INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

An Extension of Blinder-Oaxaca Decomposition on Investigating the Correlation of Maternal Education and Childhood Malaria Infection in Nigeria

OjoAdedayo Edwin
Research Project Manager, Department of Epidemiology and Medical Statistics,
University of Ibadan, Nigeria
Yusuf Oyindamola Bedemi
Lecturer, Department of Epidemiology and Medical Statistics,
University of Ibadan, Nigeria
Dr. Afolabi Rotimi Felix
Lecturer, Department of Epidemiology and Medical Statistics,
University of Ibadan, Nigeria
Kareem Yusuf Olushola
Data Analyst, Institute for Advanced Medical Research and Training,
University of Ibadan, Nigeria

Abstract:
Malaria infection is a major public health problem in Nigeria, more especially among pregnant women and children. Despite the assertion that mother's education is likely to influence her health care seeking behaviour and that of her child. The relationship between maternal education and malaria, a leading cause of child mortality, has not garnered adequate research in Nigeria. Therefore, this study used the Blinder-Oaxaca decomposition to explain the gap between maternal education and childhood malaria infection. The outcome variable was children ever had fever which was used as a proxy for occurrence of malaria, while our main explanatory variable was maternal education. The statistical methods employed were chi-square, multilevel logistic model and Blinder–Oaxaca decomposition technique. A total sample of 28,634 children aged 0-59 months wereanalysed. The overall prevalence of malaria was found to be 12.7%. The results for multilevel logistic regression revealed that there was a statistically significant association between childhood malaria infection (CMI) and maternal education. Under-five children whose mothers had higher education (OR=0.26, 95% CI: 0.05-0.48) and those in the richest wealth quintiles (OR= 0.68,95% CI: 0.51-0.85) had a lower odds of reporting CMI compared to those with no education and in the poorest quintile respectively. Also, there exist regional differential in CMI; women in the North East (OR=3.39, 95% CI: 3.25-3.52), North West (OR=1.37, 95% CI: 1.23-1.52), South East (OR=3.17, 95% CI: 3.02-3.33) and South South (OR=2.07, 95% CI: 1.92-2.23) had 3.39,1.37, 3.17and 2.07 higher odds of reporting CMI respectively. The Blinder-Oaxaca decomposition analysis revealed 0.34% gap between CMI for educated and non-educated mothers, while other differences explained by household wealth, region and age of the child were 68%, 0.06% and 1.03% respectively. Malaria infection is still highly prevalent in Nigeria. The higher prevalence of malaria among under-five children could be explained by several factors as observed in this study. Household wealth is the most contributing factor to the observed difference between maternal education and childhood malaria infection. Effort should be made in the area of women empowerment so as to broader enhance their socioeconomic status in Nigeria.

Keywords: *Malaria, childhood, maternal education, logistic regression, blinder-oaxaca decomposition*

1. Introduction

In most health researches involving risk factors, there is a challenge of estimating the contribution of each risk factor of outcome variable of interest. In response to this challenge, Oaxaca-Blinder decomposition was developed [1]. The Oaxaca-Blinder (B-D) is a multivariable statistical method widely used to identify and quantify the separate contributions of group differences in measurable or observable characteristics, such as education, marital status, geographical differences, racial and gender gaps in outcomes [2]. In other words, it is a generalized linear decomposition technique that partitions differences in mean outcomes across two groups into a part that is due to group differences in the levels of independent variables, and a part that is due to differential magnitudes of regression coefficients [3]. Besides, it could be used to decompose the difference in a distributional statistic between two groups, or its change over time into various explanatory factors (explained and unexplained parts). The explained part is the part that is explained by the group differences while the unexplained part is often used as a measure for discrimination, but it also subsumes the effects of group differences in unobserved predictors [4]. The B-D method is gaining popularity in health services research because of its ability to explain disparity issues [8]. This approach has been, and will continue to be widely used in examining differences and changes in various socio-economic variables as a result of its simplicity and flexibility in the application and the insights it offers [5]. However, the initial B-D is inappropriate when the outcome variable is binary or dichotomized; it does allow us to decompose inequalities in health data when the assumptions for the classical regression are not satisfied. Initially, the B-D decomposition technique was developed to decompose differentials or changes of any continuous variable. As a result, the technique cannot be used directly if the outcome is binary and the coefficients are from a logit or probit model [2]. The original method proposed by Oaxaca and Blinder for decomposing changes in the mean of quantitative outcome variable has been considerably improved and expanded upon over the years. Arguably, the most important development has been to extend decomposition methods to distributional parameters other than the mean [4]. The flexibility of this technique can further be demonstrated by extending it to decomposing differences or changes in outcome variables that are dichotomous in nature [6]. This method would particularly be useful in biomedical science as several measure of health outcomes is either categorical or count variable.

Malaria is a major public health concern in Nigeria, more especially among pregnant women and children because of their vulnerability. It is a major public health problem in Sub Saharan Africa, most particularly in Nigeria where widespread poverty also contributes to the burden of the disease [7,8,9,10,11]. Every single day, Nigeria loses about 2,300 under-five year old and 145 women of childbearing age, which makes the country the second largest contributor to the under–five and maternal mortality rate in the world [12,13]. With so many gains in prevention and efforts on malaria infection control, malaria remains a leading cause of morbidity and mortality worldwide. Most of these deaths also occur in children in high-transmission areas, and it accounts for approximately one in five of all childhood deaths in Africa. It is a globally accepted fact that malaria is a disease of public health importance. According to the World Malaria Report 2015, there were214 million cases of malaria globally in 2015 and 438 000 malaria deaths, representing a decrease in malaria cases and deaths of 37% and 60% since 2000, respectively [14]. Children under five are particularly susceptible to malaria illness. In 2010, it was estimated that over 500 million school-age children were at risk of malaria infection with about200 million cases in the sub-Saharan Africa [15]. In 2015, an estimated 306 000 under-fives deaths were attributed to malaria globally, with 292 000 children in the African regions alone. Between 2000 and 2015, the mortality rate among children under five fell by 65% worldwide and by 71% in Africa [16]. Children less than five years of age living in sub-Saharan Africa are mainly affected by the malaria parasite. The epidemic disease posts a significant health and economic burden in Nigeria [1]. Studies have shown that maternal education is one of the major forces that improve child health [17]. Recent decline in child mortality in the last 3rd of a century have been the result not only limited to technological and economic change, but also of social status, out of which the most significant component for the survival of the child through the first years of life has been parental education. The literacy that women have, has been shown to enhance their ability do appropriate medical treatment for their children [18,19]. This study therefore was conducted to determine the prevalence of CHI, investigate the correlates of CHI and to estimate the contribution of the significant factors associated with CHI in Nigeria.

2. Methodology

2.1. Data Source

This study is an analysis of data from the 2013 Nigeria Demographic and Health Survey (NDHS), the study design used for the investigation was a cross sectional study. The NDHS used a stratified multi-stage sampling technique to collect information on several health indicators. The study population included all women of reproductive age 15-49 years with a child who is under-five and responded to the question on child malaria infection.

2.2. Instruments

The DHS used a structured and pretested questionnaire to collect information from the respondents on different issues which include child mortality, children's nutritional status, maternal and child health services, the instrument used comprises of several categories, namely: Household (HH) questionnaire, Women's questionnaire and the Man's questionnaire. For the purpose of this study, the birth recode dataset was used.

2.3. Study Variables

Our primary outcome variable was the occurrence of fever as a condition for malaria infection among the under-five children; this was based on the occurrence of fever in the last two weeks as at the time of data collection. According to the records on the 2013 NDHS data, the variable was coded as Yes (1) and No (0). The main explanatory variables include; maternal education, family formation pattern, child health knowledge, social networking and economic empowerment, while controlling for other background characteristics that included; insecticide treated net (ITN) ownership and utilization, sex of the child, age of child, mother's age, place of residence, age at first birth, head of household (HHH) education and region as shown in table 1.

Independent Variables	Variable Description
• Maternal education level	Indication of the highest level of education attained by a mother of a child within the survey period. Education level is coded into four categories: (1) no formal education, (2) primary education only, (3) secondary and (4) higher education.
• Child health knowledge	Two indicators were used to capture maternal knowledge on their children's health: (1) reported use of intermittent treatments nets during pregnancy by mothers (2) reported ownership of any mosquito net within the household [11].
• Household wealth	Women's economic empowerment was measured by the household wealth quintiles coded in ascending order from one to five (poorest to richest).
• Family formation pattern	(1) Total children ever born was used
• Social networking	Ownership of mobile phones by mothers was used as a proxy for enhanced social networking
Other Control Variables	
Place of residence: Rural and urban areas	
Sex of the child, age of child, mother's age at first birth, education status of the head of household (HHH) and region	

Table 1: Explanatory Variables

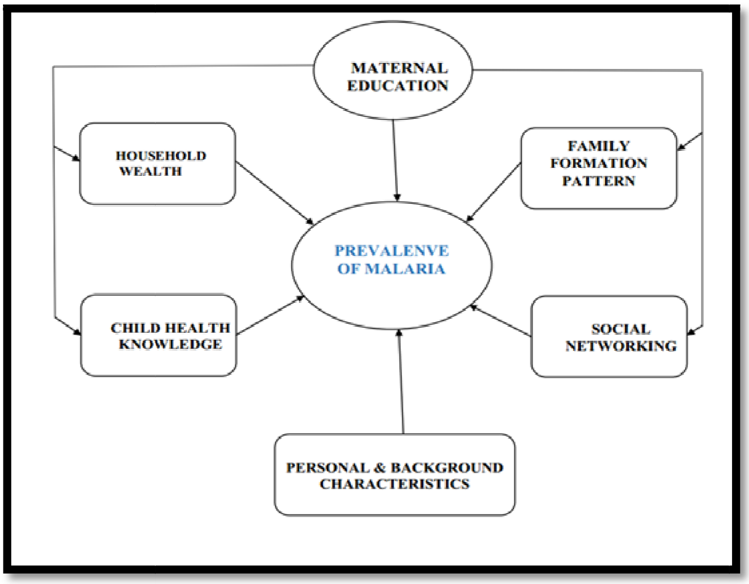

Figure 1: Conceptual Frame of CMI

2.4. Conceptual Framework

The Conceptual Framework developed around the B-D model is shown in figure 1. We considered a population of under-five children with their respective status of malaria infection, and they were then divided into two mutually exclusive groups, one with fever and the other without fever (used as a proxy for CHI). We then defined the conditional maternal educational gap between educated and non-educated mothers and was made to be dependent on the outcome variable model, the result was further modeled by partitioning the outcome variable over all the independent variables as shown in figure1.

2.5. Method

Summary statistics (frequencies and proportions) were reported for the prevalence of malaria among the under-five children. A bivariate analysis was carried out to investigate the association between proportion of the under-five children with malaria and maternal education (using SPSS version 25.0). A p-value of less than 0.05 was considered to be statistically significant. A two-level multilevel logistic regression model was fitted to investigate the correlates of CHI. Only significant factors from the 2-level multilevel model were used in the Oaxaca Blinder decomposition to investigate the contribution of each associated factor of CHI (using R language, *Version* 3.4.3). In the multilevel model, Level 1 variables were individual characteristics while the level 2 was enumeration areas (communities). The results of the fixed part of the multilevel model were expressed as odds ratios (OR) with the corresponding 95% confidence intervals, while intra-class correlation coefficient (ICC) was reported for the random effect given as $\frac{\pi^2}{3}$ $(\rho = \frac{\sigma_\varepsilon^2}{\sigma_\varepsilon^2 + \sigma_d^2})$. The model is represented as;

$$M_{ij} = ME_{ij}\beta_0 + CK_{ij}\beta_1 + PF_{ij}\beta_2 + HW_{ij}\beta_3 + SN_{ij}\beta_4 + C_{ij}\beta_{1,\dots,n} + \epsilon_i + d_j \dots \quad (2)$$

Where: M_{ij} = Childhood malaria infection rates, ME_{ij} = maternal education, CK_{ij} = knowledge about child health, PF_{ij} = family formation patterns, HW_{ij} = household wealth, SN_{ij}= social network, C_{ij} = all other controls (such as region and individual characteristics), ϵ_i is the random error, d_j is the enumeration areas controlling for fixed effect factors of the explainnary variables, $\epsilon_i \sim N(0,\sigma_\varepsilon^2)$ and $d_j \sim N(0,\sigma_d^2)$ are both random intercepts assumed to be independent of each other, the subscript ij indicates individual child i in sampling area j.

The basic setup of the Blinder-Oaxaca decomposition works as follows: Suppose we have a variable Y_i, which is our outcome variable of interest. We have two groups, which we shall call the educated and the non-educated groups. We assume $Y_i$is explained by a vector of determinants. We also assume that a relationship exists between child i's malaria infection (Y_i), and some determinants of childhood malaria infections (X_i being maternal education).

Thus, the non-linear extension of B-D can be expressed as; $Y_i = F(X_i, \hat{\beta})$ ... (3)

Equation (3) can be further partitioned into

$$Y_i^{edu} - Y_i^{noedu} = \left\{ \sum_{i=1}^{N^{edu}} \frac{F\left(X_i^{edu}\hat{\beta}^{edu}\right)}{N^{edu}} - \sum_{i=1}^{N^{noedu}} \frac{F\left(X_i^{noedu}\hat{\beta}^{edu}\right)}{N^{noedu}} \right\} + \left\{ \sum_{i=1}^{N^{noedu}} \frac{F\left(X_i^{noedu}\hat{\beta}^{edu}\right)}{N^{noedu}} - \sum_{i=1}^{N^{noedu}} \frac{F\left(X_i^{noedu}\hat{\beta}^{noedu}\right)}{N^{noedu}} \right\} \quad \ldots \quad (4)$$

Where: N is sample size for educated and non-educated mothers, first term in brackets represents the part of the malaria infections gap that is caused by differences in maternal education level, whereas the second term in bracket represents the part caused by differences in the group processes determining levels of outcome variable Y_i for childhood malaria infections, the second term also captures the portion of the malaria infections gap that is caused by group differences in immeasurable or unobserved endowments. The model simply assumed that the under-five children of educated mothers have lesser chance of having malaria parasite compared to the under-five children from non-educated mothers. The gap in variable Y_i between the educated and non-educated mothers can be thought of as being due to part differences in the intercepts (given in the first expression in the first-hand side of the R.H.S of equation 4), and the difference in change in the level of the explanatory variables (X_i) and its coefficients.

Percentage contribute = $\frac{coefficients\ of\ each\ variable}{total\ coefficients}$X 100 Uthman, 2009).

3. Results

3.1. Socio-Demographic Characteristics

In total, 28,634 under-five old children with complete records who were available for analysis were included in the study after weighting. About half (50.1%) were males, with a mean age and standard deviation of 21.0 ± 16.0 (in months) respectively. Exactly 12.7% of the children were reported to have fever as at the time of the survey. Approximately 64% of children were reported to reside in rural areas. The average age of the mothers was found to be 29.3 ± 7.1 years, with 19.4 ± 4.3 mean age at first birth. Almost half of the mothers were found not to have formal education (48.1%), while only few of them were reported with higher education (6.1%). About 39.5% was reported for HHH with no formal education while only 11.8% was reported for HHH with higher education. About 36.3% and 8.9% of the mothers were found from the North West and South East of Nigeria respectively. Higher percentage of the study participants were found in the poorest quintile (22.9%), while the least were reported to fall in the richest quintile (17.5%). Among the women, only 24.0% of them does not possess a mobile phone, 65.3% of the women reported that they had ITN while 34.7% said that children under 5 slept under mosquito bed net night before the survey. Only 36.0% of the under-five children analyzed from the data set reside in the urban areas.

3.2. Malaria Prevalence and Associated Factors among Under-Five Children

The overall malaria prevalence among the under-five was reported to be 12.7% of the under-five children as shown in figure 2. From table 3, childhood malaria infection was most prevalent among women who had only primary education (13.0%). The prevalence of malaria among under-five children whose mothers' falls between the ages of 30-34 was 13.4% while the lowest prevalence (11.8%) was reported among mothers between the ages of 20 to24.

Children within 48-59 months old (10.5%) and 24-35 months old (17.6%) were reported with lowest and highest prevalence of malaria infection respectively, while only 9.4% prevalence was observed among the males, 13.0% prevalence occurred among the under-five females. Among the six geo-political zones, South West had the least childhood malaria prevalence (7.3%) while North East had the highest (21.1%). Under-five children in the richer quintile had 8.1% malaria prevalence while those within middle quintile had 13.8% malaria prevalence. The proportion of under-five children with malaria infection was the same for women with and without mobile phone (12.7%). Women who got married early had the highest malaria prevalence (< 15 years; 13.5%) compared to women in other age groups. Prevalence of malaria was approximately the same among women with 1-2 and 3-4 children (12.6% and 12.7% respectively), only 9.3% malaria prevalence was found among those whose HHH had no formal education while 14.9% was estimated among the HHH with higher education. In the urban areas, the prevalence of CMI was 12.2%, while 12.9 was reported in the rural areas as shown in table 2 and 3.

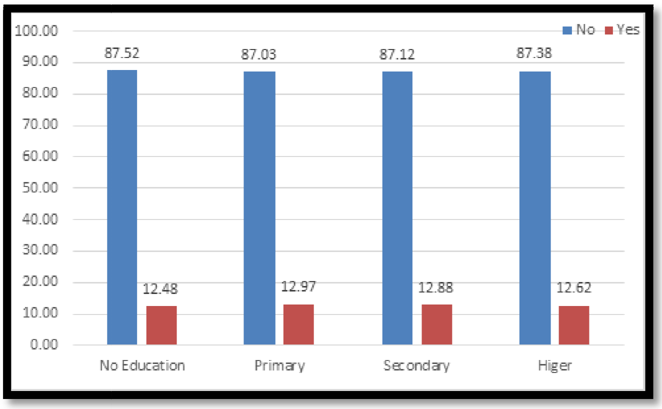

Figure 2: Proportion of Under-Five Children with Malaria Infection by Maternal Education

		Childhood Malaria Infection		
Variable		**No n (%)**	**Yes n (%)**	**P-value**
Maternal Age group	15-19	1517(87.4)	219(12.6)	
	20-24	1281(88.2)	171(11.8)	
	25-29	5084(87.1)	752(12.9)	0.259
	30-34	6907(86.6)	1067(13.4)	
	35-39	5298(87.8)	734(12.2)	
	40-44	3802(87.4)	546(12.6)	
	44-49	1870(87.6)	264(12.4)	
Age of Child	0-11	760(88.6)	98(11.4)	
	12-23	5467(87.8)	759(12.2)	
	24-35	4839(82.4)	1034(17.6)	< 0.001*
	36-47	4690(86.4)	736(13.6)	
	48-59	5056(89.5)	591(10.5)	
Sex of Child	Male	4950(90.6)	512(9.4)	
	Female	12478(87.0)	1867(13.0)	0.099
Region	North Central	3658(92.5)	297(7.5)	
	North East	3912(78.9)	1045(21.1)	
	North West	9357(90.0)	1034(10.0)	< 0.001*
	South East	2065(80.6)	498(19.4)	
	South South	2251(83.0)	460(17.0)	
	South West	3760(92.7)	297(7.3)	

Table 2: Prevalence of Malaria Infections by Selected Factors among Under-Five Children in Nigeria
**P<0.05*

Childhood Malaria Infection				
Variable		**No n (%)**	**Yes n (%)**	**P-value**
Wealth	Poorest	5668(86.3)	899(13.7)	
	Poorer	5566(86.9)	837(13.1)	
	Middle	4708(86.9)	756(13.8)	< 0.001*
	Richer	4566(8.1)	614(11.9)	
	Richest	4493(89.5)	526(10.5)	
Own a mobile phone	No	6178(87.3)	899(12.7)	
	Yes	18823(87.3)	2733(12.7)	0.057
ITN ownership	No	8814(88.7)	1125(11.3)	
	Yes	16817(86.6)	2507(13.4)	< 0.001*
ITN utilization by HH	No	10817(86.5)	1686(13.5)	< 0.001*
	Yes	3810(86.5)	593(13.5)	

Childhood Malaria Nfection				
Variable		**No n (%)**	**Yes n (%)**	**P-value**
Age of mothers at first birth	< 15	212(86.5)	33(13.5)	
	15-19	12728(87.0)	1905(13.0)	
	20-24	8952(87.6)	1266(12.4)	0.181
	25-34	3027(88.0)	414(12.0)	
	≥ 35	2(100)	0(0.0)	
Total children ever born	1-2	11994(87.4)	2599(12.6)	
	3-4	6513(87.3)	945(12.7)	0.145
	≥ 5	491(85.0)	81(15.0)	
Place of residence	Urban	9041(87.8)	1262(12.2)	
	Rural	15961(87.1)	2370(12.9)	0.01*
HHH education	No education	10260(90.7)	1055(9.3)	
	Primary	5432(85.2)	946(14.8)	
	Secondary	6434(85.1)	1128(14.9)	0.101
	Higher	2875(85.1)	504(14.9)	
*p<0.05				

Table 3: Prevalence of Malaria Infections by Selected Factors among Under-Five Children in Nigeria

3.2. MultilevelLogistic Model for Childhood Malaria Infection

The results for multivariate analyses revealed there was a statistically significant association between CMI and predictors such as: maternal education, wealth index (household wealth), ITN ownership (knowledge on child health) and other variables such as region and age of the child. However, no statistically significant association was found between CHI and ITN utilization (knowledge on child health), total children ever born (family formation pattern), ownership of mobile phone (social networking) and other variables such as maternal age, age at first birth, HHH education and sex of child.

The baseline model (model 1) explores the relationship between CMI and maternal education, the results indicated that maternal education does not independently contribute to CMI (p>0.05 for all level of education), after adjusting for wealth index in model 2, maternal education was found to be associated with CMI, children belonging to women with higher education had 0.39 lower odds (95% CI: 0.21-0.58) of reporting CMI compared to those with no education. Meanwhile, children in the middle wealth quintile had14% lower risk of having malaria infection compared to those in poorest wealth quintile (OR=0.86, 95% CI: 0.74-0.97). Model 3 indicated that children belonging to women without ITN had 19% chance of having CMI compared to those with ITN (OR=1.19, 95% CI: 1.11-1.27). Furthermore, the final model (model 6 comprising of all relevant variables considered, as presented in table 3 showed that maternal education maintained a significant relationship with childhood malaria infection. Children under-5 in the North Eastern region had 3.39 higher odds (95% CI: 3,25-3.53) of reporting CMI compared to those in the North Central while those in the South West (OR=1.09, 95% CI: 0.91-1.26) had 9% chance of reporting malaria infection among children compared to those in the North Central. Children aged 12-23 months old were about 2 times more likely to have CMI compared to those between the ages of 0-11 months (OR=1.52, 95% CI: 1.43-1.64), while children aged 48-59 months old (OR=0.87, 95% CI: 0.75-0.98) have 13% lesser chance of having CMI compared to children within the ages 0-11 months old. The intercepts reported in table 4are predicted values of the dependent variable when all the independent variables are kept constant. All the intercepts for the models revealed significant value (p<0.05), which suggest that all the levels of the models were important in the analysis.

	Null Model Model 0 OR (95% CI)	Basic Model Model 1 OR (95% CI)	Economic Empowerment Model 2 OR (95% CI)	Knowledge on Child Health Model 3 OR (95% CI)	Family Formation Pattern Model 4 OR (95% CI)	Social Networking Model 5 OR (95% CI)	Full Model Model 6 OR (95% CI)
Variables							
Maternal education							
No education		Reference	Reference	Reference	Reference	Reference	Reference
Primary		0.04 (0.95-1.14)	0.17 (0.07-0.26)*	0.17 (0.07-0.27)*	0.17 (0.07-0.27)*	0.17 (0.07-0.27)*	0.17 (0.08-0.27)*
Secondary		0.98 (0.88-1.07)	0.29 (0.18-0.39)*	0.29 (0.19-0.40)*	0.30 (0.19-0.41)*	0.30 (0.19-0.41)*	0.16 (0.03-0.29)*
Higher		0.87 (0.71-1.03)	0.39 (0.21-0.58)*	0.40 (0.21-0.58)*	0.40 (0.21-0.58)*	0.40 (0.22-0.59)*	0.26 (0.05-0.48)*
Economic empowerment							
Poorest			Reference	Reference	Reference	Reference	Reference
Poorer			0.93 (0.83-1.04)	0.93 (0.83-1.04)	0.94 (0.84-1.04)	0.93 (0.83-1.04)	1.01 (0.90- 1.15)
Middle			0.86 (0.74-0.97)*	0.86 (0.74-0.97)*	0.84 (0.75-0.98)	0.86 (0.74-0.97)*	1.02 (0.90-1.15)
Richer			0.64 (0.50-0.78)*	0.64 (0.50-0.78)*	0.64 (0.50-0.78)*	0.64 (0.49-0.78)*	0.82 (0.67-0.96)*
Richest			0.47 (0.29-0.64)*	0.47 (0.29-0.64)*	0.47 (0.30-0.64)*	0.46 (0.28-0.64)*	0.68 (0.51-0.85)*
Child health knowledge							
ITN ownership							
Yes				Reference	Reference	Reference	Reference
No				1.19 (1.11-1.27)*	1.19 (1.11-1.26)*	1.19 (1.11-1.27)*	1.08 (1.00-1.16)*
ITN utilization							
Yes					Reference	Reference	Reference
No				0.93 (0.84-1.02)	0.84 (0.84-1.02)	0.93 (0.84-1.02)	0.99 (0.90-1.08)
Family formation pattern Total child ever born							
1-2					Reference	Reference	Reference
3-4					0.98 (0.90-1.06)	0.98 (0.90-1.06)	0.97 (0.86-1.08)
>5					2.95 (0.54-5.36)	2.92 (0.52-5.31)	2.64 (0.14-5.14)
Social Networking							
Ownership of cell phone							
No						Reference	Reference
Yes						1.02 (0.93-1.11)	1.02 (0.93-1.12)
Other Variables							
Age of mother							
15-19							Reference
20-24							1.01 (0.92-1.28)

	Null model Model 0 OR (95% CI)	Basic model Model 1 OR (95% CI)	Economic Empowerment Model 2 OR (95% CI)	Knowledge on child health Model 3 OR (95% CI)	Family formation Pattern Model 4 OR (95% CI)	Social networking Model 5 OR (95% CI)	Full model Model 6 OR (95% CI)
25-29							1.15 (0.96-1.34)
30-34							1.11 (0.90-1.32)
35-39							1.08 (0.85-1.31)
40-44							1.19 (0.93-1.46)
45-49							1.39 (1.07-1.72)*
Age at first birth							
<15							Reference
15-19							0.95 (0.82-1.09)
20-24							0.92 (0.77-1.08)
25-29							0.88 (0.68-1.08)
30-34							0.82 (0.50-1.14)
35-39							0.95 (0.31-1.59)
40-44							0.52 (0.47-0.97)
45-49							0.89 (0.24-3.3.28)
HHH education							
No education							Reference
Primary							0.98 (0.87-1.09)
Secondary							0.91 (0.80-1.02)
Higher							0.91 (0.87-1.17)
Region							
North Central							Reference
North East							3.39 (3.25-3.53)*
North West							1.37 (1.23-1.52)*
South East							3.17 (3.02-3.33)*
South South							2.07 (1.92-2.23)*
South West							1.09 (0.91-1.26)
Child sex							
Male							Reference
Female							0.97 (0.90-1.04)
Child age							
0-11							Reference
12-23							1.54 (1.43-1.64)*
24-35							1.31 (1.02-1.24)*
36-47							0.87 (0.75-0.98)*
48-59							0.68 (0.56-0.81)*
Intercept	0.15 (0.07-0.22)*	0.15 (0.07-.23)*	0.17 (0.06-0.28)*	0.16 (0.02-0.29)*	0.15 (0.02-0.29)*	0.15 (0.01-0.30)*	0.18 (0.07-0.33)*

Table 4: Mixed Effect Logistic Models of the Factors Associated with Childhood Malaria among Under-Five Children in Nigeria
** p<0.05*

3.3. Goodness-of-Fit for Multilevel Logistic Models of the Relative Childhood Malaria Infection

Table 6 below gives a summary of the robustness of each of the model considered in the random effect models. Judging by the smaller value of either the AIC of 20947.1 or BIC of 21293.6, the results showed that model 6 after adjusting for other predictors is the best model, and thus fitted the data better than all the other models. Similarly, the small value of 20863.1 of the deviance (-2LL) showed that the full model best fitted the data compared to all other models. σ_{ϵ}^{2}represents the variance slope between groups, while σ_{d}^{2} is the variance in intercepts between groups. In model 6 for the ICC, it was found that approximately 25% of variation in CMI was found to be due to EA, this gives a fraction of total variability explained by EA.

	Null Model (Model 0)	Basic Model (Model 1)	Household Wealth (Model 2)	Knowledge on Child Health (Model 3)	Family Formation Pattern (Model 4)	Social Networking (Model 5)	Full Model (Model 6)
AIC	21910.4	21911.60	21816.85	21802.54	21807.36	21809.14	20947.1**
BIC	21926.9	21952.85	21891.10	21893.29	21931.11	21941.14	21293.6
LL	-10953.2	-10950.80	-10899.43	-10890.27	-10888.68	-10888.57	-10431.5
Deviance (-2LL)	21906.4	21901.60	21798.85	21780.54	21777.36	21777.14	20863.1
Random effects							
Individual:σ_{ϵ}^{2} (SE)	0.0023 (0.04845)	0.0012 (0.0352)	0.0028 (0.0525)	0.0038 (0.0613)	0.0037 (0.0608)	0.0037 (0.0610)	0.01 (0.00)
EA: σ_{d}^{2} (SE)	0.0077 (0.00026)	0.004 (0.0001)	0.009 (0.003)	0.0013 (0.0004)	0.0012 (0.0004)	0.001 (0.0003)	0.003 (0.0003)
ρ(individual, EA)	0.230	0.231	0.237	0.745	0.780	0.004	0.25
ρ(EA)	0.033	0.033	0.034	0.011	0.011	0.001	0.071

Table 5: Model Adequacy of the Relative Childhood Malaria Infection in Nigeria
**LL: Log Likelihood, AIC: Akaike Information Criteria, BIC: Bayesian Information Criteria, **: Best Model with Minimum AIC*

3.4. Contribution of Each Factor Associated With Malaria Prevalence among Under-Five Children

The results of the B-D model showed that there was a gap in CMI among educated mothers (mothers with at least primary school education) and mothers without education ranging from approximately 0.06% in model 3 to 68% in model 2. The results of the B-D analysis showed that the contribution to CMI due to lack of maternal education was found to 0.1324 (p<0.001) and 0.1289 (p<0.001) with a differential of 0.034 (p<0.001), while the gap between educated and non-educated mothers due to household wealth was 1.5516 (p<0.001), region and age of the child accounted for differences of 0.6814 (p<0.001) and 0.0230 (p<0.001) respectively. Overall, using the full adjusted model (model 6), the B-D results showed that a gap of approximately 30.0% (region) and 1.0% (age of the child) were explained in CMI due the differentials maternal education. Model 3 reports that economic empowerment (as represented by the wealth quintiles) was found to be the highest factor that contributed to CMI, explaining about 68% gap. Other factors explaining the gap between CMI and maternal education were ITN ownership and region of residence with gaps of 0.06% and 30% respectively, while only 1.03% gap was reported for the age of the child.

Variables	CMI among Non-Educated Mothers	CMI among Educated Mothers	Educated/ Uneducated Gap	Contributions from Maternal Education Differences (%)	P-value
Contributions from maternal education differencesexplained by:Maternaeducation	0.1324	0.1289	0.0034	0.15	<0.001*
Contributions from maternal education differencesexplained by:Wealth Index	3.6978	2.1462	1.5516	68.25	<0.001*
Contributions from maternal education differencesexplained by:ITN ownership	0.6632	0.6771	0.0139	0.06	<0.001*
Contributions from maternal education differencesexplained by:Region	3.5868	2.904	0.6814	7	<0.001*
Contributions from maternal education differences explained by:Age of the child	1.9185	1.9415	0.0230	1.03	<0.001*
**Significant at 5% Level*					

Table 6: Contributions to Childhood Malaria Infections in the Oaxaca Decomposition Analysis

4. Discussion

The overall prevalence of malaria infections among under-five children in this study was found to be considerably high as compared to previous study conducted [18, 19]. We observed that the prevalence of malaria slightly varied across the maternal educational groups, this is consistent with the work of Joseph conducted in Tanzania, Uganda and Angola [20]. Our study showed that a rise in the prevalence of CMI could not only be explained by maternal education, but also by other associated factors. Unlike the work of kriti et al [21] where maternal education was suggested to be the single most important factor explaining differentials in CMI. This study showed that ownership of mobile phones which was used as a proxy for enhanced social networking was actually found to be a poor proxy, suggesting that increasing use of mobile phones does not directly translate to better child health among mothers of under-five children. Despite the high levels of maternal knowledge, malaria is still highly prevalent in Nigeria. Unlike the work of Cary et al. who demonstrated that maternal education was strongly associated with childhood malaria prevalence, we found out that maternal education with other factors jointly contributed to disparities in malaria prevalence among under-five children.

Findings from the bivariate analysis showed that the use of ITNs was significantly associated with malaria prevalence. This was similarly supported by the work conducted in Nigeria by Salwa et al. and Yusuf et al. Both studies showed that childhood mortality due to malaria reduced significantly in areas reported with high percentage of children sleeping under bed nets. This is also in line with the study conducted by Siri who noted that sleeping under an ITN was associated with reduction in the odds of malaria prevalence

According to the study findings, wealth index which was used as the proxy for household wealth was found to be associated with the prevalence of malaria, this was also being revealed in Siri, et al. and Olasehinde et al findings; it was reported in their work that being in the highest wealth quintile was found to be associated with lower malaria prevalence, but this is not in agreement with the work of Don et al. Households falling in the lowest wealth quintile were found to be more likely to have CMI than those households falling in the highest quintile. The evidence from this study suggests that the burden of malaria prevalence is greatest among the poor people, poor people were found to be at increased risk of becoming infected with malaria than their counterparts. We also find out that the age of the child is an important predictor of malaria infection. As age increases, the risk of CMI reduced. The study findings suggests that most of the gap in malaria prevalence among under-five children can be explained by the differences, region, wealth quantiles and age of the child through the path way of maternal education; this implies that the differences observed in malaria prevalence can be attributed to these factors. A significant gap exists in CMI due to maternal education differences, this gab can be explained particularly due to household wealth that a particular household belong to. Children whose mothers were categorized as educated and fall under the richest quantile explained a lesser proportion of malaria prevalence unlike those who were categorized under the poorest quantile. Wealth index used as a proxy for household wealth was found to be the major contributor to CMI, which was then followed by region. In agreement with the work of Joseph, household wealth was found to be the largest factor explaining the childhood malaria infection gap between the two groups.

5. Conclusion

Our investigation suggests that CMI in Nigeria is high and maternal education remains a social vaccine for malaria infection among under five children, particularly after controlling for other factors. We have also illustrated how the B-D model can be used to explain the contributions of each associated factors to malaria prevalence among under-five due to inequality in maternal education. Evidence from this study and other related studies have found out that the relationship between maternal education and under-five malaria prevalence is a causal relationship through higher household wealth, region of residence with higher malaria prevalence and the age of the child. This investigation therefore affirms that household wealth, region of residence, age of child, bed net ownership, and maternal education in that order were the protective factors against malaria among under-five children in Nigeria. Women need to be educated beyond the primary school level. Effects should be made in the area of women empowerment so as to broader enhance their socioeconomic status in the country. Malaria intervention and control programmes should focus more on rural areas. Investigators should apply the B-D model whenever they are faced with the challenges of estimating the contributions of each associated factor with a given outcome variable.

6. List of Abbreviations

CMI:Childhood malariainfection
CDC:Centre for Disease Control
EA:Enumeration Area
ITN:Insecticide Treated Nets
B-D:Oaxaca Blinder Decomposition
WHO:World Health Organization
HHH:Head of Household

7. References

i. Blinder A: Wage discrimination: reduces form and structural estimates. *The Journal of Human Resources. 1973,*8: 436–55.
ii. Fairlie RW: An extension of the Blinder-Oaxaca decomposition technique to logit and probit models. *Journal of Economic and Social Measurement.* 2005, 30:305-316.
iii. Todd EE, John HG, Steven JH: Unexplained gaps and Oaxaca–Blinder decompositions. *Labour Economics. 2010,*17: 284-290.

iv. Bauer TK, Sinning M: An extension of the Blinder–Oaxaca decomposition to nonlinear models. *Springer-Verlag.* 2008, 92: 197-206 https://doi.org/10.1007/s10182.

v. Maryam D, Mohammad S. Khadigeh M, Masud Y, et al.: Socioeconomic Inequality and Its Determinants Regarding Infant Mortality in Iran. *Iran Red Crescent Med J.* 2014, 6: e17602.

vi. Hugo N: An extension of the Blinder-Oaxaca decomposition to a continuum of comparison groups. *Inter-American Development Bank and IZA*. 2007.

vii. Yusuf OB, Adeoye BW, Oladepo OO: Poverty and fever vulnerability in Nigeria: a multilevel analysis. Malar J. 2010, **9**: 235.

viii. Falade CO, Yusuf OB, Mokuola OA: Intermittent preventive with sulphadoxine-pyrimethamine is effective in preventing maternal and placental malaria in Ibadan, South-western Nigeria. *Malaria Journal*. 2007, 16:88.

ix. Salwa D, Hesham MA, Init I, Jamaiah I et al.: Is Nigeria winning the battle against malaria? Prevalence, risk factors and KAP assessment among Hausa communities in Kano State. *Malar J.,* 2016.*15:351.*

x. Nwoke EA, Amadi D, Ibe SNO, Nworuh OB: Factors Affecting the Prevalence of Malaria among Under-Five in Rumuigbo Town, Obio-Akpor L.G.A, Rivers State. Nigeria. *International Journal of Innovative Research and Development.* 2017*,* **6**: 19-25.

xi. Okeke OP, Imakwu CA, Eyo JE, Okafor FC: A six year review of the trends in prevalence of malaria infection in children in secondary and tertiary health care outlet in Anambra State, Nigeria. *Animal Research International.* 2015, **3**: 2311 – 2315

xii. Olasehinde G I, Ajayi AA, Taiwo SO, Adekeye B.T et al.: Prevalence and management of *falciparium*malaria among infants and children in Ota, ogun state, southwestern Nigeria. African Journal of clinical and experimental microbiology. 2010, 11: 159-163.

xiii. Maryam D, Mohammad S. Khadigeh M, Masud Y, et al.: Socioeconomic Inequality and Its Determinants Regarding Infant Mortality in Iran. *Iran Red Crescent Med J.* 2014, **6:** e17602.

xiv. World Malaria Report: Center for disease control, Malaria, webpage, www.cdc.gov/malaria/. **2**: 2015.

xv. Nankabirwa J, Brooker S J, Clarke SE, Fernando D, et al.: Malaria in school-age children in Africa: an increasingly important challenge. *Tropical Medicine and InternationalHealth*.2014,**11:**1294–1309. http://doi.org/10.1111/tmi.12374.

xvi. World Malaria Report: CDC Malaria. 2017, webpage, www.cdc.gov/malaria/;8(2).

xvii. Mikko, M., 2013. Commentary: Maternal education accentuates girls' mortality advantage overboys'. *International Journal of Epidemiology*, 2013. 42:219–220.

xviii. Caldwell J, McDonald P. Influence of maternal education on infant and child mortality: levels and causes. *Health Policy Educ*ation. 1982 Mar;2(3-4):251-67. DOI: 10.1016/0165-2281(82)90012-1. PMID: 10256648.

xix. Abuya, B.A., Ciera, J. &Kimani-Murage, E. Effect of mother's education on child's nutritional status in the slums of Nairobi. *BMC Pediatr* **12,** 80 (2012).https://doi.org/10.1186/1471-2431-12-80

xx. Uthman OA: Decomposing socio-economic inequality in childhood malnutrition in Nigeria. *Maternal and child Nutrition*. 2009, **5**: 358 – 367.