PLOS ONE

RESEARCH ARTICLE

Use of insecticide treated nets in children under five and children of school age in Nigeria: Evidence from a secondary data analysis of demographic health survey

Chinazo N. Ujuju[1]*, Chukwu Okoronkwo[2], Okefu Oyale Okoko[2], Adekunle Akerele[3], Chibundo N. Okorie[4], Samson Babatunde Adebayo[5]

1 Data for Decisions Nigeria Ltd, Abuja, Nigeria, **2** National Malaria Elimination Programme (NMEP), Federal Ministry of Health, Abuja, Nigeria, **3** Department of Medical Statistics and Epidemiology, University of Ibadan, Ibadan, Nigeria, **4** Department of Pharmaceutical Microbiology and Biotechnology, Faculty of Pharmaceutical Sciences, University of Nigeria, Nsukka, Enugu, Nigeria, **5** National Agency for Food and Drug Administration & Control, Lagos, Nigeria

* Chinazoujuju@gmail.com

OPEN ACCESS

Citation: Ujuju CN, Okoronkwo C, Okoko OO, Akerele A, Okorie CN, Adebayo SB (2022) Use of insecticide treated nets in children under five and children of school age in Nigeria: Evidence from a secondary data analysis of demographic health survey. PLoS ONE 17(9): e0274160. https://doi.org/10.1371/journal.pone.0274160

Editor: Clement Ameh Yaro, University of Uyo, NIGERIA

Received: January 30, 2022

Accepted: August 23, 2022

Published: September 29, 2022

Peer Review History: PLOS recognizes the benefits of transparency in the peer review process; therefore, we enable the publication of all of the content of peer review and author responses alongside final, published articles. The editorial history of this article is available here: https://doi.org/10.1371/journal.pone.0274160

Data Availability Statement: The data underlying the results presented in this study are available on

Abstract

Background and objective

Use of insecticide treated nets (ITN), one of the most cost-effective malaria interventions contributes to malaria cases averted and reduction in child mortality. We explored the use of ITN in children under five (CU5) and children of school age to understand factors contributing to ITN use.

Methods

A cross-sectional study analyzed 2018 Nigeria Demographic and Health Survey data. The outcome variable was CU5 or children of school age who slept under ITN the night before the survey. Independen*t* variables include child sex, head of household's sex, place of residence, state, household owning radio and television, number of household members, wealth quintile, years since ITN was obtained and level of malaria endemicity. Multi-level logistic regression model was used to access factors associated with ITN use among children.

Results

In total, 32,087 CU5 and 54,692 children of school age were examined with 74.3% of CU5 and 57.8% of children of school age using ITN the night before the survey. While seven states had more than 80% of CU5 who used ITN, only one state had over 80% of school children who used ITN. ITN use in CU5 is associated with living in rural area (aOR = 1.20, 95% CI 1.14 to 1.26) and residing in meso endemic area (aOR = 3.1, 95% CI 2.89 to 3.54). While In children of school age, use of ITN was associated with female headed households (aOR = 1.14, 95% CI 1.09 to 1.19), meso (aOR = 3.17, 95% CI 2.89 to 3.47) and hyper (aOR =

DHS program website https://www.dhsprogram.com/data/.

Funding: The authors received no funding for this work.

Competing interests: The authors have declared that no competing interest exist.

14.9, 95% CI 12.99 to 17.07) endemic areas. Children residing in larger households were less likely to use ITN.

Conclusions

This study demonstrated increased use of ITN in CU5 from poor households and children living in rural and malaria endemic areas. Findings provide some policy recommendations for increasing ITN use in school children.

Introduction

Malaria remains a global public health problem with 229 million malaria cases and 409 malaria related death reported globally in 2019 [1]. Sub-Saharan African countries contribute 85% of the malaria cases globally with Nigeria accounting for 27% of the global malaria cases and 23% of global malaria deaths [1]. Nigeria, home of over 200 million people, has the majority of her population at high risk of malaria. Prevalence of malaria in children under five (CU5) is more than 50% in Kebbi state while Lagos, Imo and Anambra state have prevalence less than 10%. The remaining 32 states and the Federal Capital Territory have prevalence between 11% and 50% [2]. The prevalence of malaria among CU5 in Nigeria decreased from 27% in 2015 to 23% in 2018 [2]. Recent studies in sub-Saharan Africa revealed an increased malaria parasitaemia in school children [3–5]. Some published and unpublished studies in Nigeria have reported increased prevalence of malaria in children of school age. For instance, a study conducted in Bayelsa state reported higher prevalence of malaria among children 6–8 years old [6]. Another study conducted in Plateau and Abia states reported high prevalence among children 5–9 years [7]. While malaria in children of school age is not associated with severity, absenteeism from school and anaemia is common among this age group [8, 9].

Several interventions have been deployed globally to tackle morbidity and mortality due to malaria. These include prompt diagnostic tests to confirm malaria prior to treatment with artemisinin-based combination therapy (ACT), prevention of malaria in pregnant women, seasonal malaria chemoprevention in children 3–59 months and vector control using insecticide treated nets and in-door residual spraying. Vector control is one of the most important approaches for eradicating malaria as it aims to interrupt malaria transmission. While all these aforementioned interventions have been found to be effective, implementation has substantial cost implications [10, 11]. Consequently, insecticide treated net (ITN) use has been identified as the most cost-effective malaria intervention and has largely contributed to over 50% of malaria cases averted and reduction of child mortality by 27% [12, 13].

To harness the benefits of ITNs, increase population access to ITN and rapidly achieve universal coverage, mass ITN distribution campaigns have been implemented in Nigeria [14–16]. ITN campaigns conducted once every three years are implemented with a lot of SBCC messages and these messages were effective in improving net culture and use especially for vulnerable groups [16]. Keep-up channels using continuous distribution mechanism maintain coverage between ITN campaigns. Children under five and pregnant women who are most vulnerable to malaria are prioritized through routine net distribution channels during antenatal care services and immunization clinics [17–19].

The Nigeria National Malaria Strategic Plan (NMSP) aims at improving access and utilization of vector control interventions to 80% of the target population by 2025. Use of ITN by CU5 living in a household with at least one ITN increased from 58.6% in 2010 to 74.3% in

2018. However, the use of ITN by children of school age increased from 37.8% to 57.6% [2] with children of school age having the lowest proportion of ITN use in 2018 compared to other age group [2]. The low use of ITN by children of school age compared to other age group in the family has also been documented by Olapeju et al. [20].

Most studies on use of ITNs focus on general population with more emphasis on pregnant women and CU5 [21–25]. No study in Nigeria has been identified that explored the use of ITN in all children including children of school age and the progress made in achieving the ITN utilization target of 80% set by the NMSP at state level using a national survey. This study aims to conduct an analysis of ITN use in CU5 and children of school age at national and sub-national level with the aim of understanding ITN use for these children. Understanding factors associated with ITN use in children is timely to inform future intervention among this target group.

Methods

This cross-sectional study analyzed the 2018 Nigeria Demographic and Health Survey (NDHS) dataset. NDHS is a nationally representative survey with samples drawn from all states and Local Government Areas (LGAs) based on the sampling frame of enumeration areas in the country. Methods for sampling and fieldwork are described in the NDHS survey report. This study analyzed merged persons recode (PR) file and the household recode (HR) filtered for household identification number, any ITN in household and number of ITN in household. Data were adjusted for survey design clustering and non-response by applying the individual weight provided in the NDHS dataset to every analysis.

Target population

Target population for the analysis was CU5 (aged 0–4 years) and children of school age (aged 5–14 years) who slept under ITN the night before the survey in households with at least one ITN.

ITN campaign in Nigeria

In Nigeria, ITN campaign was conducted for the first time in 2009 and has been implemented on a rolling basis since then. In 2015, ITN campaign was conducted in Abia, Cross River, Ebonyi, Kano and Kaduna states. In 2016, only Benue and Oyo states conducted an ITN campaign. Adamawa, Edo, Imo, Kogi, Kwara, Ondo and Osun conducted ITN campaign in 2017 and Sokoto, Bauchi, Gombe, Jigawa, Katsina, Nasarawa, Ogun and Akwa Ibom states conducted ITN campaign in 2018. The following states did not conduct ITN campaign between 2015 and 2018: Zamfara, FCT, Niger, Yobe, Borno, Kebbi, Plateau, Taraba, Ekiti, Anambra Enugu, Rivers, Bayelsa, Delta and Lagos states.

Variables

Outcome variables. The outcome variable is ITN use in CU5 and children of school age. Use of ITN was defined as whether a child under five or 5–14 years living in a household that owns at least one ITN slept under an ITN the night before the survey.

Independent variables. The dataset was examined for variables of interest that were likely to influence the utilisation of ITNs. Literatures were also considered in identifying factors that could influence the utilization of ITN in children [20, 26, 27]. The independent variables considered for analysis were child sex, household characteristics such as head of household's sex, household ownership of radio and television, number of household members, when ITN was obtained and wealth index. Demographic characteristics such as place of residence, state and region as well as malaria endemicity were included in the analysis. Malaria endemicity was classified into hypo-endemicity (states with prevalence less than 10%), meso-endemicity (10–50%) and hyperendemicity (51–75%) using state prevalence of malaria in CU5 obtained from 2018 NDHS. A study using *Plasmodium falciparum* parasite rate (*Pf*PR) provided a basis for the classical categorical measures of malaria transmission into hypo-endemic (<10%), meso-endemic (10–50%), and hyper-endemic (51–75%) and this measure has been used in previous studies [28].

Statistical analysis

Statistical analysis was conducted with STATA version 14 and three levels of analysis conducted. Firstly, distribution of variables was conducted using frequency and proportion. Bivariate analysis was subsequently conducted to determine the level of association between the outcome variable, use of ITN in CU5 or children of school age with the independent variables with significant measure at $p<0.05$. Variable Inflation Factor (VIF) was calculated to determine the extent of the multi-collinearity of the independent variables and their suitability to be included into the multilevel analysis [29]. Variables with p-value <0.2 at bivariate level were included into a multi-level logistics regression model used to assess factors influencing the use of ITN in CU5 and children of school age. The nested structure of the demographic health survey (DHS) data in which children were selected from household within communities necessitated the use of the methodology. Use of multilevel logistic regression models for the analysis of DHS data has been documented and used severally in literature [29–31] therefore we would not document the theory in this paper. For this paper we constructed a model for CU5 and children of school age independently. Three models were constructed for each category which included the household model, the community level model and the combined model. The outcome variables for each model were use of ITN with "1" for use and "0" for non-use of ITN. We reported the variance and standard deviation at the household and community levels for each model, the residual, the log likelihood, the intraclass correlation, the Akaike information criteria and the Bayesian information criteria. Variables found to be correlated with other variables would be exempted from the logistic regression analysis. Significance was assessed based on 95% confidence interval of odds ratio not including 1

Ethical consideration

This work examined a population-based dataset accessed online from The Demographic Health Survey (DHS) Program. The DHS Program adheres to guidelines for protecting the privacy of respondents by removing all personal identifiers. As The DHS Program sought and received ethical approval before the survey, this research did not require any additional ethical approvals. However, The DHS Program granted permission to use the dataset for this work.

Results

Univariate

Data on 86,778 children were analyzed with 32,087 CU5 and 54,692 children of school age. While 70% (n = 22,440) of CU5 live in households with at least one ITN, 68.6% (n = 37,502) of children of school age live in households with at least one ITN. Table 1 shows the demographic characteristics of CU5 and children of school age. Half (50.8%) of the children were male and 88.9% of the head of households were male. The majority of households (59.9%) have a radio while 44.6% indicated that the household owns a television. About 43% of nets were obtained

Table 1. Demographic characteristics of CU5 (0–4) years and children of school age (5–14 years).

Variables	Children under five	Children of school age	Total
	n (%)	n (%)	n (%)
Sex			
Male	16,366 (51.0)	27,709 (50.7)	44,075 (50.8)
Female	15,721 (49.0)	26,983 (49.3)	42,704 (49.2)
Sex of head of household			
Male	29,117 (90.8)	48,027 (87.8)	77,114 (88.9)
Female	2,969 (9.2)	6,665 (12.2)	86,778 (11.1)
Household own radio			
No	13,361 (41.6)	21,469 (39.3)	34,831 (40.1)
Yes	18,726 (58.4)	33,222 (60.7)	51,948 (59.9)
Household own TV			
No	17,760(55.4)	30,288 (55.4)	48,047 (55.4)
Yes	14,327 (44.6)	24,404 (44.6)	38,731 (44.6)
When ITN was obtained			
Less than one year	5,705 (34.0)	7,811 (35.8)	13,516 (35.1)
1–3 years	7,507 (44.8)	9,101 (41.7)	16 609 (43.0)
More than 3 years	3,550 (21.2)	4,931 (22.6)	8,481 (22.0)
Number of Household members			
1–3 persons	3,202 (10.0)	2,728 (5.0)	5,930 (6.8)
4–6 persons	14,442 (45.0)	20,750 (37.9)	35,192 (40.6)
7–9 persons	7,832 (24.4)	16,965 (31.0)	24,797 (28.6)
>9 persons	6,611 (20.6)	14,248 (26.1)	20,859 (24.0)
Wealth quintiles			
Poorest	6,988 (21.8)	12,308 (22.5)	19,296 (22.2)
Poorer	7,109 (22.2)	11,574 (21.2)	18,682 (21.5)
Middle	6,587 (20.5)	11,041 (20.2)	17,628 (20.3)
Richer	5,948 (18.5)	10,370 (19.0)	16,318 (18.8)
Richest	5,456 (17.0)	9,398 (17.2)	14,854 (17.1)
Residence			
Urban	12,638 (39.4)	22,439 (41.0)	35,077 (40.4)
Rural	19,448 (60.6)	32,253 (59.0)	51,701 (59.6)
Region			
North Central	4,371 (13.6)	7,112 (13.0)	11,483 (13.2)
North East	5,885 (18.3)	10,483 (19.2)	16,368 (18.9)
North West	11,246 (35.1)	19,088 (34.9)	30,334 (35.0)
South East	3,393 (10.6)	5,220 (9.6)	8,613 (9.9)
South South	2,915 (9.1)	5,289 (9.7)	8,204 (9.5)
South West	4,276 (13.3)	7,500 (13.7)	11,776 (13.6)
States			
Abia	426 (1.3)	607 (1.1)	1,033 (1.2)
Cross river	304 (1.0)	595 (1.1)	899 (1.0)
Ebonyi	824 (2.6)	1,287 (2.4)	2,111 (2.4)
Kano	2,471 (7.7)	4,463 (8.2)	6,934 (8.0)
Kaduna	2,090 (6.5)	3,349 (5.9)	5,339 (6.2)
Benue	921 (2.9)	1,276 (2.3)	2,197 (2.5)
Oyo	944 (2.9)	1,567 (2.9)	2,512 (2.9)
Adamawa	757 (2.4)	1,181 (2.2)	1,938 (2.2)

(*Continued*)

Table 1. (Continued)

Variables	Children under five	Children of school age	Total
	n (%)	n (%)	n (%)
Edo	409 (1.3)	786 (1.4)	1,195 (1.4)
Imo	652 (2.0)	1,010 (1.9)	1,662 (1.9)
Kogi	380 (1.2)	681 (1.3)	1,061 (1.2)
Kwara	518 (1.6)	983 (1.8)	1,501 (1.7)
Ondo	392 (1.2)	751 (1.4)	1,142 (1.3)
Osun	565 (1.8)	962 (1.8)	1,526 (1.8)
Sokoto	921 (2.9)	1,514 (2.8)	2,435 (2.8)
Bauchi	1,383 (4.3)	2,445 (4.5)	3,829 (4.4)
Gombe	647 (2.0)	1,167 (2.1)	1,814 (2.1)
Jigawa	1,319 (4.1)	2,357 (4.3)	3,677 (4.34)
Katsina	2,203 (6.9)	3,737 (6.8)	5,940 (6.8)
Nasarawa	494 (1.5)	798 (1.5)	1,292 (1.5)
Ogun	606 (1.9)	1,015 (1.9)	1,621 (1.9)
Akwa Ibom	517 (1.6)	950 (1.7)	1,467 (1.6)
Zamfara	1,209 (3.8)	2,053 (3.8)	3,262 (3.8)
FCT Abuja	217 (0.7	349 (0.6)	566 (0.7)
Niger	1,226 (3.8)	1,899 (3.5)	3,125 (3.6)
Yobe	1,210 (3.8)	2,327 (4.3)	3,537 (4.1)
Borno	1,146 (3.6)	2,155 (3.9)	3,300 (3.8)
Kebbi	1,034 (3.2)	1,715 (3.1)	2,749 (3.2)
Plateau	615 (1.9)	1,125 (2.1)	1,740 (2.0)
Taraba	743 (2.3)	1,208 (2.2)	1,950 (2.3)
Ekiti	304 (1.0)	513 (0.9)	817 (0.9)
Anambra	1,029 (3.2)	1,436 (2.6)	2,464 (2.8)
Enugu	462 (1.4)	880 (1.6)	1,342 (1.6)
Rivers	877 (2.7)	1,437 (2.6)	2,314 (2.7)
Bayelsa	224 (0.7)	422 (0.8)	1,682 (0.7)
Delta	584 (1.8)	1,099 (2.0)	1,683 (1.9)
Lagos	1,466 (4.6)	2,692 (4.9)	4, 158 (4.8)
Malaria endemicity			
Hypoendemic	3,147 (9.8.0)	5,139 (9.4)	8,285 (9.5)
Mesoendemic	27,906 (87)	47,838 (87.5)	75,744 (87.3)
Hyperendemic	1,034 (3.2)	1,715 (3.1)	2,749 (3.2)
Ownership of ITN			
No ITN	9,647(30)	17,190(31.4)	26,837(30.9)
At least 1 ITN	22,440(70)	37,502(68.6)	59,942(69.1)
Total	**32,087 (100)**	**54,692 (100)**	**86,778 (100)**

https://doi.org/10.1371/journal.pone.0274160.t001

within the past 1–3 years with more CU5 (44.8%) obtaining their net within 1–3 years ago. About forty-one percent (40.6%) of children live in households with 4–6 persons. More CU5 live in households with 4–6 person (45%) compared to children of school age. About 60% of all children included in the analysis reside in rural areas, while 87% reside in meso-endemic area with prevalence between 11% and 50%.

Bivariate

Table 2 presents the results of the bivariate analyses of ITN use in CU5 and children of school age by demographic characteristics. Findings among CU5 show that out of 22,440 children that live in households with at least one ITN, 74.3% (n = 16,671) slept under ITN the night before the survey. ITN use was associated with ownership of radio, television, when ITN was obtained, number of household members, wealth quintiles, place of residence, region, states and malaria endemicity ($p < 0.05$). Children under five from households with less than 6 members were most likely to sleep under an ITN. Similarly, CU5 who obtained ITN less than 3 years (99.7%) were also more likely to sleep under ITN.

A higher proportion of CU5 (77.9%) from the poorest wealth quintiles slept under ITN compared with those from the highest wealth quintile (67%). Use of ITN was significantly associated ($p<0.001$) with place of residence. About 75.8% of CU5 from rural areas slept under ITN compared to 71% from urban areas. A substantial geographical variation was noticed on use of ITN with CU5 from North West region being most likely to sleep under an ITN (80.3%) while in South-South, 63.1% of CU5 slept under ITN. Under five children living in malaria hypo-endemic area were least likely to sleep under ITN (56.1%) compared with 95% of under five children in hyperendemic areas. Considering the states with up to 80% ITN utilization in CU5, Ebonyi state (89.1%), Kano states (82.3%), Benue state (93.1%), Adamawa (90.0%) Kebbi (95.0%) Plateau (85.6%) and Jigawa state (90.9%) had above 80% ITN utilization in CU5.

Turning attention to findings on children of school age, out of 37,502 children of school age that live in households with least one ITN, 57.8% (n = 21,690) slept under ITN the night before the survey. Similar significant associations as in the case of CU5 were observed. While no differentials of child's sex, head of household sex and ownership of television were evident in the case of CU5, these variables were significantly associated with ITN use among children of school age. Furthermore, ITN use is significantly associated with number of household members, wealth quintiles, region, state and malaria endemicity. Considering the states with up to 80% ITN utilization in children of school age, only Jigawa state has over 80 percent of children of school age that slept under ITN the night before the survey. Table 3 with crude odds ratio (COR) of factors associated with ITN use in CU5 and children of school age is included in S1 File.

Multivariate results

The VIF computation done before fitting the multilevel logistic regression models for under five and above five revealed a mean VIF score of 3.25 and 3.91 for CU5 and children of school age respectively after removing the variable state and region due to collinearity.

Table 3 presents the results of the multilevel logistic regress with three models for each of CU5 and school age children. For the CU5, the household model demonstrated that children from richer (aOR = 0.25, 95% CI 0.09 to 0.65) and richest (aOR = 0.18, 95% CI 0.06 to 0.53) wealth quintile were less likely to utilize ITN, the community model demonstrated that households in rural area (aOR = 1.20, 95% CI 1.14 to 1.26) and in meso endemic (aOR = 3.10, 95% CI 2.89 to 3.54) areas were more likely to use ITN. The combined model for CU5 demonstrated that having TV (aOR = 2.14, 95% CI 1.02 to 4.50) and living in rural areas (aOR = 2.93, 95% CI 1.14 to 1.26) contributed to using ITN while households with 4–6 persons (aOR = 0.37, 95% CI 0.16 to 0.89), 7 to 9 persons (aOR = 0.34, 95% CI 0.14 to 0.85), and >9 persons (aOR = 0.35, 95% CI 0.14 to 0.90) and households from richest quintiles (aOR = 0.19, 95% CI 0.04 to 0.78) were less likely to use ITN. Variability in use of ITN was highest in the household with an intraclass correlation of 14%.

Table 2. Use of ITN in CU5 and children of school age living in households with at least one ITN by demographic characteristics.

Variable	Children under five		Children of school age	
	Slept under ITN	P Value	Slept under ITN	P Value
	(n = 16,671)		n = 21,690	
Sex	n (%)	<0.417	n (%)	<0.001
Male	8,353 (74.6)		10,582 (55.9)	
Female	8,148 (74.0)		11,109 (59.8)	
Sex of head of household		0.712		0.001
Male	15,277 (74.2)		19,158 (57.3)	
Female	1,394 (74.8)		2,532 (62.2)	
Household own radio		<0.001		0.267
No	7,316 (76.7)		8,800 (58.5)	
Yes	9,355 (72.5)		12,890 (57.4)	
Household own TV		<0.001		0.01
No	10,268 (77.5)		13,248 (59.1)	
Yes	6,404 (69.7)		8,442 (56.0)	
When ITN was obtained		<0.046		<0.665
Less than one year	18 (0.3)		7,708 (99.6)	
1–3 years	21 (0.3)		8,965 (99.5)	
More than 3 years	27 (0.8)		4,819 (99.5)	
Number of Household members		<0.001		<0.001
1–3 persons	1,755 (85.8)		1,018 (69.3)	
4–6 persons	7,608(78.0)		8,630(64.8)	
7–9 persons	3,980 (71.3)		6,891 (57.9)	
>9 persons	3,327 (65.7)		5,151 (47.6)	
Wealth quintiles		<0.001		<0.021
Poorest	4,165 (77.9)		5,507 (58.0)	
Poorer	4,179 (76.8)		5.219 (60.1)	
Middle	3,525 (75.4)		4,487 (59.0)	
Richer	2,667 (70.1)		3,639 (54.9)	
Richest	2,136 (67.3)		2,838 (55.8)	
Residence		<0.001		<0.116
Urban	5,640 (71.5)		7,766 (56.6)	
Rural	11,032 (75.8)		13,925 (58.6)	
Region		<0.001		<0.001
North Central	2,057 (76.2)		2,314 (56.5)	
North East	2,777 (69.7)		3,648 (51.8)	
North West	8,138 (80.3)		10,644 (62.3)	
South East	1,234 (66.2)		1,493 (54.4)	
South South	975 (63.1)		1,447 (52.9)	
South West	1,490 (67.5)		2,146 (56.3)	
		<0.001		<0.001
States				
Abia	101 (47.7)		134 (45.3)	
Cross River	130 (71.6)		234 (62.5)	
Ebonyi	556 (89.1)		777 (79.4)	
Kano	1,827 (82.3)		2,579 (65.9)	
Kaduna	1,386 (78.0)		1,667 (61.4)	
Benue	595 (93.1)		641 (76.2)	

(*Continued*)

Table 2. (Continued)

Variable	Children under five		Children of school age	
	Slept under ITN	P Value	Slept under ITN	P Value
	(n = 16,671)		n = 21,690	
Oyo	389 (76.9)		597 (73.6)	
Adamawa	360 (90.0)		478 (75.5)	
Edo	126 (53.1)		182 (38.9)	
Imo	196 (51.6)		199 (33.7)	
Kogi	205 (71.0)		291 (58.8)	
Kwara	172 (50.8)		238 (36.7)	
Ondo	232 (69.8)		340 (60.7)	
Osun	179 (62.9)		265 (49.7)	
Sokoto	516 (64.1)		529 (40.5)	
Bauchi	723 (60.8)		803 (38.7)	
Gombe	246 (52.6)		303 (34.1)	
Jigawa	1,168 (90.9)		1,941 (83.9)	
Katsina	1,597 (77.5)		2,266 (65.0)	
Nasarawa	281 (70.9)		338 (58.9)	
Ogun	296(78.4)		404 (67.5)	
Akwa Ibom	189 (52.4)		236 (37.7)	
Zamfara	678 (69.7)		395 (23.8)	
Yobe	712 (78.1)		1,080 (63.1)	
Borno	559 (77.2)		792 (62.2)	
Kebbi	967 (95.0)		1,268 (75.3)	
Niger	450 (74.9)		391 (44.7)	
FCT Abuja	76 (68.4)		67 (46.7)	
Plateau	278 (85.6)		349 (66.4)	
Taraba	178 (60.4)		192 (42.2)	
Ekiti	79 (52.9)		112 (45.2)	
Anambra	259 (59.5)		234 (46.0)	
Enugu	123 (56.9)		147 (40.1)	
Rivers	243 (65.1)		336 (59.8)	
Bayelsa	71 (69.7)		117 (59.3)	
Delta	216 (74.5)		341 (67.6)	
Lagos	315 (56.5)		369 (38.4)	
Malaria endemicity		<0.001		<0.001
Hypoendemic	770 (56.1)		802 (38.9)	
Mesoendemic	14,935 (74.5)		19,620 (58.1)	
Hyperendemic	967 (95.0)		1,268 (75.3)	
Total	16,671(74.3)		21,690 (57.8%)	

https://doi.org/10.1371/journal.pone.0274160.t002

For the school age children's models, the household model demonstrated that children from household with female head (aOR = 1.14, 95% CI 1.09 to 1.19) and having a television (aOR = 1.09, 95% CI 1.01 to 1.16) were likely to use ITN while children living in household with 7 to 9 persons (aOR = 0.67, 95% CI 0.60 to 0.74) or >9 persons (aOR = 0.39, 95% CI 0.36 to 0.44) were less likely to use ITN. The community model demonstrated that children living in rural (aOR = 1.08, 95% CI 1.04 to 1.12), coming from meso endemic (aOR = 3.17, 95% CI 2.89 to 3.47) and hyper endemic (aOR = 14.9, 95% CI 12.99 to 17.07) areas were more likely to

Table 3. Multilevel logistic regression on socio and demographic factors associated with ITN use in CU5 and children of school age in households owning at least one ITN.

Characteristics	Categories	CU5 aOR (95% CI)			Children of school age aOR (95% CI)		
		Household	Community	Combined	Household	Community	Combined
Fixed Effect							
Sex of head of household	Male						
	Female				1.14 (0.89,2.17)		1.14(1.09,1.19)
Household own radio	No						
	Yes	1.29 (0.87,1.92)					
Household own TV	No						
	Yes	1.82 (0.95,3.50)		2.14(1.02,4.50)	1.09(1.02,4.5)		1.08(1.00,1.15)
When net was obtained	Less than one year1						
	1–3 years	0.78(0.5,1.23)		0.76(0.45,1.27)			
	More than 3 years	1.03 (0.58,1.85)		0.95(0.50,1.81)			
Number of Household members	1 to 3 persons						
	4 to 6 persons	1.05 (0.59,1.86)		0.37(0.16,0.89)	0.93 (0.46,1.27)		0.92(0.84,1.02)
	7 to 9 persons	1.29 (0.67,2.48)		0.34(0.14,0.85)	0.67(0.5,1.82)		0.66(0.59,0.72)
	>9 persons	1.06 (0.54,2.07)		0.35(0.14,0.90)	0.4(0.16,0.88)		0.38(0.35,0.43)
Socio Economic Status	Poorest						
	Poorer	0.71 (0.38,1.32)		0.61(0.30,1.25)	1.01 (0.14,0.86)		1.03(0.96,1.11)
	Middle	1.22 (0.49,3.01)		1.49(0.49,4.51)	1.02(0.14,0.9)		1.08(0.99,1.19)
	Richer	0.25 (0.09,0.65)		0.3(0.08,1.06)	1.05(0.3,1.25)		1.15(1.02,1.29)
	Richest	0.18 (0.06,0.53)		0.19(0.04,0.78)	1.14 (0.49,4.52)		1.30(1.14,1.49)
Residence	Urban						
	Rural		1.20 (1.14,1.26)	2.93 (0.84,10.24)		1.08 (1.04,1.12)	1.37(1.19,1.59)
Malaria endemicity	Hypo endemic						
	Meso endemic		3.10 (2.89,3.54)	3.29 (0.66,16.42)		3.17 (2.89,3.47)	4.60(3.58,5.90)
	Hyper endemic					14.9(13,17.07)	36.10 (22.41,58.14)
Random Effect							
	Household(Variance (Std. Dev.))	33.47(5.79)		12.94(3.60)	1.69(1.30)		1.37(1.17)
	Cluster (Variance (Std.Dev.))		0.01(0.11)	0.49(0.7)		0.015(0.12)	0.01(0.12)
	Residual	1652	41786.4	1643.8	61472.7	70155.9	
	Log likelihood	-846.2	-20893.2	-821.9	-30736.3	-35077.9	-30579.3
	ICC	14%	30%	17%	23%	30%	20%
	AIC	1720.4	41796.4	1677.8	61494.7	70165.9	61188.5
	Bayesian IC	1827.9	41838.2	1808.4	61592.6	70210.3	61322

https://doi.org/10.1371/journal.pone.0274160.t003

use ITN. The combined model demonstrated that children from households with female head (aOR = 1.14, 95% CI 1.1 to 1.19), having television (aOR = 1.08, 95% CI 1.01 to 17.07), coming from richer (aOR = 1.15, 95% CI 1.03 to 1.29) or richest (aOR = 1.31, 95% CI 1.14 to 1.49) wealth quintile, living in rural areas (aOR = 1.38, 95% CI 1.2 to 1.59) and coming from meso endemic (aOR = 4.6, 95% CI 3.59 to 5.9) or hyper endemic area (aOR = 36.08, 95% CI 22.39 to 58.14) were more likely to use ITN. while children from households with 7 to 9 persons (aOR = 0.66, 95% CI 0.6 to 0.73) or > 9 persons (aOR = 0.39, 95% CI 0.35 to 0.43) were less likely to use ITN. The variability in the school age children's models was higher in the household (1.37(1.17)) while the intraclass correlation was 20%.

Discussions

This paper explored ITN use in CU5 and children of school age in Nigeria using a nationally representative study. Compared to the NDHS report, our study has established associated factors that influence ITN use in CU5 and children of school age by developing the novel multilevel logistic regression model to identify these factors [32]. Findings revealed that household and community- level factors were significantly associated with ITN use in CU5 and children of school age. Factors associated with use of ITN in CU5 include living in rural areas, meso and hyper endemic areas, poor households and owning a television. Similarly, factors associated with use of ITN in children of school age include living in rural area, meso and hyper endemic areas, female headed households, belonging to richer and richest wealth quintile and having television. These findings provide further direction for the malaria elimination strategy on how to enhance ITN use among CU5 and children of school age for malaria elimination effort.

The prevalence of malaria has been documented to be higher in rural areas and in poor population [33–35]. Findings from this study which revealed increased use of ITN in CU5 living in households in lowest wealth quintiles, rural areas showed the effectiveness of ITN campaign in increasing use of ITN to vulnerable and poor population with higher prevalence of malaria.

Furthermore, the finding demonstrates that effort of the malaria control programme in Nigeria to deploy ITN to areas of core endemicity to reduce prevalence and incidence of malaria in these areas is significant. With higher malaria prevalence reported in the northern region which mostly makes up the hyper endemic areas compared to the southern region [36], we can say that efforts to reduce malaria prevalence through use of ITN are effective and needs to be fortified to achieve greater success.

In addition, Higher ITN use and association seen in the meso and hyper endemic areas of the country also shows that people living in these areas may feel more vulnerable to malaria and hence make consistent efforts to use ITNs. Hence, location with hyper endemicity were seen to have high odds of ITN use [27]. The National Malaria Strategic Plan set target of 80% utilization for vector control intervention has not been determined at sub-national level. At state level, only seven states (Ebonyi, Kano, Benue, Jigawa, Kebbi, Plateau, Adamawa) out of the Nigerian 36 states plus FCT had over 80% ITN utilization among CU5. While only Jigawa state had 80% ITN utilization for children of school age. This result reinforces the need for concerted efforts by relevant stakeholders to increase ITN utilization in states where utilization is low, more especially in states that lack donor funding for ITN campaign.

Children of school age in richer and richest wealth quintile were more likely to use ITN. While previous studies showed that children of school age were less prioritized in ITN use at household level [20]. This study further revealed use to be higher in children of school age from rich households. Efforts should be made by the malaria programme to increase use of ITN in school children from poor households.

WHO recommends a combination of ITN mass campaign, continuous distribution of ITN through multiple channels and several other intervention strategies to eliminate malaria. In Nigeria, continuous distribution via antenatal care and immunization has been prioritized with pockets of school distribution implemented in the country. Plateau state that has been documented to have high prevalence of malaria in children of school age has about one out of every three school age children sleep under ITN. Considering the reported high prevalence of malaria among children of school age, including school distribution of ITN as one of the keep-up channels for achieving universal coverage in Nigeria could be a possible strategy for increasing use of ITN by school children from poor households. Increasing ITN distribution through schools could also sustain the decline in malaria prevalence recorded over the years as school children are reported to be an asymptomatic reservoir for malaria parasites and are the least prioritized in ITN use [20]. Findings also show that children in households with more household members were less likely to sleep under ITN. This finding further buttresses the need to consider family sizes during ITN distribution, as currently there is a cap on maximum number of nets to be given to a household.

Study strength

The main strength of this study is the representative sample at state, regional and national level to guide ITN utilization strategy and decision making. In addition, while the DHS report presented ITN use in CU5 and children of school age at national level, this paper presents ITN utilization at sub- national levels.

Study limitation

On the limitation of the study, information on ITN use in children was not verified. The question on use of ITN by children was asked mothers and caregivers of these children and could be subject to social desirability bias (respondents may want to show in their response that they are taking care of their children by making them sleep under ITNs even if this is not true). In addition, the cross-sectional nature of the study design is a limitation to the study as the cause relationship between use of ITN and the observed predisposing factors could not be established. The study was also not able to measure co-variates such as climatic factors, seasonality etc which influence prevalence of malaria. Finally, similar to studies of this nature, this study was not able to measure all factors that could influence ITN use.

Conclusion

Our study demonstrates higher use of ITN among CU5 and children of school age living in malaria endemic areas and rural areas. However associated factors differ in CU5 and children of school age. To achieve the national target of ITN utilization in children, the authors recommend concerted efforts to increase ITN use in states where utilization remain low while reviewing further household size during ITN campaign. We recommend ITN distribution via schools should be considered as one of the continuous distribution channels to increase use of ITN among children of school age.

Supporting information

S1 File. Supplementary file containing Table 3. Factors associated with ITN use in CU5 and children of school age.
(DOCX)

Acknowledgments

The authors wish to thank Cameron Taylor of DHS Programs for reviewing this work. Your valuable contribution is highly appreciated.

Author Contributions

Conceptualization: Chinazo N. Ujuju, Chukwu Okoronkwo, Okefu Oyale Okoko, Adekunle Akerele, Chibundo N. Okorie, Samson Babatunde Adebayo.

Data curation: Chinazo N. Ujuju.

Formal analysis: Chinazo N. Ujuju, Adekunle Akerele.

Supervision: Samson Babatunde Adebayo.

Writing – original draft: Chinazo N. Ujuju, Chukwu Okoronkwo, Okefu Oyale Okoko, Adekunle Akerele, Chibundo N. Okorie, Samson Babatunde Adebayo.

Writing – review & editing: Chinazo N. Ujuju, Chukwu Okoronkwo, Okefu Oyale Okoko, Adekunle Akerele, Chibundo N. Okorie, Samson Babatunde Adebayo.

References

1. WHO. World malaria report 2020: 20 years of global progress and challenges. Geneva: World Health Organization; 2020. Licence: CC BY-NC-SA 3.0 IGO. 2021 update. Geneva: World Health Organization; 2021. https://apps.who.int/iris/handle/10665/342995
2. National Population Commission (NPC) [Nigeria] and ICF. 2019. Nigeria Demographic and Health Survey 2018. Abuja, Nigeria, and Rockville, Maryland, USA: NPC and ICF. https://dhsprogram.com/pubs/pdf/FR359/FR359.pdf
3. Sarpong N, Owusu-Dabo E, Kreuels B, Fobil JN, Segbaya S, Amoyaw F, et al. Prevalence of malaria parasitaemia in school children from two districts of Ghana earmarked for indoor residual spraying: a cross-sectional study. Malar J. 2015; 14: 260. https://doi.org/10.1186/s12936-015-0772-6 PMID: 26109461
4. Yapi RB, Hürlimann E, Houngbedji CA, Ndri PB, Silué KD, Soro G, et al. Infection and Co-infection with Helminths and Plasmodium among School Children in Côte d'Ivoire: Results from a National Cross-Sectional Survey. Stothard JR, editor. PLoS Negl Trop Dis. 2014; 8: e2913. https://doi.org/10.1371/journal.pntd.0002913 PMID: 24901333
5. Walldorf JA, Cohee LM, Coalson JE, Bauleni A, Nkanaunena K, Kapito-Tembo A, et al. School-Age Children Are a Reservoir of Malaria Infection in Malawi. Snounou G, editor. PLoS ONE. 2015; 10: e0134061. https://doi.org/10.1371/journal.pone.0134061 PMID: 26207758
6. Hart A, Abinye B. The prevalence of malaria parasitaemia in children 0–11 years in twon-brass. World Journal of Pharmaceutical and Medical Research 2020; 6:25–29. 2020 [cited 26 Nov 2021]. https://journals.indexcopernicus.com/search/article?articleId=2473132
7. Noland GS, Graves PM, Sallau A, Eigege A, Emukah E, Patterson AE, et al. Malaria prevalence, anemia and baseline intervention coverage prior to mass net distributions in Abia and Plateau States, Nigeria. BMC Infect Dis. 2014; 14: 168. https://doi.org/10.1186/1471-2334-14-168 PMID: 24669881
8. Cohee L, Laufer M. Tackling malaria transmission in sub-Saharan Africa. The Lancet Global Health. 2018; 6: e598–e599. https://doi.org/10.1016/S2214-109X(18)30197-9 PMID: 29661636
9. Nzobo BJ. Prevalence of asymptomatic malaria infection and use of different malaria control measures among primary school children in Morogoro Municipality, Tanzania. 2015; 7.

10. Ezenduka CC, Falleiros DR, Godman BB. Evaluating the Treatment Costs for Uncomplicated Malaria at a Public Healthcare Facility in Nigeria and the Implications. Pharmacoecon Open. 2017; 1: 185–194. https://doi.org/10.1007/s41669-017-0021-8 PMID: 29441495

11. Conteh L, Shuford K, Agboraw E, Kont M, Kolaczinski J. Costs and Cost-Effectiveness of Malaria Control Interventions: A Systematic Literature Review | Elsevier Enhanced Reader. Value Health. 2021; 24 (8):1213–1222. 2021 [cited 10 Dec 2021]. https://doi.org/10.1016/j.jval.2021.01.013 PMID: 34372987

12. Mueller DH, Wiseman V, Bakusa D, Morgah K, Daré A, Tchamdja P. Cost-effectiveness analysis of insecticide-treated net distribution as part of the Togo Integrated Child Health Campaign. Malar J. 2008; 7: 73. https://doi.org/10.1186/1475-2875-7-73 PMID: 18445255

13. Bhatt S, Weiss DJ, Cameron E, Bisanzio D, Mappin B, Dalrymple U, et al. The effect of malaria control on Plasmodium falciparum in Africa between 2000 and 2015. NATURE. 2015; 526: 207–211. https://doi.org/10.1038/nature15535 PMID: 26375008

14. Ankomah A, Adebayo SB, Arogundade ED, Anyanti J, Nwokolo E, Inyang U, et al. The Effect of Mass Media Campaign on the Use of Insecticide-Treated Bed Nets among Pregnant Women in Nigeria. Malaria Research and Treatment. 2014; 2014: 1–7. https://doi.org/10.1155/2014/694863 PMID: 24778895

15. Ye Y, Patton E, Kilian A, Dovey S, Eckert E. Can universal insecticide-treated net campaigns achieve equity in coverage and use? the case of northern Nigeria. Malaria Journal. 2012; 11: 32. https://doi.org/10.1186/1475-2875-11-32 PMID: 22297189

16. Kilian A, Lawford H, Ujuju CN, Abeku TA, Nwokolo E, Okoh F, et al. The impact of behaviour change communication on the use of insecticide treated nets: a secondary analysis of ten post-campaign surveys from Nigeria. Malar J. 2016; 15: 422. https://doi.org/10.1186/s12936-016-1463-7 PMID: 27542940

17. Hill J, Dellicour S, Bruce J, Ouma P, Smedley J, Otieno P, et al. Effectiveness of Antenatal Clinics to Deliver Intermittent Preventive Treatment and Insecticide Treated Nets for the Control of Malaria in Pregnancy in Kenya. von Seidlein L, editor. PLoS ONE. 2013; 8: e64913. https://doi.org/10.1371/journal.pone.0064913 PMID: 23798997

18. Theiss-Nyland K, Koné D, Karema C, Ejersa W, Webster J, Lines J. The relative roles of ANC and EPI in the continuous distribution of LLINs: a qualitative study in four countries. Health Policy and Planning. 2017; 32: 467–475. https://doi.org/10.1093/heapol/czw158 PMID: 28334799

19. Mathanga DP, Luman ET, Campbell CH, Silwimba C, Malenga G. Integration of insecticide-treated net distribution into routine immunization services in Malawi: a pilot study. Tropical Medicine & International Health. 2009; 14: 792–801. https://doi.org/10.1111/j.1365-3156.2009.02295.x PMID: 19497078

20. Olapeju B, Choiriyyah I, Lynch M, Acosta A, Blaufuss S, Filemyr E, et al. Age and gender trends in insecticide-treated net use in sub-Saharan Africa: a multi-country analysis. Malaria Journal. 2018; 17: 423. https://doi.org/10.1186/s12936-018-2575-z PMID: 30428916

21. Ankomah A, Adebayo SB, Arogundade ED, Anyanti J, Nwokolo E, Ladipo O, et al. Determinants of insecticide-treated net ownership and utilization among pregnant women in Nigeria. BMC Public Health. 2012; 12: 105. https://doi.org/10.1186/1471-2458-12-105 PMID: 22309768

22. Babalola OJ, Sambo MN, Idris SH, Ajayi I-OO, Ajumobi O, Nguku P. Factors associated with utilization of LLINs among women of child-bearing age in Igabi, Kaduna State, Nigeria. Malar J. 2019; 18: 412. https://doi.org/10.1186/s12936-019-3046-x PMID: 31823793

23. Baume CA, Marin MC. Gains in awareness, ownership and use of insecticide-treated nets in Nigeria, Senegal, Uganda and Zambia. Malaria Journal. 2008; 7: 153. https://doi.org/10.1186/1475-2875-7-153 PMID: 18687145

24. Ng'ang'a PN, Aduogo P, Mutero CM. Long lasting insecticidal mosquito nets (LLINs) ownership, use and coverage following mass distribution campaign in Lake Victoria basin, Western Kenya. BMC Public Health. 2021; 21: 1046. https://doi.org/10.1186/s12889-021-11062-7 PMID: 34078333

25. Sina OJ. An Assessment of the use of Insecticide Treated Net among under Five in Ekiti State as a Means of Prevention of Malaria. PRM. 2018; 2. https://doi.org/10.31031/PRM.2018.02.000544

26. Mensah EA, Anto F. Individual and Community Factors Associated with Household Insecticide-Treated Bednet Usage in the Sunyani West District of Ghana Two Years after Mass Distribution. Journal of Environmental and Public Health. 2020; 2020: 1–7. https://doi.org/10.1155/2020/7054383 PMID: 33029158

27. Nkoka O, Chipeta MS, Chuang Y-C, Fergus D, Chuang K-Y. A comparative study of the prevalence of and factors associated with insecticide-treated nets usage among children under 5 years of age in households that already own nets in Malawi. Malaria Journal. 2019; 18: 43. https://doi.org/10.1186/s12936-019-2667-4 PMID: 30786905

28. Smith DL, Guerra CA, Snow RW, Hay SI. Standardizing estimates of the Plasmodium falciparum parasite rate. Malar J. 2007; 6: 131. https://doi.org/10.1186/1475-2875-6-131 PMID: 17894879

29. Bl S, Sa R. Multilevel analysis of factors associated with assistance during delivery in rural Nigeria: implications for reducing rural-urban inequity in skilled care at delivery. BMC pregnancy and childbirth. 2018; 18. https://doi.org/10.1186/s12884-018-2074-9 PMID: 30409121

30. Women who have not utilized health Service for Delivery in Nigeria: who are they and where do they live? | BMC Pregnancy and Childbirth | Full Text. [cited 2 Aug 2022]. https://bmcpregnancychildbirth.biomedcentral.com/articles/10.1186/s12884-019-2242-6

31. Aheto JMK, Pannell O, Dotse-Gborgbortsi W, Trimner MK, Tatem AJ, Rhoda DA, et al. Multilevel analysis of predictors of multiple indicators of childhood vaccination in Nigeria. PLOS ONE. 2022; 17: e0269066. https://doi.org/10.1371/journal.pone.0269066 PMID: 35613138

32. Aheto JMK, Dagne GA. Multilevel modeling, prevalence, and predictors of hypertension in Ghana: Evidence from Wave 2 of the World Health Organization's Study on global AGEing and adult health. Health Science Reports. 2021; 4: e453. https://doi.org/10.1002/hsr2.453 PMID: 34938897

33. Habyarimana F, Ramroop S. Prevalence and Risk Factors Associated with Malaria among Children Aged Six Months to 14 Years Old in Rwanda: Evidence from 2017 Rwanda Malaria Indicator Survey. Int J Environ Res Public Health. 2020; 13. https://doi.org/10.3390/ijerph17217975 PMID: 33142978

34. Gahutu J-B, Steininger C, Shyirambere C, Zeile I, Cwinya-Ay N, Danquah I, et al. Prevalence and risk factors of malaria among children in southern highland Rwanda. Malaria Journal. 2011; 10: 134. https://doi.org/10.1186/1475-2875-10-134 PMID: 21592380

35. Yusuf OB, Adeoye BW, Oladepo OO, Peters DH, Bishai D. Poverty and fever vulnerability in Nigeria: a multilevel analysis. Malaria Journal. 2010; 9: 235. https://doi.org/10.1186/1475-2875-9-235 PMID: 20718997

36. Oyibo W, Ntadom G, Uhomoibhi P, Oresanya O, Ogbulafor N, Ajumobi O, et al. Geographical and temporal variation in reduction of malaria infection among children under 5 years of age throughout Nigeria. BMJ Glob Health. 2021; 6: e004250. https://doi.org/10.1136/bmjgh-2020-004250 PMID: 33632771