

Determinants of Childhood Malaria Morbidities in Nigeria: Secondary Analysis of 2015 Malaria Indicator Survey

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ABSTRACT

Background: In Nigeria, malaria remains an important public health problem accounting for 25% of infant mortality, 30% of under-five mortality and 11% of maternal mortality. Between 2000 and 2010, at least 50% of the population had an episode of malaria per year while under-five children had 2-4 episodes. Currently, malaria parasite prevalence is still high with average prevalence of 45.0%.

Methods: This study was a cross-sectional survey utilizing data from the Nigeria 2015 MIS. The outcome variables were fever in the past two before the survey, positive blood smear for malaria parasite and positive rapid malaria diagnostic test (RDT). Statistical analysis was the survey logistic regression.

Results: A total number of 6632 children and 8034 mothers were used for the analysis. Overall, prevalences of fever, malaria parasitaemia and positive RDT are 41%, 27% and 45% respectively. Significant and uniform determinants of the three outcomes are: geopolitical zone, place of residence, wealth quintile and indoor residual spray; other maternal factors are preventive practices and knowledge of malaria prevention.

Conclusion: Socio-economic status and maternal knowledge of malaria prevention are important factors that influence childhood malaria morbidities. These factors need to be taken into consideration when planning malaria control programmes in order to have effective programmes.

Keywords: Childhood malaria; determinant; logistic regression; Nigeria; MIS.

1. INTRODUCTION

Malaria is by far the most important vector-transmitted disease in the world. The infection especially in children is characterized by fever, chills, rigor and sometimes even seizures. There were 216 million cases reported annually, 91

countries reported malaria cases in 2016 with 15 countries all in Sub-Saharan Africa (SSA) accounting for 80% of global malaria burden. Current estimates of annual death due to malaria is put at 445, 000 [1] most of them children under five years of age. These childhood deaths resulting mainly from cerebral malaria

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and anaemia constitute between 20% and 25% of child mortality in Africa. [2] Malaria transmission in Africa is governed by the existence of mosquitoes of *Anopheles gambiae* Giles complex which are highly efficient vectors. [3] It is estimated that 70% of the total sub-Saharan population lives in areas infested with malaria vectors, thus it is not surprising that 90% of all clinical cases and about 90% of deaths caused by the disease are reported in this region. [4,5] Majority of people in Africa live in areas where malaria transmission is intense and occurs throughout the year, thus with time some degree of immunity to malaria develops. [6] In such areas young children and pregnant women are at greatest risk of malaria infection and death due to low levels of immunity.

Malaria is both a social and economic burden not only to the country, but to individuals and families. SSA bears the heavy burden of malaria as these countries are among the poorest in the world and the widespread poverty in the continent continues to play a role in the disease burden. It is reported that malaria slows economic growth in African countries by 1.3% of the population annually [7] and the effects are worse in rural communities where economic activities are centred on family members. The annual economic loss to SSA due to malaria is up to 12 billion dollars. [8]

Malaria is transmitted by the bite of female *Anopheles* mosquito which needs proteins from a blood meal to produce a batch of eggs. The mosquito is highly anthropophilic and bites indoors (endophagy). The disease is caused by protozoan parasites of the genus *Plasmodium*; the most prevalent and most deadly is *P. falciparum* which accounts for majority of deaths due to malaria globally. [9]

Malaria is holoendemic in Nigeria with 97% of the population at risk and *P. falciparum* as the dominant species. [10] It is a major cause of morbidity and mortality and main reason for visit to health facilities, in-patient admissions and is responsible for most deaths of pregnant women and children under five years of age in Nigeria. [11,12] Malaria is responsible for 110 million clinical cases in Nigeria, 60% of all outpatient clinic attendances, 30% of all hospital admissions and 300, 000 deaths per year. [13] According to World Health Organization (WHO), the number of deaths due to malaria in children aged five years (U5) has decreased since 2000. However, it remains a major cause of morbidity

in children in SSA with 10% of all deaths of children U5 due to malaria. That means a child dies of malaria every 2 minutes in SSA. [14] Malaria is associated with environmental/ climatic factors (rainfall, altitude and temperature) [15,16] which affects both the parasite and the mosquito. Mosquitoes are unable to survive in low humidity while rainfall provides breeding sites and increases humidity which enhances their survival. *Plasmodium* parasites are affected by temperature where their development slows as temperature drops and stops at high temperatures.

In Nigeria, malaria remains an important public health problem accounting for 25% of infant mortality, 30% of U5 mortality and 11% of maternal mortality [13] respectively. Between 2000 and 2010, at least 50% of the population had an episode of malaria per year while children U5 had 2-4 episodes. [17] Prior to 2010, available data was insufficient to clearly micro-stratify the country's malaria epidemiological profile. However, the 2010 Nigeria Malaria Indicator Survey (NMIS) revealed that malaria parasite prevalence is still high with average prevalence of 42.0% among children U5 years of age with zonal variations ranging from 27.6% in the South-east to 50.3% in the South-west zone. [18] The 2015 NMIS shows a decreasing trend with average parasite prevalence of 27.4% and zonal variations ranging from 14.0% in South-east to 37% in North-west. [19] Substantial investments have been made in Nigeria by the Government and partners on malaria. Nigeria was one of the countries included in WHO large scale malaria control initiative between 1955 and 1969 (Malaria Eradication Programme) that relied on indoor residual spraying (IRS) of DDT (Dichloro-diphenyl-trichloroethane). [13] WHO, UNICEF and partners developed a simple, affordable and effective intervention for the integrated management of major childhood illnesses (IMCI). [20] Thus malaria management will be through community systems (integrated community case management) and ward minimum health package. Furthermore, Nigeria launched National Malaria Strategic Plans (NMSP), 2001-2005, 2006-2010, 2009-2013 and 2014-2020 respectively.

The NMSP 2009-2013 aimed at malaria control through three interventions; prevention of malaria transmission through integrated vector management (IVM) strategy, prompt diagnosis and adequate treatment of clinical cases and prevention and treatment of malaria in pregnancy. During this period over 60 million

long lasting insecticidal nets (LLINS) were distributed. [18] The 2014-2020 NMSP presents a major scale up of key interventions that aim to achieve pre-elimination status and reduction of malaria related deaths to zero by 2020 in Nigeria. [18] In line with this, the Government re-designed the National Malaria Control Programme (NMCP) to National Malaria Elimination Programme (NMEP). Despite all these measures put in place by government and other stakeholders to effectively reduce the number of malaria cases and deaths among U5 children in Nigeria over the decades, the prevalence is still high. Therefore in order to apply successful implementations to substantially reduce the burden of malaria there is a need to continuously understand the epidemiology and determinants associated with malaria. Also, malaria interventions usually target households, individuals and the environment. This necessitates the use of multi-level analyses to identify factors associated with malaria that can be used by governments and stake holders for programme intervention and or scale up in order to reduce/eliminate the scourge of this disease. Globally, a number of studies have identified a range of factors associated with malaria infection; socio-economic, demographic and environmental etc [16,21-24], it is pertinent to identify these factors and their influence in Nigerian context.

Most previous studies [10, 25-27] have either been based in institutions or local communities, hence the use of demographic and health survey (DHS) data which have a large sample size and nationally representative that allows for generalization of findings for national policy formulation and programme intervention. Thus the aim of this secondary analysis was to investigate the determinants of childhood malaria morbidity-fever in the past two weeks prior to the survey, parasitaemia using microscopy and positive malaria test using rapid diagnostic test (RDT) in children under five years of age in Nigeria.

2. METHODS

2.1 Study Area

Nigeria is situated in West African sub-region lying between latitudes 4°16' and 13°53' north and longitudes 2°40' and 14°41' east. It has Niger Republic to its northern border, Chad to its Northeast, Republic of Cameroun at its Eastern border and Benin Republic to its West. To its Southern border is an 850 kilometer stretch of

coastal area provided by the Atlantic Ocean. Nigeria has a landmass of approximately 923,768square kilometers. It is traversed by two famous and long rivers: Rivers Niger running from North West and Benue running from North East joining together at Lokoja to a confluence before travelling southwards to empty into the Atlantic Ocean through the Niger Delta. Nigeria has an estimated population of 177 million in 2016 making it the seventh in the world and largest in Africa. It has three major ethnic groups: Hausa, Igbo and Yoruba. The diverse nature of climatic and topographic conditions of Nigeria supports malaria transmission all year round. The World Malaria Report of 2016 indicates that the entire population of Nigeria is at risk of malaria while 76% is at high risk.

2.2 Data

The data for this study was derived from the 2015 Nigeria MIS. The 2015 Nigeria MIS was carried-out between October and November 2015 and implemented by National Malaria Elimination Programme (NMEP), the National Population Commission (NPopC), the National Bureau of Statistics (NBS), and the Malaria Partnership in Nigeria. It involved a nationally representative sample of more than 8,000 households in 329 clusters and women aged 15-49 years in these households were eligible for individual interviews. During the interviews, respondents were asked questions about malaria prevention during pregnancy and treatment of fever among their children. Children aged 6 to 59 months were tested for anaemia and malaria using finger-or heel-prick blood samples. The survey is a two-stage sampling scheme to provide most of the indicators at the national level. In the first stage, nine clusters (EAs) were selected from each state (from a list of 36 states), including the FCT (Federal Capital Territory). A total of 333 clusters throughout the country were finally selected, 138 in urban areas and 195 in rural areas. In the second stage of the sampling scheme, 25 households were selected in each cluster by equal probability systematic sampling. All women aged 15-49 who were either permanent residents of the households in the 2015 NMIS sample or visitors present in the households on the night before the survey were eligible to be interviewed. In addition, all children age 6-59 months were eligible to be tested for malaria and anaemia.

2.3 Statistical Methodology

2.3.1 Variables

The primary outcome variables are: fever in children in the previous two weeks before the survey, malaria parasitaemia and positive rapid diagnostic test (RDT). The following potential predictor variables were identified: maternal age, child's age (in months), household wealth index, maternal level of education, child's birth order, number of under-five children in the household, haemoglobin level of child, sleeping under ITN/LLIN by the child the previous night before the survey, zone, residence, household ownership of ITN/LLIN, indoor residual spray of dwelling, maternal knowledge of cause and prevention of malaria.

2.3.2 Statistical analysis

The main statistical approach was the survey adjusted logistic regression of the outcome variables and the independent variables identified above. In each case, the dependent variable (malaria morbidity) was regressed against a set of independent variables to determine the significant factors associated with any of the malaria morbidity (fever, parasitaemia and positive RDT).

3. RESULTS

The result of the survey revealed that 8034 women were interviewed in 329 clusters. The total number of children aged 6-59 involved was 6358 with mean age of 32.8 months. Table 1 provides the descriptive statistics of individual and household characteristics of the respondents (mothers of under-five children) and under-five children. The distribution of respondents (women) by wealth showed an almost equal distribution in the five wealth quintiles and majority of them had at least primary school education (61%). Approximately one in ten of the respondents was the household head. About

30% of the respondents resided in North West while only 10% were in South East. Majority were rural dwellers (61%). The age distribution of the children showed an almost uniform distribution of around 20% in the age groups except in the age group of 6-11months with 10% of children. Knowledge of and prevention practices showed that over 87% of respondents had ever heard of malaria, 59% in the last six months before the survey, 83% knew at least one cause of malaria, 81% knew of at least one prevention method of malaria and malaria in pregnancy respectively. Overall, 44% of children slept under an LLIN/ITN the night before the survey.

Table 2 showed the percent distribution of childhood malaria morbidity by selected background characteristics. Overall, 41% of mothers reported their children having fever in the two weeks preceding the survey. Children in the age range of 24-35months old, living in rural areas, those living in North West, among mothers with no formal education and children in lowest wealth quintile were more likely to have experienced fever in the two weeks before the survey. Children with these background characteristics had highest prevalence/incidence of fever two weeks before the survey. Similarly, oldest children (48-59months old), living in rural areas as well as in North West zone; children of women with no formal education and living in household in the lowest wealth quintile were more likely to be tested positive for both rapid diagnostic test (RDT) and microscopy. This table indicates that older age, rural and North West, lack of maternal educational and poverty increased the chances of childhood malaria infection in Nigeria. Malaria prevention practices such as ITN/LLIN ownership, sleeping under ITN/LLIN did not appear to be protective against childhood malaria morbidity; however, spraying the household with IRS appeared to protect against childhood malaria morbidity.

Table 1. Individual and household characteristics, Nigeria MIS 2015

Characteristic	Number	Percentage
Age of respondent (years)		
15-19	1376	17.1
20-24	1533	19.1
25-29	1636	20.4
30-34	1325	16.5
35-39	971	12.1
40-44	729	9.1
45-49	464	5.8
Wealth index		
Poorest	1448	18.0

Characteristic	Number	Percentage
Poor	1530	19.0
Middle	1564	29.5
Rich	1653	20.6
Richest	1840	22.9
Education		
None education	3119	38.8
Primary	1244	15.5
Secondary	2848	35.5
More than secondary	823	10.2
Sex of head of household		
Male	3129	87.8
Female	4905	12.3
Age of child in months		
0-5	644	9.1
6-11	665	9.4
12-23	1375	19.5
24-35	1360	19.3
36-47	1511	21.4
48-59	1495	21.2
Zone		
North Central	1357	16.9
North East	1077	13.4
North West	2359	29.4
South East	811	10.1
South South	1080	13.5
South West	1351	16.8
Residence		
Rural	4905	61.0
Urban	3129	39.0
Altitude in meters		
0-200	3082	38.4
201-400	2632	32.8
401-600	1856	23.1
601-800	364	4.5
801-1000	39	0.5
>1000	60	0.8
Ever heard of malaria		
Yes	7015	87.4
No	1016	12.7
Ever heard of malaria prevention message in past 6 months		
Yes	4153	59.2
No	2862	40.8
Knows at least one symptom of malaria		
Yes	6685	83.2
No	1346	16.8
Knows at least one cause of malaria		
Yes	7015	87.4
No	1016	12.7
Knows at least one prevention method of malaria		
Yes	6503	81.0
No	1527	19.0
Knows at least one prevention method of malaria in pregnancy		
Yes	6503	81.0
No	1527	19.0
Slept under ITN/LLIN previous night(U5)		
Yes	3496	44.0

Characteristic	Number	Percentage
No	444	56.0

Tables 3, 4 and 5 showed the results of the univariate and multivariate survey logistic regression of the determinants of childhood malaria morbidity. As regard Table 1, age of child (in months), number of under-five children in the household, haemoglobin level of child and zone were uniform determinants of childhood fever in the weeks before the survey. Older children, especially those aged 48-59months [OR=1.43; 95%CI: 1.25-1.65] were more likely to experience fever than younger children. Living in the southern zones of the country was associated with lower risks of experiencing fever while living in the northern zones is associated with elevated risks of fever; children in rural parts of the country have increased odds of having fever compared to their urban colleagues [OR=1.41; 95%CI: 1.27-1.58]. Preventive practices appeared to be protective against fever. Sleeping under ITN/LLIN is associated with decreased odds of fever [OR=0.59; 95%CI: 0.55-0.65]. Also household ownership of at least one ITN/LLIN [OR=0.81; 95%CI: 0.74-0.89], indoor residual spray (IRS) [OR=0.1; 95%CI: 0.11-0.27] and knowledge of at least one method of malaria prevention [OR=0.29; 95%CI: 0.25-0.33] decreased the odd of fever. With regards to malaria parasitaemia (Table 4), only household wealth quintile and place of residence (among the selected socio-demographic characteristics) appeared to be the uniform determinant in both univariate and multivariate logistic regression. Preventive practices and knowledge of preventive practices were significant determinants of malaria parasitaemia in multivariate model: household ownership of ITN/LLIN [OR=0.76; 95%CI: 0.63-0.90], IRS [OR=0.18; 95%CI: 0.04-0.87], knowledge of one cause of malaria [OR=1.43; 95%CI: 1.03-1.98] and knowledge of at least one preventive method [OR=0.64; 95%CI: 0.48-0.84]. Table 5 indicates that wealth index was a strong predictor of positive RDT test among children. Rural residence was equally a strong determinant of positive RDT test [OR=1.95; 95%CI: 1.62-2.33]. In summary, geopolitical zone, place of residence (rural/urban), household wealth quintile and indoor residual spray in the past 12 months were the consistent determinants of childhood malaria morbidity; knowledge of prevention and practice of prevention (besides

IRS) were not consistent across the three models.

4. DISCUSSION

In this study, we demonstrated the significant roles played by several factors in predicting three childhood malaria morbidities using the most recent Nigeria Malaria Indicator Survey data. We modelled 14 potential factors of which only two show consistencies and uniformity in their role as determinants of childhood morbidities: place of residence and indoor residual spray. However, with respect to experiencing fever in the two weeks prior to the survey (Table 3), the multivariate logistic regression showed that age of the child, number of under-5 children in the households, haemoglobin level of the child, sleeping inside LLIN/ITN the previous night before the survey, zone, household ownership, household being sprayed with IRS and knowledge of malaria prevention and causes are significant determinants. With regards to parasitaemia (through microscopy), household wealth quintile, place of residence, household ownership, IRS of household as well as knowledge of causes and prevention of malaria are the consistent determinants. Lastly, only household wealth quintile and place of residence are the significant determinants of positive RDT test for malaria in these children.

In this study, household ownership of at least one LLIN/ITN is found to be protective against fever in the past two weeks before the survey as well as parasitaemia; however, it is not protective against positive RDT. From previous studies across the world, use of LLIN/ITN has been shown to protect against malaria infection; Lengeler [29] and Gamble [30] conducted two separate Cochrane Reviews, one for general populations and one for pregnant women respectively which led to the conclusion that use of LLIN/ITN has a protective efficiency against *Plasmodium* parasitaemia of between 13% and 29% in areas of stable malaria transmission among the general population. Our study indicates that use of LLIN/ITN reduces childhood fever (from malaria) by 19% and *Plasmodium*

Table 2. Percent distribution of childhood malaria morbidity by selected characteristics, Nigeria MIS 2015

Characteristic	Fever past two weeks	Malaria (microscopy)	Malaria (RDT)
Age of child in months			
0-5	23.4	31.8	49.9
6-11	60.0	27.4	44.3
12-23	43.0	26.1	40.9
24-35	38.7	29.7	50.4
36-47	38.4	21.6	40.8
48-59	51.3	30.3	47.2
Wealth index			
Poorest	51.0	42.9	64.1
Poor	48.5	41.0	62.6
Middle	41.7	27.4	49.1
Rich	34.4	16.8	30.1
Richest	26.0	4.4	12.6
Education			
No formal education	47.6	37.7	59.7
Primary	40.3	26.2	44.3
Secondary	35.1	16.7	29.9
More than secondary	27.0	3.6	12.5
Zone			
North Central	29.9	32.0	50.7
North East	48.0	25.9	42.8
North West	52.1	37.1	58.3
South East	38.3	13.7	31.7
South South	42.9	19.3	28.6
South West	23.5	16.6	32.1
Residence			
Rural	46.3	35.6	55.7
Urban	30.2	11.5	24.2
ITN/LLIN ownership			
Yes	43.7	27.7	46.1
No	37.6	27.2	42.4
Child slept inside ITN/LLIN previous night			
Yes	42.4	25.4	49.8
No	43.4	29.3	41.0
IRS previous 12months			
Yes	8.9	10.2	15.2
No	42.7	27.6	45.5

Table 3. Univariate and multivariate logistic regressions of determinants of fever in the past two weeks before the survey, Nigeria MIS 2015

Variable	Univariate analysis odds ratio (95%CI)	Multivariate analysis odds ratio (95%CI)
Age of respondent (years)		
15-19	1.00	1.00
20-24	1.12 (1.00-1.26)	3.52 (2.94-4.21)***
25-29	0.94 (0.84-1.06)	3.04 (2.56-3.62)***
30-34	1.37 (1.22-1.54)***	3.64 (3.04-4.37)***
35-39	0.32 (0.28-0.37)***	0.88 (0.72-1.08)
40-44	1.89 (1.60-2.23)***	4.43 (3.51-5.59)***
45-49	7.36 (5.63-9.62)***	8.75 (6.27-12.21)***
Wealth index		
Poorest	1.00	1.00
Poor	2.83 (2.61-3.07)***	2.20 (1.95-2.47)***
Middle	1.03 (0.95-1.12)	1.23 (1.08-1.40)**
Rich	0.93 (0.85-1.01)	1.34 (1.14-1.57)***

Variable	Univariate analysis odds ratio (95%CI)	Multivariate analysis odds ratio (95%CI)
Richest	0.66 (0.60-0.72)***	0.99 (0.81-1.21)
Age of child in months		
6-11	1.00	1.00
12-23	0.50 (0.45-0.56)***	0.73 (0.64-0.84)***
24-35	0.42 (0.38-0.47)***	0.68 (0.59-0.78)***
36-47	0.41 (0.37-0.47)***	0.42 (0.36-0.48)***
48-59	0.70 (0.63-0.78)***	1.43 (1.25-1.65)***
Child birth order		
1 st	1.00	1.00
2 nd	0.74 (0.70-0.83)***	0.92 (0.81-1.04)
3 rd	0.67 (0.60-0.74)***	0.79 (0.69-0.91)**
4 th and more	1.08 (1.00-1.16)**	0.75 (0.68-0.84)***
Number of under fives		
None	1.00	1.00
One	13.94 (8.04-24.16)***	10.18 (5.20-19.93)***
Two	11.67 (6.73-20.22)***	6.46 (3.30-12.61)***
Three	9.40 (5.41-16.33)***	6.29 (3.20-12.35)***
Four and more	9.57 (5.50-16.64)***	4.92 (2.50-9.69)***
Haemoglobin level of child		
Severe anaemia	1.00	1.00
Mild anaemia	0.32 (0.28-0.37)***	0.58 (0.49-0.68)***
Moderate anemia	1.18 (1.04-1.34)	1.33 (1.13-1.55)***
Not anaemic	0.47 (0.42-0.54)***	0.78 (0.66-0.91)***
Child slept under net last night		
No	1.00	1.00
Yes	0.97 (0.91-1.02)	0.59 (0.55-0.65)***
Education		
No formal education	1.00	1.00
Primary	0.98 (0.91-1.05)	1.02 (0.92-1.12)
Secondary	0.60 (0.56-0.64)***	0.97 (0.86-1.10)
More than secondary	0.74 (0.65-0.84)***	1.77 (1.43-2.18)***
Zone		
North Central	1.00	1.00
North East	1.06 (0.96-1.17)	1.88 (1.64-2.16)***
North West	1.58 (1.46-1.72)***	2.44 (2.14-2.79)***
South East	0.45 (0.40-0.52)***	0.68 (0.57-0.80)***
South South	0.81 (0.73-0.90)***	0.84 (0.72-0.97)**
South West	0.44 (0.39-0.49)***	0.55 (0.47-0.64)***
Residence		
Urban	1.00	1.00
Rural	1.68 (1.58-1.78)***	1.41 (1.27-1.58)***
Household has at least one net		
No	1.00	1.00
Yes	1.29 (1.21-1.37)***	0.81 (0.74-0.89)***
Indoor Residual Spray (IRS)		
No	1.00	1.00
Yes	0.13 (0.09-0.19)***	0.17 (0.11-0.27)***
Knowledge of malaria cause		
No	1.00	1.00
Yes	1.22 (1.12-1.33)***	3.94 (3.30-4.71)***
Knowledge of malaria prevention		
No	1.00	1.00
Yes	0.82 (1.04-1.34)**	0.29 (0.25-0.33)***

Table 4. Univariate and multivariate logistic regressions of determinants of parasitaemia, Nigeria MIS 2015

Variable	Univariate analysis Odds Ratio (95%CI)	Multivariate analysis Odds Ratio (95%CI)
Age of respondent (years)		
15-19	1.00	1.00
20-24	1.24 (1.03-1.50)**	1.13 (0.89-1.44)
25-29	1.01 (0.83-1.23)	1.03 (0.79-1.33)
30-34	1.09 (0.89-1.33)	0.99 (0.76-1.30)
35-39	1.15 (0.93-1.43)	1.45 (1.08-1.93)**
40-44	0.64 (0.49-0.84)***	0.78 (0.56-1.09)
45-49	0.97 (0.72-1.32)	0.88 (0.601-1.28)
Wealth index		
Poorest	1.00	1.00
Poor	0.69 (0.59-0.81)***	0.81 (0.66-1.00)*
Middle	0.52 (0.44-0.61)***	0.78 (0.61-0.99)*
Rich	0.29 (0.24-0.36)***	0.52 (0.38-0.70)***
Richest	0.07 (0.05-0.09)***	0.11 (0.07-0.18)***
Age of child in months		
6-11	1.00	1.00
12-23	0.94 (0.73-1.19)	1.02 (0.77-1.36)
24-35	1.12 (0.88-1.42)	1.19 (0.90-1.56)
36-47	0.73 (0.58-0.92)**	0.86 (0.65-1.13)
48-59	1.15 (0.92-1.45)	1.25 (0.96-1.64)
Child birth order		
1 st	1.00	1.00
2 nd	0.75 (0.62-0.90)***	0.83 (0.64-1.06)
3 rd	1.16 (0.95-1.41)	0.93 (0.72-1.19)
4 th and more	1.05 (0.90-1.23)	0.76 (0.63-0.93)**
Number of under fives		
None	1.00	1.00
One	1.14 (0.96-1.37)	1.03 (0.83-1.28)
Two	1.66 (1.40-1.98)***	0.96 (0.76-1.20)
Three	1.38 (1.12-1.71)***	0.96 (0.73-1.28)
Four and more	1.79 (1.44-2.23)***	0.87 (0.63-1.20)
Haemoglobin level of child		
Severe anaemia	1.00	1.00
Mild anaemia	0.55 (0.40-0.75)***	0.62 (0.43-0.89)**
Moderate anemia	1.13 (0.85-1.51)	1.05 (0.75-1.47)
Not anaemic	0.43 (0.32-0.58)***	0.57 (0.40-0.811)**
Child slept under net last night		
No	1.00	1.00
Yes	1.21 (1.08-1.37)***	0.86 (0.73-1.02)
Education		
No formal education	1.00	1.00
Primary	0.63 (0.54-0.73)***	0.73 (0.60-0.89)**
Secondary	0.37 (0.32-0.43)***	0.96 (0.76-1.21)
More than secondary	0.18 (0.13-0.26)***	1.01 (0.59-1.72)
Zone		
North Central	1.00	1.00
North East	0.76 (0.62-0.93)***	0.72 90.57-0.93)**
North West	1.25 (1.07-1.46)***	0.93 (0.73-1.18)
South East	0.34 (0.26-0.45)***	0.71 (0.50-1.01)

Variable	Univariate analysis Odds Ratio (95%CI)	Multivariate analysis Odds Ratio (95%CI)
South South	0.51 (0.40-0.64)***	0.84 (0.62-1.13)
South West	0.38 (0.31-0.48)***	0.85 (0.63-1.15)
Residence		
Urban	1.00	1.00
Rural	4.31 (3.69-5.03)***	1.79 (1.44-2.22)***
Household has at least one net		
No	1.00	1.00
Yes	0.97 (0.86-1.11)	0.76 (0.63-0.90)***
IRS		
No	1.00	1.00
Yes	0.30 (0.15-0.59)***	0.18 (0.04-0.87)**
Knowledge of malaria cause		
No	1.00	1.00
Yes	0.58 (0.49-0.69)***	1.43 (1.03-1.98)**
Knowledge of malaria prevention		
No	1.00	1.00
Yes	0.52 (0.49-0.65)***	0.64 (0.48-0.84)***

parasitaemia by 24% showing that our results are consistent with that of the review by Lengeler [29]. Related to LLIN/ITN ownership is sleeping under the net the night before the survey. This variable has been used as a proxy for utilization of LLIN/ITN in surveys. The finding from this study indicates that sleeping under LLIN/ITN the night before the survey is protective against childhood fever only; not protective against *Plasmodium* parasitaemia or positive RDT. It has been shown that use of mosquito nets irrespective of whether it is treated or not, the number of the nets in the household and whether the child slept under it or not the night before the survey are significantly associated with child's malaria status [31]. Our results are partly (with respect to childhood fever) consistent with those

reported by Gahutu et al. [22] and Okebe et al. [32].

Indoor residual spray (IRS) of houses/households showed significant protective effect against all the three childhood morbidities modelled in this study, even though the coverage of this intervention is one of the lowest in the country at only 1.3%. Indoor residual spray either alone or in combination with ITN has been shown to provide protection against malaria infection. In a systematic review published in 2010 by Pluess and colleagues [33], IRS had been demonstrated to significantly reduce malaria transmission by as much as 14% in children aged one to five years. In our study, the risk of childhood fever, *Plasmodium* parasitaemia and positive RDT are

Table 5. Univariate and multivariate logistic regressions of predictors of positive RDT, Nigeria MIS 2015

Variable	Univariate analysis Odds Ratio (95%CI)	Multivariate analysis Odds Ratio (95%CI)
Age of respondent (years)		
15-19	1.00	1.00
20-24	1.14 (0.97-1.35)	1.06 (0.86-1.32)
25-29	0.95 (0.80-1.12)	1.01 (0.81-1.27)
30-34	1.02 (0.86-1.21)	0.99 (0.78-1.25)
35-39	0.84 (0.69-1.01)	0.99 (0.76-1.28)
40-44	0.90 (0.73-1.11)	1.18 (0.89-1.57)
45-49	0.91 (0.69-1.18)	0.97 (0.71-1.35)
Wealth index		
Poorest	1.00	1.00
Poor	0.72 (0.61-0.84)***	0.76 (0.62-0.92)**
Middle	0.48 (0.41-0.56)***	0.68 (0.55-0.85)**
Rich	0.25 (0.21-0.30)***	0.44 (0.34-0.57)***
Richest	0.08 (0.07-0.10)***	0.15 (0.11-0.21)***

Age of child in months		
6-11	1.00	1.00
12-23	0.87 (0.70-1.07)	1.10 (0.86-1.41)
24-35	1.28 (1.04-1.57)*	1.47 (1.15-1.88)**
36-47	0.86 (0.71-1.06)	1.15 (0.91-1.47)
48-59	1.12 (0.92-1.38)	1.24 (0.97-1.58)
Child birth order		
1 st	1.00	1.00
2 nd	0.92 (0.78-1.08)	0.98 (0.80-1.22)
3 rd	1.26 (1.06-1.51)**	1.01 (0.80-1.26)
4 th and more	1.25 (1.09-1.43)***	0.86 (0.72-1.02)
Number of under fives		
None	1.00	1.00
One	0.98 (0.84-1.13)	0.98 (0.81-1.18)
Two	1.50 (1.30-1.74)***	0.98 (0.80-1.19)
Three	1.18 (0.98-1.41)	0.88 (0.69-1.13)
Four and more	2.03 (1.66-2.46)***	1.11 (0.84-1.48)
Haemoglobin level of child		
Not anaemic	1.00	1.00
Severe anaemia	2.94 (2.26-3.82)***	1.86 (1.36-2.56)***
Mild anaemia	2.49 (2.18-2.85)***	1.58 (1.34-1.86)***
Moderate anemia	1.31 (1.12-1.53)***	1.68 (0.98-1.40)
Child slept under net last night		
No	1.00	1.00
Yes	1.42 (1.28-1.58)	1.01 (0.87-1.17)
Education		
No formal education	1.00	1.00
Primary	0.61 (0.53-0.70)***	0.74 (0.62-0.89)**
Secondary	0.36 (0.31-0.41)***	0.99 (0.80-1.21)
More than secondary	0.15 (0.11-0.20)***	0.79 (0.52-1.20)
Zone		
North Central	1.00	1.00
North East	0.73 (0.61-0.88)***	0.69 (0.55-0.86)**
North West	1.35 (1.17-1.57)***	1.12 (0.90-1.39)
South East	0.45 (0.36-0.56)***	1.08 (0.82-1.43)
South South	0.40 (0.32-0.49)***	0.71 (0.55-0.92)**
South West	0.46 (0.39-0.55)***	1.26 (0.98-1.62)
Residence		
Urban	1.00	1.00
Rural	3.96 (3.52-4.46)***	1.95 (1.62-2.33)***
Household has at least one net		
No	1.00	1.00
Yes	1.16 (1.04-1.30)**	1.01 (0.87-1.17)
IRS		
No	1.00	1.00
Yes	0.21 (0.12-0.38)***	0.20 (0.07-0.57)**
Knowledge of malaria cause		
No	1.00	1.00
Yes	0.62 (0.53-0.72)***	1.18 (0.86-1.61)
Knowledge of malaria prevention		
No	1.00	1.00
Yes	0.62 (0.55-0.71)***	0.78 (0.60-1.01)

all significantly reduced (by between 80% and 83%) if the child lives in households that have been sprayed within the previous 12months. Similar results were reported by Roberts (31) in

which they reported that child's malaria status is significantly associated with the incidence of IRS within the last six months. Specifically, risk of malaria parasitaemia is increased over seven-

fold if the household was not sprayed in the last six months.

That rural location turned out to be a significant risk factor for malaria morbidities could be the result of interplay of several factors operating in the rural areas. It could be lack of knowledge of prevention of malaria, lack of access to malaria prevention methods such as long-lasting insecticidal nets (LLIN)/ITN, behavioural factors of poor environmental sanitation and management of vector ecology to prevent breeding of mosquitoes as well screening of windows and doors. Living arrangement in rural areas where animals (goats, sheep, oxen and cattle) are kept and reared within the household could be associated with increased risk of malaria. Killeen and Smith TA have argued that presence of animals particularly cattle provides alternative blood meal to mosquitoes but in the absence of protective and preventive measures, they feed on humans [28]. The data set used here captured household ownership of animals (goats, cattle, sheep, chickens and donkeys/horses) which showed that ownership of these animals is highest among rural dwellers than urban dwellers.

We are unable to demonstrate the important roles of wealth, age of child, education of the mother as reported by previous researchers [31, 34, 35]. In these investigations, it was reported that the older the child the greater the risk of malaria childhood morbidities. This relationship could be due to the fact that the older children are likely to be part of the preventive measures adopted by their mother/care givers possibly there is already a younger child being born into the family. This older child might be taken care of by older siblings while the mother focuses her efforts on the new born baby. Gahutu [22], Pullan et al. [36], and Krefis et al. [37] reported similar relationship between age of child and childhood malaria morbidities. Similarly, we are unable to demonstrate the effect of wealth on childhood malaria morbidities despite that fact that malaria has been shown to be a disease of the poor or disease of poverty. This claim can be substantiated by noting the global distribution of malaria where the concentration of the disease is in poorest continents and countries; and among poorest households within countries or communities. This relationship is clearly shown in Table 2 where incidence of fever in past two weeks, parasitaemia and positive RDT decreases massively as the wealth level increases. Being a primary cause of poverty, some studies suggest that a better

understanding of the relationships between malaria and poverty is needed to enable the design of coherent and effective policies and tools to tackle the problem. Since poverty is related to socio-economic factors, it is important to identify those factors that are also related to the risk of malaria [38, 39].

5. CONCLUSION

While some of the results of this study agreed with those of other studies, some do not. As pointed out at the beginning of our discussion, only place of residence and indoor residual spray turned out to be the uniform determinants of three childhood malaria morbidities examined here. The role of IRS as an important determinant of childhood morbidity is unexpected keeping in mind that only around 1.3% of households were sprayed with IRS within the past 12 months before the survey. However, this result is indicative that IRS is a promising intervention in the control of malaria if only small proportion of household are covered with this intervention, yet it turned out to be significant protector against malaria.

6. LIMITATION

An important limitation of this study is the fact it utilized the Malaria Indicator Survey which was a cross-sectional study, meaning that temporal sequence of association between significant risk factors and childhood malaria morbidities could not be established. However, the study has its strengths. The complex design of the study was accounted for by including the effect of the clusters in the model as a random effect. The test of covariance parameters confirmed that accounting for this cluster effect was necessary in order to make meaningful and accurate statistical inferences. The use of a multivariate GLMM allowed an assessment of the association between the prevalence of malaria and a potential risk factor, while adjusting for other variables. In this study, several important socio-economic, demographic and environmental risk factors for malaria were identified using a population-based survey.

CONSENT

It is not applicable.

ETHICAL APPROVAL

This study was primarily granted ethical approval by the National Health Research Ethics

Committee of the Federal Ministry of Health, Abuja, Nigeria (Assigned Number NHREC/01/01/2007-11/05/2015). Permission to use the 2015 Nigeria MIS data sets was obtained from MEASURE DHS

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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