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The Association between Undernutrition and Malaria among Under-five Children in Nigeria, 2018

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ABSTRACT

THE ASSOCIATION BETWEEN UNDERNUTRITION AND MALARIA AMONG UNDER-FIVE CHILDREN IN NIGERIA, 2018

BY

DAENA M. MANN

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INTRODUCTION: Malaria and undernutrition have independently contributed to mortality and morbidity among the under-five population of Nigeria. However, there remains complexity in the association between stunting, underweight, wasting, and malaria.

AIM: To evaluate the association between stunting, underweight, wasting, and malaria among under-five children of Nigeria, while assessing the effects of sociodemographic factors.

METHODS: Cross-sectional data from the most recent Demographic and Health Surveys for Nigeria 2018 was used, which included 13,058 children ages 0-59 months. Stunting (WHO height-for-age z-score below -2.0 SD), underweight (WHO weight-for-age z-score below -2.0 SD), wasting (WHO weight-for-height z-score below -2.0 SD), and the malaria blood smear test results were obtained. Sociodemographic factors, such as child's age, sex, place of residence, educational level of the mother, and wealth quintile, were also obtained and examined. Logistic regression modeling was used to determine the associations between undernutrition status and sociodemographic factors, malaria and sociodemographic factors, and undernutrition status and malaria.

RESULTS: The prevalence of stunting was 37.0%, with 22.2% underweight, 7.0% wasting, and 22.6% tested positive for malaria. Stunting was frequent among 24-35 months old, 12-23 months old were mostly underweight and wasted, and 48-59 months old frequently suffered from malaria. Stunting, underweight, wasting, and malaria frequently occurred among males, residents of rural areas, poorest wealth quintile, and children of uneducated mothers. The odds of having malaria was 81% higher among under-five stunted children (AOR=1.81, 95% CI=1.55,2.12; p-value=<0.0001) and 23% higher among under-five underweight children (AOR=1.23, 95% CI=1.02,1.49; p-value=0.0339). However, wasting (AOR=0.91, 95% CI=0.69,1.19; p-value=0.4832) was not significantly associated with malaria.

DISCUSSION: There exists an association between stunting, underweight and malaria. However, there was no association between wasting and malaria. Sociodemographic factors can influence the effects between the variables, and therefore, policymakers also need to consider these factors when implementing strategies to decrease undernutrition and malaria.

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Author's Statement Page

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CHAPTER I

INTRODUCTION

1.1 Background

In 2018, malaria was deemed a threat to approximately half of the world's population. Malaria is a life-threatening disease that is caused by *Plasmodium* parasites, which is spread to people via the bites of infected female Anopheles mosquitoes. Five parasite species cause malaria in humans with P. falciparum and P. vivax, posing the most significant threat (WHO, 2020). According to the World Malaria Report, there was a global estimate of 228 million cases of malaria in 2018 compared with 231 million cases in 2017. Furthermore, approximately 405,000 malaria deaths occurred in 2018 compared with 416,000 malaria deaths in 2017 (WHO, 2020) worldwide. However, a disproportionately higher portion of the global burden of malaria exists in the African Region, as it comprises of 93% and 94% of malaria cases and deaths, respectively. Children under five years of age are the most vulnerable group affected by malaria, as they account for approximately 272,000 malaria deaths worldwide. Among the countries accounting for the high burden of malaria, Nigeria ranks the highest with an estimated 25% of all malaria cases worldwide (WHO, 2020). In 2018, Nigeria had a population of approximately 195.9 million individuals (Countryeconomy.com, 2018). According to the United States Embassy in Nigeria, malaria is a risk for 97% of Nigeria's population, and there are an estimated 100 million malaria cases with over 300,000 deaths per year in the country (United States Embassy in Nigeria, 2011).

Undernutrition is also recognized as a global health issue that has claimed the lives of many individuals, especially among the under-five population. A total of 45% of the deaths among under-five children were linked to undernutrition (WHO, 2018). Undernutrition encompasses three main forms: stunting (low height-for-age), underweight (low weight-for-age), and wasting (low weight-for-height). Stunting is recognized as the most common form of undernutrition globally (Prendergast & Humphrey, 2014). Stunting is defined as a child who is too short for their age (UNICEF, WHO, & IBRD, 2019). In 2018, there was a global estimate of 149 million (21.9%) children under the age of five who were stunted **(**UNICEF, WHO, & IBRD, 2019). Poor nutrition, both in-utero and early childhood, is the main contributing factor to the devastating outcome of stunting. The lack of proper nutrition is often attributed to inaccessibility to food, improper food preparation, inequitable distribution of food within households, and dietary taboos (Girma & Genebo, 2002). Children who fall victim to stunting may never reach their full possible height, and due to the possibility of an underdeveloped brain, they may never achieve full cognitive potential (UNICEF, WHO, & IBRD, 2019). Therefore, these children often face barriers, such as difficulties in learning and the ability to participate in daily activities. Nigeria possesses the second highest burden of stunted children in the world, with a national prevalence rate of 32% of children under five years of age (UNICEF, n.d.).

Evidence has shown that there is an increase in mortality risk among mildly underweight children, with severely underweight children being at an even greater risk (WHO, 2010). According to UNICEF, WHO, and The World Bank (2012), there was a global estimate of 101 million (16%) children under the age of five who were underweight in 2011. This estimate reflects a 36% decrease from approximately 159 million underweight children in 1990. In 2016, the prevalence of underweight among the under-five population of Nigeria was 31.5% (IndexMundi, n.d.). The multidimensional nature of poverty has contributed immensely to the prevalence of underweight among the under-five population. Poverty contributes to poor child care, unhealthy environments, maternal undernutrition, poor health care, and household food insecurity, which are all risk factors of underweight (WHO, n.d.). Furthermore, underweight can result from either wasting or stunting, or both. However, despite the possible intersection in conditions, it is essential to note that they have different risk factors and respond to various interventions.

According to UNICEF, WHO, and IBRD (2019), there was a global estimate of 49 million (7.3%) children under the age of five who were wasted in 2018. Wasting is defined as a child who is too thin for their height, and poor nutrient intake is often associated with the susceptibility to being wasted. Poor nutrient intake can result from several factors, such as famine and the loss of nutrients due to infection. Often, children who suffer from wasting have weakened immunity and are susceptible to lasting developmental delays along with an increased risk of death, especially when wasting is severe (UNICEF, WHO, & IBRD, 2019). Urgent feeding, treatment, and care are vital to survival for these children. As of 2016, Nigeria's under-five wasting prevalence is 10.8%, which is greater than the developing country's average of 8.9% (Global Nutrition Report, 2020).

1.2 Research Questions and Aims

In Nigeria, morbidity and mortality in children under-five years of age are strongly associated with malaria and undernutrition independently. According to numerous studies done in several countries, the effect of the various types of undernutrition; stunting, underweight, and wasting on malaria status is not well understood. Studies have shown conflicting results, with some depicting an association between the several types of undernutrition and malaria, while others showing no association. However, a study that aims to analyze the interaction between undernutrition and malaria among the under-five population of Nigeria has not been executed. Therefore, the association between both conditions remains a mystery among under-five Nigerian children.

This study will thus provide new information on the association between the independent variables, stunting, underweight, and wasting and the dependent variable, malaria, among the under-five Nigerian population. Such information can aid in narrowing the gaps in knowledge on the topic and therefore improve understanding. However, in an effort to highlight a more in-depth view of the effects of undernutrition on malaria, additional factors need to be taken into consideration. Therefore, this study aims first to uncover further evidence on the underlying factors, such as child's age, sex, place of residence, wealth quintile, and maternal educational level, that may contribute to the effects of undernutrition and malaria independently. Furthermore, the effects of stunting, underweight, and wasting on malaria status will then be evaluated.

Based on the magnitude of deaths and illnesses that have been attributed to undernutrition and malaria, the necessary precautions must be enforced to help in reducing these effects. The implementation of policies and recommendations can aid in the process of addressing the arising issues from these conditions. Therefore, this study also aims to provide vital information that can aid in the process of generating effective strategies. As such, the main research questions for this study are as follows:

1. What are the prevalence, demographic characteristics, and risk factors for stunting among children under five years of age in Nigeria?
2. What are the prevalence, demographic characteristics, and risk factors for underweight among children under five years of age in Nigeria?

3. What are the prevalence, demographic characteristics, and risk factors for wasting among children under five years of age in Nigeria?
4. Are stunting, underweight, and wasting associated with malaria among children under five years of age in Nigeria?

CHAPTER II

REVIEW OF THE LITERATURE

2.1 Undernutrition and Malaria

Yearly, undernutrition contributes to the deaths of approximately three million under-five children, globally (Global Nutrition Report, 2016). Despite the global decline in undernutrition among children under five years of age of approximately 25% in 1990 to 15% in 2015, the risk of undernutrition remains considerably high (Roser & Ritchie, 2020), especially in Sub-Saharan Africa. Within this region, a significant amount of mortalities and morbidities are attributed to the effects of undernutrition among the under-five population, compared to other illnesses. The prevalence of stunting was noted to be highest in Burundi (57.7%) followed by Malawi (47.1%); Niger (18.0%) was recognized to have the highest prevalence of wasting followed by Burkina Faso (15.5%); and underweight was highest in Niger (36.4%) followed by Burundi and Chad with 28.8% and Nigeria with 28.7% (Akombi, Agho, Merom, Renzaho, & Hall, 2017). However, the study was limited as several Sub-Saharan African countries were disregarded due to incomplete data on the undernutrition indicators or a lack of recent data from the Demographic and Health Surveys, which was the primary source of data in this study.

The burden and risk factors of undernutrition vary across several demographic characteristics, which was highlighted in a cross-sectional study conducted in Ghana. Results showed the association of age with stunting, underweight, and wasting, while sex was primarily associated with stunting and wasting (Boah, Azupogo, Amporfro, & Abada, 2019). This was confirmed by a study conducted in Ethiopia, which highlighted that rural-born male children possess a higher burden of stunting, underweight, and wasting compared to urban-born females (Woldeamanuel & Tesfaye, 2019). Additionally, children younger than 30 months old were more wasted compared to older children (Nzefa, Monebenimp, & Äng, 2019). However, based on the study designs, the causal link is not depicted, only the nature of the association. Moreover, Protein Energy Malnutrition (PEM) often manifests as stunting, underweight, and wasting. In a retrospective study conducted at the University of Nigeria Teaching Hospital among 212 children aged 0 to 59 months that were admitted to the hospital for PEM, there was a noticeable difference across several demographic characteristics. Most of the patients were males (59.9%), the most common age group was 6 to 12 months (55.7%), most of the patients were from lower socioeconomic class, and malaria and diarrhea were the most commonly associated co-morbidities (Ubesie, Ibeziako, Ndiokwelu, Uzoka, & Nwafor, 2012).

Severe malaria is also highly associated with mortality and morbidity in Sub-Saharan Africa, regardless of numerous efforts in management and prevention. The pattern of presentation of the illness and the prevalence may differ across age groups and locations. A retrospective study of 102 participants conducted at the Enugu State University Teaching Hospital and University of Nigeria Teaching Hospital highlights a majority of male, under-five children (66.7%) succumbing to severe malaria (Edelu, Ndu, Igbokwe, & Iloh, 2018). However, knowledge, practices, and attitudes about malaria often act as contributing factors to malaria status. A cross-sectional survey of 192 households of an urban community in south-western Nigeria underscores that 93.2% of the respondents were familiar with malaria being transmitted through the bites of mosquitoes, with approximately 90% of the cases being treated with local drugs and herbs at home. Though 79.7% of the respondents reported the use of insecticides, only 16.7% of them used insecticide-treated nets (ITNs), and 8.9% lack screening nets for their windows, which are fundamental preventative methods, especially for children (Adedotun, Morenikeji, & Odaibo, 2010). This study predicted that the prevalence of malaria in households is often significantly associated with environmental factors.

Additional factors contributing to malaria status was highlighted in a cross-sectional household survey among 1882 children aged 6-59 months. In this study, malaria prevalence differed by sex, with 5.5% being males and 7.5% being females (OR=0.72; P=0.034). Additionally, among older children, malaria prevalence was significantly higher but was noted to be lower among children from high socioeconomic status (OR=0.37; P=0.029). However, based on speculations, an increased practice of precautionary measures taken among younger children may be attributed to malaria being more prevalent in older children. One such precautionary measure is sleeping under insecticide-treated bed nets (ITNs). Furthermore, older children are likely to tolerate malaria parasites without necessarily showing symptoms. Based on this study, undernutrition was not associated with malaria parasitemia overall (Kateera et al., 2015). However, in compartmentalizing the various types of undernutrition: stunting, underweight, and wasting, it will allow for a more in-depth analysis of its association with malaria among the under-five population.

2.2 Stunting (low height-for-age)

Deen, Walraven, and Seidlein (2002) shed light on the relationship between nutritional status and malaria. It is recognized that the various forms of nutritional status—wasting, stunting, and underweight are possibly associated with malaria status. A prospective cohort study was conducted among 487 under-five rural Gambian children who were followed weekly during a malarial season. The primary goal of the study was to assess whether wasting or stunting is associated with the risk of succeeding malaria episodes during the rainy season, as this is when most P. falciparum malaria transmission occurs. A total of 200/487 (41.1%) of the children had one to four malaria attacks. Furthermore, 55/107 (51.4%) of the children with baseline stunting successively experienced malaria episodes compared to 145/380 (38.2%) of the children who were not stunted (RR= 1.35; 95% CI=1.08-1.69; p-value = 0.01). Neither underweight nor wasting influenced vulnerability to malaria. However, the article highlights that there may be several confounding factors contributing to the malaria status of the children. Potential confounders include socioeconomic status and the conditions of the household. It appears that there is a higher risk for malaria episodes in the Gambian children due to stunting. However, it is essential to note that there may be other unknown factors that could predispose the children to malaria and stunting. Additional studies are needed to explain these possibilities. Similar results were noted in a cross-sectional study produced by Friedman et al. (2005) that aims to analyze whether undernutrition increases or decreases the risk of malaria-attributable morbidity among 0-36 months old in Western Kenya using cross-sectional surveys. It was noted that stunted children succumbed to more malaria parasitemia (OR=1.98, P<0.0001), clinical malaria (OR=1.77, P<0.06), severe malarial anemia (OR=2.65, P<0.0001), and high-density parasitemia (OR=1.84, P<0.0001) compared to children who are not stunted. The study also highlights that some of the relationships between infectious diseases, such as malaria, may be confounded by HIV status. Furthermore, the cross-sectional study design limited the interpretation of cause and effect. However, the findings support observations that stunted children are at a greater risk of malaria infection compared to children who are not stunted.

On the contrary, Müller, Garenne, Kouyaté, and Becher (2003) present evidence suggesting that there is no association between nutritional status and malaria attacks. Longitudinal malaria surveillance supplemented with cross-sectional clinical surveys was conducted in Nouna Health District in northwestern Burkina Faso, among 685 children aged 6-30 months. The study suggested that malnutrition is a major risk factor for all-cause mortality in West African children; however, not necessarily associated with malaria morbidity. Additionally, Fillol et al. (2009) highlight a cohort study of 874 rural preschool children that was conducted in Senegal, which also puts forth evidence that stunting (z-score<-2) was not associated with clinical malaria. Similar results were highlighted by Wilson et al. (2018) in a cohort study conducted in under-five children in rural Gambia, which presented evidence that there was no association between stunting and malaria incidence (OR=0.79, 95% CI=0.60-1.05). Additionally, a prospective cohort study conducted in Malawi among 6-18 months old children, which aimed to determine whether undernutrition predicts the over-dispersion of malaria infections in settings of high undernutrition and malaria prevalence, was outlined by Bendabenda et al. (2019). It was noted that stunting at 6 months old was not associated with malaria outcomes. However, misclassification bias may be present in this study as compared to baseline; more children became stunted (41.5% vs. 28.3%) by 18 months. Furthermore, maternal education, food insecurity, and household assets were significantly associated with malaria.

On the other hand, Mitangala et al. (2013) outline evidence to suggest that stunting might be protective against being infected with malaria. This was proposed based on results obtained from a cohort study of 790 children aged 6-59 months, which was done in the eastern Democratic Republic of the Congo. Children with severe stunting were at a lower risk of malaria parasitemia compared to children with a more improved nutritional status (OR=0.48, 95% CI=0.25-0.91).

2.3 Underweight (low weight-for-age)

Hassen and Ali (2015) suggest evidence supporting that wasting and underweight were significantly associated with malaria. An unmatched case-control study was performed among 621 Ethiopian children aged 6-59 months to assess the influence of underweight and wasting on malaria status. Compared to the referent group of children who were not underweight, the odds of developing malaria was 1.7 times more among underweight children (AOR=1.69, 95% CI=1.11-2.9). This was confirmed by Ehrhardt et al. (2006) who revealed through cross-sectional surveys in Ghana, that underweight was significantly linked to a higher risk of clinical malaria (OR=1.67, 95% CI=1.10-2.50), fever (OR=1.59, 95% CI=1.13-2.23), and anemia (OR=1.68, 95% CI=1.38-2.04). Similar evidence was presented in a cross-sectional study on the prevalence of nutritional status on the influence of malaria parasitemia among children in Mount Cameroon. Sumbele, Bopda, Kuokuo, Ning, and Nkuo-Akenji (2015) offered evidence suggesting 21.6% of the children who were underweight developed clinical malaria compared to 8.2% of their adequately nourished counterparts.

On the contrary, Bendabenda et al. (2019) highlight that being underweight at 6 months old was not associated with the incidence of malaria. However, misclassification bias may be present in this study, as compared to baseline; more children became underweight (16.5% vs. 12.9%) by 18 months. Similar results were highlighted by Deribew et al. (2010), who conducted research in south-west Ethiopia. Results showed that there is no association between under-nutrition and malaria. However, children who have malaria are more likely to be anemic.

2.4 Wasting (low weight-for-height)

Hassen et al. (2015) present evidence suggesting that wasting is significantly associated with malaria. The odds of developing malaria was 2.4 times more among wasted than non-wasted children (AOR=2.44; 95% CI=1.15-5.19). This was confirmed by Shikur, Deressa, and Lindtjørn (2016), who highlighted similar results from a case-control study that was done in south-central, Ethiopia, among under-five children. Uneducated caretakers (AOR=3.00, 95% CI=1.27-7.10) and severe wasting (AOR = 2.90, 95% CI=1.14-7.61) were independently associated with malaria attack among children under five years of age. However, these studies did not assess the level of micronutrient status, the level of parasitemia, and anemia, which could influence malaria morbidity. Additionally, Bendabenda et al. (2019) suggest that a lower prevalence of malaria parasitemia at 18 months (prevalence ratio=0.80, 95% CI=0.67-0.94, p=0.007) was associated with higher weight-for-height at six months.

On the contrary, Fillol et al. (2009) note that there was a lower risk of having at least one subsequent clinical malaria attack (OR = 0.33; 95% CI=0.13-0.81, P=0.02) among wasted children. However, several hypotheses were highlighted as to why such results might have occurred. One such hypothesis indicates that there is a link between the risk of malaria among wasted children and the mother's behavior. Based on studies performed on this study population, results indicate that mothers are able to accurately assess their children's nutritional status and furthermore attempt to alleviate the harmful effects of malnutrition on survival. Therefore, there is a possibility that mothers may use preventative measures, such as bed nets, more regularly for wasted children. Similar results were outlined by Sumbele et al. (2015) in a cross-sectional study among children in Mount Cameroon. Evidence suggests that the prevalence of malaria parasitemia was lower in children who were wasted compared to well-nourished children, which may indicate that wasting might be protective against the infection.

Based on the literature provided, there remains conflicting results regarding the effects of stunting, underweight, and wasting on malaria status. Several studies highlight that there is an association between undernutrition and malaria, while other studies reveal that there is no association between the conditions. This study consists of a large sample size and therefore provides a representative picture of the under-five population of Nigeria. Therefore, this study can aid in filling in the gaps in knowledge on whether or not there is an association between undernutrition and malaria. Furthermore, the results from this study will not only highlight novel information about Nigeria but also contribute to the debate of understanding the complex interaction between undernutrition and malaria.

Stunting, underweight, wasting, and malaria have contributed significantly to morbidity and mortality among the under-five population on a global scale, compared to other illnesses. Therefore, there is a dire need for a reduction of these adverse conditions in an effort to lessen its effects. Furthermore, the identification of underlying factors, such as place of residence, maternal education, and wealth quintile, that play a role in increasing the risk of undernutrition and malaria, are essential to aid in implementing effective policies and recommendations. Therefore, the information provided by this study can contribute to the implementation of interventions targeted to lessening the likelihood of becoming undernourished or infected with malaria. As such, this study can be used as a tool for policymakers to create and administer effective nutrition interventions and to inform public policies.

CHAPTER III

METHODS AND PROCEDURES

3.1 Background

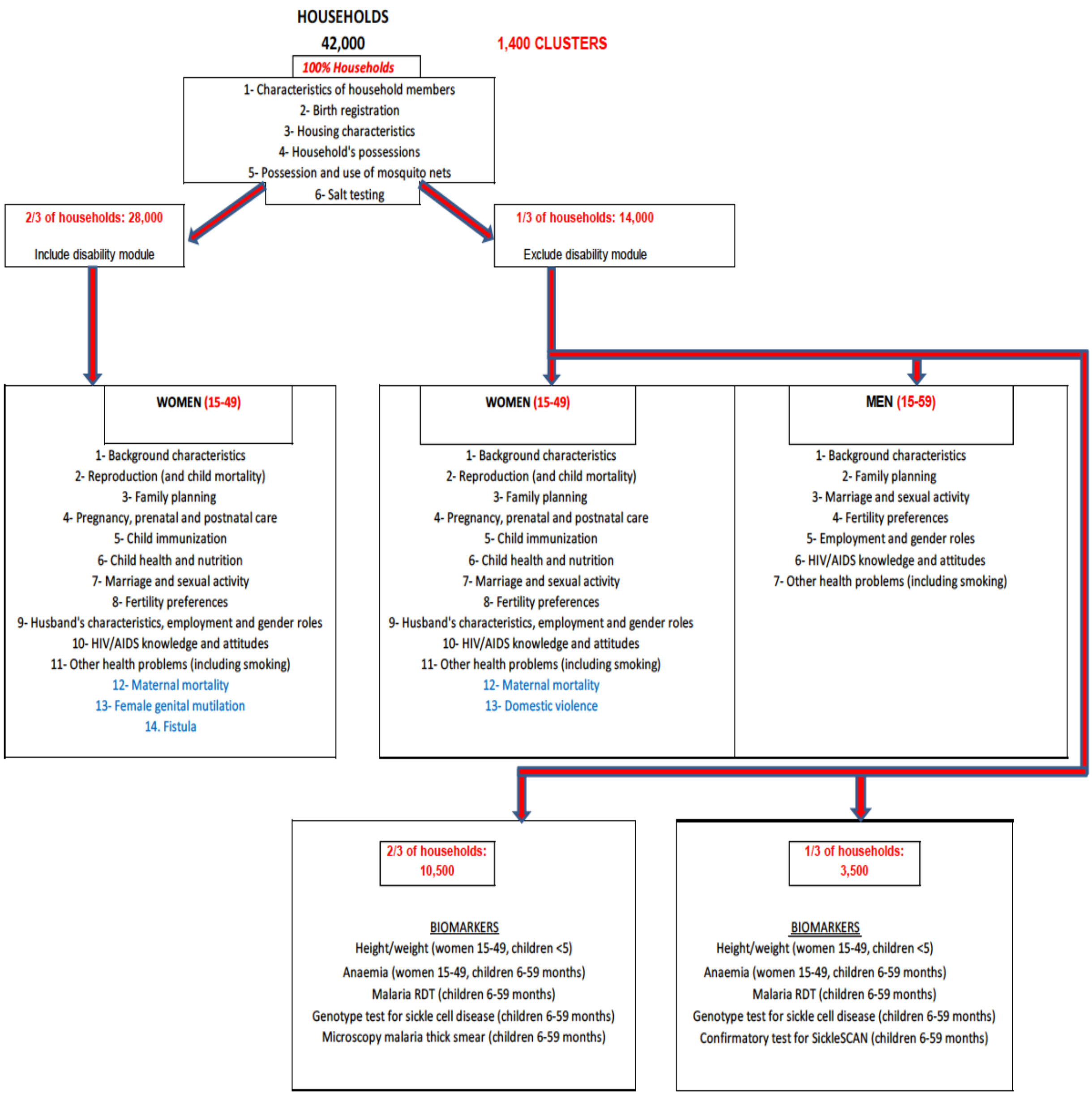
The data analyzed in this study was obtained from the most recent Demographic and Health Surveys (DHS) for Nigeria 2018, which was requested then downloaded from the DHS website. The Nigeria Demographic and Health Survey (2018 NDHS) was implemented by the National Population Commission (NPC). Data collection for this survey occurred on August 14, 2018, to December 29, 2018. The DHS contains two survey types: Standard DHS Surveys and Interim DHS Surveys. The Standard DHS Surveys, which include large sample sizes, which are generally between 5,000 and 30,000 households and are usually conducted around every five years to allow comparisons over time, were used for this study (The Demographic and Health Surveys Program, n.d.). The main objective of the 2018 NDHS is to provide current estimates of basic demographic and health indicators by offering data for a wide range of monitoring and impact evaluation indicators in the areas of population, health-related issues, and nutrition (National Population Commission (NPC) & ICF, 2019).

3.2 Sample Design

The Population and Housing Census of the Federal Republic of Nigeria (NPHC), which was conducted in 2006 was used as the sampling frame for the 2018 NDHS. Nigeria is divided into states, administratively. Each state is then subdivided into local government areas (LGAs), and each LGA is divided into wards. Additional to these administrative units, each locality during the 2006 NPHC is subdivided into enumeration areas (EAs). The cluster, which is also known as the primary sampling unit (PSU), is defined based on the EAs from the 2006 EA census frame. A two-stage stratified cluster sample was used for the 2018 NDHS. Stratification was attained by separating each of the 36 states and the Federal Capital Territory into urban and rural areas. Furthermore, the calculation of the sampling weights was based on independent sampling probabilities for each cluster and each sampling stage. The sample weight is an eight-digit variable with six implied decimal places. The sample weight was divided by 1,000,000 before applying the weighting factor (National Population Commission (NPC) & ICF, 2019).

Figure 3.1

2018 Nigeria DHS sample design



Source: National Population Commission (NPC) [Nigeria] and ICF, 2019.

There are four core questionnaires in the 2018 NDHS: the Woman's Questionnaire, Man's Questionnaire, Household Questionnaire, and Biomarker Questionnaire. All women between 15-49 years of age who are either visitors who stayed in the household the night before the survey or permanent residents of the selected households were eligible to be interviewed. Furthermore, the men's survey was conducted in one-third of the sample households, which included men between 15-59 years of age (**Figure 3.1**). Information on their background, child health, knowledge and use of family planning methods, reproductive health, and additional information that are helpful to administrators and policymakers in health and family planning are usually obtained from these respondents (National Population Commission (NPC) & ICF, 2019).

3.3 Sample Population

The biomarker questionnaire was used to provide anthropometric data of living children born 0-59 months before the survey was administered. The de facto population was used in this study, which is referred to as the group of individuals that stayed in the household the previous night of the survey. The z-scores for stunting (height-for-age) and underweight (weight-for-age) of children with an incomplete date of birth were excluded from this study, as z-scores are sensitive to changes in age. Additionally, children with height-for-age z-scores below -6 SD or above +6 SD, weight-for-age z-scores below -6 SD or above +5 SD, and weight-for-height z-scores below -5 SD or above +5 SD were recognized as flagged cases and, therefore, excluded from this study. Furthermore, children with weight-for-height z-score above +2 SD and weight-for-age z-score above +2 SD were categorized as overweight and, therefore, also excluded from this study, as only undernourished children were of interest (Croft et al., 2018). Moreover, blood specimens for the malaria blood smear test were collected from children 6-59 months of age for whom consent was obtained from their parents or the adult responsible for them. Children whose values for the malaria blood smear test that were not recorded, and children who were not tested for malaria using microscopy were excluded from this study. Furthermore, basic demographic information such as age (months), sex, place of residence, mother's educational level, and wealth quintile of children ages 0-59 months were obtained from the household questionnaire and included in this study (Croft et al., 2018). The data for this study was restricted to a weighted sample of 13,058 children ages 0-59 months.

3.4 Dependent Variable

The final result of the malaria blood smear test was obtained from de facto children age 6-59 months who were tested for malaria by microscopy. The final result was coded as positive or negative.

3.5 Independent Variables

Stunting:

Severely stunted: Number of children whose height-for-age z-score is below -3.0 standard deviations (SD) below the mean on the WHO Child Growth Standards (Croft et al., 2018).

Moderately or severely stunted: Number of children whose height-for-age z-score is below -2.0 SD below the mean on the WHO Child Growth Standards (Croft et al., 2018).

For this study, stunting was recoded as a binary variable with the number of children whose height-for-age z-score below -2.0 SD below the mean on the WHO Child Growth Standards as "stunted" and z-scores above -2.0 SD above the mean on the WHO Child Growth Standards as "not stunted."

Underweight:

Severely underweight: Number of children whose weight-for-age z-score is below -3.0 SD below the mean on the WHO Child Growth Standards (Croft et al., 2018).

Moderately or severely underweight: Number of children whose weight-for-age z-score is below -2.0 SD below the mean on the WHO Child Growth Standards (Croft et al., 2018).

For this study, underweight was recoded as a binary variable with the number of children whose weight-for-age z-score below -2.0 SD below the mean on the WHO Child Growth Standards as "underweight" and z-scores between -2.0 SD and +2.0 SD as "not underweight." The z-scores above +2.0 SD were excluded from this study.

Wasting:

Severely wasted: Number of children whose weight-for-height z-score is below -3.0 SD below the mean on the WHO Child Growth Standards (Croft et al., 2018).

Moderately or severely wasted: Number of children whose weight-for-height z-score is below -2.0 SD below the mean on the WHO Child Growth Standards (Croft et al., 2018).

For this study, wasted was recoded as a binary variable with the number of children whose weight-for-height z-score below -2.0 SD below the mean on the WHO Child Growth Standards as "wasted" and z-scores between -2.0 SD and +2.0 SD as "not wasted." The z-scores above +2.0 SD were excluded from this study.

Child's age

Age was grouped into less than 12 months, 12-23 months, 24-35 months, 36-47 months, and 48-59 months.

Child's sex

The sex of the child was reported as female or male.

Place of residence

The place of residence of the child was categorized as urban and rural. Any locality with a population size greater than 20,000 was considered to be urban.

Educational level of the mother

The mother's highest educational level was categorized as no education, primary, secondary, and higher.

Wealth quintile

The wealth index was categorized as the poorest, poorer, middle, richer, and richest. It is a measure of a household's cumulative living standard. The DHS calculated the wealth index using data on the household's ownership of selected assets, such as bicycles and televisions, types of sanitation and water access facilities, and materials used for housing construction.

3.6 Statistical Analysis

The Statistical Analysis System (SAS) version 9.4 was used to perform the data analysis. The chi-square test of independence was used to determine if there was an association between stunting, underweight, and wasting independently with the child's age, child's sex, place of residence, educational level of the mother, and wealth quintile. Additionally, the chi-square test of independence was also used to determine if there was an association between malaria independently with the child's age, child's sex, place of residence, educational level of the mother, wealth quintile, stunting, underweight, and wasting. P-values less than 0.05 were considered statistically significant. Logistic regression modeling was used to determine the associations between stunting, underweight, and wasting independently with the child's age, child's sex, place of residence, educational level of the mother, and wealth quintile. Additionally, logistic regression modeling was used to determine the associations between the outcome of interest, malaria, and child's age, child's sex, place of residence, educational level of the mother, wealth quintile, stunting, underweight, and wasting.

CHAPTER IV

RESULTS

The study population consisted of 13,058 under-five children who resided in Nigeria. Among the various age groups in this study, the percentage of individuals were almost evenly distributed with a slightly higher percentage within the 12-23 months age range (20.5%). Also, there was an approximately equal percentage of females (49.0%) and males (51.0%), with most of the study population residing in the rural area (56.0%), and being within the middle wealth quintile (21.0%). Additionally, a majority of the mothers of the children did not have formal education (39.2%), and a significantly lower percentage possessed higher education (9.9%). The prevalence of stunting was 37.0%, with underweight being 22.2%, and 7.0% were wasted. Furthermore, there was a positive malaria test among 22.6% of the study population (**Table 4.1**).

Among the age groups in this study, the 24-35 months age range had the highest percentage of children who were stunted (47.4%). Additionally, most of the stunted children were males (39.5%), resided in rural areas (44.9%), and were within the poorest wealth quintile (55.6%). Furthermore, a higher percentage of mothers of stunted children did not have formal education (54.2%) (**Table 4.2**).

There was no significant difference in the odds of stunting between under-five children who resided in urban areas and rural areas (AOR=1.07, 95% CI=0.95,1.22; p-value=0.2645). However, there was a significant association between stunting among age groups, sex, educational level of mother, and wealth quintile. There was a significant difference in the odds of stunting among children 12-23 months (AOR=2.63, 95% CI=2.22,3.12; p-value=<0.0001), 24-35 months (AOR=3.86, 95% CI=3.22,4.62; p-value=<0.0001), 36-47 months (AOR=3.07, 95% CI=2.58,3.66; p-value=<0.0001), and 48-59 months (AOR=2.14, 95% CI=1.81,2.54; p-value=<0.0001) compared to infants. Also, females were less likely to be stunted (AOR=0.77, 95% CI=0.70,0.85; p-value=<0.0001) compared to males. Furthermore, the odds of stunting among under-five children of mothers that do not have formal education was 3.95 times the odds of stunting among under-five children of mothers that have higher education (AOR=3.95, 95% CI=2.96,5.27; p-value=<0.0001). The odds of stunting among under-five children of mothers that possess a primary education was 2.39 times the odds of stunting among under-five children of mothers that have higher education (AOR=2.39, 95% CI=1.78,3.21; p-value=<0.0001) and 48% higher among children whose mothers had a secondary educational level (AOR=1.48, 95% CI=1.13,1.95; p-value=0.0049). Additionally, there was a significant difference in the odds of stunting among children who were poorest (AOR=2.65, 95% CI=2.05,3.42; p-value=<0.0001), poorer (AOR=2.45, 95% CI=1.93,3.11; p-value=<0.0001), middle (AOR=1.93, 95% CI=1.53,2.43; p-value=<0.0001), and richer (AOR=1.44, 95% CI=1.15,1.81; p-value=0.0016) compared to children who were within the richest wealth quintile (**Table 4.3**).

Children who were 12-23 months old had the highest percentage of under-five children who were underweight (25.6%). Additionally, most of the underweight children were males (23.5%), resided in rural areas (27.4%), and were within the poorest wealth quintile (37.3%). Furthermore, a higher percentage of mothers of underweight children did not have formal education (34.6%), and a significantly lower percentage possessed higher education (9.5%) (**Table 4.4**).

Underweight was significantly associated with children 12-35 months old but not associated with children 36-59 months old. The odds of being underweight was 55% higher among children 12-23 months (AOR=1.55, 95% CI=1.30,1.84; p-value=<0.0001) and 48% higher among children 24-35 months (AOR=1.48, 95% CI=1.24,1.76; p-value=<0.0001) than infants. Also, females were less likely to be underweight (AOR=0.85, 95% CI=0.77,0.95; p-value=0.0032) compared to males. Additionally, the odds of being underweight among under-five children whose mothers did not have a formal education was 2.83 times the odds of being underweight among under-five children whose mothers had a higher education (AOR=2.83, 95% CI=2.07,3.89; p-value=<0.0001) and 55% higher among children whose mothers had a primary educational level (AOR=1.55, 95% CI=1.12,2.15; p-value=0.0077). Furthermore, there was a significant difference in the odds of underweight among children who were within the poorest (AOR=2.49, 95% CI=1.87,3.33; p-value=<0.0001), poorer (AOR=2.01, 95% CI=1.53,2.64; p-value=<0.0001), and middle (AOR=1.55, 95% CI=1.19,2.02; p-value=0.0013) wealth quintile, compared to children who were within the richest wealth quintile (**Table 4.5**).

A majority of the children who were wasted were 12-23 months old (11.5%). Additionally, males (8.3%), under-five children who resided in rural areas (8.2%), and under-five children who were within the poorest wealth quintile (10.8%) possessed the highest percentage of being wasted. Furthermore, a higher percentage of mothers of wasted children did not have formal education (9.7%) (**Table 4.6**).

Wasting was significantly associated with children 24-59 months old but not associated with children less than 24 months old. Compared to infants, children 24-35 months (AOR=0.47, 95% CI=0.36,0.62; p-value=<0.0001), 36-47 months (AOR=0.26, 95% CI=0.19,0.36; p-value=<0.0001), and 48-59 months (AOR=0.32, 95% CI=0.23,0.43; p-value=<0.0001) were less likely to be wasted. Also, females were less likely to be wasted (AOR=0.69, 95% CI=0.58,0.83; p-value=<0.0001) compared to males. Furthermore, the odds of being wasted was 99% higher among children who were within the poorest wealth quintile (AOR=1.99, 95% CI=1.33,2.97; p-value=0.0008) and 49% higher among children who were within the poorer wealth quintile (AOR=1.49, 95% CI=1.00,2.22; p-value=0.0481) than children who are in the richest wealth quintile. There was no statistically significant difference in the odds of being wasted among place of residence, and educational level of the mother (**Table 4.7**).

Among the age groups in this study, the 48-59 months age range had the highest percentage of children who had a positive malaria test (30.7%). Additionally, a higher percentage of under-five children who had a positive malaria test were males (23.4%), resided in rural areas (31.4%), and were within the poorest wealth quintile (38.3%). Furthermore, a higher percentage of mothers of children who tested positive for malaria did not have formal education (34.2%). Among the children who tested positive for malaria, the prevalence of stunted and not stunted were 29.9% and 17.9%, respectively. Additionally, the prevalence of underweight and not underweight were 30.5% and 20.5%, respectively with the prevalence of wasted and not wasted being 24.9% and 22.5%, respectively (**Table 4.8**).

A positive malaria test was significantly associated with children 36-59 months old but not associated with children 12-35 months. Compared to infants, children 36-47 months (AOR=1.69, 95% CI=1.29,2.21; p-value=0.0001) and 48-59 months (AOR=2.42, 95% CI=1.89,3.10; p-value=<0.0001) were more likely to have malaria compared to infants. The odds of having malaria was 53% higher among children who resided in rural areas than urban areas (AOR=1.53, 95% CI=1.25,1.88; p-value=<0.0001). Furthermore, the odds of malaria among under-five children with mothers that do not have formal education was 2.48 times the odds of malaria among under-five children with mothers that have higher education (AOR=2.48, 95% CI=1.64,3.75; p-value=<0.0001). The odds of malaria among under-five children with mothers that possess a primary education was 2.15 times the odds of malaria among under-five children with mothers that have higher education (AOR=2.15, 95% CI=1.42,3.27; p-value=0.0004) and 56% higher among children whose mothers had a secondary educational level (AOR=1.56, 95% CI=1.06,2.29; p-value=0.0244). Additionally, there was a significant difference in the odds of malaria among children who were within the poorest (AOR=4.85, 95% CI=3.22,7.29; p-value=<0.0001), poorer (AOR=4.38, 95% CI=2.96,6.47; p-value=<0.0001), middle (AOR=3.37, 95% CI=2.34,4.86; p-value=<0.0001), and richer (AOR=2.29, 95% CI=1.60,3.26; p-value=<0.0001) wealth quintile, compared to children who were within the richest wealth quintile. Furthermore, the odds of having malaria was 81% higher among under-five children who were stunted (AOR=1.81, 95% CI=1.55,2.12; p-value=<0.0001) and 23% higher among under-five children who were underweight (AOR=1.23, 95% CI=1.02,1.49; p-value=0.0339) than under-five children who were not stunted and not underweight. On the other hand, sex (AOR=0.90, 95% CI=0.79,1.02; p-value=0.1064) and wasting (AOR=0.91, 95% CI=0.69,1.19; p-value=0.4832) were not significantly associated with a positive malaria test (**Table 4.9**).

Table 4.1

General demographic characteristics of under-five children in Nigeria, 2018 (N=13058)

Characteristic	Number of individuals N = 13058	Percentage of Individuals (%)
Age (months)		
<12	2632	20.15
12-23	2679	20.51
24-35	2511	19.23
36-47	2600	19.91
48-59	2637	20.20
Sex		
Male	6660	51.00
Female	6398	49.00
Place of residence		
Urban	5747	44.01
Rural	7311	55.99
Educational Level of Mother		
No Education	4785	39.24
Primary	1946	15.96
Secondary	4261	34.94
Higher	1201	9.85
Wealth Quintile		
Poorest	2430	18.61
Poorer	2560	19.61
Middle	2739	20.97
Richer	2734	20.94
Richest	2595	19.87
Stunted (height-for-age)		
Stunted	4670	37.01
Not Stunted	7948	62.99
Underweight (weight-for-age)		
Underweight	2799	22.15
Not Underweight	9839	77.85
Wasted (weight-for-height)		
Wasted	868.35	7.00
Not Wasted	11539	93.00
Malaria		
Negative Malaria Test	6436	77.38
Positive Malaria Test	1882	22.62

Table 4.2

Participants' characteristics and stunting status (low height-for-age) among under-five children in Nigeria, 2018

Participant Characteristics	Stunted N=4670 (37.01) N(%)[R]	Not Stunted N=7948 (62.99) N(%)[R]	Chi-Square P-value[c]
Age (months)			**<0.0001***
<12	537.70 (21.30)	1987 (78.70)	
12-23	1015 (38.94)	1592 (61.06)	
24-35	1153 (47.37)	1281 (52.63)	
36-47	1072 (42.64)	1442 (57.36)	
48-59	892.13 (35.15)	1646 (64.85)	
Sex			**<0.0001***
Male	2542 (39.53)	3888 (60.47)	
Female	2128 (34.39)	4060 (65.61)	
Place of residence			**<0.0001***
Urban	1509 (27.03)	4072 (72.97)	
Rural	3161 (44.92)	3876 (55.08)	
Educational Level of Mother			**<0.0001***
No Education	2479 (54.21)	2094 (45.79)	
Primary	725.13 (38.19)	1174 (61.81)	
Secondary	978.97 (23.51)	3186 (76.49)	
Higher	161.89 (13.92)	1001 (86.08)	
Wealth Quintile			**<0.0001***
Poorest	1287 (55.59)	1029 (44.41)	
Poorer	1229 (49.67)	1245 (50.33)	
Middle	1009 (37.97)	1648 (62.03)	
Richer	720.09 (27.01)	1946 (72.99)	
Richest	425.31 (16.97)	2081 (83.03)	

[c]Two-sided Chi-square test comparing participant's characteristics associated with stunted and not stunted.
*Bold indicates statistically significant P-value <0.05.
[R]Row percentages were used.
Missing values were not included in the total count of individuals who were and were not stunted.

Table 4.3

Participants' characteristics associated with stunted and not stunted among under-five children in Nigeria, 2018

	Stunting Status		
Participant Characteristics	**OR (95% CI)**	**Adjusted OR[A]**	**P-value**
Age (months)			
<12	REF (1.00)	REF (1.00)	REF
12-23	2.36 (2.03, 2.73)	2.63 (2.22, 3.12)	**<0.0001***
24-35	3.33 (2.85, 3.88)	3.86 (3.22, 4.62)	**<0.0001***
36-47	2.75 (2.36, 3.20)	3.07 (2.58, 3.66)	**<0.0001***
48-59	2.00 (1.72, 2.33)	2.14 (1.81, 2.54)	**<0.0001***
Sex			
Male	REF (1.00)	REF (1.00)	REF
Female	0.80 (0.74, 0.87)	0.77 (0.70, 0.85)	**<0.0001***
Place of residence			
Urban	REF (1.00)	REF (1.00)	REF
Rural	2.20 (1.96, 2.47)	1.07 (0.95, 1.22)	0.2645
Educational Level of Mother			
No Education	7.32 (5.70, 9.39)	3.95 (2.96, 5.27)	**<0.0001***
Primary	3.82 (2.94, 4.95)	2.39 (1.78, 3.21)	**<0.0001***
Secondary	1.89 (1.48, 2.44)	1.48 (1.13, 1.95)	**0.0049***
Higher	REF (1.00)	REF (1.00)	REF
Wealth Quintile			
Poorest	6.12 (5.03, 7.46)	2.65 (2.05, 3.42)	**<0.0001***
Poorer	4.83 (3.97, 5.88)	2.45 (1.93, 3.11)	**<0.0001***
Middle	2.99 (2.47, 3.64)	1.93 (1.53, 2.43)	**<0.0001***
Richer	1.81 (1.48, 2.22)	1.44 (1.15, 1.81)	**0.0016***
Richest	REF (1.00)	REF (1.00)	REF

Abbreviations: OR, odds ratio; CI, confidence interval; REF, referent category.

*Bold indicates statistically significant P-value <0.05.

[A]Adjusted model included the following covariates: Age, sex, place of residence, educational level of mother, wealth quintile

Table 4.4

Participants' characteristics and underweight status (low weight-for-age) among under-five children in Nigeria, 2018

Participant Characteristics	Underweight N=2799 (22.15) N(%)[R]	Not Underweight N=9839 (77.85) N(%)[R]	Chi-Square P-value[c]
Age (months)			**<0.0001***
<12	470.60 (18.82)	2031 (81.18)	
12-23	671.08 (25.62)	1948 (74.38)	
24-35	616.08 (25.20)	1828 (74.80)	
36-47	549.63 (21.69)	1984 (78.31)	
48-59	491.30 (19.35)	2048 (80.65)	
Sex			**0.0013***
Male	1514 (23.49)	4932 (76.51)	
Female	1284 (20.75)	4907 (79.25)	
Place of residence			**<0.0001***
Urban	861.82 (15.51)	4693 (84.49)	
Rural	1937 (27.35)	5146 (72.65)	
Educational Level of Mother			**<0.0001***
No Education	1595 (34.55)	3022 (65.45)	
Primary	367.15 (19.29)	1536 (80.71)	
Secondary	542.30 (13.06)	3611 (86.94)	
Higher	108.78 (9.49)	1038 (90.51)	
Wealth Quintile			**<0.0001***
Poorest	876.15 (37.33)	1471 (62.67)	
Poorer	736.96 (29.56)	1756 (70.44)	
Middle	545.49 (20.51)	2114 (79.49)	
Richer	387.33 (14.54)	2276 (85.46)	
Richest	252.76 (10.21)	2222 (89.79)	

[c]Two-sided Chi-square test comparing participant's characteristics associated with underweight and not underweight.
*Bold indicates statistically significant P-value <0.05.
[R]Row percentages were used.
Missing values were not included in the total count of individuals who were and were not underweight.

Table 4.5

Participants' characteristics associated with underweight and not underweight among under-five children in Nigeria, 2018

	Underweight Status		
Participant Characteristics	**OR (95% CI)**	**Adjusted OR[A]**	**P-value**
Age (months)			
<12	REF (1.00)	REF (1.00)	REF
12-23	1.49 (1.27, 1.74)	1.55 (1.30, 1.84)	**<0.0001***
24-35	1.45 (1.24, 1.69)	1.48 (1.24, 1.76)	**<0.0001***
36-47	1.19 (1.01, 1.42)	1.19 (0.99, 1.44)	0.0689
48-59	1.04 (0.88, 1.22)	1.02 (0.85, 1.23)	0.7999
Sex			
Male	REF (1.00)	REF (1.00)	REF
Female	0.85 (0.77, 0.94)	0.85 (0.77, 0.95)	**0.0032***
Place of residence			
Urban	REF (1.00)	REF (1.00)	REF
Rural	2.05 (1.79, 2.35)	1.01 (0.88, 1.16)	0.8876
Educational Level of Mother			
No Education	5.04 (3.85, 6.59)	2.83 (2.07, 3.89)	**<0.0001***
Primary	2.28 (1.69, 3.07)	1.55 (1.12, 2.15)	**0.0077***
Secondary	1.43 (1.09, 1.89)	1.18 (0.89, 1.58)	0.2520
Higher	REF (1.00)	REF (1.00)	REF
Wealth Quintile			
Poorest	5.24 (4.19, 6.54)	2.49 (1.87, 3.33)	**<0.0001***
Poorer	3.69 (2.95, 4.61)	2.01 (1.53, 2.64)	**<0.0001***
Middle	2.27 (1.81, 2.85)	1.55 (1.19, 2.02)	**0.0013***
Richer	1.49 (1.15, 1.95)	1.24 (0.93, 1.66)	1.1458
Richest	REF (1.00)	REF (1.00)	REF

Abbreviations: OR, odds ratio; CI, confidence interval; REF, referent category.
*Bold indicates statistically significant P-value <0.05.
[A]Adjusted model included the following covariates: Age, sex, place of residence, educational level of mother, wealth quintile

Table 4.6

Participants' characteristics and wasting status (low weight-for-height) among under-five children in Nigeria, 2018

Participant Characteristics	Wasted N=868.35 (7.00) N(%)[R]	Not Wasted N=11539 (93.00) N(%)[R]	Chi-Square P-value[c]
Age (months)			**<0.0001***
<12	264.67 (10.89)	2166 (89.11)	
12-23	295.25 (11.47)	2278 (88.53)	
24-35	128.76 (5.36)	2273 (94.64)	
36-47	80.32 (3.22)	2415 (96.78)	
48-59	99.34 (3.96)	2407 (96.04)	
Sex			**<0.0001***
Male	522.30 (8.27)	5795 (91.73)	
Female	346.04 (5.68)	5744 (94.32)	
Place of residence			**<0.0001***
Urban	300.81 (5.49)	5179 (94.51)	
Rural	567.54 (8.19)	6360 (91.81)	
Educational Level of Mother			**<0.0001***
No Education	438.96 (9.70)	4085 (90.30)	
Primary	107.22 (5.73)	1763 (94.27)	
Secondary	216.64 (5.32)	3855 (94.68)	
Higher	57.30 (5.05)	1078 (94.95)	
Wealth Quintile			**<0.0001***
Poorest	246.55 (10.77)	2043 (89.23)	
Poorer	191.79 (7.89)	2239 (92.11)	
Middle	179.46 (6.83)	2448 (93.17)	
Richer	144.47 (5.54)	2464 (94.46)	
Richest	106.08 (4.33)	2346 (95.67)	

[c]Two-sided Chi-square test comparing participant's characteristics associated with wasted and not wasted.
*Bold indicates statistically significant P-value <0.05.
[R]Row percentages were used.
Missing values were not included in the total count of individuals who were and were not wasted.

Table 4.7

Participants' characteristics associated with wasted and not wasted among under-five children in Nigeria, 2018

	Wasting Status		
Participant Characteristics	**OR (95% CI)**	**Adjusted OR[A]**	**P-value**
Age (months)			
<12	REF (1.00)	REF (1.00)	REF
12-23	1.06 (0.85, 1.33)	1.05 (0.82, 1.33)	0.7149
24-35	0.46 (0.36, 0.60)	0.47 (0.36, 0.62)	**<0.0001***
36-47	0.27 (0.20, 0.37)	0.26 (0.19, 0.36)	**<0.0001***
48-59	0.34 (0.25, 0.45)	0.32 (0.23, 0.43)	**<0.0001***
Sex			
Male	REF (1.00)	REF (1.00)	REF
Female	0.67 (0.56, 0.79)	0.69 (0.58, 0.83)	**<0.0001***
Place of residence			
Urban	REF (1.00)	REF (1.00)	REF
Rural	1.54 (1.28, 1.85)	1.04 (0.84, 1.30)	0.7061
Educational Level of Mother			
No Education	2.02 (1.43, 2.86)	1.39 (0.89, 2.17)	0.1481
Primary	1.14 (0.74, 1.77)	0.89 (0.54, 1.49)	0.6687
Secondary	1.06 (0.74, 1.52)	0.91 (0.61, 1.36)	0.6367
Higher	REF (1.00)	REF (1.00)	REF
Wealth Quintile			
Poorest	2.67 (2.02, 3.53)	1.99 (1.33, 2.97)	**0.0008***
Poorer	1.89 (1.41, 2.55)	1.49 (1.00, 2.22)	**0.0481***
Middle	1.62 (1.19, 2.20)	1.46 (0.99, 2.16)	0.0581
Richer	1.29 (0.91, 1.85)	1.28 (0.86, 1.89)	0.2296
Richest	REF (1.00)	REF (1.00)	REF

Abbreviations: OR, odds ratio; CI, confidence interval; REF, referent category.
*Bold indicates statistically significant P-value <0.05.
[A]Adjusted model included the following covariates: Age, sex, place of residence, educational level of mother, wealth quintile

Table 4.8

Participants' characteristics and malaria test status among under-five children in Nigeria, 2018

Participant Characteristics	**Negative Malaria Test N = 6436 (77.38) N (%)[R]**	**Positive Malaria Test N = 1882 (22.62) N (%)[R]**	**Chi-Square P-value[c]**
Age (months)			**<0.0001***
<12	780.84 (83.80)	150.98 (16.20)	
12-23	1565 (81.33)	359.25 (18.67)	
24-35	1420 (79.91)	357.10 (20.09)	
36-47	1408 (75.59)	454.49 (24.41)	
48-59	1262 (69.27)	559.97 (30.73)	
Sex			0.1011
Male	3282 (76.57)	1005 (23.43)	
Female	3154 (78.24)	877.26 (21.76)	
Place of residence			**<0.0001***
Urban	3435 (87.04)	511.30 (12.96)	
Rural	3001 (68.65)	1370 (31.35)	
Educational Level of Mother			**<0.0001***
No Education	1916 (65.80)	995.72 (34.20)	
Primary	938.93 (75.39)	306.46 (24.61)	
Secondary	2408 (86.59)	372.86 (13.41)	
Higher	730.36 (94.22)	44.84 (5.78)	
Wealth Quintile			**<0.0001***
Poorest	918.29 (61.74)	569.06 (38.26)	
Poorer	1044 (66.40)	528.38 (33.60)	
Middle	1332 (75.84)	424.31 (24.16)	
Richer	1506 (85.24)	260.83 (14.76)	
Richest	1636 (94.28)	99.21 (5.72)	

[c]Two-sided Chi-square test comparing participant's characteristics associated with negative malaria test and positive malaria test.
*Bold indicates statistically significant P-value <0.05.
[R]Row percentages were used.
Missing values were not included in the total count of individuals who had a negative malaria test and positive malaria test.

Table 4.8

Participants' characteristics and malaria test status among under-five children in Nigeria, 2018 (continued)

Stunted (height-for-age)			**<0.0001***
Stunted	2210 (70.05)	944.82 (29.95)	
Not Stunted	4175 (82.03)	914.56 (17.97)	
Underweight (weight-for-age)			**<0.0001***
Underweight	1250 (69.48)	549.29 (30.52)	
Not Underweight	5135 (79.51)	1323 (20.49)	
Wasted (weight-for-height)			0.2570
Wasted	418.80 (75.09)	138.94 (24.91)	
Not Wasted	5854 (77.47)	1702 (22.53)	

[c]Two-sided Chi-square test comparing participant's characteristics associated with negative malaria test and positive malaria test.
*Bold indicates statistically significant P-value <0.05.
[R]Row percentages were used.
Missing values were not included in the total count of individuals who had a negative malaria test and positive malaria test.

Table 4.9

Participants' characteristics associated with the outcome of negative malaria test and positive malaria test with primary exposures being stunted, underweight, and wasted among under-five children in Nigeria, 2018

	Malaria Test Status		
Participant Characteristics	**OR (95% CI)**	**Adjusted OR^A^**	**P-value**
Age (months)			
<12	REF (1.00)	REF (1.00)	REF
12-23	1.19 (0.91, 1.54)	1.17 (0.89, 1.54)	0.2745
24-35	1.30 (1.00, 1.69)	1.30 (0.99, 1.71)	0.0558
36-47	1.67 (1.31, 2.14)	1.69 (1.29, 2.21)	**0.0001***
48-59	2.29 (1.80, 2.92)	2.42 (1.89, 3.10)	**<0.0001***
Sex			
Male	REF (1.00)	REF (1.00)	REF
Female	0.91 (0.81, 1.02)	0.90 (0.79, 1.02)	0.1064
Place of residence			
Urban	REF (1.00)	REF (1.00)	REF
Rural	3.07 (2.56, 3.68)	1.53 (1.25, 1.88)	**<0.0001***
Educational Level of Mother			
No Education	8.47 (5.83, 12.29)	2.48 (1.64, 3.75)	**<0.0001***
Primary	5.32 (3.60, 7.85)	2.15 (1.42, 3.27)	**0.0004***
Secondary	2.52 (1.74, 3.65)	1.56 (1.06, 2.29)	**0.0244***
Higher	REF (1.00)	REF (1.00)	REF
Wealth Quintile			
Poorest	10.22 (7.40, 14.11)	4.85 (3.22, 7.29)	**<0.0001***
Poorer	8.34 (6.08, 11.45)	4.38 (2.96, 6.47)	**<0.0001***
Middle	5.25 (3.82, 7.22)	3.37 (2.34, 4.86)	**<0.0001***
Richer	2.86 (2.05, 3.99)	2.29 (1.60, 3.26)	**<0.0001***
Richest	REF (1.00)	REF (1.00)	REF

Abbreviations: OR, odds ratio; CI, confidence interval; REF, referent category.
*Bold indicates statistically significant P-value <0.05.
[A]Adjusted model included the following covariates: Age, sex, place of residence, educational level of mother, wealth quintile

Table 4.9

Participants' characteristics associated with the outcome of negative malaria test and positive malaria test with primary exposures being stunted, underweight, and wasted among under-five children in Nigeria, 2018 (continued)

Stunted (height-for-age)			
Stunted	1.95 (1.71, 2.23)	1.81 (1.55, 2.12)	**<0.0001***
Not Stunted	REF (1.00)	REF (1.00)	REF
Underweight (weight-for-age)			
Underweight	1.70 (1.47, 1.98)	1.23 (1.02, 1.49)	**0.0339***
Not Underweight	REF (1.00)	REF (1.00)	REF
Wasted (weight-for-height)			
Wasted	1.14 (0.91, 1.43)	0.91 (0.69, 1.19)	0.4832
Not Wasted	REF (1.00)	REF (1.00)	REF

Abbreviations: OR, odds ratio; CI, confidence interval; REF, referent category.
*Bold indicates statistically significant P-value <0.05.
[A]Adjusted model included the following covariates: Age, sex, place of residence, educational level of mother, wealth quintile

CHAPTER V

DISCUSSION AND CONCLUSION

5.1 Discussion of Research Questions

Over the years, malaria and undernutrition have independently contributed to mortality and morbidity among under-five children in Nigeria. However, whether there is an increased or decreased odds for the presence of malaria parasitemia among children based on their nutritional status has often been debated. This study aims to shed light on the association between stunting, underweight, wasting, and malaria among under-five children in Nigeria. The effects of additional factors, such as child's age, sex, place of residence, wealth quintile, and maternal educational level on both undernutrition and malaria status, also need to be taken into consideration. The interactions of these demographic factors with stunting, underweight, wasting, and malaria provide vital information to understand potential underlying effects. Therefore, this study aims to examine the following research questions:

1. What are the prevalence, demographic characteristics, and risk factors for stunting among children under five years of age in Nigeria?
2. What are the prevalence, demographic characteristics, and risk factors for underweight among children under five years of age in Nigeria?
3. What are the prevalence, demographic characteristics, and risk factors for wasting among children under five years of age in Nigeria?
4. Are stunting, underweight, and wasting associated with malaria among children under five years of age in Nigeria?

Based on this study, the prevalence of stunting, underweight, and wasting is recognized to be almost twice as high among children in rural areas (45%, 27%, and 8%, respectively) as among those in urban areas (27%, 16%, and 5% respectively). In a sample of 13,058 under-five Nigerian children, stunting (height-for-age) and underweight (weight-for-age) were associated with the presence of malaria parasitemia, while being wasted (weight-for-height) was not associated with the presence of malaria parasitemia.

In this study, under-five children who were stunted experienced malaria attacks more often than under-five children who were not stunted. Such findings were corroborated by Friedman et al. (2005), which highlight an association between stunting and the presence of malaria parasitemia (OR=1.98, P<0.0001). Evidence suggests that there is usually a greater risk of illnesses among children who experience growth retardation as a result of poor diets and recurrent infections. However, several confounding factors may contribute to the risk of stunting and the susceptibility of malaria attacks. Based on previous literature, the most significant risk factors for stunting among under-five Nigerian children were low household wealth index, perceived birth size, sex of the child, and duration of breastfeeding (Akombi et al., 2017). Additionally, low maternal education and low social class are also recognized as risk factors for stunting among the under-five population of Nigeria (Senbanjo, Oshikoya, Odusanya, & Njokanma, 2011). Similar findings were noted in a prospective cohort study done by Deen, Walraven, and Seidlein (2002), which highlighted that socio-economic status and educational level of the mother may influence the risk of stunting. Evidence suggests that these factors could possibly be associated with the child's risk for malaria attacks as well. This study reflected similar results. Additionally, age, place of residence, and housing type are also major risk factors for malaria occurrence among under-five children in Nigeria (Morakinyo, Balogun, &

Fagbamigbe, 2018). Evidence has shown that encouraging female education may improve healthcare-seeking behavior and the use of health services, which can aid in reducing stunting (Senbanjo, Oshikoya, Odusanya, & Njokanma, 2011). Such an approach could also contribute to lessening the risk of malaria attacks.

Furthermore, this study also presents evidence highlighting greater odds of experiencing malaria attacks among under-five children who were underweight compared to under-five children who were not underweight. The odds of malaria parasitemia among under-five children who are underweight in this study is similar to the findings of a case-control study conducted in Ethiopia, which revealed that the odds of developing malaria was 1.7 times more among underweight children than the referent group (Hassen and Ali, 2005). According to previous literature, factors such as residing in the rural area, parents' educational level, and being born to mothers who had a BMI less than 18.5 kg/m^2 increased the chance of being underweight (Akombi, Agho, Merom, Hall, & Renzaho, 2017). Additionally, wealth quintile is also recognized to be highly associated with underweight status. According to this study, individuals who are within the poorest, poorer and middle wealth quintile are more susceptible to being underweight, which is also recognized to occur among under-five children that tested positive for malaria.

On the contrary, according to this study, wasting among under-five children did not influence susceptibility to malaria. Children who were 24-59 months were more susceptible to being wasted, along with those of the most impoverished population. Wasting is most often related to acute starvation and severe diseases (Deen, Walraven, & Seidlein, 2002). Additionally, previous studies have presented evidence suggesting that low maternal income, overcrowding, and the use of infant formula for children six months and over were associated with higher risks of wasting among under-five Nigerian children (Senbanjo & Oluwagbemiga, 2006). Furthermore, place of residence, low parental education, perceived birth size, and sex of the child were also risk factors of wasting among under-five Nigerian children (Akombi, Agho, Merom, Hall, & Renzaho, 2017). Though chronic and seasonal food insecurity occurs throughout Nigeria and can worsen by a surge in food prices, conflict can also contribute to acute levels of food insecurity, which can worsen wasting (USAID, 2018). There is a shortage of comprehensive literature on wasting as it relates to malaria compared to the other forms of undernutrition; stunting, and underweight, especially among the under-five population of Nigeria. Wasting often occurs rapidly and reflects existing or recent food deprivation. Due to the rapid process, wasting may be more difficult to measure over time; and therefore, could contribute to the shortage of studies. Thus, additional research on the burden of wasting and its susceptibility to malaria is of significant importance to gain a better understanding of their association.

5.2 Study Strengths and Limitations

There were several strengths and limitations to this study. The use of a nationally representative survey data is one such strength as it provides representativeness and generalizability for the target population. The survey research method allows the researcher to collect data from a very large sample size, which highlights a representative picture of the characteristics of a larger group. Furthermore, a suitable statistical adjustment was made for the cluster sampling design, which reduces variability and therefore provides a more accurate reflection of the larger population.

However, the de facto population was used as the sample population which takes into consideration the group of individuals that stayed in the household the previous night, whether they are a resident to the household or not. The adult who responds on behalf of these children may have limited knowledge on the child, and therefore the data obtained may be inaccurate or incomplete, thus limiting the study. Additionally, a cross-sectional study design was used, which limits the interpretation of cause and effect. Furthermore, there was a lack of control over the effects of unmeasured covariates, which may result in underlying confounders influencing both the independent and dependent variables causing a spurious association.

5.3 Policy Implications and Recommendations

Though there remain gaps in the interpretation of cause and effect, evidence provided by this study on the association between undernutrition and the presence of malaria parasitemia among under-five children in Nigeria can be used to aid in implementing policies and practices to address the issue. Early diagnosis and treatment are usually the methods of malaria control in Sub-Saharan Africa, with transmission control often being neglected. More emphasis should be placed on implementing preventative interventions to inhibit or delay the occurrence of malaria. This can be accomplished with the aid of antimalarial drugs, insecticide-treated bed nets (ITNs), the application of insect repellent, and the use of protective clothing to minimize exposed skin. These interventions can also be used to reduce further transmission or exposure to the disease.

Furthermore, educational programs should be mandatory for the public, especially mothers, to inform them about proper dietary recommendations for their children to aid in tackling the issue of undernutrition. Additionally, community-level health services that offer dietary advice and nutritional programs should be readily available and provide inexpensive resources for the victims who are suffering from undernutrition. Such facilities could aid in the battle against undernutrition and, in turn, contribute to lessening the susceptibility to harmful illnesses, such as malaria. Moreover, the introduction of genetically modified foods can help to expand food production, and the process of micronutrient fortification can aid in supplying vitamin-rich nourishment for the vulnerable population. These processes will help in the battle against undernutrition, especially wasting.

Socio-economic factors, such as maternal educational level, wealth quintile, and place of residence, are deemed key influences on the adverse effects of undernutrition and malaria. Therefore, these factors should be addressed. Policies that promote growth in the accessibility of affordable housing with proper structure can lessen the susceptibility of getting malaria. Furthermore, the implementation of conditional cash transfer programs can help obtain vital resources, such as nutritional and health advice, among impoverished households. These programs provide incentives in the form of cash to poor households in return for their compliance with health-related conditions, such as mandatory prenatal and postnatal visits. Therefore, this approach can aid in addressing the income factor, as the recipients are improving their health while evaluating the issue of poverty. Additionally, educating mothers on maternal and child health nutrition can help in the fight against both the susceptibility to malaria parasitemia and undernutrition independently and, in turn, diminish their impact regarding the association. This can be accomplished with the help of community-based approaches, such as home visiting programs.

Additionally, contaminated water and poor sanitation can result in a range of diseases, including malaria. The availability of water is closely associated with the ecology of malaria, as the larval stage of mosquitoes develops in various types of water bodies, such as stagnant freshwater, which is frequently found around the home. Drains, swamps, puddles, and improper storage of water are a few examples that can create stagnant water sources around the household. Therefore, the implementation of water resource management is essential in malaria prevention. The process of water resource management includes the installation, cleaning and maintenance of drains, and the elimination of standing water pools. This can be accomplished by draining swamps and filling depressions that collect water. The application of these management stages will contribute to lowering mosquito larval abundance, which will ultimately reduce malaria risk to human populations in surrounding areas to the water bodies.

5.4 Conclusion

According to this study, stunting and underweight among the under-five population in Nigeria are associated with the presence of malaria parasitemia, which supports existing literature. However, more research is needed on the burden of wasting and its susceptibility to malaria parasitemia within this population, though there is supportive evidence that wasting is not associated with the presence of malaria parasitemia, based on this study. Furthermore, there are underlying factors that may contribute to an increase in stunting, wasting, and underweight and, in turn, heightens vulnerability to the malaria parasite. Some of such factors include child's age, sex, place of residence, maternal educational level, and wealth quintile. Though there lies complexity in the interaction between undernutrition and malaria, its comprehension is nonetheless fundamental for our understanding of childhood mortality and morbidity related to these illnesses and the development of appropriate strategies. The information presented in this study could provide public health professionals with vital data to aid in implementing evidence-based interventions for the target group. During the implementation of the necessary policies and recommendations, such as malaria prevention control, the effects of underlying factors including child's age, sex, place of residence, maternal educational level, and wealth quintile should also be taken into consideration. These factors may have hidden effects on the dependent variable, malaria, and the independent variables, stunting, underweight, and wasting, which can result in a spurious association. Therefore, these factors need to be taken into account to minimize the presence of bias in the study, and to ensure that the most suitable strategies are being implemented.

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