SOCIODEMOGRAPHIC CHARACTERISTICS AND SPATIAL DISTRIBUTION OF MALARIA IN NIGERIAN CHILDREN

By

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Declaration

I declare that this research report is my work. It is being submitted in partial fulfilment of the requirements for the degree of Master of Science in Epidemiology in the field of Epidemiology and Infectious Disease at the University of the Witwatersrand, Johannesburg. The contents of this research report are original and have not been submitted for any other degree or qualification in this or any other university.

Lovelyn Uzoma Ozougwu

Dedication

Firstly, I want to thank the God Almighty for giving me life and strength to complete my study. Secondly, my profound gratitude goes to my husband Pastor Obed Mondale Nnaji for believing in me and for all his support during this course, God bless you.

Abstract

Background

Malaria is a significant public health concern in the world. It causes mortality and morbidity especially in children under five years of age and pregnant women. Nigeria contributes about 25% to the malaria burden in Africa, with one million lives lost annually. Several factors including poverty, ownership of bed nets, socioeconomic status are associated with malaria morbidity. This study aimed to determine the factors associated with malaria morbidity and its spatial distribution in Nigerian regions among children under five years in 2010.

Methods

This study used cross-sectional data from the 2010 Nigeria Malaria Indicator Survey (NMIS) which was downloaded from DHS website. The primary sampling unit (PSU) which was referred as the cluster for the 2010 NMIS was defined based on the enumeration areas (EAs) from the 2006 EA census frame. The 2010 NMIS sample was selected using a stratified, two - stage cluster design consisting of 240 clusters, 83 clusters in the urban areas and 157 in the rural areas. The research was restricted to children under five years (6-59 months). The outcome variable was defined as the presence or absence of malaria. It was measured using rapid diagnostic test and microscopic examination of blood smear. Clustered adjusted Pearson's chi-square test was used to show associations between explanatory variables and malaria. A clustered t-test was used to determine differences in the mean for continuous variables. Multilevel logistic regression models, taking into account random effects were fitted. Choropleth maps were used to display the distribution of malaria by geopolitical zones.

Results

There were 5137 children aged 6-59 months for this study out of 5612 children that were selected for the survey, 41.97% had malaria, and there was no difference in prevalence between males and females. The mean age was 34.96±0.33 months. There was a higher prevalence (60.19%) of malaria in the areas where there was no LLIN campaign coverage compared to areas with LLIN coverage (39.81%) (OR 0.65, 95% CI 0.43-0.97). Children from rural areas were three times more likely to have malaria than those from urban areas (OR 3.13,95%CI 2.18-4.49). The odds of malaria increased significantly with increasing age in months (OR 1.02, 95% CI 1.02-1.03, P-value<0.0001). The richest household children were less likely to have high prevalence of malaria compared to children from the poorest households (OR 0.23, 95%CI 0.15-0.37). Choropleth maps showed a high prevalence in the North-West and North-Central regions and lowest prevalence in the South-East region.

Conclusion

Although efforts have been made to control malaria in Nigeria, its elimination is not forthcoming. The prevalence in children under five years was high. Those who live in the rural areas, wealth index, geopolitical region and child's age were the determining factors associated with the high prevalence of malaria in those children. There was a regional variation of malaria prevalence among the children. Children from the North-Central and North-West regions had the highest prevalence of malaria. All these factors could be as a result of policy issues, policy formulations, management, implementation, compliance and sustenance issues. However, a lot can be done in the malaria control and prevention programme in Nigeria towards vaccine development, policy formulation and implementation based on evidence, increased public health and environmental education, incorporation of the communities in activities towards

malaria control, mapping of the spatial distribution of malaria as well as stepping up of ongoing control programmes.

Keywords: children under five years, spatial analysis, Nigeria.

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Abbreviations

ACT- Artemisinin-based Therapy

AIDS- Acquired Immunodeficiency Syndrome

DHS- Demographic and Health Survey

FCT- Federal Capital Territory

GIS- Geographic Information System

HIV- Human Immunodeficiency Virus

IPT- Intermittent Preventive Treatment

IRS- Indoor Residual Spray

LLIN- Long Lasting Insecticide Treated Nets

MDGs- Millennium Development Goals

NMCP- National Malaria Control Programme

NMIS- Nigeria Malaria Indicator Survey

NSPMC- National Strategic Plans for Malaria Control in Nigeria

RBI- Roll Back Malaria Initiative

WHO- World Health Organisation

Chapter 1

1.1 Background

Malaria is one of the most significant parasitic infections of public health importance (1). This concern is because it causes a high level of morbidity and mortality in endemic areas. The parasite that causes malaria belongs to the *Plasmodium* genus, and its vector of transmission is the female Anopheles mosquito. There four types of malaria species that infect humans (*P. falciparum, P. malariae, P. Vivax and P.ovale.),* of which *P. falciparum* and *P. vivax* are the most common ones in the endemic areas globally. The prevalence of malaria depends on various factors which include an abundance of female Anopheles mosquitoes, the tendency of mosquitoes to bite, the rate at which mosquitoes bite, the longevity and also the rate at which the *Plasmodium* parasites develop inside mosquitoes (2).

In 2014, the World Health Organisation (WHO) reported malaria as the second important cause of mortality in Africa after HIV/AIDS (3). It has been said globally that approximately 214 million cases of malaria occurred in 2015 which ranges from 148-305 million (4,5). The majority (90%) of all malaria cases occur in African region followed by the South-East Asian region (7%) and the Eastern Mediterranean region (2%). Nigeria contributes about 25% of the malaria burden in African region. Approximately, 429000 malaria deaths (range 235000-639000) occurred worldwide in 2015 where children under five years contributed 303000 deaths which claims the life of one child every 30 seconds (6). Majority of the malaria deaths approximately 292000 occurred in the African region.

In Nigeria, the prevalence of malaria is high and ranges between 80%-85% (7). Malaria is endemic in Nigeria which form a major public health problem despite the curable nature of the disease(8). Malaria-related deaths accounts for about 11% maternal mortality, 25% infant

mortality and 30% under five mortality resulting to 300,000 childhood deaths annually (5,9). It contributes up to 30% of admission to the healthcare facilities and 60% of outpatient visits (5). Fifty percent of the Nigerian population suffers at least one episode of malaria yearly (10). The heightened risk could be due to increased resistance to cost-effective antimalarial drugs, treatment failure, global warming, climatic change, conflicts, insurgency and internal displacement of persons (11).

Despite the fact that malaria is preventable and treatable, it still has an overwhelming impact on health and livelihood globally (6). Children under five years and pregnant women are mostly affected in malaria-endemic countries (12). In the most endemic countries, the disease affects the underprivileged people, who have inadequate access to health facilities and who cannot pay for the treatment. The disease is one of the most important cause of low birth weight, foetal and maternal mortality (12).

Geographic Information System (GIS) is a powerful tool that is used to monitor public health in various geographical locations because it gives accurate mapping (13). It has been continuously used for the analysis of spatial health-related data and analysing the spread of diseases in both the developing and developed countries (14). The spatial distribution enables efficient resource allocation through identification of most affected regions.

1.2 Literature Review

1.2.1 Malaria life cycle

Malaria is caused is caused by Plasmodium spp, a genus of unicellular parasite. The most prevalent species of malaria parasite in Nigeria is the *Plasmodium falciparum* (>95%) which is responsible for the most severe forms of the disease (8). *Plasmodium ovale* and *Plasmodium malariae* are the other types of malaria species found in the country but they play a minor role. The malaria parasite life cycle is divided into two hosts as shown in fig 1 below. During a blood meal, a malaria-infected female *Anopheles* mosquito inoculates sporozoites into the human host. The sporozoites infect the liver cells and then mature into schizonts, which rupture and release merozoites. After the initial replication in the liver (exo-erythrocytic schizogony), the parasites undergo asexual multiplication in the erythrocytes (erythrocytic schizogony). The ring stage trophozoites mature into schizonts, which ruptures and releases merozoites. The blood stage parasites are responsible for the clinical manifestations of the disease.

The gametocytes, male (microgametocytes) and female (macrogametocytes), are ingested by an *Anopheles* mosquito during a blood meal. The multiplication of the parasite in the mosquito is known as the sporogonic cycle. While in the mosquito's body, the microgametes penetrates the macrogametes generating zygotes. The zygotes in turn become motile and elongated (ookinetes) which invade the midgut wall of the mosquito where they develop into oocysts. The oocysts grow, rupture, and release sporozoites, which make their way to the mosquito's salivary glands. Inoculation of the sporozoites into a new human host perpetuates the malaria life cycle.

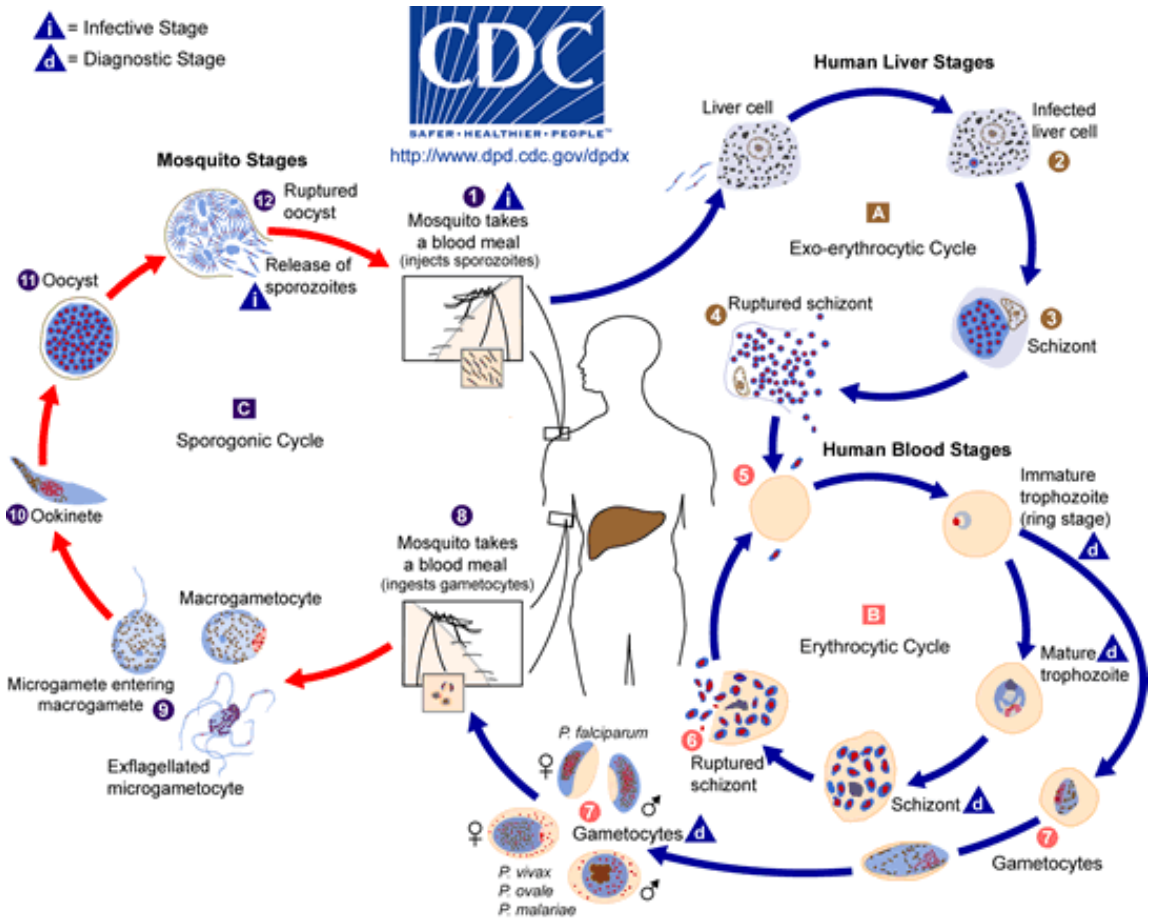

Figure 1: Malaria life cycle (15)

1.2.2 Malaria Transmission in Nigeria

The geographic location of Nigeria makes the climate suitable for malaria transmission throughout the country (8). Nigeria has a tropical climate. The dry and wet seasons are associated with the movement of two dominant winds – the rain which bears the south westerly winds and the cold, dry and dusty North easterly winds which is commonly referred to as the Harmattan. The dry season occurs from October to March while the wet season occurs from April to September with temperatures ranging from 25^{o}C to 40^{o}C (8).

During the 2010 NMIS, it was estimated that 97% of Nigerian population are at risk of getting malaria (8). The remaining 3% of the population who live in the mountains in Southern Jos

(Plateau State) at an altitude ranging from 1,200-1,400 metres are at relatively low risk for malaria.

1.2.3 Malaria diagnosis and treatment

Rapid diagnosis and effective treatment are the important components of malaria control and elimination strategies (16). Parasitological tests which include microscopy or the use of Rapid Diagnostic Test (RDT) should be conducted in all cases of suspected malaria to confirm diagnosis. Malaria parasites can be identified by examining under the microscope a drop of patient's blood, spread out as a blood smear on a microscope slide. The slide is most often stained with Geimsa stain prior to the examination to give the parasite a distinctive appearance (16). Antimalarial treatment should be used to ensure that only confirmed malaria cases receive antimalarial drugs and that the use of combination therapy in prevention or delayed development of drug resistance.

1.2.4 Burden of malaria

Malaria burden can be estimated based on the number of clinical cases and number of deaths (17). The approaches for the estimation of number of clinical cases can be categorised into two groups;

1. Case report based where reported cases are adjusted for health facility attendance, level of diagnostic efforts and underreporting in the health sector.

2. Risk based where geographic areas are categorised by level of malaria risk. The risk is then converted to malaria incidence based on relationships derived from longitudinal studies and adjusted for the estimated deployment of preventive measures e.g. bed-nets. The malaria incidence is multiplied by the relevant population to obtain the number of malaria cases.

Malaria death estimates fall into three categories, two of the categories are similar to case estimates (17). There is a risk based approach in which the level of malaria risk is linked to malaria mortality rates and population through mapping. In the case report based, the adjusted case counts are multiplied by a fixed case fatality rate (CFR) to get the number of malaria deaths. The last approach which is the vital registration (VR) based approach is used to provide direct estimate from recorded deaths.

There is a high prevalence of malaria in Nigeria especially among children under five years which depict the country's declining health outcome (18). More than one in every ten children born in Nigeria on average does not survive to their fifth birthday. The evidence was based on a study conducted in Nigeria on exploring variations in children under five malaria mortality using control chart, league table and spatial analysis (19). The result also showed a vast difference in the under-five mortality rate among the 36 states including the federal capital. Children spend days away from school and adult too loose work days as a result of malaria (2). A study has shown that severe malaria is the reason for hospital admission with children in Nigeria especially those less than five years of age (20). Malaria greatly contributes to anaemia in pregnancy which increases the occurrence of low birth weights (21). It is also associated with preterm deliveries, stillbirth and perinatal mortality (21).

The problem of malaria has caused a significant challenge in both the human capital and economic development in Nigeria (18). It was found that there is a substantial cost on the country's economy through government and individuals spending on malaria programmes and drugs. Nigeria lost about N132 billion annually in the form of malaria treatment costs, prevention and loss of person-hours (22). The result of a study that was done on cost-

effectiveness and resource allocation in Nigeria stated that on average, every household spends N1112 ($9.3) per month on malaria treatment (23).

1.2.2 Change in the burden of malaria

In Africa, a substantial decrease in malaria transmission has been achieved between 2000 and 2010 in malaria endemic countries (24). The incidence of malaria was reduced by 15% between 2010-2015 (6). There was also estimated decrease in the mortality rate of 29% from 2010-2015 (6). In the hyperendemic or holoendemic areas, the transmission was reduced from 218.6 million (34.4%) to 183.5 million (25.5%) across 44 malaria endemic countries.

These observed changes and decline in malaria burden are as a result of scaling up of prevention, diagnosis and treatment of malaria (25). This was made possible by significant growths in funding for malaria control programs. This led to improvement in procuring and distributing effective control measures such as LLINs and medication (25). In spite of the reduction in the transmission intensity, 57% of the population still lives in areas where malaria risk remains high (24).

1.2.3 Factors associated with malaria

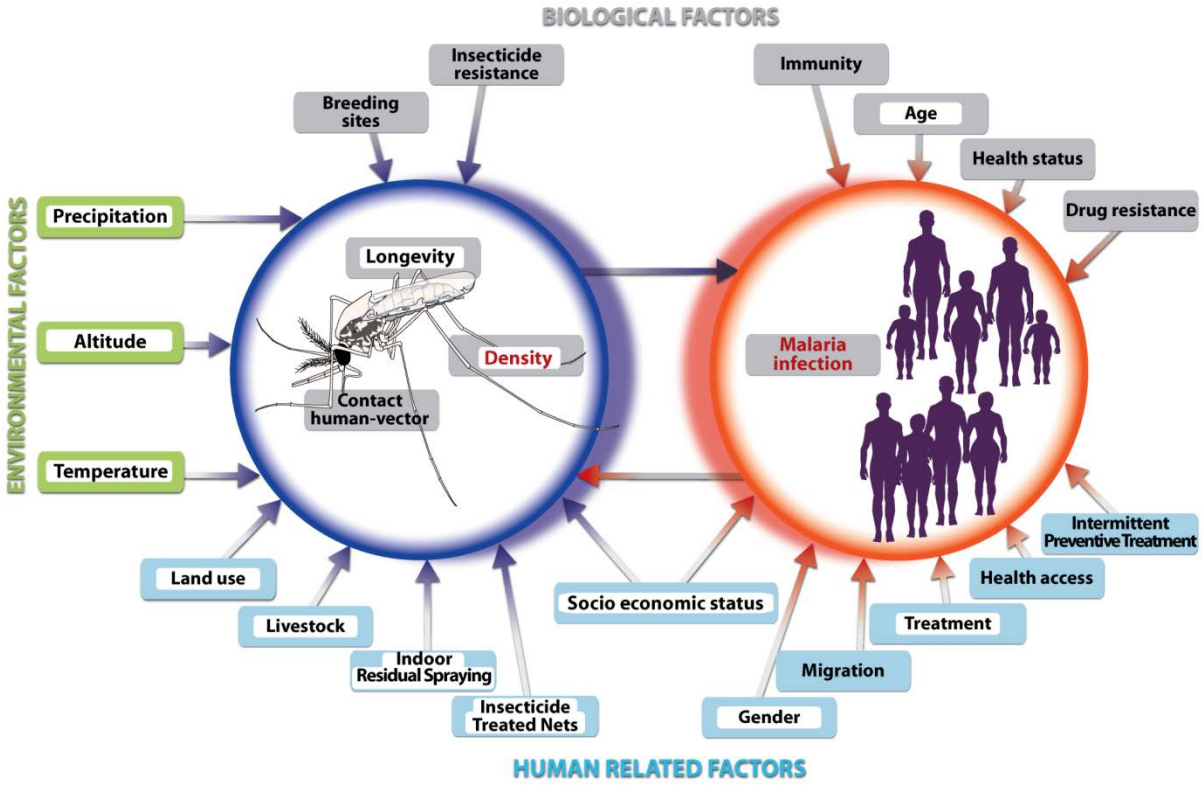

Figure 2: Conceptual framework of important risk factors affecting malaria prevalence in the African Highlands (26)

The factors associated with malaria are grouped into three main categories as shown in figure one above. They include; the human-related factors, the biological factors and the environmental factors (26).

1.2.3.1 Human-related factors

The human-related risk factors of malaria are gender, migration, treatment, socioeconomic status, health access, insecticide-treated nets, intermittent preventive treatment, indoor residual spraying, livestock and land use (26). Sex is not an important risk factor of malaria according to a study that was done in Uganda (27). However, People's migration and inaccessibility of health systems can create enabling conditions for malaria outbreaks (28).

Studies have shown that households and socioeconomic factors have effect in the malaria transmission by influencing the human-vector contact (1,28,29). Socioeconomic factors like availability of electricity , main floor material and main wall material in the households were associated with malaria from a study that was done in Uganda (27). There were more mosquitoes in the poor constructed houses compared to good quality ones. Children that reside in the households that had sand as their main floor material has shown high prevalence of malaria when they are compared to households with a complete floor surface (27,30). The study also showed that ownership of television, bicycle and radio were not associated with malaria. Poverty is a significant risk factor in determining the high incidence of malaria according to a study that was conducted on malaria risk assessment in Koton Karfe watershed catchment in Nigeria in 2009 (31).

The use of mosquito bed nets is a protecting factor against the risk of malaria in children less than five years. The finding was reported from a study on socio-demographic determinants of malaria among children less than five years of age in Ghana (32). In other similar studies, the households that reported having mosquito bed nets had fewer malaria cases among children less than five years compared to those households that do not have bed nets (33,34).

1.2.3.2 Biological factors

The biological factors are the age, immunity, health status, drug resistance, insecticide resistance and breeding site. The likelihood of malaria increases as the child increases with age (27,32). The prevalence of malaria is similar in all age groups in low transmission areas, (28). A study has shown that the capacity to suppress malaria illness depends on the immunity and that acquired immunity depends on age and exposure (28). Immunity develops with increasing transmission but becomes independent of transmission intensity as child reaches age three

years.

The healthiness of the population may have impact on malaria infection (28). Malnutrition can weaken the children's immunity which could result to high level of malaria morbidity and mortality (28,35). A study that was done in South Africa has shown that there is a relationship between HIV and increased level of malaria transmission in South Africa (28).

The treatment failure of malaria with sulphadoxine-pyrimethamine and chloroquine contributes to the enhanced transmission of malaria in the human reservoir (26,36). In other words, it causes the resurgence of malaria in several countries which leads to the emergence and spread of drug-resistant parasites (37).

1.2.3.3 Environmental factors

The environmental factors are temperature, altitude and precipitation. An altitude of around 1800 and 2000 are the upper limit at which malaria transmission occur (38). However, a study has shown that as the cluster altitude increases, the likelihood of malaria for a child decreases (27). This finding means that the odds of malaria in a child reduced by approximately 10% for every 100m increase of the cluster altitude.

The most favourable conditions for the extrinsic growth of malaria parasite are between 25ºc and 30ºc, below 16-19 ºc only some vectors will live before the completion of the sporogonic cycle. This temperature is considered as the threshold for steady malaria spread (28). Temperature influences the longevity and the feeding occurrence of a mosquito, however, a small temperature rise through seasonal variability will increase malaria transmission and distribution (26). This is the reason why malaria is found in the temperate regions (27).

1.2.4 Spatial distribution of malaria

In a high malaria prevalence country like Nigeria, the prevalence varies across space. The distribution and transmission also differ from place to place (13). The distribution ranges between 0.4% to 90% with the southern-most and the South-Eastern part of the country having relatively low prevalence (5). Studies have shown that rain is an essential driver of malaria because it provides breeding sites for the aquatic stages of mosquito's life cycle (5,26).

The risk was higher in the South-Western region (~48%) (5). The highest burden was found in the North-Central and South-West region which is as a result of shallow rainfall which provides suitable breeding conditions for the vector (5). In contrast, the increase in rainfall and temperature increases the development of mosquitoes and also improves breeding sites which determines the corresponding increase in malaria prevalence (39)

A study that was carried out in Warri in the South-South region of Nigeria on the spatial distribution of malaria showed that rainfall was a driver of malaria (40). The results showed a high prevalence of malaria during the heavy rainfall month (June) with a significant difference in the distribution of malaria in the metropolis. This finding agrees with another study which showed a spatial variation of malaria incidence among children in different villages (41). Malaria incidence decreased with increasing distance from the forest outside the village to the centre of the village.

1.2.5 Malaria control measures in Nigeria

In Nigeria, the malaria control has attained several milestones with the help of the National Malaria Control Program (NMCP) since the beginning of the Roll Back Malaria (RBM) Initiative (42). The initiatives were focused on three main interventions which consist of case

management, use of insecticide-treated nets (ITNs) and promotion of intermittent preventive treatment (IPT). The plan is to achieve 80% coverage LLINs, to expand indoor residual spraying (IRS) to 20% of houses in targeted areas and the expansion of distribution of intermittent preventive therapy (IPT) coverage to about 100% of pregnant women that attend antenatal clinics.

There are ABCD measures for prevention of malaria (43). This includes;

1. Awareness of risk of malaria.
2. Bite prevention: This is through the use of insect repellent creams, insecticide-treated nets, wearing trousers and long sleeves.
3. Antimalarial medication- Taken Chemoprophylaxis (Artemisinin-based combination therapies).
4. Prompt Diagnosis and treatment.

The antimalaria treatment that is recommended for the treatment of malaria in Nigeria is the intravenous or the intramuscular Artesunate (43). In the case where it is not available, intravenous or intramuscular Quinine or Artemether can be used as an alternative.

Despite the improvements in malaria control, the burden of the disease is still high especially among children under five years and pregnant women. Bureaucracy, poor resource management in the healthcare system, Boko-Haram insurgency in the northern part of Nigeria and kidnappings in the southern region could be the reason while the plan has not been achieved (44).

1.3 Problem Statement

There is a high burden of malaria in Nigeria especially in children under five years. This subsequently affects the economic growth of the country (23). The nation spends about 880,801 million Naira (USD 5,866667) on malaria treatment every year which represents approximately 12.0% of gross domestic product (GDP) (23). Malaria was the primary reason Nigeria did not attain the health-related Millennium Development Goals (MDGs) that ended in May 2015 (9). This is because in a year, at least half of Nigerian's population get infected with malaria. Malaria in pregnancy has been reported to have a link with intra-uterine growth retardation (9). Malaria illness has shown adverse effects on the economic development of the country which subsequently affects the health of the people (23).

1.4 Justification

Understanding the determinants of malaria is essential in reducing disease morbidity. There is a need to identify the risk factors or determinants to have a targeted interventions aimed at the susceptible groups. Geographic location can be considered a risk factor; it is crucial to determine the spatial distribution of malaria in the regions.

1.5 Research Question

What are the sociodemographic characteristics and spatial distribution of malaria in Nigerian children?

1.6 Study Aim

To determine the sociodemographic characteristics and spatial distribution of malaria in Nigerian children

1.7 Study Objectives

1. To describe the prevalence of malaria in children under five years in Nigeria in 2010

2. To identify the socio-demographic and household determinants of malaria in children under five years in Nigeria in 2010

3. To determine the spatial distribution of malaria in children under five years within the geopolitical zones and their respective states in Nigeria in 2010

CHAPTER 2

This study was a secondary data analysis. The section explains the process of primary sample collection, the methods and the statistical analysis including mapping that was carried out in this study.

2.1 Primary study

The primary study was the 2010 Nigeria Malaria Indicator Survey (NMIS). The main aim of the study was to measure progress towards achieving the goals and targets of 2009-2013 National Strategic Plan for Malaria Control in Nigeria (NSPMC). The plan was to provide data on key malaria indicators, diagnosis and prompt treatment of malaria using artemisinin-based therapy (ACT), ownership and use of bed nets, indoor residual spraying (IRS) and behaviour change communication.

2.1.1 Primary study area

The study was conducted in Nigeria, a West African sub-region. It has a tropical climate with a surface area of about 923,768 square kilometres and is the fourteenth largest country in Africa (8). Nigeria is divided into six geopolitical regions. Each region is made up of at least six states as shown in Fig 1 below. There are 36 states and a Federal Capital Territory (FCT). The population of Nigeria is approximately 140 million according to the 2006 census report (45).

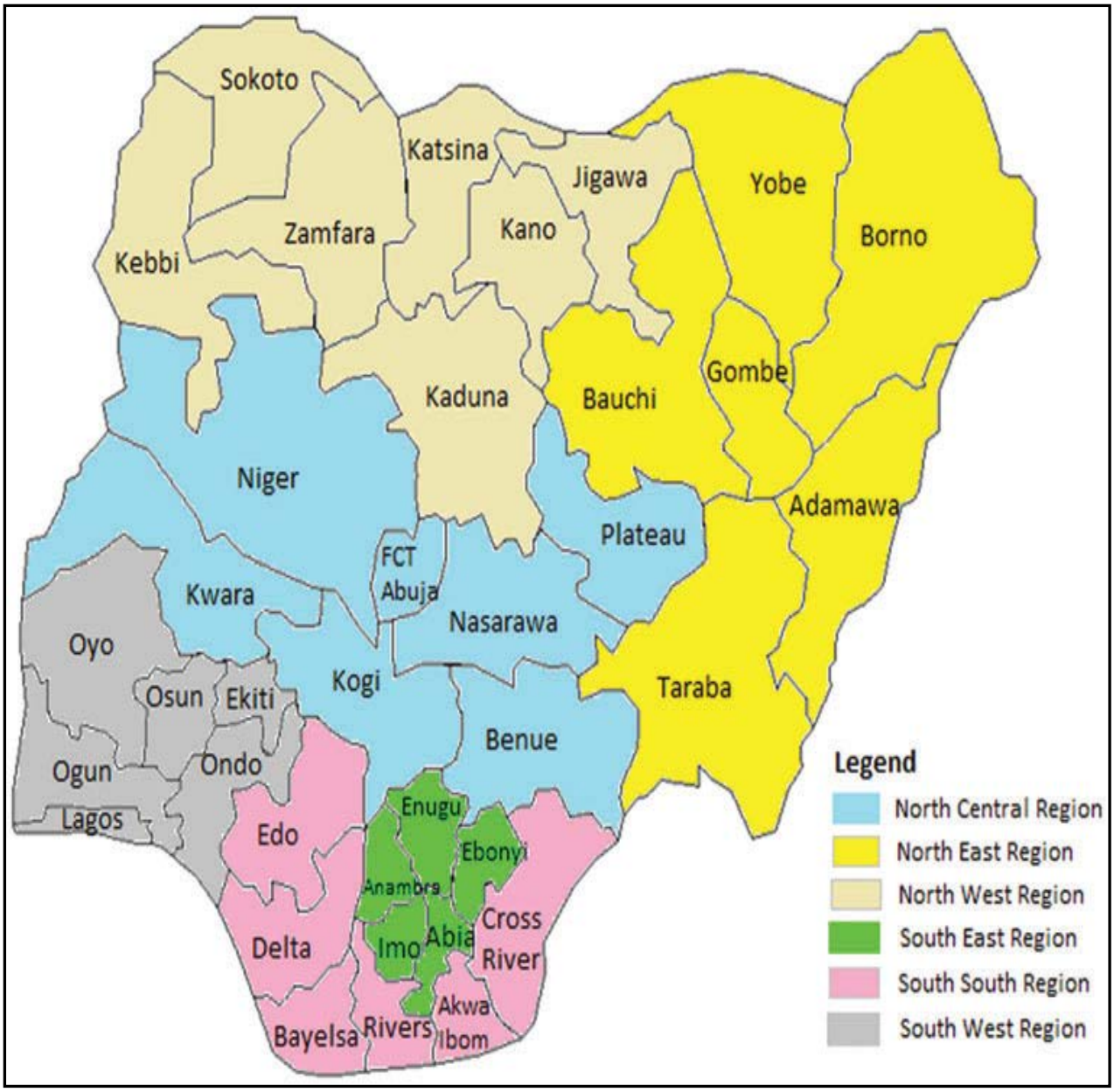

Figure 3: Map of Nigeria showing the six geopolitical regions and states

2.1.2 Primary study design/ sampling method

The cross-sectional study was carried out from October to December 2010 on a nationally representative sample of more than 6000 households. The primary sampling unit (PSU) which was referred as the cluster for the 2010 NMIS was defined based on the enumeration areas (EAs) from the 2006 EA census frame. The 2010 NMIS sample was selected using a stratified, two -stage cluster design consisting of 240 clusters, 83 clusters in the urban areas and 157 in the rural areas (8). The final sample included 239 clusters due to lack of access to the cluster because of communal clash. A complete listing of households was conducted and a mapping exercise was carried out from August to September 2010. The lists of the households served as the sampling frame for the selection of households in the second stage.

In the second stage of the selection process, an average number of 26 households were selected from each cluster by equal probability systematic sampling. All women who were either permanent resident of the households in 2010 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 (8).

2.1.3 Primary data collection

The data was collected by the trained field workers which includes the field interviewers nurses and the laboratory scientist.(8). The questionnaires were administered by the quality control interviewers. All children aged 6 to 59 months in each household who met inclusion criteria and for whom consent was obtained were enrolled for malaria and anaemia testing. Approval was obtained from the parents or guardian of the children before blood was collected. Children were pricked either on the finger or the heel with the use of a microcuvette to collect a drop of blood. Two methods were used in the diagnosis; the Paracheck Pf rapid diagnostic test and

microscopic examination using blood smear (thin and thick film) (8). The blood smears were transported to the Department of Medical Microbiology and Parasitology Laboratory at the University of Lagos to determine the presence of malaria parasiteamia. The result of the blood smear from microscopic examination was considered for this study because it was the gold standard for detection of malaria parasites and its species in the survey (8).

Information on mother's education, geopolitical region, place of residence (urban or rural), wealth quintile, child's sex, child's age, use of LLINs, the number of household members, and whether mother took antimalarial drug during pregnancy were obtained using a researcher-administered questionnaire.

2.2 Secondary analysis methods

2.2.1 Study design/study population

The study design was a cross-sectional survey of children 6 to 59 months who lived in Nigeria in 2010.The dataset used was from the 2010 Nigeria Malaria Indicator Survey (NMIS) through the DHS website.

2.2.2 Power computation

There was no sampling for this study, that is, all the data provided was analysed. A power computation was performed using clustersampsi ado file (46). A sample prevalence of 42% was obtained from positive microscopy results from the 2010 NMIS (8) and assuming a 47% population prevalence at an alpha level of 0.05.

The following were used in the calculation: a design effect of 4, inter-cluster correlation (ICC) of 0.12, a total of 239 clusters and 26 households per cluster. Power was calculated to be at least 80%.

2.2.3 Inclusion criteria

The inclusion criteria were children whose mothers were consented to be interviewed and had also given consent for collection of blood samples from their children.

2.2.4 Study participants

A total of 6197 households were selected during the 2010 NMIS. Out of the selected households, 5,986 households were occupied. Of the occupied households 5,895 had occupants who were successfully interviewed. Of the 5,895 households that were successfully interviewed, 5,612 children under five years were tested for malaria using microscopy and 5,137 of them were used for this study as shown in Fig 2 below.

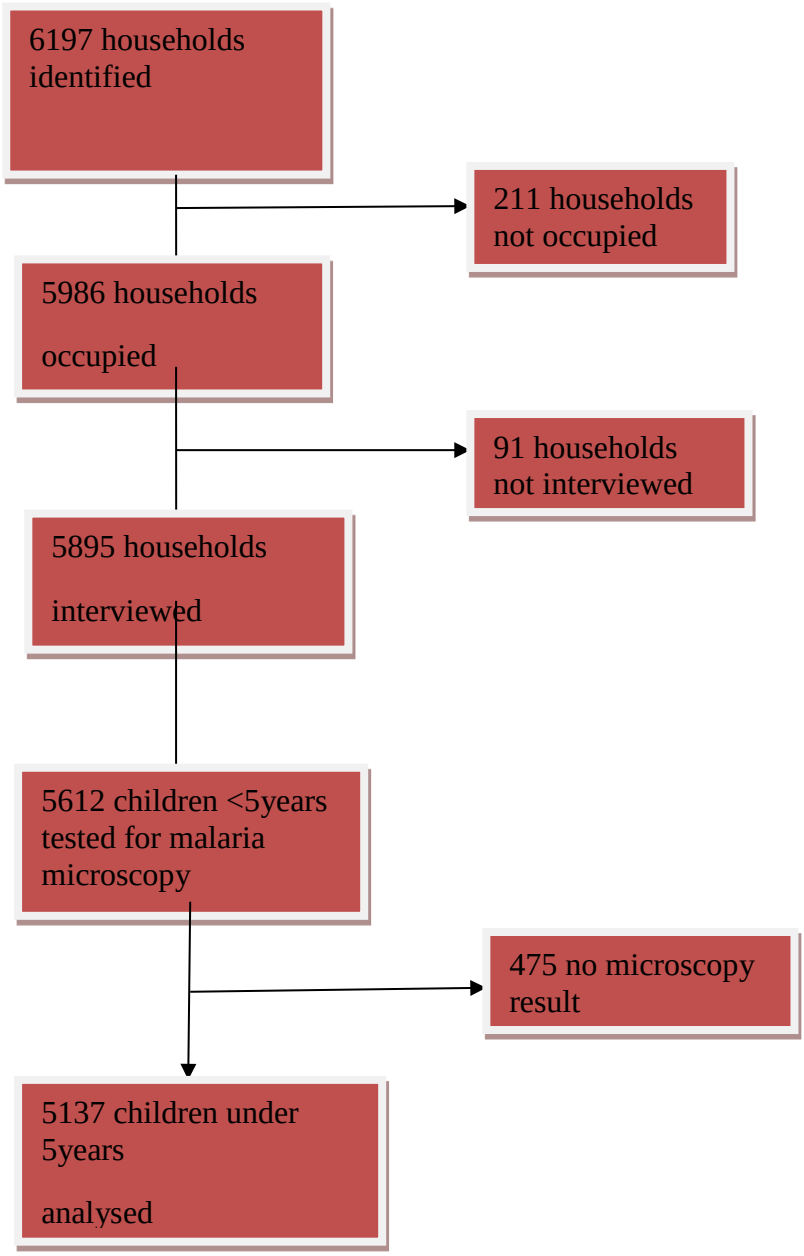

Figure 4: Flow diagram of households and children participants in 2010 NMIS

2.3 Data management and analysis

2.3.1 Data management

The dataset provided by Measure DHS was in a format compatible for analysis using Stata (StataCorp LP, Texas USA). Data was reshaped from wide to long form to store the data in multiple rows so that each individual will have a unique identification with the variables measured for each. The reshaped data was cleaned by checking for missing values, deleting duplicate observations, recoding and generating new variables.

The data was survey set before using it for analysis to take into account the characteristics of survey design which include sampling or probability weighting, cluster sampling and stratification (47). The sample weight was calculated by dividing the household sample weight by 1000000.

2.3.2 Measurement of variables

2.3.2.1 Outcome variable

Malaria as the outcome variable was defined as presence of the malaria parasite. Malaria parasites were detected using Giemsa staining and microscopy.

2.3.2.2 Explanatory variables:

The explanatory variables were grouped into two categories (A and B) and discussed below;

A. Children's variables (characteristics)

- Age in months: age of a child was calculated from the date of birth to the date of survey. It was categorised into five groups as follows; <12 months, 12-23 months, 24-35 months, 36-47 months and 48-59 months.
- Sex: male and female.

- Does a child have a fever in the last two weeks before the survey? Yes and no.
- Does a child under five years sleep under bed net a night before the survey? No net in the household, no children, all children, some children and missing.

B. Household variables (characteristics)

- Place of residence: rural or urban.
- Geopolitical region: They are classified into six;

  North-Central: Benue States, Kogi State, Abuja-FCT, Kwara State, Niger State, Nassarawa State and Plateau State

  North-East: Adamawa State, Bauchi State, Borno State, Gombe State, Taraba State and Yobe State

  North-West: Jigawa State, Kaduna State, Kano State, Katsina State, Kebbi State, Sokoto State and Zamfara State

  South-East: Abia State, Anambra State, Ebonyi State, Enugu State and Imo State

  South-South: Akwa-Ibom State, Bayelsa State, Cross-River State, Delta State, Edo State and Rivers State

  South-West: Ekiti State, Lagos State, Ogun State, Ondo State, Osun State and Oyo State

- Wealth index: This was used as an indicator to determine the economic status of households that is consistent with income and expenditure. It was calculated using household data on ownership of consumer goods, the source of drinking water, sanitation facilities, dwelling characteristics, and other characteristics that relate to socio-economic status of households. A factor score was assigned to each of the assets to construct the index through principal component analysis. Scores for each asset of the entire households were summed. Ranking of individuals were done according to the

total score of the household in which they reside and were then divided into quintiles representing poorest, poorer, middle, richer and richest (48).

- Whether the dwelling has been sprayed against mosquitoes in the last 12 months. It was categorised as “yes” if the interior walls of the dwelling were sprayed in the last 12 months, “no” if it not and “missing” if not known.
- Areas with long-lasting insecticide-treated bed net campaign: The LLIN campaign was supported by the Global Fund, World Bank, Support for the National Malaria Control Programme (SuNMaP), Department for International Development (DFID) and Millennium Development Goals (MDG) funds through the government of Nigeria to distribute over 63 million LLINs to the population by the end of 2010 (8). The variable was categorised into areas with World Bank campaigns, other campaigns and no campaigns.
- Has a television was a measure of household assets? It was categorised into yes (presence of television in good working order) and no (absence of television in good working order).
- The main source of drinking water was categorised into improved source (tube well or borehole , piped water into dwelling/yard, public tap, protected dug well, protected spring, rainwater, sachet water and bottled water) which means that by nature of its construction it adequately protects the water from outside contamination especially faecal contamination (49) and non-improved source (unprotected spring , unprotected dug well, surface water and tanker truck with small tank) which is contaminated from the source.

2.3.3 Statistical Analysis

2.3.3.1 Analysis of Objective 1: To describe the prevalence of malaria in children under five years in Nigeria in 2010

The prevalence of malaria in children was calculated as the number of positive malaria cases divided by the number of children tested in the 2010 NMIS. Contingency and frequency distribution tables were created for categorical variables (such as sex, place of residence etc.) with malaria as the outcome of interest. Pearson's chi-square test and clustered adjusted Pearson's chi-square test were used to check for associations between malaria and the categorical variables. Stratified by malaria (present or absent), age (in months) as a continuous variable was described using mean and standard deviation. The histogram was used to check for normality. The difference in means was calculated using Student's t-test. Clustered t-test was also used while taking care of clustering (clttest in Stata) (50).

2.3.3.2 Analysis of Objective 2: To identify the socio-demographic and household determinants of malaria in children under five years in Nigeria in 2010

Univariate analysis using logistic regression methods was performed to determine the association between each independent variables and the outcome malaria. The backward elimination selection method was used to select variables for inclusion in the multivariate logistic regression models. Variables with alpha level ≥ 0.20 were automatically dropped by Stata and not included in the model. The explanatory variables that were included in the logistic regression models were sex, age, place of residence, region, wealth index, did a child have a fever in the past two weeks, possession of television and children less than five years that slept under a mosquito net in the previous night. A multilevel logistic regression model was fitted to take into account the random effects. The multilevel model is the most satisfactory approach to the analysis of clustered data because it allows for clustering thereby giving an efficient

statistical efficient estimate of the regression coefficients. It helps to model the manner in which children are nested within the clusters and the clusters within the regions. The model was built using the cluster number.

2.3.3.3 Model goodness of fit test

The wald test was used to check for the significance of each variable before removal from the model. The likelihood ratio test was used to compare between two models and the model with a significant p-value (p-value ≤ 0.05) was considered. The post-estimation approach using the estat icc was used to estimate intra-class correlation among children within each household. The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were also performed using the 'estat ic' command to check for the model goodness of fit. The model with the lower AIC and BIC was considered for this study.

2.3.3.4 Analysis of Objective 3: To determine the spatial distribution of malaria in children under five years within the geopolitical regions and their respective states in Nigeria in 2010

The shapefile of Nigeria was obtained from the Global Administrative Areas (GADM) database (51) and was converted into Stata format. The maps were produced using the Spmap ado file in Stata (StataCorp LP, Texas, USA) (52). The Spmap is aimed at visualising several kinds of spatial data, and it is appropriate for drawing thematic maps and displaying the results of spatial data analysis (52). The results were presented in the form of choropleth maps with colour coded hot spots and cold spots to show the distribution of malaria in the six regions of Nigeria.

2.4 Ethical consideration

For the primary study, the National Population Commission (NPC) obtained approval from the Federal Ministry of Health (FMH) in collaboration with its Roll Back Malaria Partners to conduct the survey. Verbal informed consent for testing of children less than five years was obtained from the child's parent or guardian at the end of the household interview (8). For the secondary data analysis, approval to use NMIS data was obtained from the Measure DHS website. Ethics approval was obtained from the University of the Witwatersrand Human Research Ethics Committee (M170154) (APPENDIX 2).

CHAPTER 3

This chapter presents the results of the comparison of the socio-demographic and other malaria-related characteristics of children and households in children with and without malaria. This is followed by results of the univariable and multivariable analyses. Finally, the maps showing the spatial distribution of malaria in Nigeria from the final multivariable model will be presented.

3.1 Description of children and households analysis of malaria among children under five years in Nigeria in 2010

There were 5137 children less than five years in this study. Of these, (41.97%) had malaria. The characteristics of the study population are summarised in Table 1. Here, the weighted and un-weighted results were shown, but the discussion will only be on the population weight adjusted results. There was no difference in prevalence of malaria between males and females. Children with malaria were older (34.96±0.33 months) than those without malaria (30.88±0.33 months).

Children from the most affluent households (richest and richer) had significantly lower prevalence of malaria (23.72%) compared to those from the least affluent (poorest and poorer) households (49.93%). Prevalence in children from middle-income households was 26.35%. Prevalence was also lower in households that had a television and in those with non-improved drinking water sources.

Most of the children lived in rural areas (72.6%). Of those with malaria, 87.72% lived in rural areas. The highest prevalence of malaria was observed in the North-West and the North-Central regions (35.88% and 19.41%, respectively). There were more cases of malaria (60.19%) in

areas where there were no LLIN campaigns compared to areas where there were campaigns (39.81%). There was significantly low prevalence of malaria in children living in households that had been sprayed against mosquitoes in the last 12 months (0.72%).

Taking into account the clustering that is the weighted, the test statistics were slightly lower and had higher p-values. However, the overall conclusions are similar. Children from the households with no television had a significantly high prevalence of malaria (26.34%). There was a decrease in the mean age in months of children with positive malaria. About (51.14%) children under five years who reported no net in the household had the highest prevalence of malaria in 2010. Areas for LLIN campaign were highly significant ($p<0.0001$) during the normal chi-squared test, but when clustered adjusted chi-square test was used, it became non-significant ($p<0.0613$). Source of drinking water and whether children under five slept under mosquito bed net last night were not significant when adjusted for survey design effects ($p=0.1977$) and ($p=0.1880$) respectively.

Table 1: Description of children and households adjusting for survey design

	Un-weighted			**Weighted**		
	Malaria Positive	Malaria Negative		Malaria Positive	Malaria Negative	
Variables	n=1958 (38.12%)	n=3179 (61.88%)	X2 (p-value)	n=1958 (41.97%)	n=3179 (58.03%)	P-value
Sex						
Male	1003(51.23%)	1599 (50.30)		1003 (50.73)	1599 (50.38)	
Female	955 (48.77)	1580 (49.70)	0.4165 (0.519)	955 (49.27)	1580 (49.62)	0.8501
Child's age (month)						
Mean +/-s.e	35.11 ±0.35	31.06 ±0.28	8.98 (<0.001)	34.96 ±0.33	30.88 ±0.33	<0.0001
Geopolitical Zones						
North-Central	433 (22.11)	454 (14.28)		433 (19.41)	454 (14.31)	
North- East	278 (14.20)	629 (19.79)		278 (11.07)	629 (18.07)	
North- West	566 (28.91)	696 (21.89)		566 (35.88)	696 (27.86)	
South- East	168 (8.58)	471 (14.82)		168 (5.09)	471 (9.77)	
South-South	315 (16.09)	642 (20.2)		315 (12.01)	642 (18.20)	
South West	198 (10.11)	287 (9.03)	139.106 (<0.0001)	198 (16.55)	287 (11.79)	0.0002
Place of residence						
Urban	295 (15.07)	1113 (35.01)		295 (12.28)	1113 (30.49)	
Rural	1663 (84.93)	2066 (64.99)	242.253 (<0.0001)	1663 (87.72)	2066 (69.51)	0.0001
Wealth Index						
Poorest	442 (22.57)	495 (15.57)		442 (24.83)	495 (18.31)	
Poorer	450 (22.98)	507 (15.95)		450 (25.1)	507 (18.50)	
Middle	513 (26.20)	644 (20.26)		513 (26.35)	644 (19.25)	
Richer	391 (19.97)	746 (23.47)		391 (16.37)	746 (20.73)	
Richest	162 (8.27)	787 (24.76)	268.643 (< 0.0001)	162 (7.35)	787 (23.22)	0.0001
Areas for LLIN campaign						
World Bank	426 (21.76)	899 (28.28)	30.104 (< 0.0001)	426 (18.66)	899 (27.11)	0.0613

	Un-weighted			Weighted		
Areas with another campaign	393 (20.07)	528 (16.61)		393 (21.15)	528 (16.27)	
Areas with no campaign	1139 (58.17)	1752 (55.11)		1139 (60.19)	1752 (56.62)	
Does child had fever last 2 weeks before survey						
No	1098 (56.08)	1971 (62)		1098 (54.84)	1971 (60.18)	
Yes	793 (40.50)	1079 (33.94)		793 (41.25)	1079 (35.54)	
Missing	67 (3.42)	129 (4.06)	22.7045 (<0.0001)	67 (3.91)	129 (4.28)	0.0384
Dwelling sprayed against mosquito last 12 months.						
No	1928 (98.47)	3131 (98.49)		1928 (98.72)	3131 (98.80)	
Yes	20 (1.02)	29 (0.91)		20 (0.72)	29 (0.80)	
Missing	10 (0.51)	19 (0.6)	0.3138 (0.855)	10 (0.57)	19 (0.40)	0.6892
Children < 5 that slept under mosquito net last night						
No children	301 (15.37)	561 (17.65)		301 (14.82)	561 (17.35)	
All children	462 (23.60)	841 (26.45)		462 (22.21)	841 (25.54)	
Some children	245 (12.51)	338 (10.63)		245 (11.36)	338 (10.29)	
No net in household	942 (48.11)	1417 (44.57)		942 (51.14)	1417 (46.14)	
Missing	8 (0.41)	22 (0.69)	16.3833 (0.003)	8 (0.48)	22 (0.68)	0.188
Source of drinking water						
Improved	1374 (70.17)	2323 (73.07)		1374 (67.88)	2323 (71.86)	
Non-improved	583 (29.78)	849 (26.71)		583 (32.06)	849 (27.86)	
Missing	1 (0.05)	7 (0.22)	7.7345 (0.021)	1 (1.00)	7 (0.27)	0.1977
Television						
No	1377 (70.33)	1638 (51.53)		1377 (73.43)	1638 (54.11)	
Yes	576 (29.42)	1524 (47.94)		576 (26.34)	1524 (45.39)	
Missing	5 (0.26)	17 (0.53)	176.869 (< 0.0001)	5 (0.23)	17 (0.50)	0.0001

Key: SE = Standard Error, X2= Chi-square

3.2 Univariable analyses of the explanatory variables from survey weights adjustment.

The association between malaria and independent unadjusted variables were analysed, and the results were shown in Table 2. The result showed that child's age, place of residence, geopolitical region, wealth index, areas for LLIN campaign, whether a child had a fever for two weeks and possession of television had significant p-values. However, sex, dwelling sprayed against mosquito in the last 12 months, children below 5years who slept under mosquito a night before the survey and source of drinking water showed no association with malaria.

Compared to children <12months, there was significantly increased odds of malaria as children grow from month to month. Children from the older age group (48-59 months) had the highest odds of malaria compared to children in age group <12months (OR 2.35, 95% CI 1.84-3.01) while children from age group 12-23months had the lowest odds ratio (OR 1.39, 95% CI 1.13-1.72).

The result also showed that the females had almost the same odds of malaria compared to males (OR 0.99, 95% 0.85-1.14). Children who had a fever last two weeks before the survey were more likely to have malaria compared to those children who did not have a fever last two weeks before the study (OR 1.27, 95% CI 1.06-1.53).

The children who live in the rural area were three times more likely to have malaria compared to those children that live in the urban area (OR 3.13, 95% CI 2.18-4.49). Compare to children from the North-West, the odds of malaria were low among children from the South-East and the North-East. The richest household children were less likely to have malaria compared to children from the poorest households (OR 0.23, 95% CI 0.15-0.37).

Table 2: Univariable analyses of the explanatory variables from survey weights adjustment

Categories and variables	OR (95% CI)	P-value
Sex		
Male	ref	
Female	0.99 (0.85,1.14)	0.850
Child's age (months)		
<12	ref	
12-23	1.39 (1.13, 1.72)	0.002
24-35	1.70 (1.36, 2.13)	<0.0001
36-47	2.09 (1.68, 2.61)	<0.0001
48-59	2.35 (1.84, 3.01)	<0.0001
Geopolitical Zone		
North- West	ref	
North- Central	1.05 (0.63,1.75)	0.841
North- East	0.48 (0.29,0.79)	0.004
South- East	0.40 (0.26,0.63)	<0.0001
South -South	0.51 (0.32,0.83)	0.007
South West	1.09 (0.63,1.90)	0.761
Place of residence		
Urban	ref	
Rural	3.13(2.18,4.49)	<0.0001
Wealth Index		
Poorest	ref	
Poorer	1.00 (0.71,1.42)	0.999
Middle	1.00 (0.67,1.51)	0.965
Richer	0.58 (0.39,0.85)	0.006
Richest	0.23 (0.15,0.37)	<0.0001
Areas for LLIN campaign		
Areas with no campaign	ref	
World Bank campaign	0.65 (0.43,0.97)	0.034
Does child had fever last 2 weeks before survey		
No	ref	
Yes	1.27 (1.06,1.53)	0.009
Dwelling sprayed against mosquito last 12 months		
No	ref	
Yes	0.89 (0.47,1.72)	0.741
Children < 5 that slept under mosquito net last night		
No children	ref	
All children	1.02 (0.78,1.34)	0.897
Some children	1.29 (0.92,1.81)	0.132
No net in household	1.29 (0.96,1.75)	0.089
Source of drinking water		
Improved	ref	
Non-improved	1.22(0.89-1.68)	0.220
Television		
No	ref	
Yes	0.42 (0.33,0.54)	<0.0001

Key: OR (Odds Ratio)

Table 3.3 Multivariable analyses of factors associated with malaria from survey weights adjustment and random effects.

The variables such as the age of a child, geopolitical zones, place of residence, wealth index etc. that showed significant bivariate association with malaria were selected and included in the multivariate analysis. Non-random effects models were fitted as well as the random effects model to take into account the intercluster correlation among children within the clusters as shown in Table 3. The result of the random effects model was discussed.

The results showed that child's age, regions, place of residence, wealth index, television, had fever two weeks and children <5years slept in the net a night before significantly increased the odds ratio. The odds ratio for a place of residence was significantly decreased from 3.13 to 2.04. Children who live in the rural area had 2.04 odds of malaria compared to children who live in the urban area (95% CI 1.49-2.79). The results also showed that possession of television and children under five years that slept in bed net last night were not significantly associated with malaria.

Table 3: Multivariable analyses of factors associated with malaria

Category and variables	Multivariable (non-random effects)	Multivariable (random-effects)
	AOR (95% CI) p-value	AOR (95%CI) p-value
Sex		
Male	ref	ref
Female	0.97 (0.84,1.12) 0.672	0.91 (0.80,1.04) 0.162
Child's age (months)		
<12	ref	ref
12 23	1.40 (1.10,1.78) 0.007	1.27 (0.98,1.66) 0.073
24-35	1.86 (1.45,2.37) <0.0001	2.01(1.55,2.60) <0.0001
36-47	2.20 (1.73,2.81) <0.0001	2.27(1.76,2.94) <0.0001
48-59	2.49 (1.91,3.25) <0.0001	2.64(2.05,3.41) <0.0001
Geopolitical Zones		
North- West	ref	ref
North- Central	1.01 (0.60,1.70) 0.959	1.38 (0.82,2.35) 0.228
North- East	0.46 (0.29,0.75) 0.002	0.49 (0.29,0.84) 0.009
South- East	0.62 (0.38,1.02) 0.057	0.63 (0.36,1.10) 0.105
South –South	0.79 (0.49,1.29) 0.359	0.79 (0.47,1.37) 0.413
South- West	1.82 (1.08,3.08) 0.025	1.38 (0.77,2.50) 0.281
Place of Residence		
Urban	ref	ref
Rural	2.04 (1.49,2.79) <0.0001	3.05(2.09,4.44) <0.0001
Wealth Index		
Poorest	ref	ref
Poorer	0.84 (0.60,1.18) 0.315	1.04 (0.82,1.33) 0.730
Middle	0.89 (0.61,1.29) 0.537	1.08 (0.81,1.43) 0.596
Richer	0.69 (0.44,1.09) 0.112	0.91 (0.63,1.31) 0.622
Richest	0.30 (0.17,0.50) <0.0001	0.44(0.28,0.69) <0.0001
Does child had fever last 2 weeks		
No	ref	ref
Yes	1.37 (1.16,1.60) <0.0001	1.34(1.16,1.56) <0.0001
Children < 5years that slept under mosquito net last night		
No children	ref	
All children	1.03 (0.78,1.36) 0.847	n/s
Some children	1.39 (1.03,1.89) 0.032	
No net in household	1.17 (0.90,1.51) 0.233	
Television		
No	ref	
Yes	0.73 (0.58,0.92) 0.007	n/s

AOR (Adjusted Odds Ratio), ref (Reference), n/s (Not Significant), CI (Confidence Interval)

ICC= 0.25 (95%CI 0.21-0.32)

3.4: Spatial distribution of malaria in the geopolitical regions of Nigeria

The maps shown in figure 3 are choropleth maps showing the observed prevalence of malaria, predicted prevalence and standard error of the mean of malaria in children less than five years in different regions including their states in Nigeria in 2010. Adjusting for the states in the geopolitical regions, the regions in red colours represent the hot spots which indicate that they had the highest prevalence of malaria ranging from 0.42 to 0.72 in 2010. The regions in blue colours had prevalences ranging between 0.10 and 0.31 represent the cold spots which are the low malaria prevalence regions. There were also regions which showed moderate prevalence (0.32-0.41). The observed map showed that the highest prevalence of malaria (0.42 to 0.72) was found in the North-Central and North-West region of the country. The map showed low prevalence for all the states in the South-East region. Most of the states in the South-West region showed moderate case of malaria. The map of the predicted prevalence of malaria showed overall similarity to the observed map. The difference was seen in Sokoto state where the predicted prevalence was higher than the unadjusted.

The map of the standard error of mean showed in figure 3 shows the variability in the results of unadjusted and adjusted maps. The map showed a low standard error in most of the states in the North-West region which implies reduced variability. There was a high variability in the results that were found in the North-Central region and some parts of the South-West region.

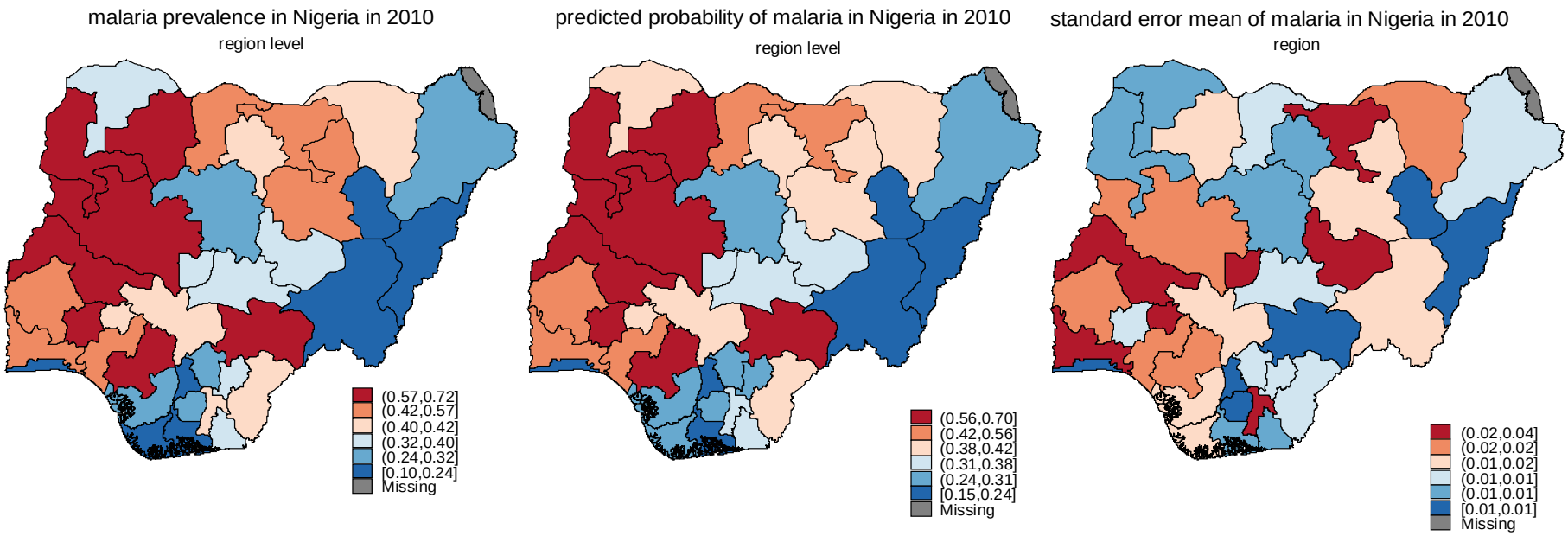

Figure 5: Prevalence (Observed), Predicted Probability and Standard error mean of Malaria in Children under five years in Nigeria, 2010

CHAPTER 4

This chapter includes the discussion, the limitations and the strengths of this study. It also includes the conclusion and the recommendations that were made based on the findings.

4.1 Discussion

This study estimated the prevalence, factors associated with malaria and the spatial distribution of malaria in children less than five years in Nigeria in 2010. Malaria has been found as one of the public health problems among children less than five years in Nigeria (33). It is important to determine the factors associated with malaria and its spatial distribution at geopolitical zones and also at the state level to help the policymakers to carry out proper interventions. The findings of this study show that malaria is associated with the place of residence, geopolitical zones, wealth, the age of a child and children with fever two weeks before the survey. The study will be discussed under children's variables and household variables as follows;

4.1.1 Children's variables

The likelihood of malaria was less among younger children (age group <12 and 12-23 months) and higher among the older age group (36-47 and 48-59 months) as was shown in this study. The low likelihood in the younger age group may be as a result of the antibodies that children acquire from their mothers during pregnancy and during exclusive breastfeeding which protects them from diseases (32). It could also be due to use of LLINs because younger children tend to sleep under bed nets. The study has also shown that the high risk in the older age group could also be attributed to a nutrient deficiency which makes them vulnerable to malaria and other communicable diseases (32). Malnutrition can increase the level of malaria morbidity and mortality in children by weakening their immunity (28).

Male children were found to have a high prevalence of malaria than their female counterpart although the difference was not statistically significant. This agrees with the findings from previous studies that were done in Nigeria and Ghana (5,32), which suggested biological susceptibility to infectious diseases as the reason males have high prevalence of malaria. Another study that was conducted in Nigeria also states that parental gender preference still exists in some Nigeria communities which result in discriminatory practices against children of less desired sex (53). Preference is giving to female children because of the supposed dowry that the parents will get when they are getting married.

4.1.2 Household variables

Children from the households that were sprayed against mosquitoes were at lower risk of malaria. This is as a result of indoor residual spray pilot project which was initiated by the National Malaria Elimination Programme of Nigeria to combat malaria in 2006 and 2007 (8). Areas that were covered during the LLIN campaign in Nigeria in 2010 have shown a protective effect against malaria in this study. The campaigns were adopted during the 2009-2013 National Strategic Plan for Malaria Control (NSPMC) in Nigeria (8).

There were two phases of the campaign, the catch-up phase and the keep up phase. In the catch-up phase, there were scaling up ownership of bed nets through the LLIN campaigns for universal coverage while the keep-up phase is to maintain the coverage through the routine distribution of LLINs. Households that had no net in the household showed a high prevalence of malaria; this means that having LLINs and sleeping under it was protective against malaria. The result agreed with other findings which reported that areas with high proportion of children sleeping under bed nets had fewer cases of malaria (32,54).

The children from the rural areas had more malaria cases compared to their urban counterpart. This study showed that there was greater proportion of children in the rural areas than in the urban areas. This study agrees with the evidence of informal settlement in Nigeria. The result showed that almost three-quarters of the people live in the rural areas (53). The high risk in rural area was associated with poor knowledge and perception of malaria control among people living in the rural areas compared to those from the urban areas (55). The high risk of malaria could also be related to poor access to treatment as well as poor access to IRS and LLINs in hard to reach areas for distribution (42). Also, a similar study in Ghana also showed a high prevalence of malaria in rural areas compared to the urban areas (32).

Other studies have shown malaria as a disease of the poor (29,33), the findings of this study complement with their findings. The risk of malaria was high among children from the poor households. In other words, it is believed that there is a correlation between poverty and place of residence; mostly poor people live in the rural areas. Ownership of television and source of drinking water were not associated with malaria in this study. Other risk factors like education level, availability of electricity, main floor material and main wall material which could not be included in this study were found to be associated with a child's malaria status (27).

A greater proportion of children from the Northern Nigeria live in the rural areas where the risk of malaria is high. This is an evidence of geographical variation in the malaria distribution in Nigeria. The high prevalence of malaria in the North-Central and North-West regions has been linked to shallow rainfall in those regions which provide suitable breeding conditions for the mosquitoes (5). Heavy rainfall flushes away and kills the parasite larva (28). In a similar study that was conducted in Nigeria on regional analyses of fever, the study showed that fever is more prevalent in the North Central Nigeria and fever is associated with malaria (33). This

agrees with the findings of this study which shows that children that had fever had a high prevalence of malaria. A study also shows that children from the Northern part of the country were found to be associated with low haemoglobin as the study has shown a strong correlation between low haemoglobin and malaria (53). However, there is a low prevalence of malaria in the South-East region and some states in the North-West region. The low prevalence could be attributable to LLINs coverage in those regions during LLIN campaign (8). This study, therefore, confirms the variation in the geographical distribution of malaria in under five children.

4.2 Limitations

This study has several limitations. There are limitations that are related to the use of secondary data. The available data were not collected to address the research question of this study or to test the hypothesis. For example, the data for the spatial aspect of the study was sourced from a different website. It is common that some important third variables such as mothers education were not available for the analysis which could have explained the relationship between mothers illiteracy and malaria (56). There may have been measurement errors during the survey which include- error from the questionnaire, data collection mode, the interviewer and the respondent (57). For the fact that household characteristics such as wealth index and other information were self-reported, there is a tendency of incorrect recall which could result in misclassification bias. There is a possibility that not all malaria cases were confirmed by either microscopy or RDT. The two tests microscopy and RDT have limited sensitivity and specificity because they cannot detect sub patent malaria parasite threshold in the blood sample (58). There is a possibility of underestimation of malaria prevalence because of lack of accessibility to some clusters due to the insurgency in some parts of the Northern Nigeria during the survey.

4.3 Strengths

Despite the study limitations, it also has some strength. The 2010 NMIS was the first of its kind in Nigeria. It provides the malaria prevalence baseline rate that can be compared to subsequent zonal and national prevalence estimates which are used to measure the progress aimed at reducing the malaria prevalence in Nigeria. Multiple regression models taking into account non-spatial (cluster) random effects were used to control for confounding variables. After adjusting for the random effects, the narrower confidence intervals were obtained.

4.4 Conclusions

Although efforts have been made towards the control of malaria in Nigeria, the prevalence is still high. Rural settlements have contributed immensely to the heightened risk of malaria among the Nigerian children. It was also found that LLINs campaign was a good measure in the malaria control programme and it should be expanded to the rural communities. The study shows that there is a variation in the spatial distribution of malaria in Nigerian regions and the prevalence was high in the North-West, North-Central and the South-West regions. It was also found that poverty is a major determinant factor that is associated with malaria; effort should be made to alleviate poverty in the country to eliminate malaria prevalence.

4.5 Recommendations

There must be targeted interventions in disease prevention programs and more concentration on the areas with higher prevalence. It will help to maximise the use of limited or available resources in the fight against the elimination of malaria. There is also need for the policymakers to increase the awareness of LLINs use and IRS as they have shown a protective effect against malaria. In designing malaria control and intervention strategy, efforts should be made to reach the communities and at individual levels to empower the target population so to improve their

socioeconomic status; this will help to reduce the prevalence of malaria. The government should also explore dimension which includes vaccine development through increased research funding, evidence based policy formulation and implementation, increased environmental and public health education, integration of the communities towards malaria control and primary health care activities. Mapping the distribution of malaria is a good approach in identifying areas with high risk which will guide the policymakers to target the interventions to where they are most needed. More risk factors like mother's education level, availability of electricity, main floor material and main wall material, altitude and rainfall should be included in other studies.

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Appendix 1: Plagiarism Declaration form

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I LOVELYN UZOMA OZOUGWU (Student number: 1226801) am a student

Registered for the degree of MSC EPIDEMIOLOGY AND INFECTIOUS DISEASES in the academic year 2016.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.

Signature: _____ Date: March 2018

Appendix 2: Ethics Clearance Certificate

R14/49 Miss Lovelyn Uzoma Ozougwu

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M170154

NAME: (Principal Investigator)	Miss Lovelyn Uzoma Ozougwu
DEPARTMENT:	School of Public Health Division of Epidemiology and Infectious Diseases
PROJECT TITLE:	Spatial Analysis of Malaria in Nigeria in 2010
DATE CONSIDERED:	27/01/2017
DECISION:	Approved unconditionally
CONDITIONS:	Additional Supervisor (11/08/2017)
SUPERVISOR:	Dr Eustasius Musenge and Dr Zodwa Ndlovu
APPROVED BY:	Professor P. Cleaton-Jones Chairperson, HREC (Medical)
DATE OF APPROVAL:	03/02/2017

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 10004,10th floor, Senate House/3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand. I/We fully understand the conditions under which I am/we are authorised to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. in this case, the study was initially review January and will therefore be due in the month of January each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix 3: Change of Title Approval

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

23 August 2017
Person No: 1226801
TAA

Ms LU Ozougwu
C/O Engr Jude Okafor
Department of Town& reginal Planning
University of Johannesburg
2028
South Africa

Dear Ms Ozougwu

Master of Science in Epidemiology: Change of title of research

I am pleased to inform you that the following change in the title of your Research Report for the degree of **Master of Science in Epidemiology** has been approved:

From:	**Spatial analysis of Malaria in Nigeria in 2010**
To:	**Sociodemographic charecteristics and spatial distribution of Malaria in Nigerian children**

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences