstone of malaria prevention in Nigeria, there exist disparity in access to this MTN. The data for the study was extracted from the 2018 National Demographic Health Survey (NDHS). Descriptive statistic was adopted to describe and explain the effects of the variances present in the study on the variables of interest using STATA15 software are presented. The results reveal that out of the 8627 household with under five children considered in the analysis 7431 (86.14%) have access to MTN while 1196 (13.86%) have no access to MTN at the time of data collection. The wealth index of parents, educational attainment and regions were found to be the major determinants of under-5 access to MTN in Nigeria. The results also reveals that the null random intercept model best fit the data. The intra- class-correlation coefficient reveals a regional variation in the numbers of under-5 that have access to MTN across geopolitical zones in Nigeria. The result shows a statistically significant result for the random intercepts at 5% level of significance with a variation of 0.044154. The estimate of the intra-class-correlation coefficient indicates a total variability of 0.2051(20.51%). The research concludes that wealth index, educational attainment and region are the major determinants of access to MTN in Nigeria.

Keywords: Mosquito treated net, multilevel, logistic regression

INTRODUCTION

Because of the number of deaths reported each year, malaria continues to be the top concern for many health interventions around the world, especially in sub-Saharan Africa. The World Health Organization (WHO) estimates that 97% of Nigerians are at risk for malaria, with pregnant women and children under five being the most vulnerable. The majority of people on earth reside in nations where malaria is prevalent or at risk of spreading. According to the WHO, there were 212 million cases of malaria worldwide in 2015 (and 627,000 deaths). 90% of the cases and 92% of the fatalities occurred in Africa, and over 75% of the fatalities involved children under the age of five (WHO, 2017). The 2019 world malaria day found that no significant gains were made in reducing malaria cases in the period 2015 to 2017, and that the estimated number of malaria deaths in 2017, which stood at 435,000, remained virtually unchanged over the years across the world with 266,000 (66%) of these deaths in children aged under 5 years. Among these deaths, sub-Saharan Africa counted for about 93% of all deaths in 2017 (WHO, 2019). Nigeria accounted for 52% of the 110 million malaria cases in the West Africa region in 2016 (WHO, 2017).

The most economical method of preventing malaria is using insecticide-treated nets (ITNs), which includes long-lasting insecticidal nets (LLIN). In order to increase ITN distribution in malaria-prone areas, mass distribution campaigns are advised by WHO, who acknowledges this approach as the primary preventive tool (WHO, 2017). Through the National Malaria Elimination Programme (NMEP), it continues to be the cornerstone of the fight against malaria in Nigeria (NMEP, 2015). The Federal Ministry of Health (FMOH), 2014, states that the goal of Nigeria's 2014–2020 National Malaria Strategic Plan is to bring the country's malaria burden down to pre–elimination levels and eliminate all malaria-related deaths by that year. Although an integrated management approach is said to be the best for malaria control, the insecticide-treated net is however considered as the most efficacious of all the currently feasible interventions for malaria control in Africa (Lengeler, 2000).This explains the current efforts at providing free Insecticide Treated Nets to vulnerable groups as part of the attainment of the Millennium Development Goals (MDGs),and the recognition by the Nigerian government that , access to Insecticide Treated Nets to all vulnerable Nigerians is important (FMOH, 2009). The African Malaria report shows that many countries are quite far from reaching the target of 60% Insecticide Treated Nets coverage in Sub-Saharan African countries by the year 2015 which was set in Abuja by the African Heads of State (NMEP, 2015).

In sub-Saharan Africa, notably in Nigeria, ownership and use of insecticide-treated nets are still low among various socioeconomic categories. Insecticide-treated net ownership, use, and inequality in Nigeria have all been addressed through various initiatives, including recent Federal Government of Nigeria free distribution programs (Grabowsky et al., 2007). From 33% in 2010 to 56% in 2017, the percentage of the population with access to an ITN rose.However, coverage has stagnated since 2016 and has only slightly improved since 2015. Between 2010 and 2017, the proportion of households with at least one ITN for every two persons quadrupled to 40%. But with only a slight gain over the previous three years, this number is still far from the goal of universal coverage (WHO, 2017).

Numerous studies have been done on the variables influencing availability to and usage of long-lasting insecticide nets in Nigeria. Babalola et al. (2018)'s study on the variables influencing caregivers' consistency in using bed nets in Nigeria is particularly noteworthy. Alawode et al. (2019) found the same things in their study, which involved a multilevel multinomial analysis of survey data. These characteristics included sociodemographic and household variables, which are related with utilizing a bed net every

night as opposed to rarely or never doing so. The assessment of the utilization of Insecticide Treated nets (ITNs) in Calabar Metropolis, Cross River State, Nigeria found out that utilization of ITNs recorded in the study of Komomo *et al* (2016) is similar to the study carried out by Blackburn *et al*. (2006) in Nigeria, which showed that despite high rates of household ownership of ITNs, only a few make proper use of it. Some findings also show that negative perceptions on ITNs are held by most people who have not used them and do not have first-hand experience Chukwuocha *et al* (2010).

Despite the large amount of research done in this field, only a small portion of it is from Nigeria, and the researchers are mainly interested in evaluating the factors that affect caregivers' or pregnant women's regular use of LLIN without taking those people's interactions in groups (levels) into account.This may be the reason why both government and non-governmental organizations are investing more in the purchase of LLIN to reach every household, which is considered to be the most effective way of preventing malaria for people at risk of malaria. The WHO has set a goal for all people at risk of malaria, including Nigeria, to have universal access to and use of LLINs since 2011, but the goal has not yet been met in Nigeria. That is why we still have increasing cases of malaria deaths in the country on a yearly basis.

If effective interventions like long-lasting insecticide-treated nets (LLINs) to prevent malaria are made widely accessible, millions of lives could be saved from malaria episodes and fatalities. The majority of families in the country have received safety nets from the government, but many of the recipients aren't using them properly. While many programs have reported successful LLIN utilization following mass distribution, there is concern that LLINs distributed for free in mass exercises may not always be used for the purpose that was intended. The evaluation of LLIN utilization following mass distribution has provided a mixed picture. The World Health Organization (2011) states that all individuals at risk of malaria, especially children under the age of five in Nigeria, should continue to have access to and use LLINs. This study therefore intends to assess the current situation for access to Mosquito Treated Net and the use of Mosquito Treated Nets (MTN) in Nigeria using Multilevel Logistic Regression (MLR) to check the variability across different regions/units in Nigeria on the determinants of access to Mosquito Treated Net for under 5 children.

METHODOLOGY

Data

The data used was obtained from National Demographic Health Survey (NDHS) in 2013. The information on individuals that participated in the survey was extracted for use in this study. The sample size was 8627. The sample was design to provide population and health indicator estimates at the national, zonal and state levels. The sample indicators allow for specific indicators to be calculated for each of the 6 zones. The data was analyzed using a two level multilevel Logistic regression model.

Multilevel Regression Model

A two-level modeling framework was implemented in this study. The first level was the individual level. The second level is the regional (zone) level, this level is made up of the 6 geopolitical zones (North Central, North East, North West, South East, South West and South South) in Nigeria containing individuals in level I model. The variables measured include the following:

Y_{ij} = Access to Mosquito Treated Net. (Categories: 0-No and 1-Yes)

X_{1ij} = Health insurance cover. (Categories: 0-No and 1-Yes)

X_{2ij} = Residence. (Categories: 0-Rural and 1-Urban)

X_{3ij} = Wrong believes about the use of MTN. (Categories: 0-No and 1-Yes)

X_{4ij} = Educational attainment. (Categories: 0- None, 1-Incomplete Primary, 2-Complete Primary, 3-Incomplete Secondary, 4-Complete Secondary and 5-Tertiary)

X_{5ij} = Wealth Index. (Categories: 0-Poor, 1-Middle class and 2-Rich)

X_{6ij} = Region (zones) (Categories: 0-North Central, 1-North East, 2-North West, 3-South East, 4-South West, 5-South South)

The first step in the evaluation of multilevel models is to compare an ‘‘unconditional” null model without independent variables and fixed intercepts to a null model with intercepts considered as random effects. The model likelihood ratio test was applied to decide whether the introduction of random intercepts make improvements or not. The first model (I) includes intercept and slope effects at individual level.

The null intercept model for the outcome variable Y_{ij} for the i^{th} individual in the j^{th} group (zone) without the inclusion of the independent variables is represented by;

$$Y_{ij} = \beta_{0j} \quad (1)$$

Where β_{0j} is the average intercept for the null model

The outcome Y_{ij} for case i^{th} individual in the j^{th} group (zone) with the inclusion of the explanatory variablesis represented as:

$$Y_{ij} = \beta_{0j} + \sum_{p=1}^{P} \beta_{pij} X_{pij} + e_{ij} \qquad where,\ p = 1,2,...,P = 6 \quad (2)$$

Where β_{pij} are the level-1 coefficients, with the corresponding level-1 predictors X_{pij}, e_{ij} is the residual at the individual level.

The second model (II) combined individual level model (I), and Zonal-dependent intercept β_{0j} which is further divided into an average intercept β_{p0} and the Zonal-dependent deviation r_{pij}

$$Y_{ij} = \beta_{p0} + \sum_{q=1}^{Q} \beta_{pq} X_{pij} + r_{pij} + \sum_{p=1}^{P} \beta_{pij} X_{pij} + e_{ij} \quad (3)$$

Where, β_{pq} are Zone level (level-II) coefficients, X_{pij} level 2 predictors, and r_{pij} is the

Level-II residuals (random effect)

The intra class correlation coefficient was calculated by first estimating an intercept only model and then using the first level variance and the second level random intercept estimate to obtain the Intra-class Correlation Coefficient (ICC) as,

$$\psi = \frac{\sigma_{u0}^2}{\sigma_e^2 + \sigma_{uo}^2} \quad (4)$$

Where,

σ_{u0}^2 = Zone Model Variance (level II)

σ_e^2 = Error or Individual Model variance (level I)(Adeniyi *et al*, 2017)

Multilevel Logistic Regression Model

Multilevel statistical approach was used to model the relation between access to/use of Mosquito Treated Nets (MTN) and the explanatory variables. Two levels of data hierarchy were stated (for instance under 5 year child using MTN and Zone) in a multilevel logistic regression model. Under-5 year children (level I) are nested within the zones (level II) the next higher level. In this study the basic data structure of the two-level logistic regression is a collection of J groups (Zones) and within-group j (j=1,2,…,J), a random sample n_j of level I units (under-5 year child using MTN). The response variable is denoted by;

$$Y_{ij} = \begin{cases} 1 & if\ the\ i^{th}\ under\ 5\ child\ in\ the\ j^{th}\ Zone\ is\ using\ MTN \\ 0 & if\ the\ i^{th}\ under\ 5\ child\ in\ the\ j^{th}\ Zone\ is\ not\ using\ MTN \end{cases} \quad (5)$$

With the probabilities, $P_{ij} = \mathrm{P}\left(Y_{ij} = 1/X_{ij}, U_{ij}\right)$ is the probability of not using MTN for the i^{th} under 5 child in the j^{th} Zone and 1- $P_{ij} = P\left(Y_{ij} = 0/X_{ij}\right)$ is the probability of using MTN for the i^{th} under 5 child in the j^{th} Zone.

The Random Intercept Model

The Random intercept model is used to model unobserved heterogeneity in the overall response by introducing random effects (Snijders & Roel, 1999). The random intercept model expresses the log-odds, i.e. the logit of P_{ij}, as a sum of a linear function of the explanatory variables. That is,

$$\log\left(P_{ij}\right) = \log\left(\frac{P_{ij}}{1-P_{ij}}\right) = \beta_{0j} + \beta_1 X_{1ij} + \beta_2 X_{2ij} + \ldots + \beta_k X_{kij}, i = 1,2,\ldots,n;\ j = 1,2,\ldots,J = 6 \quad (6)$$

Where the intercept term β_{0j} is assumed to vary randomly and is given by the sum of an average intercept β_0 and group dependent random errors μ_{0j}, that is,

$\beta_{0j} = \beta_0 + \mu_{0j}$

As a result where

$$\mathrm{Logit}\left(P_{ij}\right) = \beta_0 + \sum_{h=1}^{k} \beta_h X_{hij} + \mu_{0j} \quad (6)$$

Where $\beta_0 + \sum_{h=1}^{k} \beta_h X_{hij}$ is the fixed part of the model. The remaining μ_{0j} is called the random part of the model. It is assumed that the residual μ_{0j} is mutually independent and normally distributed with mean zero and variance σ_0^2

The Random Coefficient Model

The random coefficients build up on the random intercept model by allowing the effects of individual predictors to vary randomly across level-II, that is, level-I slope coefficients are allowed to take on different values in different aggregate groupings. In the random coefficient model both the intercepts and slopes are allowed to differ across the Zones. It is given by;

$$\log\left(P_{ij}\right) = \log\left(\frac{P_{ij}}{1-P_{ij}}\right) = \beta_0 + \sum_{h=1}^{k} \beta_h X_{hij} + \mu_{0j} + \sum_{h=1}^{k} \mu_{1j} X_{1ij} \quad (7)$$

as described by Teshita (2018)

RESULTS

The intercept only model

This model contains no explanatory variables to determine the average proportion of under-5children with access to MTN in Nigeria. Table 4.2 shows that about 16.09% do not have access to MTN on average, it also shows that there is a significant difference in access to MTN among under-5 children in Nigeria at 5% level of significance since the p-value = 0.000<0.05, that is not all Under-5 children have access to MTN in Nigeria and thus, multilevel analysis can be considered as an appropriate approach for further analysis.

Table 1: Result of a multilevel logistic regression without explanatory variables.

Under 5 year child	Odd	Standard error	z-value	p-value	95%CI	
					Lower	Upper
Constant	.1609474	.0050145	-58.63	.0000*	.1514133	.1710818

*P-Value<0.05 level of significance

The random intercept and fixed coefficient of the individual and zonal levels multilevel logistic regression model

This model includes the individual level (level-I) and the zonal level (level-II) variables to access the variation of each variable in the model. Table 4.3 shows the regression estimate of the individual level predictors and the random intercept. The table also indicates the variation of 13.89% average access which indicates that individual level variables are responsible for the variation in access to MTN at 5% level of significance since the random intercept p-value = 0.000<0.05. The Table 4.3 also indicates that only educational attainment is statistically significant at 5% level of significance. The result reveals in particular that the parents of children who have completed primary education are 0.280738 times more likely not to have access to MTN than the parents that has no education, the parents with incomplete secondary education is 0.515544 times more likely not having access to MTN than those that have no educational attainment, the parents that have completed secondary education ware 0.454178 times more likely not to have access to MTN than those parents that have no educational attainment and the parents who have attained tertiary education are 0.528081 times more likely not to have access to MTN than those whose parents have no educational attainment while the health insurance cover, wrong belief about the use of MTN and the residence are not significant for Under 5 year children to have access to MTN in Nigeria.

Table 2: Result for random intercept with the inclusion of fixed coefficients of the individual (level-I) variables.

Variables	Categories	Odds	Standard error	Z-value	P-value	95%CI	
						Lower	Upper
Health Insurance Cover	No(Ref)						
	Yes	.7413199	.1725393	-1.29	0.198	.4697771	1.169821
Wrong belief about the use of MTN	No(Ref)						
	Yes	1.140968	0.923013	1.63	0.103	.9736735	1.337006
Residence	Urban(Ref)						
	Rural	.9343686	.0768382	-0.83	0.409	.7952787	1.097785
Wealth index	Poor(Ref)						
	Middle class	1.135763	.1046188	1.38	0.167	.9481579	1.360488
	Rich	.8907146	.0955209	-1.08	0.281	.7218634	1.099062
Educational attainment	None						
	Incomplete primary	1.264009	.1743481	1.70	0.089**	.9645873	1.656374
	Complete primary	1.280738	.1287764	2.46	0.014*	1.051655	1.559723
	Incomplete secondary	1.515544	.1728446	3.65	0.000*	1.211967	1.895161
	Complete secondary	1.454178	.162341	3.35	0.001*	1.168399	1.809854
	Tertiary	1.528081	.2228467	2.91	0.004 *	1.148185	2.033671
Constants		.13885	.0131014	-20.92	0.000*	.1154062	.1670561

*P-Value<0.05 level of significance, **P-Value<0.1 level of significance

The result of Table 4.4 shows the inclusion of the second level variable that is the zones (regions). The table reveals that 17.80% variation in the inclusion of regions and it has clearly shown that it is statistically significant at 5% level of significance since the p-value = 0.000<0.05 and a non-zero inclusion in the confidence interval suggesting that under 5 year child access to MTN with the same characteristics in different zones have different access status in Nigeria. That is, there is a clear regional (zonal) effect. The result of the analysis also reveals that wealth index, educational attainment levels and the regions (zones) are statistically significant at 5% significance level since one or more of the category's p-values<0.05.

The analysis reveals that with the inclusion of the second level variable (zones), the parents of under 5 year children who are rich was .7986443 times less likely to have access to MTN than the children whose parents are poor, the parents of children who have incomplete secondary, complete secondary and tertiary education was respectively 0.388279, 0.320725 and 0.359503 times more likely to have access to MTN than those whose parents have no education. It also shows that only the North east zone has a significant effect in Under 5 year children having access to MTN in Nigeria with the odds of 0.5542985 that of the North Central (reference category).

Table 3: Result for random intercept with the inclusion of regional level (level-II) factors.

Variables	Categories	Odds	Standard error	Z-value	P-value	95%CI	
						Lower	Upper
Health Insurance Cover	No(Ref)						
	Yes	.7605117	.1777991	-1.17	0.242	.4809552	1.202561
Wrong belief about the use of MTN	No(Ref)						
	Yes	1.11884	.091233	1.38	0.168	.9535838	1.312735
Residence	Urban(Ref)						
	Rural	.9558328	.0813227	-0.53	0.595	.8090239	1.129282
Wealth index	Poor(Ref)						
	Middle class	1.05582	.1005037	0.568	0.57	.8761209	1.272378
	Rich	.7986443	.090077	-1.99	0.046	.6402486	.9962266
Educational attainment	None(Ref)						
	Incomplete primary	1.204905	.1704715	1.32	0.188	.9131111	1.589944
	Complete primary	1.173225	.1238802	1.51	0.130	.9539013	1.442976

	Incomplete secondary	1.388279	.1671719	2.72	0.006*	1.096422	1.757825
	Complete secondary	1.320725	.1561513	2.35	0.019*	1.047548	1.665142
	Tertiary	1.359503	.2065026	2.02	0.043*	1.009454	1.830939
Regions	North central(Ref)						
	North east	.5542985	.0644292	-5.08	0.000*	.441371	.6961191
	North west	.8398636	.0841484	-1.74	0.082**	.6901196	1.022099
	South east	1.127519	.1582056	0.86	0.392	.8564249	1.484426
	South south	.9158656	.1072996	-0.75	0.453	.7279607	1.152273
	South west	1.101385	.1259605	0.84	0.398	.8802197	1.378121
Constants		.1779986	.023549	13.05	0.000*	.137342	.2306904

*P-Value<0.05 level of significance, **P-Value<0.1 level of significance

The result displayed in the Table 4.5 shows the result of varying intercept with individual level variables and the Regional level coefficients and an Intra-class Correlation Coefficient (ICC) is estimated as, 0.044154/ (0.044154 + .1609474) =0.2051, which indicates that it is statistically significant at 5% level of significance which means that 20.51% of the total variability in under 5 year children that does not have access to MTN is due to the difference across the zones, with the remaining unexplained 79.49% attributed to individual differences.

The Table 4.5 also reveals that the wealth index and educational attainment are found to be significant determinants and also the factors that contributed to the variation in access to MTN across the zones of the under 5year children in Nigeria. The result from the multilevel logistic regression analysis reveals that wealth index of parents of under 5 year child is statistically significant at 5% level of significance, the table shows that the under 5 year children that their parents are rich was 0.7986443 times less likely (OR =0 .7986443.CI= (0.6402486, 0.9962266) not to have access to MTN than the under 5 year children whose parents are poor and the parents of under 5 year children that are middle rich was 0.05582 times (OR= 1.05582. CI= (0.8761209, 1.272378) more likely not to have access to MTN than those whose parents are poor. Also the educational attainment of parents of under 5 year children has been found to be statistically significant at 5% level of significance. Here the under 5 year child parent who have incomplete secondary education was 0.420918 (OR=1.420918 CI(1.123431, 1.797181)) times more likely not to have access to MTN for their under 5 year child than those whose parents have no education, the parents that have completed secondary education was 0.353672 times(OR= 1.353672,CI(1.074727, 1.705017)) more likely not to have access to MTN for their children than those with on education attainment and the parents that have attained tertiary education was 0.398173 times (OR=1.398173, CI(1.038716, 1.882022)) more likely not to have access to MTN than the parents with no education attainment.

Table 4: Result of varying random intercept with the regional level coefficient

Variables	**Categories**	**Odds**	**Standard deviation**	**Z-value**	**P-value**	**95% C I**	
						Low	**Upper**
Health Insurance Cover	No(Ref)						
	Yes	.7605117	.1777991	-1.17	0.242	.4809552	1.202561
Wrong belief about the use of MTN	No(Ref)						
	Yes	1.11884	.091233	1.38	0.168	.9535838	1.312735
Residence	Urban(Ref)						
	Rural	.9558328	.0813227	-0.53	0.595	.8090239	1.129282
Wealth index	Poor(Ref)						
	Middle class	1.05582	.1005037	0.57	0.568	.8761209	1.272378
	Rich	.7986443	.090077	-1.99	0.046*	.6402486	.9962266
Educational attainment	None(Ref)						
	Incomplete primary	1.222508	.1724418	1.42	0.154	.9272244	1.611828
	Complete primary	1.197372	.1260177	1.71	0.087**	.9741907	1.471682
	Incomplete secondary	1.420918	.1703074	2.93	0.003*	1.123431	1.797181
	Complete secondary	1.353672	.1593731	2.57	0.010*	1.074727	1.705017
	Tertiary	1.398173	.2119987	2.21	0.027*	1.038716	1.882022
Constants		.1550546	.0213769	-13.52	0.000*	.1183402	.2031595
Region var(cons)		.044154	.0310586			.011123	.1752745

*P-Value<0.05 level of significance, **P-Value<0.1 level of significance

CONCLUSION

Based on the results of the analysis in this research work we have found out that the random intercept model with the inclusion of regions (level-II) variable is the best model in classical multilevel logistic regression for modeling the determinants of access to MTN in Nigeria among the classical multilevel models considered in the analysis. The result of the analysis from Table 4.4 shows that wealth index of parents, educational attainment and regions (zones) are the major determinates of under 5 children to have access to MTN in Nigeria. We also found out that the parents whom are rich have more chances of having access to a Mosquito Treated Net for under 5children in Nigeria when compared with the poor parents. We further found out that the under 5 children with parents having secondary education and tertiary education attainment have more access to MTN for their children when compared with children whose parents have no education attainment. We also found out that "Region" is an important determinant in access to MTN in Nigeria for under 5 children, in particular the North Eastern region.

We also found out that Intra-class Correlation Coefficient (ICC) is estimated to be 0.2051 which is also statistically significant at 5% level of significance which means that 20.51% of the total variability in under 5 children that have access to MTN is due to the difference across the zones, with the remaining unexplained 79.49% attributed to individual differences.

In using the classical multilevel logistic regression for access to Mosquito Treated Net in Nigeria found that the odds of under 5 children using MTN was significantly associated with wealth index of parents and educational attainment of parents in the individual level also the rich parents and parents who have secondary, and tertiary education were found to be significant factors for under 5 children to have access to Mosquito Treated Net. The study also shows that the geopolitical zones (region) vary in access to Mosquito Treated Net in Nigeria. North east shows a significant effect in access to Mosquito Treated Net.

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