2016

Insecticide Treated Nets as an Effective Malaria Control Strategy in Liberia

Taiyee Nelson Quenneh
Walden University

Walden University

College of Health Sciences

This is to certify that the doctoral dissertation by

Taiyee Quenneh

has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

Review Committee
Dr. Shanna Barnett, Committee Chairperson, Public Health Faculty
Dr. Daniel Okenu, Committee Member, Public Health Faculty
Dr. Mehdi Agha, University Reviewer, Public Health Faculty

Chief Academic Officer
Eric Riedel, Ph.D.

Walden University
2016

Abstract

Insecticide Treated Nets as an Effective Malaria Control Strategy in Liberia

by

Taiyee Nelson Quenneh

MBA, Walden University, 2011

BS, New York Institute of Technology, 1994

Dissertation Submitted in Partial Fulfillment

Of the Requirements for the Degree of

Doctor of Philosophy

Public Health

Walden University

July 2016

Abstract

Malaria is a vector-borne disease that presents the most persistent and serious public health burden in Liberia. Numerous studies have examined the relationship between ITN use and malaria prevalence. However, little research has explored the effectiveness of ITNs in controlling malaria among children in postwar Liberia. The aim of this study was to examine the association between ITN ownership, parental economic status, ITN installation support, and malaria prevalence among children. This was a quantitative cross-sectional study guided by the health belief model. The study used secondary data from the 2011 Liberia Malaria Indicator Survey. Chi-square for association and Logistic regression were used to analyze the data. The results revealed a significant association between parental education and malaria prevalence. There was also a significant association between parental economic status and malaria prevalence. However, there was no significant association between ITN ownership and malaria prevalence after controlling for parental education and ownership of structure. These findings may foster social change by helping public health authorities in Liberia integrate ITN use with other strategies like mosquito larvae elimination and indoor/outdoor insecticide spraying as part of a comprehensive approach to malaria control. Additionally, massive awareness and economic capacity building should be undertaken to empower malaria endemic communities with the understanding that malaria can be rapidly reduced with other robust strategies in combination with ITN use. These strategies, if implemented, may effectively control malaria prevalence among children and the emotional and financial burdens endure by their families.

Insecticide Treated Nets as an Effective Malaria Control Strategy in Liberia

by

Taiyee Nelson Quenneh

MBA, Walden University, 2011

BS, New York Institute of Technology, 1994

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health

Walden University

July 2016

Dedication

This dissertation is dedicated to all the young children in malaria endemic countries, especially Liberia, who bear the greatest burdens of the malaria disease each day. I also dedicate this dissertation to my loving wife, Bermina, and my daughter, Audrey, whose patience and support I enjoyed through this academic journey. My dad, Mr. Alfred Davies, and my entire family and friends were most supportive. I dedicate this dissertation to them as well.

Acknowledgments

I would like to acknowledge the chair of my committee, Dr. Shanna Barnett, my committee member, Dr. Daniel Okenu, and my URR, Dr. Mehdi Agha, for their guidance as I prepared this work. Special acknowledgement goes to the Program Director, Dr. Nancy Rea, the IRB Committee, and all my professors at Walden University. I also want to thank Dr. George Kieh, Dr. Etrenda Dillon, and Jonathan Geegbae, who provided additional set of eyes by reading and editing some parts of my dissertation.

Table of Contents

List of Tables iv

List of Figures vi

Chapter 1: Introduction to the Study 1

Introduction 1

Background of the Study 2

Geography and Climate of Liberia 3

Epidemiology of the Malaria Parasite 4

Malaria Impact on Children 5

Brief History of Insecticide Treated Nets as a Malaria Control Tool 7

Statement of the Problem 8

Purpose of the Study 10

Research Questions and Hypotheses 10

Theoretical Framework of the Study 12

Nature of the Study 13

Definitions of Terms 14

Assumptions 16

Scope and Delimitations 16

Limitations of the Study 17

Significance of the study 18

Bridging the Gaps in the Literature 18

Contribution to Social Change 19

Summary 20

Chapter 2: Literature Review 21

Introduction 21

Literature Search Strategy 22

Theoretical Foundation 23

Literature Review Related to Malaria and ITNs 27

Epidemiology of Malaria in Liberia 27

Malaria Transmission 28

Life Cycle of the Malaria Parasite 29

Environmental Dimension of Malaria 29

Chapter 3: Research Method 39

Introduction 39

Research Design and Rationale 39

Research Questions 40

Variables 42

Methodology 43

Population 43

Sampling and Sampling Procedures 44

Procedure for Archival Data 46

Instrumentation and Operationalization of Constructs 47

Data Analysis Plan 49

Variable Recoding 51

Chapter 4: Results 58

Introduction....................58

Data Collection 60

Data Exclusion 61

Sample Representation of Population 62

Fidelity of Statistical Test and Categorization of Variables 62

Descriptive Statistics....................63

Data Analysis Results 65

Chapter 5: Discussions, Conclusions, and Recommendations 85

Introduction....................85

Interpretation of Findings 87

Findings in Relation to the Health Belief Model (HBM) 91

Limitations of the Study....................92

Recommendations....................94

References....................98

Appendix A: Authorization to Use Data....................110

Appendix B: NIH Training Certificate 112

List of Tables

Table 1. Malaria Mortality Estimates Among Children in Liberia.................................... 6

Table 2. Relevant Variables Being Analyzed in This Study 43

Table 3. Variable Definition and Measurement Scale 48

Table 4. Relevant Variables From the DHS/MIS Database 50

Table 5. Recoded Variables From the DHS/MIS Database... 51

Table 6. Frequency Distribution for Participants' Sex 64

Table 7. Statistics on Study Participants Age (in Months) 64

Table 8. Chi-Square Results for ITN Ownership and Malaria Prevalence....................... 66

Table 9. Chi-Square Results for Parental Education and Malaria Prevalence.................. 68

Table 10. Contingency Table of Mother's Education Level and Malaria Prevalence...... 69

Table 11. Odds Ratios against Baseline Category (0 = No Education)........................... 70

Table 12. Chi-Square Results for Parental Economic Status and Malaria Prevalence..... 72

Table 13. Contingency Table of Parental Economic Status and Malaria Prevalence 73

Table 14. Odds Ratios Against Baseline Category (1 = Poorest)......................................74

Table 15. Chi-Square Results for Ownership of Structure and Malaria Prevalence 77

Table 16. Logistic Regression Based on ITN Ownership...79

Table 17. Logistic Regression Based on Parental education and Ownership of Structures. 80

Table 18. Logistic Regression based on ITN ownership, Parental Education, and Ownership of Structures 81
Table 19. Logistic Regression based on Parental Education 82
Table 20. Logistic Regression Based on ITN Ownership, Parental Education, Ownership of Structures, and Economic status 83

List of Figures

Figure 1. Conceptual model of the health belief model.. 25

Figure 2. Malaria prevalence among children by region 33

Figure 3. Map of Liberia indicating health regions 33

Figure 4. Geographic location of study participants... 65

Figure 5. Relationship between ITN ownership and malaria prevalence 67

Figure 6. Relationship between parental education and malaria prevalence…………….70

Figure 7. Relationship between parental ES and malaria prevalence ………………..……70

Figure 8. Relationship between ownership of structure and malaria prevalence 77

Chapter 1: Introduction to the Study

Introduction

Malaria is a preventable disease that presents one of the greatest public health dangers in sub-Saharan Africa (World Health Organization [WHO], 2015). Children under the age of 5 years bear a disproportionate burden of malaria deaths (WHO, 2015). Previous studies by the WHO (2015) revealed that about 90% of all malaria deaths (525,600) in 2013 occurred in Africa, and 81.8% (430,000) of which were children under the age of 5 years. In Liberia, a sub-Saharan African nation that is considered as malaria hyper-holoendemic (Liberia National Malaria Control Program [NMCP], 2011), the disease kills about eight children under the age of 5 years each day (Murray et al., 2012).

There are several intervention strategies that are scientifically proven to reduce or eliminate malaria as a public health concern (Centers for Disease Control and Prevention [CDC], 2010; WHO, 2012). These strategies include malaria awareness and education, the use of insecticide treated nets (ITN), mosquito larvae elimination, indoor residual spraying, treatment, and poverty reduction (WHO, 2012). Morocco, Turkmenistan, the United States, and Ecuador are a few of the countries that have eliminated malaria by adopting a comprehensive strategy that includes those mentioned (CDC, 2010; Pinault & Hunter, 2012; WHO, 2012). In Liberia, however, the primary malaria control strategy is the use of ITN and malaria treatment (NMCP, 2011). Nonetheless, an estimated eight children under the age of 5 years die every day from malaria (Murray et al., 2012). With such an alarming rate of malaria deaths among children the question remains if ITN is an effective malaria control strategy. In this study, I examined the association between ITN ownership and other variables such as parental education, the economic status of parents, and reduced malaria prevalence among children. Findings from this study could lead to further studies on new malaria prevention strategies as well as the adoption of a comprehensive malaria control model in Liberia.

Background of the Study

ITN use is touted by the WHO as an effective malaria prevention mechanism. This is the basis on which public health authorities in Liberia have adopted ITN use as the primary malaria control strategy, distributing 1,185,780 ITNs to Liberian households in 2012 alone (Ministry of Health and Social Welfare – Liberia [MOHSW], 2012). There exists in literature an enormous body of work on the efficacy of ITNs in reducing malaria incidence when combined with other prevention strategies (Eisele, Larsen, & Steketee, 2010; Strode, Donegan, Garner, Enayati, & Hemingway 2014; Tokponnon et al., 2014). Similarly, there is growing evidence that malaria vectors are resisting the chemicals used in ITNs (Sougoufara et al., 2014; Temu et al., 2012). In addition, ITNs are designed to be used at bed time (Sougoufara et al., 2014). Unfortunately, children have to play outdoors; they cannot wear ITNs when they are outdoors where they are more likely to come in contact with malaria vectors (Sougoufara et al., 2014). There are also both tangible and psychological costs to obtaining ITNs. For example, rural villages in Liberia are isolated and far removed from health centers that distribute ITNs (MOHSW, 2012). The physical demands of walking 2 to 3 hours to the nearest health center to take delivery of an ITN present an obvious physical cost. Requirements for the proper setup or installation of an

ITN present yet another physical cost. For instance, beds with a post provide a grounding anchor for ITNs (Sangaré et al., 2012). Rural families who cannot afford beds with posts but are accustomed to using floor mats as beds may stay away from using ITNs (Sangaré et al., 2012). Itch/rashes, irritation, and discomfort engendered by ITN use, according to a study by Koenker et al. (2013), is another tangible and psychological cost of using ITNs. With eight children dying each day in Liberia as a result of malaria (Murray et al., 2012) in the face of increased ITN use, my desire is to first explore whether ITN use is effective by conducting a comprehensive analysis of the factors outlined above, and in the process, reveal other malaria control options that can better protect Liberian children from the vectors that carry the malaria parasite.

Geography and Climate of Liberia

Liberia is a relatively small country located south of the Sahara dissert on the west coast of Africa. It is bounded on the west by Sierra Leone, on the north by Guinea, on the east by Ivory Coast, and on the south by the Atlantic Ocean (World Bank, 2015). Liberia has a land mass of 43,000 square miles that lies at latitudes of 4° 20’ to 8° 30’ North and longitudes of 7° 18’ to 11° 30’ West (World Bank, 2015). Liberia has 350 miles of coastline rich with mangrove swamps that separate a blend of highland areas, green plateau, and tropical rain forest (World Bank, 2015).

Liberia has 15 administrative subdivisions that are called counties (NMCP, 2011). It also has six health regions, which are relevant in measuring health service provisions and disease prevalence (NMCP, 2011).

Liberia has a warm and mostly wet climate (NMCP, 2011). There are two main seasons: rainy season and dry season (NMCP, 2011). The rainy season runs from May to October at which time there are heavy rain falls, and the relative humidity is between 90 and 100% (NMCP, 2011). The dry season runs from November to April at which time the temperature ranges from 89 °F to 82°F (NMCP, 2011). The wet and warm climate combined with the geography of the country makes a conducive breeding ground for vectors of the malaria parasite (Govoetchan et al., 2014).

Epidemiology of the Malaria Parasite

The existence of the malaria parasite can be traced back to 2700 BC (Cox, 2010). However, the parasite was scientifically discovered in a malaria patient by Charles Louis Laveran in 1880, and between 1898 and 1900, the parasite was traced to mosquitoes as the vector by six Italian scientists--Amico Bignami, Angelo Celli, Camillo Golgi, Ettore Marchiafava, Giovanni Battista Grassi, and Giuseppe Bastianelli (Cox, 2010). In the years that followed, scientists have classified the malaria parasite that infects humans into five species: *plasmodium falciparum, plasmodium ovale, plasmodium vivax, plasmodium malariae,* and *plasmodium knowlesi*. (Calderaro et al, 2013; WHO, 2012). The most common of these species in sub-Saharan Africa are *plasmodium falciparum* and *plasmodium viva* with *plasmodium falciparum* being the most deadly (Chen, 2014; WHO, 2015).

The parasite that causes malaria is transmitted to humans when an anopheles mosquito hosting the *plasmodium falciparum* bites a person while feeding (Cox, 2010). In a biological process of multiplication, the parasite affects the red blood cells of the infected person (Cox, 2010). Within 15 to 20 days, the infected person begins to exhibit malaria symptoms (Cox, 2010; WHO, 2015). The most common malaria symptoms are fever, chills, headache, sweating, and vomiting (Nsagha et al., 2011; WHO, 2015). A person infected with malaria can also exhibit symptoms such as convulsion, jaundice, anemia, and bloody stools (WHO, 2015). Death may result especially in vulnerable populations such as children and pregnant women.

According to the WHO, an intermediary vector can transmit malaria from person to person. When a noninfected anopheles mosquito bites an infected person, the parasite is transmitted to the mosquito (Cox, 2010). If the infected mosquito bites the second person, the parasite is transmitted to the second person (Cox, 2010). This cycle of transmission continues, thus spreading the infection within households and communities (Cox, 2010; WHO, 2015).

Malaria Impact on Children

Children under the age of 5 years bear a disproportionate burden of malaria deaths (WHO, 2015). According to WHO (2015), an estimated 90% of all malaria deaths in 2013 occurred in Africa, and of that number, 430,000 children under the age of 5 years died (WHO, 2015). In other words, 1,178 children die each day in sub-Saharan Africa as a result of malaria. Other studies put the child mortality figure even higher. According to the John Hopkins Malaria Institute (2015), about 3,000 children die each day in sub-Saharan Africa from malaria, and 23% of children are born with the malaria parasite. Like other sub-Saharan African countries, the malaria statistics on Liberia are grim.

Murray et al. (2012) conducted a predictive analysis of malaria prevalence and mortality among both children and adults in malaria endemic countries using data from 1980 to 2010. The findings were compiled in 10 year intervals. As Table 1 shows, I extrapolated from the Murray et al. (2012) analysis of malaria mortality statistics for children younger than 5 years old in Liberia.

Table 1

Malaria Mortality Estimates among Children in Liberia

Malaria mortality estimates for children under 5 years In Liberia			
1980	1990	2000	2010
2,052	2,905	5,391	4,593

Note. Data culled from Murray et al. (2012)

As shown in Table 1, there were 2,052 malaria deaths among children in 1980. In 1990, malaria mortality among children increased by 42% to 2,905 deaths. In 2000, malaria deaths jumped by 85.6% from the 1990 level. The trend slightly reversed by 14.8% in 2010 with 798 fewer deaths. The decrease coincides with the period when Liberia began to enjoy political stability. Four years earlier, in 2006, the country installed a peaceful democratic government. Unfortunately, from 1990 to 2003, Liberia experienced a brutal civil war that displaced most of its population and disrupted the healthcare system and infrastructure (Challoner & Forget, 2011). This is the same period that Liberia saw an exponential increase in malaria mortality among children.

Over the years, medicinal therapy and prevention regimes such as ITNs and indoor residual spraying have emerged as strategies to address the epidemic of malaria (NMCP, 2011). Until 2003, Chloroquine was the first line and the least expensive drug treatment of choice in Liberia (NMCP, 2011). By 2001, it was documented in Liberia that the malaria parasite was resistant to Chloroquine upward of 84% (Checchi et al., 2002). As a result, in 2003, the NMCP halted the use of Chloroquine and adopted Artesunate and Amodiaquine as first line drugs for malaria treatment (NMCP, 2011).

Brief History of Insecticide Treated Nets as a Malaria Control Tool

Using nets as a protective shield against flying insects at nights was practiced long before mosquitoes were incriminated in 1898 as vectors of the malaria parasite (Institute of Medicine - Committee on the Economics of Anti-malarial Drugs [IOM], 2004). Ancient Egyptians living in the lowlands area of the Nile used fishing nets at nights to wall off mosquitoes (IOM, 2004). It was not until World War II that nets became impregnated with insecticides to protect solders against malaria on the war front (IOM, 2004). American soldiers fighting on the Pacific front used chemically treated bed nets to protect against malaria (Kitchen, Lawrence, & Coleman, 2009), while a similar protective shield was used by Soviet troops in Central Asia (Blagoveschensky, Bregetova, & Monchadsky, 1945).

According to IOM (2004), ITNs began to gain traction as a malaria control tool in the late 1970s and early 1980s. China, Philippines, Vietnam, and several other countries including Liberia adopted ITN use as part of their malaria control strategy (IOM, 2004). The civil war in Liberia that lasted for 14 years (1989 – 2003) disrupted any form of disease control program in place (Challoner & Forget, 2011). The Roll Back Malaria Partnership, established in 1998 for effective malaria intervention and sponsored by WHO, UNDP, UNICEP, and the World Bank, of which Liberia is a member, reintroduced ITN use as part of the country's malaria control policy (Roll back Malaria Partnership, 2011). With the Liberian civil war now history and a democratic government elected in 2006, renewed efforts were focused on malaria control in Liberia. Like many malaria endemic countries in sub-Saharan Africa, the primary malaria control policy in Liberia since 2006 has been the distribution and use of ITNs (NMCP, 2011). The general statistics on malaria deaths among children does not appear to support the effectiveness of ITNs in controlling malaria deaths. This study is needed because its findings could lead to the exploration of new and scientifically effective malaria prevention strategies as well as the adoption of a comprehensive malaria control model in Liberia.

Statement of the Problem

One of the greatest infectious disease control challenges Liberia faces is the development and institution of strategy that will effectively reduce malaria deaths among children (MOHSW, 2012). Malaria is a vector-borne disease that presents a persistent and the most serious public health burden in Liberia (NMCP, 2011; Whitman et al., 2010). The disease not only threatens the health security of the country's entire population, it also overburdens the country's meager healthcare delivery system, and at the same time, undermines economic growth (The World Bank, 2013a ; WHO, 2014). A predictive analysis conducted by Murray et al. (2012) estimated that eight children under the age of 5 years die each day from malaria in Liberia. A 2013 World Bank report estimated that malaria reduces Gross Domestic Product (GDP) growth in malaria endemic countries by 1.3% (The World Bank, 2013a). With an annual GDP of $1.95 Billion (The World Bank, 2013b), malaria causes Liberia's GDP to contract by $25.3 million. In the face of these statistics, the government of Liberia's primary malaria intervention strategy since 2006 has been the distribution and use of ITNs (MOHSW, 2012). In 2012, 1,185,780 ITNs were distributed to households throughout the country (MOHSW, 2012). However, malaria remains a persistent epidemic disease in the country. A report from the NMCP, Liberia Institute of Statistics and Geo-Information Services [LISGIS] & ICF Macro (2011) revealed that malaria accounts for 33% of all in-patient deaths and 41% of deaths among children under the age of 5 years (NMCP, 2011).

Though several researchers have examined the efficacy of ITN as an effective malaria control tool (Eisele et al., 2010; Strode et al., 2014; Tokponnon et al., 2014), little or no research study has addressed the effectiveness of ITNs in controlling malaria among children in postwar Liberia. Liberia is a sub-Saharan country that is considered by the Liberia National Malaria Control Program as having holoendemic malaria. A holoendemic malaria designation indicates that the malaria disease is endemic among children and adults at prevalence rates that are very high (NMCP, 2011).

This study contributes to the body of knowledge by investigating the effectiveness of ITNs in controlling malaria among children using ITN ownership, parental education, and parental economic status as predictors of malaria prevalence among children. As a holoendemic malaria country, one which until 2003 experienced total breakdown of law and order where every form of organized public and medical health institutions were destroyed (Challoner & Forget, 2011), Liberia presents a unique case and appropriate target population for this study.

Purpose of the Study

The purpose of this quantitative study was to examine the association between ITN ownership, parental education, and the economic status of parents, and reduced malaria prevalence among children under 5 years old. ITN ownership, parental education, ownership of ITN anchoring structure (bed with post), and the economic status of parents measured in wealth index were the independent variables. Malaria prevalence was the dependent variable.

Other variables that contribute and provide descriptive statistics in this study were age of the child, sex of the child, type of place of residence, and region of the country.

Research Questions and Hypotheses

This study is guided by the following research questions:

RQ1: Is there an association between ITN ownership and reduced malaria prevalence among children under 5 years old?

$H_0 1$: There is no association between ITN ownership and reduced malaria prevalence among children under the age of 5 years. In other words, households or parents who own ITN in Liberia do not report lower malaria prevalence among their children who are less than 5 years old.

H_a1: There is an association between ITN ownership and reduced malaria prevalence among children under the age of 5 years. In other words, households or parents who own ITN in Liberia do report lower malaria prevalence among their children who are less than 5 years old.

RQ2: Is there an association between parental education level and the prevalence of malaria among children under 5 years old?

H_02: There is no association between parental education level and the prevalence of malaria among children under 5 years old.

H_a2: There is an association between parental education level and the prevalence of malaria among children under 5 years old.

RQ3: Is there an association between parental economic status and the prevalence of malaria among children under 5 years old?

H_03: There is no association between parental economic status and the prevalence of malaria among children under 5 years old.

H_a3: There is an association between parental economic status and the prevalence of malaria among children under 5 years old.

RQ4: Among those who own an ITN, is there an association between ownership of structure (beds/mattresses that can anchor ITN) and the prevalence of malaria among children under 5 years old?

H_04: There is no association between ownership of structure (beds/mattresses that can anchor ITN) and the prevalence of malaria among children under 5 years old. Let it be noted that 70% of participants with ITN also slept on mattresses or beds with posts that can anchor ITN, and 30% did not.

H_a4: There is an association between ownership of structure (beds with posts that can anchor ITN) and the prevalence of malaria among children under 5 years old.

Theoretical Framework of the Study

This study is guided by the theoretical framework known as the health belief model (HBM), a social science theory developed by Irwin Rosenstock, Godfrey Hochbaum, and Stephen Kegels in the 1950s (Glanz, Rimer, & Viswanath, 2008).

The constructs that underlie HBM provide context for one's personal beliefs and perceptions about a disease, and these constructs are widely used in social science research (Glanz et al, 2008). The HBM constructs are perceived susceptibility, perceived severity, perceived benefit, perceived barrier, cues to action, and self-efficacy (Glanz et al, 2008).

Perceived benefit, perceived susceptibility, and perceived barrier are three constructs of the HBM that were relevant to this study. Perceived benefit refers to the benefits of avoiding a disease threat (Glanz et al., 2008). It is the belief that any measure recommended to prevent or reduce a disease threat can actually prevent or reduce the disease threat (Glanz et al., 2008). Social variables such as cultural beliefs, knowledge of the disease, and health education do influence this HBM construct (Glanz et al., 2008). For example, there is a sizable portion of Liberia's rural population that holds to the belief that illnesses and diseases are punishments brought unto people who violate cultural and social norms (Baden & Moss, 2014).

The inadaptability of ITN comes to focus since they are only useful in the bedroom during bed time. They cannot be used outdoors when children and families are more likely to be exposed to malaria vectors (Sangaré et al., 2012). As a result, the benefits of using ITN to prevent malaria tend to be obscured by factors such as cultural beliefs and inadaptability of ITNs.

Perceived barrier refers to the cost involved when one undergoes prevention practices such as the ownership of ITN (Glanz et al., 2008). These costs are both tangible and psychological. For example, rural villages in Liberia are isolated and far removed from health centers that distribute ITNs (NMCP, 2011). The physical demands of walking about 2 to 3 hours to the nearest health center to take delivery of an ITN present an obvious barrier. Requirements for the proper setup of an ITN present another barrier. For instance, beds with posts provide a grounding anchor for ITNs (Sangaré et al., 2012). Rural families who cannot afford beds with posts but are accustomed to using floor mats as beds may stay away from using ITNs (Sangaré et al., 2012). Itch/rashes, irritation, and discomfort engender by ITN use, according to a study by Koenker et al. (2013), underlie another tangible and psychological barrier to ITN use. These HBM constructs help guide this investigation of the effectiveness of ITN use as a primary malaria control strategy.

Nature of the Study

The nature of this study focuses on a quantitative approach. A quantitative approach allows the use of numerical data to explain the relationship between ITN ownership and malaria prevalence (Creswell, 2009). It also describes outcomes, community behaviors, trends, or events (Creswell, 2009). The quantitative approach is also in line with the HBM constructs that guide this study.

The sample used in this study was gathered from the 2011 Liberia Malaria Indicator Survey (LMIS), a secondary data source that is part of the Demographic and Health Survey Programs (DHSP). The LMIS survey was targeted at a particular group in the population – women and children (DHSP, n.d.). The sample was collected from 4,162 households, and it included 3,939 females between the ages of 15 and 49 years with children under the age of 5 years (DHSP, n.d.). No men were included in the surveys. Detailed explanations of the target population, sampling and sample size, and strategies for data analysis are discussed in Chapter 3.

Definitions of Terms

Based on the research questions, the dependent variable in this study is malaria prevalence among children under 5 years old. The dependent variable measures malaria prevalence from the results of rapid detection test conducted during the survey. The independent variables are ownership of ITNs, parental awareness/education, economic status of parents, and ownership of structure (e.g., bed). Other variables that contributed and provided descriptive statistics in this study were age of the child, sex of the child, number of children living in a household, type of place of residence, and region of the country.

This was a quantitative study that relied on secondary data. The measurement scale of data are nominal (categorical), ordinal, and continuous. Variables that define gender, region/residence, and ITN ownership are measured on a nominal scale. The variable that defines parental education level is ordinal, and the variables that define age (in months) and number of children per household are measured on a continuous scale. Malaria prevalence is measured on a nominal/dichotomous scale.

The following terms and phrases are specially defined in this study:

Enumerated areas (EA): A geographically demarcated area used for census purposes. The EA in this study is a geographic area constructed during the Liberia National Population and Housing Census conducted in 2008 and was used to define the sampling cluster during the original study. A cluster contained 30 households in the 2011 LMIS (DHSP, n.d).

Holoendemic: A description of a disease where its prevalence begins early in life affecting mostly children but later becomes uncommon in the adult population. If a country is designated as having holoendemic malaria, it means the malaria disease is endemic among children in a geographic area at prevalence rates that are very high but levels off in the adult population (NMCP, 2011).

Ownership of structure: This phrase defines an independent variable in this study. It refers to a bed or mattress on which people rest or sleep. A bed or mattress is an anchor to secure the installation of ITNs.

Economic status (ES): In this study, ES is an independent variable that defines parental wealth index. It is an ordinal scale that measures economic status on the following levels–poorest, poorer, middle, richer, and richest.

Type of place of residence: This is a contributing variable or covariate in this study in which the country is stratified as urban and rural.

Assumptions

In analyzing whether ITN use is an effective malaria control strategy in Liberia, I relied on the use of secondary data. As a result, the following assumptions characterize this study:

- The dataset used was not purposely collected for this study. As a result, missing data may have occurred, a phenomenon that is all too common in secondary data. The instrument used to collect data may have malfunctioned, survey respondents may have failed to complete specific aspects of a questionnaire, and misclassification or error in data entry may have occurred (Howell, 2012). A scientifically appropriate technique was used to handle missing data.
- As the researcher, I have the technical knowledge to manipulate the dataset to address issues of missing data, incomplete data, and data splitting in a manner that does not compromise the validity of the dataset.
- The study population is defined as a population of children under the age of 5 years and their mothers living in Liberia, and that the dataset used is a representation of the study population.

Scope and Delimitations

The scope of this research was limited to the analysis of ITN ownership and its impact on malaria prevalence among the children population of Liberia. However, with most malaria endemic countries in sub-Saharan Africa having similar economic and cultural influences and adopting ITN use as a primary malaria control strategy, the results of this study may be generalizable to those countries.

In Liberia, men or husbands are not the primary caregivers to their children. As a result, the data analyzed do not include fathers of children and the husbands of women in the study. Due to the scope of this research, malaria treatment related to hospital care, traditional herbal medicines, and spiritual houses were not analyzed. Other scientifically tested prevention strategies such as mosquito larvae elimination, outdoor residual spraying using approved dichlorodiphenyltrichloroethane (DDT) and other chemicals, and antimalarial drugs were not analyzed. Additionally, this study did not extend to regions outside of Liberia.

Limitations of the Study

This study used secondary data to analyze the association between the independent and dependent variables. As such, the limitations incumbent in using secondary data did apply to this study: (a) The purpose and collection method of the original data was not influenced by the current research topic; as a result, some data are incomplete or missing for the current research topic, and (b) the format of the dataset–scale of measurement and label categories–differed from the format suitable for this study. Additional data manipulation may be required, which can lead to errors that can jeopardize the validity of the study results. To mitigate this threat, extra care was taken to use a scientifically-proven method such as dropping cases if the number of cases with missing or inconsistent data is less than 10% or applying multiple imputation or reweighting (Langkamp, Lehman, & Lemeshow, 2010).

In assessing the independent variable ownership of structure, the data indicated that 70% of participants with ITN also slept on mattresses or beds that can anchor ITN, while 30% of participants did not sleep on mattresses.

I did not seek cause and effect outcome, but rather an association between variables. Therefore, internal validity and its threats were not examined. However, this study used a large sample size (n = 562) to mitigate threats to external validity.

The focus of this study and the data used are specific to the malaria epidemic in Liberia. Though most countries in sub-Sahara Africa face similar malaria crises, the results cannot be generalized to other malaria endemic countries.

Significance of the study

The significance of this study can be explained as follows: (a) bridging the gaps in the literature and (b) contribution to social change.

Bridging the Gaps in the Literature

There is an enormous body of work on the efficacy of ITNs in reducing malaria incidence when combined with other prevention strategies (Eisele et al., 2010; Strode et al., 2014; Tokponnon et al., 2014). Equally, there is growing evidence that malaria vectors are building resistance to the chemicals used in ITNs, which poses a threat to ITN efficacy (Sougoufara et al., 2014; Temu et al., 2012). Consequently, Liberia being a holoendemic malaria country, and one which is recovering from 14 years of war (NMCP, 2011), little or no research study has addressed the effectiveness of ITNs in controlling malaria among children in postwar Liberia. This study contributes to the body of knowledge by investigating the effectiveness of ITNs in controlling malaria among children using ITN ownership, parental education level, and parental economic status as predictors of malaria prevalence among children. As a holoendemic malaria country, one which until 2003 experienced total breakdown of law and order where every form of organized public and medical health institutions were destroyed, Liberia presents a unique setting and appropriate target population for this study.

Contribution to Social Change

In Liberia, like in all malaria endemic countries, children under the age of 5 years bear a disproportionate burden of the malaria disease (WHO, 2015). According to WHO (2015), an estimated 90% of all malaria deaths in 2013 occurred in Africa, and of that number, 430,000 children under the age of 5 years perished. Malaria mortality among children in Liberia is estimated at eight deaths a day (Murray et al., 2012). Given these statistics, ITN use, it seems, is a temporary fix or a bandage on a persistent disease epidemic. My intent is to use this study to advocate for a new approach to malaria control in Liberia, one that can introduce social change in the following ways: (a) Empowering malaria endemic communities with the understanding that the disease can be rapidly reduced with other robust strategies other than the sole reliance on ITNs, (b) relieving the emotional and financial burdens of families often affected by malaria and its fatal consequences, and (c) allowing public health authorities in Liberia to prudently allocate limited resources to other pressing health concerns. Social change will then be actualized when a comprehensive malaria control strategy is adopted that protects and saves human lives.

Summary

Malaria presents one of the greatest public health challenges to the people of Liberia (WHO, 2015). Relying solely on the use of ITNs may not adequately address the challenge given the alarmingly high statistics on malaria mortality among children. In this chapter, I contextualized the intent of this study by discussing the malaria parasite and the challenges it presents, the role of ITN as a prevention strategy, and the research problem being addressed. I also presented four research questions, paramount to the association between ITN ownership and malaria prevalence among children under 5 years old. The theoretical framework, the nature of the study, assumptions, scope, delimitations, and significance of the study, which includes contributions to knowledge and social change, were also discussed.

Chapter 2 is a review of the literature in relation to the main ideological and theoretical foundations of this study. I discuss what is already known in literature about ITN use and malaria prevalence among children in Liberia. Chapter 3 addresses the methodology used in this study. The research design, the study population and participants, the sampling procedure, and the procedures and data collection instruments are discussed in Chapter 3. In Chapter 4, the results of the study are presented without interpretation. In Chapter 5, I present the study's summary and conclusion. Interpretation of the study findings is provided including implications of the study as they relate to positive social change.

Chapter 2: Literature Review

Introduction

Malaria is one of the greatest public health epidemic diseases in sub-Saharan Africa (WHO, 2015). Children under the age of 5 years bear a disproportionate burden of malaria deaths (WHO, 2015). Previous studies by the WHO revealed that about 90% of all malaria deaths (525,600) in 2013 occurred in Africa, 81.8% (430,000) of which were children under the age of 5 years (WHO, 2015). In Liberia, a sub-Saharan African nation that is considered to be malaria hyper-holoendemic (NMCP, 2011), the disease kills about eight children under the age of 5 years each day (Murray et al., 2012).

Like other sub-Saharan African countries, the primary malaria control strategy in Liberia is the use of ITNs, a strategy that was reintroduced in 2006 by the new Liberian government after a long period of civil unrest (MOHSW, 2012). Between 2007 and 2012, more than 4 million ITNs were distributed to households throughout the country (MOHSW, 2012). Nevertheless, malaria remains a persistent epidemic disease in the country. The purpose of this quantitative study was to explore the effectiveness of ITNs in controlling malaria among children using ITN ownership, parental education, and parental economic status as predictors of malaria prevalence among children.

In this chapter, I will discuss the threats represented by the fact that malaria vectors are becoming resistant to the insecticides used in ITNs (Sougoufara et al., 2014). The changing and adaptable biting habits of malaria vectors (Sougoufara et al., 2014) will also be discussed. The epidemiology and life cycle of the malaria parasite, the efficacy of ITNs, ITN ownership in Liberia, parental education, and the economic status of parents will also be covered in this chapter. In addition, I will discuss the HBM and how it relates to ITN ownership and malaria prevalence among children.

Literature Search Strategy

Internet technology has made access to research literature for this review quite effective and inexpensive. There are numerous public and private research databases that are readily available online. However, I was able to use PubMed, a publicly available online database for this review. PubMed database is fed by MEDLINE, which contains research articles from more than 3,000 journals (Fink, 2010). The search criteria I employed are as follows: (a) Research articles are peer reviewed and (b) research articles are published in the last 5 years (2009 – 2015). I also used the following key words to search the database: *malaria, malaria in Liberia, malaria deaths, mosquito nets, insecticide treated nets, ITN, Liberia malaria control strategy, insecticide resistance, mosquito nets misuse*, and *ITN misuse*. Reports and publications from the WHO, the Centers for Disease Control and Preventions, and the Liberian Ministry of Health and Social Welfare were used as references. Additionally, literature for this review was taken from other journals such as *Lancet Global Health* and *Malaria Journal*.

Little or no research literature published by Liberian scholars on ITN effectiveness was found during my search. Moreover, there was little or no literature found on the effectiveness of ITN in Liberia. As a result, the set of literature reviewed in this chapter contains research studies conducted in other sub-Saharan African countries with economic and environmental influences similar to Liberia.

Theoretical Foundation

The main theoretical foundation of this study was the HBM. HBM is a social science theory that explains human behavior towards a disease threat, disease treatment, or the strategies for disease prevention. HBM essentially explains why people exhibit the attitudes and behaviors they do towards a disease threat (Glanz et al., 2008).

In the 1950s, a free tuberculosis (TB) screening program for adults was launched from mobile units in various neighborhoods in the United States. Surprisingly, very few people turned out for the screening. To understand why more people stayed away from the free screening, social psychologists Irwin Rosenstock, Godfrey Hochbaum, and Stephen Kegels, who were then working at the U.S. Public Health Service, a division of the U.S. Department Health and Human Services, developed the HBM theory (Glanz et al., 2008).

The core concept of HMB is that health behavior is influenced by a person's beliefs and perceptions about a disease (Glanz et al., 2008). Rosenstock, Hochbaum, and Kegels categorized those perceptions into the following constructs: perceived susceptibility, perceived severity, perceived benefit, perceived barrier, cues to action, and self-efficacy (Glanz et al., 2008).

Perceived susceptibility is the belief one harbors that he or she is capable of contracting a disease (Glanz et al., 2008; Strecher & Rosenstock, 1997). For example, if a person feels that he or she can contract the malaria disease, that person will most likely take preventive actions such as using mosquitoes repellent, wearing protective clothing outdoors, or sleeping under an ITN. Perceived severity refers to one's belief about the seriousness and consequences of a disease threat, while perceived benefit is the outcome derived from taking the necessary action to reduce the threat of a disease (Glanz et al., 2008). The benefits may include avoiding financial losses, death, pain, and social stigma (Glanz et al., 2008; Strecher & Rosenstock, 1997). If a person does not see any benefit, for example in using ITN as a malaria control tool, he or she will not use ITN. Perceived barrier is similar to a person conducting a cost-benefit analysis (Glanz et al., 2008). For example, it is necessary to determine if the time and cost involved in walking 2 to 3 hours to the nearest health center to secure an ITN is worth the benefit of shielding oneself from mosquito bites or if the time and cost of running 1 mile a day is worth losing some excess weight. Cues to action refer to social events that trigger response to the treat of a disease (Glanz et al., 2008). Financial loss, social stigma or isolation, death from a disease, and physical pain are events that can trigger response. Self-efficacy is the trust in one's own confidence and ability to respond to a disease threat (Glanz et al., 2008). Self-efficacy was added to the original HBM constructs in 1988 to align with changing social behaviors (Glanz, Rimer, & Lewis, 2002). Figure 1 shows a rendering of the conceptual diagram of the HBM as developed by Glanz et al. (2002).

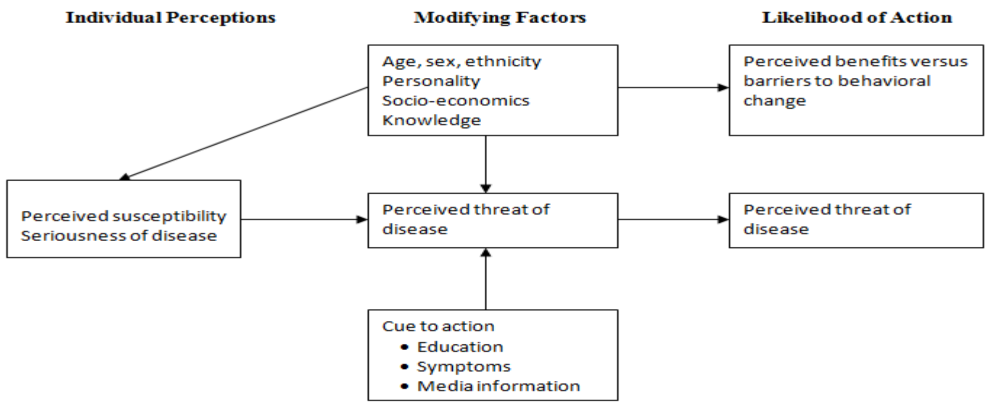

*Figure 1***.** Conceptual model of the health belief model. Adapted from "Health behavior and health education. Theory, research and practice," by Glanz et al., 2002, p.52.

Since the development of the HBM theory, it has had a wide range of applications and is perhaps the most commonly used psychosocial theory in preventive health promotion (Strecher & Rosenstock, 1997). In addition to the HBM theory being used by Loll et al. (2014) to understand the behavior and perceptions of people in the sub-Saharan country of Senegal towards ITN upkeep for longevity, HBM was also used to explore the challenge of compliance of ITN use in the Vanuatu islands near Australia (Watanabe et al., 2014). Similarly, the HBM theory is applicable in this study to understand the social factors that underlie ITN use in Liberia.

As shown in the diagram in Figure 2, there is interconnectivity between the social factors or variables that underlie the HBM constructs and the threat of disease and how that can lead to actions that can produce positive outcome.

As Figure 1 shows, perceived benefit, perceived susceptibility, and perceived barriers are three constructs of the HBM that are relevant to this study. As defined earlier, perceived benefit refers to the benefits of avoiding a disease threat (Glanz et al., 2008).

Social variables such as cultural beliefs, ITN adaptability, proper use or knowledge of ITN, and ownership of ITN influence this HMB construct. In Liberia, for example, there is a sizable portion of the rural population that holds to the belief that illnesses and diseases are punishments brought unto people who violate cultural and social norms (Baden & Moss, 2014).

The inadaptability of ITN comes to focus since they are only useful in the bedroom during bed time. They cannot be used outdoors when children and families are likely to be exposed to mosquito bites (Sangaré et al., 2012). As a result, the benefits of using ITN to prevent malaria tend to be obscured by factors such as cultural beliefs and inadaptability of ITNs.

Perceived barrier, on the other hand, is concerned with the costs involved when one attempts prevention practices such as obtaining or owning ITN (Glanz et al., 2008). These costs are both tangible and psychological. For example, rural villages in Liberia are isolated and far removed from health centers that distribute ITNs (NMCP, 2011). The physical demands of walking about 2 to 3 hours to the nearest health center to pick up an ITN present an obvious barrier. Second, requirements for the proper installation of an ITN present another barrier. For instance, beds with a post provide a grounding anchor for ITNs (Sangaré et al., 2012). Rural families who cannot afford beds with posts but are accustomed to using floor mats as beds will stay away from using ITNs (Sangaré et al., 2012). Third, itch/rashes, irritation, and discomfort engender by ITN use are another tangible and psychological barrier to ITN use (Koenker et al., 2013). These HBM constructs help explain the foundation for analyzing the effectiveness of ITN use as a primary malaria control strategy in Liberia.

Literature Review Related to Malaria and ITNs

Epidemiology of Malaria in Liberia

Malaria is reported to be the leading cause of morbidity and mortality in Liberia (WHO, 2014a). For a country with a population of 4.1 million people, there were 1,265,268 and 1,244,220 confirmed cases of malaria in 2010 and 2013, respectively (WHO, 2014b, 2014c). In 2010, children under the age of 5 years accounted for 38.3% of all malaria cases (WHO, 2014b, 2014c). According to the Liberian National Malaria Control Program (2011), malaria accounted for 38% of outpatient attendance, 42% of all in-patient deaths, and 42% of deaths among children under the age of 5 years (NMCP, 2011, WHO, 2014c). An estimated eight children under the age of 5 years died each day from malaria (Murray et al., 2012).

The parasite that causes malaria is called plasmodium, and is hosted by a flying insect that is all too common in Liberia (WHO, 2015). The insect is the female anopheles mosquito species called *An.gambiae*. Of the five plasmodium species–*p.falciparum, p.vivax, p.malariae, P. knowlesi, and p.ovale* that infect humans, the most common species in sub-Saharan Africa are the *p. falciparum* and the *p.vivax* with *p.falciparum* being the most deadly (Kamareddine, 2012; WHO, 2015). All malaria cases in Liberia are confirmed to be caused by the *p.falciparum* species (WHO, 2014b).

Malaria Transmission

The malaria disease is transmitted to humans quite easily. When an anopheles mosquito (*An.gambiae*) carrying the *p.falciparum* parasite comes in contact with a person as it tries to feed on the person's blood, the parasite gets injected into the person (Griffin et al., 2010). The parasite multiplies while it infects the red blood cells and the liver cells of the infected person (Griffin et al., 2010). During the incubation period (15 to 20 days), the infected person will begin to show symptoms that include fever, headache, chills, and increased sweating (WHO, 2015). Vomiting, anemia, jaundice, convulsion, and bloody stools are other known and severe symptoms of the malaria (WHO, 2015). The disease can result to death, especially among vulnerable populations such as children and pregnant women.

Malaria transmission from mosquitoes to humans is the most common mode of transmission (Griffin et al., 2010). However, malaria can also be transmitted from human to human with (a) the mosquito as an intermediate vector and (b) from mother to fetus (NIH, n.d.). I will focus on the former. A mosquito serves an intermediate vector when an anopheles mosquito (*An.gambiae*) that does not have the malaria parasite bites a person who is already infected with the malaria parasite (Nilsson, Childs, Buckee, & Marti, 2015). In such contact, the infected person transmits the parasite to the mosquito. In the event that the now infected mosquito bites a second person, the parasite gets transmitted to the second person (Nilsson et al., 2015). Such is the cycle of transmission that expands from human to human, from one family to another family, and then spreads from community to community.

Life Cycle of the Malaria Parasite

The life cycle of the malaria parasite extends beyond the symptomatic phase of the disease. When a mosquito bites a person, it injects into the person the plasmodium sporozoites, a motile spore-like stage of the life cycle (Griffin et al., 2010). Within 5 to 15 days, the sporozoites attack the human liver cells and begin the process of multiplication (National Institute of Allergies and Infectious Disease [NIAID], 2012). During this period, the infected person begins to show symptoms (WHO, 2015). However, some sporozoites species will stay dormant in the human body, and as a consequence, delay symptoms beyond the incubation period. In other words, a person can have malaria but show no symptoms (NIAID, 2012).

The sporozoites species that remain dormant in the human blood cells are known as merozoites (NIAID, 2012). After a period of time, the merozoites become active and begin to multiply in the red blood cells again (NIAID, 2012). At this stage of the multiplication process, merozoites become gametocytes, the sexual-stage of the parasite where it can be transmitted to a mosquito when that mosquito bites the human host (NIAID, 2012). Preventive drugs or other therapeutic interventions are required to break both the transmission cycle and the life cycle of the parasite.

Environmental Dimension of Malaria

In the context of disease and health, the environment is not just the quality of air, water, the soil, and the built systems; the environment includes socioeconomic condition, and other social factors external to people (Prevention Institute, 2002). The environmental condition in a malaria endemic country like Liberia includes the weather, climate, and poverty, all of which provide the ideal habitat for the development of *Anopheles* mosquitoes, the main vectors of the malaria parasite (Govoetchan et al., 2014).

In the Govoetchan et al. (2014) study, high humidity, tropical settings, wet and warm climates support *Anopheles* mosquitoes breeding. With a tropical climate, a raining season that runs from May to October each year, relative humidity between 90-100%, and temperatures as high as 89 °F (NMCP, 2011), Liberia has the perfect environment for *Anopheles* mosquitoes breeding. As long as the environment that supports mosquito larvae development and survival exist, there is a high likelihood of increased *Anopheles* mosquitoes development, which in turn contributes to increased malaria prevalence in Liberia and tropical Africa (Govoetchan et al., 2014; NMCP, 2011).

Socioeconomic condition, especially poverty, is a risk factor that contributes to increased malaria risk (Sonko et al., 2014; WHO, 2015). In studies reported by the WHO, the brunt of malaria burdens is borne by the poorest regions of the world particularly in sub-Saharan Africa (WHO, 2015). These reports are supported by numerous other studies that link poverty to malaria (de Castro & Fisher, 2012; Krefis et al., 2010; Ricci, 2012; Sonko et al., 2014). An estimated 90% of malaria deaths, 77% of whom are children under 5 years, occur in sub-Saharan Africa; and in majority of the cases, malaria prevalence is higher among people with low socioeconomic status (Krefis et al., 2010; Sonko et al., 2014).

In Liberia, 83.8% of the population has a poverty headcount ratio of $1.25 a day (Purchasing Power Parity), and in 2013, Liberia ranked 175 out of 187 countries on the Human Development Index (WHO, 2014a; United Nations Development Program

[UNDP], 2014). With such level of poverty, Liberia provides an ideal environment for the malaria disease to thrive. Preventive efforts are primarily focused on the use of ITNs which are unevenly distributed among the populations most vulnerable to malaria and have a limited coverage ratio (NMCP, 2011).

ITN Ownership and Efficacy

Bed nets have been used as a protective shield against insects since the 19^{th} century (IOM, 2004). Ancient Egyptians living in the lowlands area of the Nile used bed nets to wall off mosquitoes at nights (IOM, 2004). During World War II, a new element was added to bed nets – chemicals that will not only ward of mosquitoes but kill them (IOM, 2004). American soldiers fighting on the Pacific front used chemically treated bed nets to protect themselves against malaria (Kitchen, Lawrence & Coleman, 2009), while similar protective shield was applied by Soviet troops in Central Asia (Blagoveschensky, Bregetova, & Monchadsky, 1945).

In the late 1970s and early 1980s, the chemically treated nets, now known as insecticide treated nets, gained traction as a malaria control tool (IOM, 2004). Liberia, together with other countries like China, the Philippines, and Vietnam, adopted ITN use as part of its malaria control program (IOM, 2004). But 14 years (1989 – 2003) of civil strife in Liberia interrupted all forms of disease control (Challoner & Forget, 2011). In 2005, the Liberian government and the Roll Back Malaria Partnership, a malaria intervention initiative established in 1998 and sponsored by the World Bank, WHO, UNDP, and UNICEP, reintroduced ITN use as part of Liberia's malaria control policy (Roll Back Malaria Partnership, 2011; NMCP, 2011).

According to the 2011 Liberia Malaria Indicator Survey (LMIS), 50% of all households in Liberia owned at least one ITN, and only 37% of children under the age of 5 years slept under an ITN the night prior to the survey (NMCP, 2011). In 2007, 655,860 ITNs were distributed to households with children, 1,221,700 ITNs distributed in 2009 and 883,400 ITNs distributed in 2010 (WHO, 2014c). In 2012, 1,185,780 ITNs were distributed to households with children (MOHSW, 2012).

In 2005, an estimated 18% of households with children owned ITN (MOHSW, 2012). That number grew to 30% in 2007, 49% in 2009, and 50% in 2010 (MOHSW, 2012). Interestingly, of the 18% of households with ITNs in 2005, only 6% used it; of the 49% of households with ITNs in 2009, only 30% used them, and 32% out of the 50% of households with ITN used them in 2010 (MOHSW, 2012). While there are tremendous efforts by the government and its international partners to increase ITN coverage and use, the national average of malaria prevalence among children stands at 32% (NMCP, 2011). Figures 5 and 6 below show the distribution of malaria prevalence among children in the six health regions in Liberia.

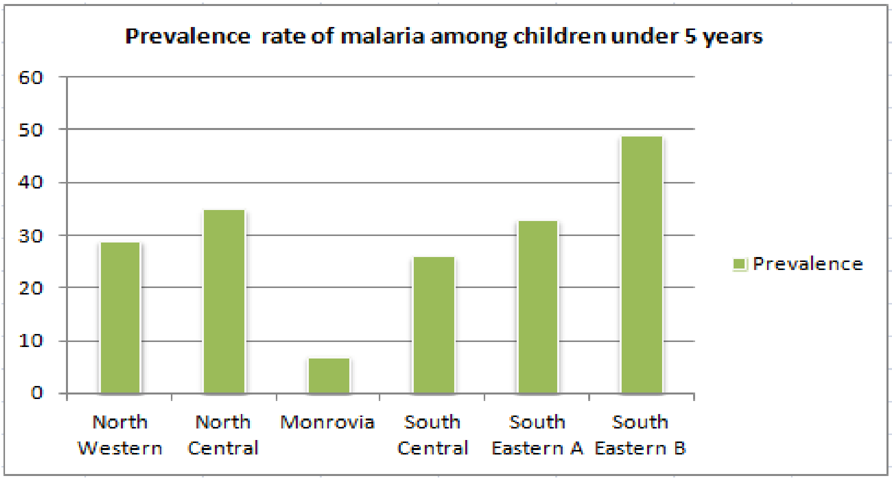

Figure 2. Malaria Prevalence among Children in Liberia by Region. Adapted from "Liberia Malaria Indicator Survey 2011," by National Malaria Control Program [Liberia], Ministry of Health and Social Welfare, Liberia Institute of Statistics and Geo-Information Services, and ICF International. (2012). Monrovia, Liberia: NMCP, LISGIS, and ICF International

Figure 3. Map of Liberia Indicating Health Regions. Adapted from "LIBERIA: National Policy and Strategic Plan on Integrated Vector Management," by RTI International, 2012, USAID.gov.

There is a vast body of work on the efficacy of ITNs in reducing malaria incidence among children (Eisele, Larsen, & Steketee, 2010; Strode et al., 2014; Tokponnon et al.; 2014). In 2005, the Liberia Malaria Indicator Survey showed malaria prevalence in children to be 66% (NMCP, 2011; WHO, 2014a). That figure dropped to 32% in 2010 (WHO, 2014a). The 2011 Liberia Malaria Indicator Survey showed another 4% decline (WHO, 2014a). Similarly, there are declines in malaria deaths among children as well. As shown in Table 1, from 2000 to 2010, there were 798 fewer malaria deaths among children under 5 years old, a 14.8% drop. Whereas in the previous decade (1990 – 2000) and the decade before that (1980 – 1990), malaria deaths among children increased by 85.6% and 42%, respectively (Murray et al., 2012). The period from 2000 to 2010 when Liberia saw a decline in malaria deaths is likely associated with the reintroduction of ITN use as a malaria control strategy.

While ITNs may be slowing the rate of malaria transmission and malaria deaths among children (Kariuki et al., 2013; Murray et al., 2012; NMCP, 2011; WHO, 2014a;), there are other research studies that expose various threats to ITNs as an effective malaria control mechanism. In a study by Temu et al. (2012), there was widespread resistance to pyrethroid, the class of insecticides used in ITNs, by *An.gambiae*, the predominant plasmodium vector in Liberia. This finding is supported by other studies, one of which was conducted in neighboring Burkina Faso, showing *An.gambiae* to be resistant to ITNs (Jones, et al., 2012; Sougoufara et al., 2014). Although *An.gambiae* may be resistant to ITNs, a systematic review of the literature by Strode et al. (2014) showed that ITNs are more effective in preventing malaria when compared to untreated bed nets (UTNs). The insight provided by the Strode et al. (2014) study may be true; however, it did not take into consideration vector behavior, the social behavior of people for whom the ITNs are intended, and the alarming levels of morbidity and mortality caused by malaria.

An.gambiae are also changing their biting habits. Instead of feeding at nights when ITNs are widely used as shields against mosquito bites, *An.gambiae* are feeding in the day time when people are not protected by ITNs (Sougoufara et al., 2014).

In some malaria endemic regions, people reject or refused to use ITNs because they find them to be irritating, uncomfortable, and reported to cause itching/rashes (Koenker et al., 2013). In other regions, villagers are misusing ITNs as fishing tools (Minakawa, Dida, Sonye, Futami, & Kaneko, 2008). Other factors such as parental education and the social ability to maintain ITN for their proper application may contribute to ITN efficacy. These factors are examined next in this review.

Parental Education Level

Given that parents play a large role in protecting the health of their children and ensuring that children are protected against malaria, their education level and knowledge of the role of ITN are important to reducing malaria prevalence among children. According to the NMCP (2001), 80% of parents in Liberia were fully aware that sleeping under an ITN provides protection against malaria. Among the same group of parents, 86% of those with secondary and higher education believed ITNs provide protection against malaria compared to 73% of those with no education (NMCP, 2001). Though ITN ownership is a determinant to ITN use, knowledge of ITN as a protective tool is equally important. One must have awareness of a phenomenon for such to influence his or her behavior. In examining the determinants of ITN use, Esimai, & Aluko (2014) found in their study of parents of children less than 5 years in South-Western Nigeria, that parental knowledge of ITN was a key determinant of ITN use. Mass education campaigns to parents about the usefulness of ITNs are a helpful way to prevent child malaria (Kyu, Georgiades, Shannon, & Boyle, 2013). Access to ITN, free distribution, and ITN ownership may not be helpful in protecting children against malaria if parental knowledge of the role of ITN is lacking.

Economic Status (ES) of Parents

The economic status of parents is measured as an index of their wealth. In discussing this variable, the focus is poverty as a barrier to attaining ITN. Evidence shows that poverty increases malaria risk (Sonko et al., 2014; Ricci, 2012). In numerous research studies, the brunt of the heaviest malaria burdens is borne by the poorest regions of the world particularly in sub-Saharan Africa (de Castro & Fisher, 2012; Krefis et al., 2010; Ricci, 2012; Sonko et al., 2014).

In Liberia, for example, 83.8% of the population has a poverty headcount ratio of $1.25 a day (Purchasing Power Parity)(UNDP, 2014). According to the United Nations Development Program, in 2013, Liberia ranked 175 out of 187 countries on the Human Development Index (UNDP, 2014; WHO, 2014a). Though ITNs are distributed free of charge to the population, most Liberians in the rural parts of the country live far away from health facilities or ITN distribution points (NMCP, 2011). The physical demands of walking 2 to 3 hours to the nearest health center to take delivery of an ITN pose an obvious barrier. In a study by Larson, Mathanga, Campbell, & Wilson (2012) in Malawi on the influence of distance on ITN ownership, the researchers found that people living closest to ITN distribution points or health facilities were most likely to have ITN compared to people who live far away from ITN distribution points. The same can be attributed to Liberia where distance, fewer or poorly constructed roads, and few health facilities are hindrance to accessing ITNs (NMCP, 2011).

Another aspect of poverty that poses a challenge to the proper utilization of ITN is the requirements or dwelling structure for the proper installation of an ITN. For instance, beds with post provide a grounding anchor for ITNs. Rural families who cannot afford beds with posts, but are accustomed to using floor mats as beds may not find ITNs to be useful.

Summary and Conclusion

Malaria is a preventable disease that presents one of the greatest public health dangers in sub-Saharan Africa. In Liberia, the disease is the leading cause of morbidity and mortality among children under 5 years (NMCP, 2011). Since 2005, the government of Liberia's primary malaria control strategy is the free distribution of insecticide treated nets to vulnerable populations such as children and pregnant women. Nearly 4 million ITNs were distributed to households with pregnant women and children under 5 years from 2007 to 2012. Even though malaria deaths among children in Liberia were still alarmingly high from 2007 to 2012, the deaths rates were on the decline. In this literature review, there is ample evidence that insecticide treated nets can reduce malaria prevalence and deaths among children. However, of all the many studies that have examined the effectiveness of ITN as a malaria control tool, none was performed in

Liberia in the form of a comprehensive analysis of the effectiveness of ITN. This study performs such analysis.

As I reviewed the literature, I found that the following factors threatened the effectiveness of ITNs: (a) Low ITN ownership and coverage, (b) parental knowledge of the role and use of ITN, and (c) poverty as a barrier to accessing and properly using ITN. There were also widespread resistance by malaria vectors to pyrethroid, the class of insecticides used in ITNs (Sougoufara et al., 2014) ; malaria vectors were adapting to human bed time schedules by changing biting habits (Sougoufara et al., 2014); and the reported irritation, discomfort, and allergic reactions caused by ITNs.

Based on this review, secondary data from the 2011 Liberia Malaria Indicator Survey was used to examine the association between the independent variables - ITN ownership, parental education, and economic status of parents – and malaria prevalence among children under 5 years old. A complete description of the study design and methodology is presented in Chapter 3.

Chapter 3: Research Method

Introduction

The purpose of this quantitative study is to analyze whether ITN use is an effective strategy in reducing malaria prevalence among children in Liberia. The role of ITN ownership on malaria prevalence will be examined, and whether factors such as maternal knowledge of ITN and economic status of parents influence ITN ownership.

In this chapter, I will discuss the research design and rationale. This includes the appropriateness of study design choice and study variables. I also discuss the methodology employed in this study including components such target population, data collection procedure for using secondary data, strategy for recruitment, sampling, and the data collection instruments associated with the original study. The threats to validity and how they will be mitigated are also discussed. This chapter concludes with description of ethical concerns that will be adhered to in this study.

Research Design and Rationale

This is a cross-sectional quantitative study that uses secondary data from the 2011 LMIS. A cross-sectional design is appropriate in this study because relationships between study variables can be measured and analyzed without manipulating the study environment. The study subjects do not have to be influenced, and comparisons between many groups or variables can be made at a single time point (Smith et al., 2011). For example, variables representing ITN ownership, parental education, and economic status of parents can be compared or measured against malaria prevalence among children under 5 years old. Experimental design or its variations were not appropriate for this study because the researcher's intervention or the altering of variables or study environment to influence the outcome of the study is not required. The use of a cross-sectional retrospective design is less time-consuming and less expensive in terms of data collection since the data are already available (Smith et al., 2011). Such designs are common in social science studies where disease prevalence and the effectiveness of public health strategies are measured (Frankfort-Nachmias & Nachmias, 2008). Additionally, I do not seek to establish cause-and-effect relationships among variables, but rather provide a descriptive, correlational, and predictive relationship among the study variables.

Research Questions

This study is guided by the following quantitative research questions and hypotheses:

RQ1: Is there an association between ITN ownership and reduced malaria prevalence among children under 5 years old?

$H_0 1$: There is no association between ITN ownership and reduced malaria prevalence among children under the age of 5 years. In other words, households or parents who own ITN in Liberia do not report lower malaria prevalence among their children who are less than 5 years old.

$H_a 1$: There is an association between ITN ownership and reduced malaria prevalence among children under the age of 5 years. In other words, households or parents who own ITN in Liberia do report lower malaria prevalence among their children who are less than 5 years old.

RQ2: Is there an association between parental education level and the prevalence of malaria among children under 5 years old?

$H_0$2: There is no association between parental education level and the prevalence of malaria among children under 5 years old.

H_a2: There is an association between parental education level and the prevalence of malaria among children under 5 years old.

RQ3: Is there an association between parental economic status and the prevalence of malaria among children under 5 years old?

$H_0$3: There is no association between parental economic status and the prevalence of malaria among children under 5 years old.

H_a3: There is an association between parental economic status and the prevalence of malaria among children under 5 years old.

RQ4: Among those who own an ITN, is there an association between ownership of structure (beds/mattresses that can anchor ITN) and the prevalence of malaria among children under 5 years old?

$H_0$4: There is no association between ownership of structure (beds/mattresses that can anchor ITN) and the prevalence of malaria among children under 5 years old. Let it be noted that 70% of participants with ITN also slept on mattresses or beds with posts that can anchor ITN, and 30% did not.

H_a4: There is an association between ownership of structure (beds with posts that can anchor ITN) and the prevalence of malaria among children under 5 years old.

Variables

Based on the research questions, the dependent variable in this study was malaria prevalence among children under 5 years old. The dependent variable measures malaria prevalence from the results of the rapid detection test conducted during the survey. The independent variables were ownership of ITNs, parental education, economic status of parents, and ownership of structure (e.g., bed/mattress). Other variables that contributed and provided descriptive statistics in this study were age of the child, sex of the child, type of place of residence, and region of the country.

The measurement scales used in this study were nominal (categorical/dichotomous), ordinal, and ratio (continuous). Variables that define sex, region/residence, and ITN ownership were measured on a nominal scale. The variable that defined parental education level was ordinal, and the variable that defined age (in months) was measured on a continuous scale. Malaria prevalence was measured on a nominal/dichotomous scale. Table 2 lists the study variables and their measurement scales.

Table 2

Relevant Variables Being Analyzed in This Study

Variable name	Variable label	Level of measurement
AGE_CHILD	Age of child	Nominal
SEX_CHILD	Sex of child	Nominal
PARENTAL_KNOW	Parental education level	Ordinal
REGION	Region of the country	Nominal
PLACE	Type of place of residence (rural/urban)	Nominal
WEALTHINDEX	Wealth classification of parents	Ordinal
BED_STRUC	Bed structure ownership	Dichotomous/Nominal
INT_OWN	ITN ownership	Dichotomous/Nominal
MALARIA_STATUS	Measures malaria status from testing results	Dichotomous/Nominal

Methodology

Population

The target population in this study comprised of children under the age of 5 years (0 to 59 months) living in the sub-Saharan country of Liberia. According to the most recent national census conducted in 2008, Liberia has a total population of 3.4 million people (LISGIS, 2009). Of that number, the population of children under the age of 5 years accounted for 19.5% (677,889; WHO, 2013). This segment of the population is the most vulnerable to the malaria disease and bears the brunt of the disease burdens (WHO, 2014b).

Sampling and Sampling Procedures

Sampling is a method of selecting a unit from a population of interest and using it to understand a specific phenomenon about that population. Often in social science research or in research in general, it may be impractical to survey or use an entire population of interest. Sampling provides a way to use a subset of the population to make generalization on the entire population.

This quantitative study used secondary data from the 2011 LMIS conducted by the Liberia National Malaria Control Program, LISGIS, and ICF International. The LMIS was originally collected to measure malaria indicators such as the proportion of households with ITN, malaria prevalence among children, treatment, and ITN use among children and pregnant women (DHSP, n.d.). LMIS was a nationwide survey that covered all regions of Liberia.

The sampling frame was based on the most recent Liberia National Population and Housing Census conducted in 2008 (DHSP, n.d). In the 2008 census process, 7,021 EAs were constructed to ensure that the entire country was covered. There are 15 counties in Liberia. These counties are grouped into six regions and then further grouped into urban and rural areas (NMCP, 2011). Sampling was stratified by region. Each census EA was identified as a cluster in the 2011 LMIS study with each cluster containing 30 households. The samples were equally apportioned with 25 clusters to each region. Of the total of 150 clusters used, 69 clusters were urban and 81 clusters were rural. An equal number of households (750) in each of the six regions were selected. With women being the primary caregiver in a typical Liberian household, only women and their children were selected for the survey (NMCP, 2011). A total of 4,162 households were included in the survey with 3,939 females between the ages of 15 and 49 years and 3,319 children under the age of 5 years (DHSP, n.d). House to house fieldwork for the survey was conducted from September 2011 to December 2011 (DHSP, n.d).

Power analysis provides a way of determining the sample size that will be needed to detect the kind of effect desire. However, sample size calculation relies on three factors-- effect size, statistical power, and alpha level (Suresh & Chandrashekara, 2012). Effect size measures the numerical strength of the relationship between the independent and dependent variables, while the power or 1- beta (1- β) measures the chance of rejecting the null hypothesis (McDonald, 2014). Alpha value is a measure of the significance level of the statistical test. Most often in social science research, the values of effect size, statistical power, and alpha level tend to be default values or crude estimates (McDonald, 2014).

To avoid an effect size that is neither difficult nor easy to identity, a medium effect size of (0.3) was used in this study. A default power of 95% was used as well since there are fewer consensuses on the value of statistical power to use. The default alpha value of (.05) was used. Based on the target population, a statistical power analyses tool called G*Power 3.1.7 was used to estimate the size of the sample required to detect effect in this study. Using a correlation statistical technique in G*Power with a two-tailed Alpha, the minimum sample size calculated to realize a minimum effect between the independent and dependent variables was 136 samples. However, the available dataset far exceeds the minimum sample size calculated for this study. The available dataset contained 4,162 samples. Initially, age and ITN ownership were used as the inclusion criteria to filter the dataset, which resulted in a proposed sample size of *n* = 2,162. However, an actual analysis of the data revealed that filtering the data based on an independent variable (ITN ownership) that is measured on a categorical scale violated the chi-square rule that requires a categorical variable to have two or more groups. A new inclusion criterion–age and malaria rapid test–was used. The new criterion resulted in a sample size of *n* = 566.

Procedure for Archival Data

LMIS is a study that measures malaria indicators such as the proportion of households with ITN, malaria prevalence among children, treatment, and ITN use among children and pregnant women (DHSP, n.d.). The 2011 LMIS is the third of such studies in Liberia. The first LMIS was in 2005 and the second in 2009 (NMCP, 2011). In collecting the data for the 2011 LMIS, the country was stratified by region where household clusters were constructed based on the region. One hundred and fifty clusters, each of which containing 30 households, were identified. A total of 4,162 households were included in the survey with 3,939 females between the ages of 15 and 49 years and 3,319 children under the age of 5 years (DHSP, n.d).

The 2011 LMIS dataset and all previous LMIS data are publicly available on the Demographics and Heath Survey Program website. To gain access to the data, registration with DHS is required on its website. Personal information such name, address, associated institution, and personal phone numbers must be provided. The title, purpose, and a brief description of the study for which the data are being requested must also be provided. On January 28, 2015, I submitted a request for permission to use the DHS 2011 LMIS data for this study. On January 29, 2015, I received authorization or permission to download and use the 2011 LMIS for this study. The authorization letter is included in Appendix A.

Instrumentation and Operationalization of Constructs

Data source: 2011 LMIS from the Demographics and Heath Survey Program database. Survey conducted between September 2011 and December 2011.

Sample size: Original dataset included 4,162 samples with 3,939 females between the ages of 15 and 49 years and 3,319 children under the age of 5 years (DHSP, n.d). The dataset was filtered using age and malaria rapid test as the inclusion criterion. The sample size used in this study is *n* = 566.

Variables: There are 2,648 variables in the dataset. However, only nine variables are relevant to this study. Table 3 shows variable names, variable labels, measurement scale, value, and value definition.

Table 3

Variable Definition and Measurement Scale

Variable name	Variable label	Measurement scale	Value	Definition
AGE_CHILD	Child's age in months	Ratio/Continuous	6 - 59	Months
SEX_CHILD	Child's sex	Nominal/Dichotomous	1	Male
			2	Female
PARENTAL_KNOW	Parental malaria education level	Ordinal	0	No Education
			1	Primary school
			2	HS & Above
REGION	Region of the country	Nominal	1	Monrovia
			2	North Western
			3	South Central
			4	South Eastern A
			5	South Eastern B
			6	North Central
PLACE	Type of place of residence (rural/urban)	Nominal	1	Rural
			2	Urban
WEALTH_INDEX	Economic status/Wealth classification of parents	Ordinal	1	Poorest
			2	Poorer
			3	Middle
			4	Richer
			5	Richest
BED_STRUC	Bed/mattress structure ownership	Nominal/Dichotomous	0	No
			1	Yes

Table 3 Cont'd

Variable Definition and Measurement Scale

Variable name	Variable label	Measurement scale	Value	Definition
INT_OWN	ITN ownership	Nominal/Dichotomous	0	No
			1	Yes
MALARIA_STATUS	Malaria rapid test results	Nominal/Dichotomous	0	Negative
			1	Positive

Data Analysis Plan

Statistical Program for the Social Sciences (SPSS) version 21, a popular and common statistical application developed by IBM, is being used to analyze the study data. SPSS was selected for two reasons: a) it has the capability to conduct both descriptive and inferential statistical analyses using all of the statistical tests appropriate to addressing the research questions in this study; and b) the researcher has the proficiency required to use SPSS.

The data for the study are gathered from the 2011 LMIS hosted by the Demographics and Heath Survey Program (DHSP, n.d.). Given that the 2011 LMIS dataset was not originally collected for this study, it may require data cleaning that involves identifying and appropriately coding variable measurement scales and mitigating other data quality issues such as missing data. The LMIS data file provided by DHS for this study is called **LBHR61FL.SAV**. In its original form, the data file has the following characteristics:

Data file: LBHR61FL.SAV

Number of records: 4162

Number of variables: 2648

After filtering samples using age and malaria rapid test, the new data file is called **LBHR61FL-INTS.SAV** and has the following characteristics:

Data file: LBHR61FL-ITNS.SAV

Number of records: 566

Number of variables: 2648

The nature of the variables being analyzed is an essential component to addressing the research questions in this study. There are roughly 2648 variables in the DHS/LMIS dataset. However, only nine variables were identified as essential to addressing the research questions. Table 4 below lists the nine variables as represented in the original dataset:

Table 4

Relevant variables from the DHS/MIS Database

Variable name	Variable label
HC1$1	Child's age in months
HC27$1	Child's sex
HC61$1	Mother's highest level of schooling
HC024	Region of the country
HV025	Type of place of residence (rural/urban)
HC270	Wealth classification of parents
SH107I	Bed structure ownership
HV227	ITN ownership
HML35$03	Malaria rapid test results

Variable Recoding

The nine variables as represented in the original dataset were recoded into different variables with new names to make them self-explanatory and easier to discern their meaning. Table 5 contains the recoded names of the variables, labels, and the statistical test performed.

Table 5

Recoded variables from the DHS/MIS Database

Original Name	**Recoded Name**	**Variable Label**	**Analysis**
HC1$1	AGE_CHILD	Child's age in months	Frequencies
HC27$1	SEX_CHILD	Child's sex	Frequencies
HC61$1	PARENTAL_KNOW	Mother's highest level/schooling	Chi-square, Logistic regression
HC024	REGION	Region of the country	NA
HC025	PLACE	Type of place of residence	Frequencies
HC270	WEALTH_INDEX	Wealth classification of parents	Chi-square, Logistic regression
SH107I	BED_STRUC	Bed structure ownership	Chi-square, Logistic regression
HV227	INT_OWN	ITN ownership	Chi-square, Logistic regression
HML35$03	MALARIA_STATUS	Malaria rapid test results	Chi-square, Logistic regression

Handling of Missing Values

Since the data used in this study was not originally collected for this study, it is not unexpected that some data were missing (Cheng & Phillips, 2014). The dependent variable was missing four pieces of data in the filter dataset. The missing data was handled through the application of list-wise deletion. List-wise deletion may not be an optimum option, but it was applied because the number of missing records amounted to less than 10% (Langkamp, Lehman, & Lemeshow, 2010) of the dataset. If the size of missing data was more than 10% of the dataset, multiple imputation would have been used to handle missing data. With a sample size of (n=566), there is sufficient power to detect any meaningful effects.

Research questions

Here are the research questions and hypotheses of this study:

RQ1: Is there an association between ITN ownership and reduced malaria prevalence among children under 5 years old?

$H_0 1$: There is no association between ITN ownership and reduced malaria prevalence among children under the age of 5 years. In other words, households or parents who own ITN in Liberia do not report lower malaria prevalence among their children who are less than 5 years old.

$H_a 1$: There is an association between ITN ownership and reduced malaria prevalence among children under the age of 5 years. In other words, households or parents who own ITN in Liberia do report lower malaria prevalence among their children who are less than 5 years old.

RQ2: Is there an association between parental education level and the prevalence of malaria among children under 5 years old?

$H_0 2$: There is no association between parental education level and the prevalence of malaria among children under 5 years old.

H_a2: There is an association between parental education level and the prevalence of malaria among children under 5 years old.

RQ3: Is there an association between parental economic status and the prevalence of malaria among children under 5 years old?

H_03: There is no association between parental economic status and the prevalence of malaria among children under 5 years old.

H_a3: There is an association between parental economic status and the prevalence of malaria among children under 5 years old.

RQ4: Among those who own an ITN, is there an association between ownership of structure (beds/mattresses that can anchor ITN) and the prevalence of malaria among children under 5 years old?

H_04: There is no association between ownership of structure (beds/mattresses that can anchor ITN) and the prevalence of malaria among children under 5 years old. Let it be noted that 70% of participants with ITN also slept on mattresses or beds with posts that can anchor ITN, and 30% did not.

H_a4: There is an association between ownership of structure (beds with posts that can anchor ITN) and the prevalence of malaria among children under 5 years old.

Statistical Tests for the Study Outcome

This study does not seek cause-and-effect outcome, but rather an association or relationship between variables that can refute or validate the study hypothesis. As a result, two statistical methods are used to analyze the data. To address RQ1, Chi-square with cross-tabulation was used to test the association between the independent variable

(ITN ownership) and the dependent variable (malaria prevalence). To address RQ2, Chi-square with cross-tabulation was used to test the association between the independent variable (parental education) and the dependent variable (malaria prevalence). In RQ3, Chi-square with cross-tabulation was used to test the association between the independent variable (Wealth index) and the dependent variable (malaria prevalence). In RQ4, Chi-square with cross-tabulation was used to test the association between the independent variable (ownership of bed structure) and the dependent variable (malaria prevalence). Phi (φ) and Cramer's V were used to measure the strength of the association between the independent variables and the dependent variable.

Logistic regression was used to test the predictive influence of the independent variables on the dependent variable. All statistical tests in this study were conducted at a 5% significance level with estimate of effects measured at 95% Confidence Interval (CI) and a p-value of .05.

Summary statistics including frequencies and measures of central tendency for the variables being analyzed was also calculated.

Threats to Validity

Internal and external validity are important concepts in research. Internal validity is concerned with establishing that there is a causal relationship between the independent variable and the dependent variable, while external validity is concerned with being able to generalize the findings of a study to a larger population group (Frankfort-Nachmias & Nachmias, 2008). In addition to relying on secondary data, this study does not seek to make causal inferences; therefore threats to internal validity are limited.

Threats to external validity included an instance in the 2011 LMIS survey questionnaire where participants were asked to identify the brand/type of bed nets they owned. With 65.6% of survey participants having only primary or no education, very few responses to that survey question were contained in the dataset (DHSP, n.d.). To mitigate this threat, survey responses that identified age and rapid malaria test were instead used as inclusion criteria to filter the dataset for this study.

The overall threats to validity in this study are associated with the limitations incumbent in using secondary data. Secondary data are limited by the following factors: (a) The purpose and collection method of the original data was not influenced by the current research topic; as a result, the data may be inconsistent and incomplete for the current research topic; (b) in some instances, the format of the data differed from the format suitable for this research analysis. This required additional data manipulation which can lead to errors that can jeopardize the validity of the study results. This threat was mitigated using a scientifically-proven method such as dropping cases since the number of cases with missing or inconsistent data was less than 10% (Langkamp et al., 2010).

Ethical Procedures

This quantitative study relies on secondary data from the 2011 Liberia Malaria Indicator survey. The dataset does not include the identity of the study participants. The de-identified dataset provides adequate privacy protection for the study participants. The 2011 LMIS dataset is publicly available on the Demographics and Heath Survey Program website. To gain access to the data, registration with DHS is required on its website.

Personal information such as name, address, associated institution, and phone number must be provided. The title, purpose, and a brief description of the study for which the data is being requested must be provided as well. On January 28, 2015, I submitted a request for permission to use the DHS 2011 LMIS data for this study by registering and submitting the required information on the DHS website. A day later, on January 29, 2015, I received authorization to download and use the 2011 LMIS. The authorization letter is included in Appendix A.

An approval from the Institutional Review Board (IRB) at Walden University was granted on September 18, 2015, IRB approval # (09-18-15-0157829) to use the 2011 LMIS data for this study. The data shall not be shared with any other party, and approval from DHS will be obtained prior to disseminating the study outcome.

Summary

In this chapter, the research design and rationale of the study methodology were discussed. Components of the study methodology such as target population, study participants, and the sampling procedure used were also discussed. This is a quantitative, cross-sectional study design that relies on secondary data from the 2011 LMIS. A total of 4,162 households were included in the 2011 LMIS with 3,939 females between the ages of 15 and 49 years and 3319 children under the age of 5 years (DHSP, n.d). After filtering the data using age and malaria rapid test as the inclusion criteria, the sample size used in this study is (n=566).

Internal validity was not assessed since the study does not seek cause-and-effect outcome. However, external validity (generalizability) was supported since the sample size had sufficient power. Ethical concerns related to how the data was obtained and disseminated, human participants and Institutional Review Board (IRB) authorization were also addressed.

In Chapter 4, the statistical results of the study including descriptive statistics, probability values, and confidence intervals are presented.

Chapter 4: Results

Introduction

The purpose of this quantitative study was to analyze the effectiveness of ITN in reducing malaria prevalence among children under the age of 5 years in Liberia. In this study, I used a cross-sectional design that relied on secondary data from the 2011 LMIS, conducted jointly by the Ministry of Health and Social Welfare of Liberia, LISGIS, and ICF International. The 2011 LMIS survey was sponsored by the United States Agency for International Development (USAID) as part of the Demography and Health Survey Program. The original dataset contained 4,162 samples. For this study, the original dataset was filtered to include only children who had taken the rapid malaria test during the original data collection. A total sample size of n = 562 was analyzed in this study.

With SPSS version 21, the following research questions and hypotheses were addressed using Chi-Square for Association and Logistic Regression to analyze the dataset:

RQ1: Is there an association between ITN ownership and reduced malaria prevalence among children under 5 years old?

$H_0 1$: There is no association between ITN ownership and reduced malaria prevalence among children under the age of 5 years. In other words, households or parents who own ITN in Liberia do not report lower malaria prevalence among their children who are less than 5 years old.

$H_a 1$: There is an association between ITN ownership and reduced malaria prevalence among children under the age of 5 years. In other words, households or parents who own ITN in Liberia do report lower malaria prevalence among their children who are less than 5 years old.

RQ2: Is there an association between parental education level and the prevalence of malaria among children under 5 years old?

$H_0$2: There is no association between parental education level and the prevalence of malaria among children under 5 years old.

H_a2: There is an association between parental education level and the prevalence of malaria among children under 5 years old.

RQ3: Is there an association between parental economic status and the prevalence of malaria among children under 5 years old?

$H_0$3: There is no association between parental economic status and the prevalence of malaria among children under 5 years old.

H_a3: There is an association between parental economic status and the prevalence of malaria among children under 5 years old.

RQ4: Among those who own an ITN, is there an association between ownership of structure (beds/mattresses that can anchor ITN) and the prevalence of malaria among children under 5 years old?

$H_0$4: There is no association between ownership of structure (beds/mattresses that can anchor ITN) and the prevalence of malaria among children under 5 years old. Let it be noted that 70% of participants with ITN also slept on mattresses or beds with posts that can anchor ITN, and 30% did not.

H_a4: There is an association between ownership of structure (beds with posts that can anchor ITN) and the prevalence of malaria among children under 5 years old.

The data collection and preparation process will be discussed in this chapter. I will also report descriptive, demographic characteristics and explain the representativeness of the sample in this chapter. The applicability of the analytical tests used in this study will be discussed, and the results from the analytical tests will be reported in a manner consistent with the research questions.

Data Collection

There were no discrepancies in data collection from the plan presented in Chapter 3. However, there was a slight adjustment in the criteria used to filter the original dataset. The study data were gathered from the 2011 LMIS dataset, which is publicly available on the website of the DHS. To gain access to the data, an online request that included my personal information such name, address, phone contact, and affiliated institution was submitted. Other required information included the title, purpose, and a brief description of the study for which the data was needed. The request was submitted to DHS on January 28, 2015. An authorization to use the dataset was granted by DHS on January 29, 2015. A letter authorizing the use of the data is included in the Appendix A.

The original data were collected as follows: The samples were equally apportioned with 25 clusters to each of Liberia's six health regions (DHSP, n.d.). Of the total of 150 clusters used, 69 clusters were urban and 81 clusters were rural (DHSP, n.d.). An equal number of households (750) in each of the six regions were selected. With women being the primary caregiver in a typical Liberian household, only women and their children were selected for the survey. A total of 4,162 households were included in the survey with 3,939 females between the ages of 15 and 49 years and 3,319 children under the age of 5 years (DHSP, n.d.). House to house fieldwork for the survey was conducted from September 2011 to December 2011 (DHSP, n.d.).

The original dataset of 4,162 samples was filtered to include only children under the age of 5 years who had taken the rapid malaria test during the original data collection or survey. The inclusion filter yielded 566 samples. In Chapter 3, only children under the age of 5 years who slept under or owned ITN were the proposed inclusion criteria. That yielded a sample size of n = 2,162. With ITN ownership being a predictor variable that is measured on a categorical scale (0 = *No*, 1 = *Yes*), its use as an inclusion criterion violated the Chi-square rule stating that there must be two or more groups in each variable. To mitigate this violation, rapid malaria test was used as a criterion instead to filter the dataset. Though the new inclusion criterion has produced a dataset that is smaller than the dataset proposed in Chapter 3, it is 76% (430) larger than the minimum sample size of n = 136 calculated in Chapter 3 to address the research questions in this study.

Data Exclusion

Age and rapid malaria test were the two exclusion criteria used to filter the secondary dataset. Participants who were older than 5 years were excluded. Participants who did not take the rapid malaria test during the survey were also excluded. As a result of the exclusions, 566 participants were used in this study.

Sample Representation of Population

The sampling frame of the dataset was based on the most recent Liberia National Population and Housing Census conducted in 2008 (DHSP, n.d.). In the 2008 census process, 7,021 EAs were constructed to cover the entire country. There are 15 counties in Liberia. These counties were grouped into six regions and then further grouped into urban and rural areas. Each census EA was identified as a cluster, and each cluster contained 30 households. The samples were equally apportioned with 25 clusters to each region.

According to the 2008 national census, Liberia has a total population of 3.4 million people (LISGIS, 2009). Of that number, the population of interest in this study--children under the age of 5 years--accounted for 19.5% (677,889; WHO, 2013). A total of 3,319 children under the age of 5 years were included in the secondary dataset (DHSP, n.d). Malaria prevalence among children in rural areas is higher compared to children in urban areas (MOHSW, 2012). The makeup of the sample in this study is 62% rural and 38% urban. The population of Liberia by sex, according to the 2008 Population and Housing Census, is equally distributed among males and females (LISGIS, 2009). The distribution of the sample in this study by sex is 50.4% male and 49.6% female. All of these characteristics present the sample as representative of the target population.

Fidelity of Statistical Test and Categorization of Variables

In accordance with the plan presented in Chapter 3, Chi-square of Association and Logistic Regression were the two statistical tests used to analyze the samples. Given that the key variables that were analyzed were qualitative in nature (nominal), the challenges encountered while applying Chi-square of Association and Logistic Regression in SPSS were negligible. In analyzing the independent variable (**HC61$1** – Mother's highest level of education), the value categorization were as follows: 1 = *No Education*, 2 = *Primary Education*, 3 = *Secondary Education*, and 4 = *Higher*. The number of samples for those with education level higher than secondary education was too low--1.76% or 10 samples. To overcome the low level of samples in that category, both the secondary education and higher categories were combined to create a single category called high school and higher under a recoded variable called **PARENTAL_KNOW**. A further evaluation of the dataset showed that four samples contained missing data for the dependent variable (malaria prevalence). Since the number of missing data (4 or .71%) is less than 10% of the sample size, a list-wise deletion was applied. List-wise deletion may not be an optimum option. However, it was an acceptable option since the missing data amounts to less than 10% of the sample size (Langkamp et al., 2010). The resulting sample size used in this analysis was n = 562.

Descriptive Statistics

The size of the sample analyzed in this study was n = 562. As shown in Table 6, males accounted for 50.4% (283) of the sample, and females accounted for 49.6% (279). Table 7 shows the mean age of the study participants to be 36.29 months or (3yrs; SD = 14.84) with a minimum age of 6 months and maximum age of 59 months. The geographic location of participants is mainly rural, accounting for 61.7% (347) of the sample, while 38.3% (215) of participants was drawn from urban areas.

Table 6

Frequency Distribution for Participants' Sex

Sex	Frequency	Percent
Male	283	50.4%
Female	279	49.6%
Total	562	100.0

Table 7

Statistics on Study Participants Age (in Months)

Valid	562
Missing	0
Mean	**36.29**
Median	38.00
Std. Deviation	14.838
Range	53
Minimum	6
Maximum	59

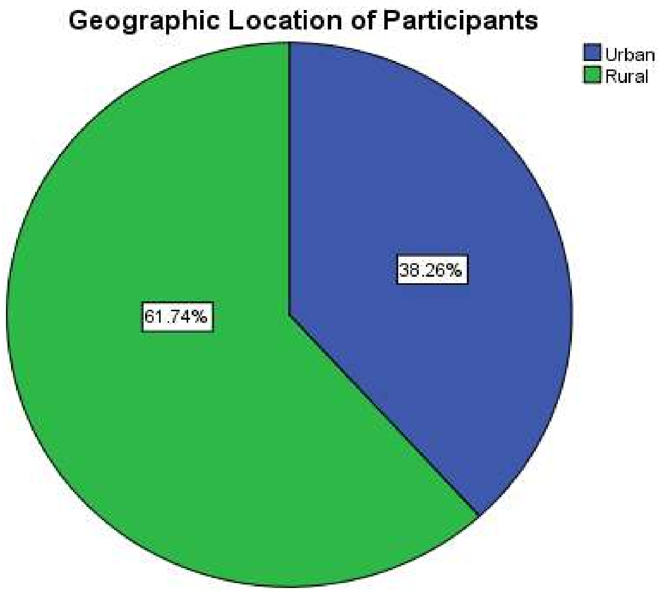

Figure 4. Geographic location of study participants.

Data Analysis Results

Two statistical tests were conducted to address the four research questions in this study. Chi-square for association was used as the primary statistical test to assess whether there is an association between the variables in each research question, while Logistic Regression was used to determine whether the independent variables (ITN ownership, parental education, parental economic status, and ownership structure –bed/mattress) have any predictive influence on the dependent variable (malaria prevalence).

RQ 1**:** Is there an association between ITN ownership and malaria prevalence among children under 5 years old?

$H_0 1$: There is no association between ITN ownership and reduced malaria prevalence among children under the age of 5 years. In other words, households or parents who own ITN in Liberia do not report lower malaria prevalence among their children who are less than 5 years old.

H$_a$1: There is an association between ITN ownership and reduced malaria prevalence among children under the age of 5 years. In other words, households or parents who own ITN in Liberia do report lower malaria prevalence among their children who are less than 5 years old.

Using a sample size of *n* = 562, a chi-square test for association was performed between ITN ownership and malaria prevalence among children under the age of 5 years. All expected cell frequencies were greater than five. There was no statistically significant association between ITN ownership and malaria prevalence among children under the age of 5 years, $\chi^2(1) = 0.980$, *p* = .322, Odds = .843, $CI_{0.95}$=[.601, 1.182] . This is further shown by the measure of effect between ITN ownership and malaria prevalence among children under the age of 5 years, φ = -0.42, *p* = .322. See Table 8.

Table 8

Chi-Square Results for ITN Ownership and Malaria Prevalence

	Value	*P*	95% CI	
			Lower	Upper
Pearson chi-square	0.980	.322		
df	1			
Phi	-0.42			
Odds Ratio	.843		.601	1.182

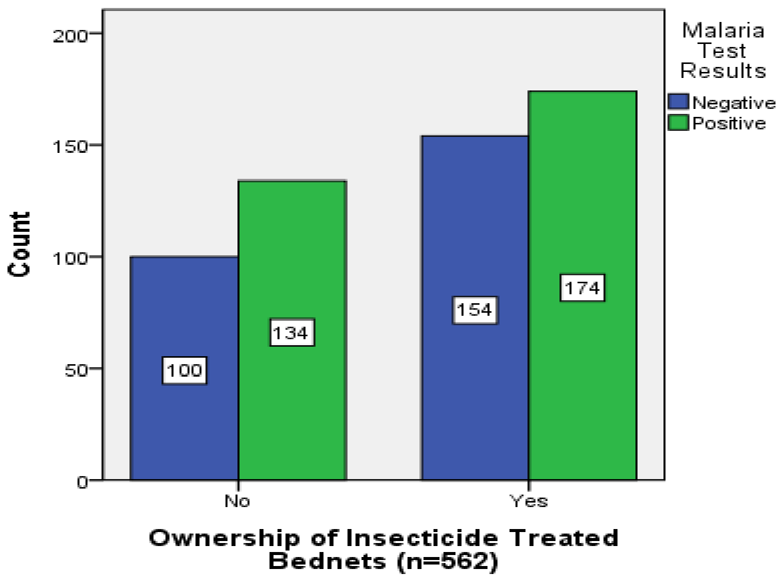

Figure 5. Relationship between ITN ownership and malaria prevalence.

As shown in Figure 5, 53% (174 out of 328) of children who owned ITN tested positive for malaria, while 47% (154 out of 328) tested negative for malaria. In the case of participants who did not own ITN, 57.3% (134 out of 234) tested positive for malaria, while 42.7% (100 out of 234) tested negative for malaria. The results from this chi-square test as shown in Table 8 and Figure 8 support the *null* hypothesis that there is no association between ITN ownership and reduced malaria prevalence among children under the age of 5 years. As a result, we fail to reject the *null* hypothesis. Given that these results are contrary to a vast number of research findings, a regression test was performed in which parental education and ownership bed/mattress were controlled for as confounding factors. See results in the logistic regression section.

RQ2: Is there an association between parental education level and the prevalence of malaria among children under 5 years old?

$H_0$2: There is no association between parental education level and the prevalence of malaria among children under 5 years old.

H_a2: There is an association between parental education level and the prevalence of malaria among children under 5 years old.

Using a sample size of n=562, a chi-square test for association was performed between parental education level and malaria prevalence among children under the age of 5 years. All expected cell frequencies were greater than five. There is statistically significant association between parental education level and malaria prevalence among children under the age of 5 years, $\chi^2(2) = 8.941$, $p = .011$. This is further shown by the measure of effect between parental education level and malaria prevalence among children under the age of 5 years, $\varphi = 0.126$, $p = .011$ (Table 9).

Table 9

Chi-square Results for Parental education and Malaria prevalence

	Value	*P*
Pearson chi-square	8.941	.011
df	2	
Cramer's V	0.126	

Since the predictor variable (parental education level) contains more than two categories and the relationship between the predictor variable and the response variable (malaria prevalence) is found to be statistically significant in the chi-square analysis, the data was closely examined using Odd ratios. The categories of the predictor variable are ordered as follows: 0 = *No Education*, 1 = *Completed Primary Education* and 2 = *Completed HS and Higher*. A conventional technique where Odds ratios are considered relative to a fixed baseline category was applied. In the 2x3 contingency table shown in Table 10, the category 0 = *No Education* was used as a baseline against which odds ratios of the other categories were considered.

Table 10

Contingency table of Mother's Education level and Malaria Prevalence

			Mother's Highest Education Level			
			No Education **(0)**	Completed Primary Edu. **(1)**	High School & Higher **(2)**	Total
Rapid Malaria Test	Negative	Observed	91	93	70	254
		Expected	108.0	85.9	60.1	254
	Positive	Observed	148	97	63	308
		Expected	131.0	104.1	72.9	308
Total		Observed	239	190	133	562
		Expected	239	290	133	562

The Odds ratios computations in Table 11 show that the effect of mother's education level on malaria prevalence is captured through two effects – *Completed Primary School* and *High School & Higher*.

Table 11

Odds Ratios against baseline category (0 = No education)

	Odds ratio	95% CI	
		Lower	Upper
Completed primary School (1) vs. No Education (0)	.641	.436	.944
High School & Higher (2) vs. No Education (0)	.553	.360	.850

As shown in Table 11, a mother who completed primary education had 35.9% odds of reduced malaria prevalence level among her children than a mother who did not complete primary education. This odd is statistically significant as indicated by a Confidence Interval that is less than 1, $CI_{0.95}$ = [.436, .944]. See Table 11. A mother who attained a high school degree or higher had 44.7% odds of reduced malaria prevalence level among her children than a mother who did not complete high school. This Odds is also statistically significant as indicated by the Confidence Interval in Table 11, $CI_{0.95}$ = [.360, .850].

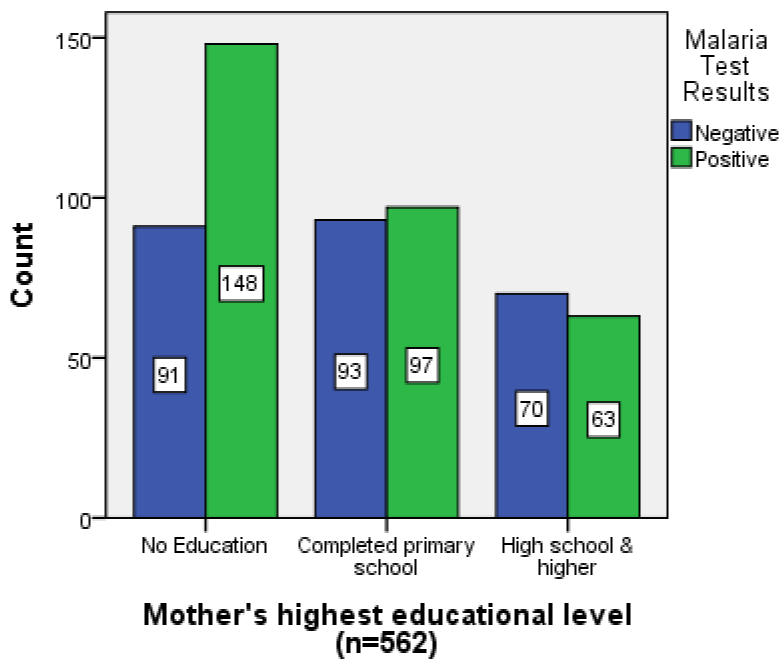

Figure 6. Relationship between Parental Education and Malaria Prevalence

Figure 6 shows the association between parental education and malaria prevalence among children. Children whose parents had no education experienced a higher malaria prevalence rate compared to children whose parents completed high school and higher. The results from the chi-square test as shown in Table 9 and Figure 6 support the alternate hypothesis that there is an association between parental education level and reduced malaria prevalence among children under the age of 5 years. As a result, the *null* hypothesis was rejected.

RQ3: Is there an association between parental economic status and the prevalence of malaria among children under 5 years old?

$H_0$3: There is no association between parental economic status and the prevalence of malaria among children under 5 years old.

H_a3: There is an association between parental economic status and the prevalence of malaria among children under 5 years old.

Relying on the same sample size n=562, a chi-square test for association was performed between parental economic status and malaria prevalence among children under the age of 5 years. All expected cell frequencies were greater than five. There is statistically significant association between parental economic status and malaria prevalence among children under the age of 5 years, $\chi^2(4) = 40.193$, $p < .01$. This is further shown by the measure of effect between parental economic status and malaria prevalence among children under the age of 5 years, $\varphi = 0.267$, $p < .01$. See Table 12.

Table 12

Chi-square Results for Parental economic status (wealth index) and Malaria prevalence

	Value	*P*
Pearson chi-square	40.193	<.01
df	4	
Cramer's V	0.267	

In this analysis, the data was closely examined using Odd ratios since the predictor variable (parental economic status) contains five categories and the relationship between the predictor variable and the response variable (malaria prevalence) was found to be statistically significant in the chi-square analysis. The categories of the predictor variable are ordered as follows: 1 = *Poorest*, 2 = *Poorer*, 3 = *Middle*, 4 = *Richer* and 5 =

Richest. A conventional technique where Odds ratios are considered relative to a fixed baseline category was applied. In the 2x5 contingency table shown in Table 13, the category 1 = *Poorest* was used as a baseline against which odds ratios of the other categories were considered.

Table 13

Contingency Table of Parental Economic Status and Malaria Prevalence

			Parental Economic Status (Wealth Index)					
			Poorest **(1)**	Poorer **(2)**	Middle **(3)**	Richer **(4)**	Richest **(5)**	Total
Rapid Malaria Test	Negative	Observed	71	68	43	37	35	254
		Expected	88.6	76.8	42.9	26.7	19.0	254.0
	Positive	Observed	125	102	52	22	7	308
		Expected	107.4	93.2	52.1	32.3	23.0	308.0
Total		Observed	196	170	95	59	42	562
		Expected	196.0	170.0	95.0	59.0	42.0	562.0

The Odds ratios computations in Table 14 show that the effect of parental economic status on malaria prevalence is captured through four effects – *Poorer, Middle, Richer,* and *Richest*.

Table 14

Odds Ratios against baseline category (1 = Poorest)

	Odds ratios	95% CI	
		Lower	Upper
Poorer (2) vs. Poorest (1)	.852	.558	1.301
Middle (3) vs. Poorest (1)	.687	.417	1.130
Richer (4) vs. Poorest (1)	.338	.185	.617
Richest (5) vs. Poorest (1)	.114	.048	.269

As shown in Table 14, a parent who falls in the wealth index category of *poorer* has 14.8% odds of reducing malaria prevalence level among her children than a parent who falls in the poorest wealth index category. This odd is not statistically significant as indicated by a Confidence Interval that is higher than 1, $CI_{0.95}$ = [.558, 1.301]. See Table 14. A parent who falls in the wealth index category of Middle has 31.3% odds of reducing malaria prevalence level among her children than a parent who falls in the poorest wealth index category. This odd is also not statistically significant as indicated by a Confidence Interval in Table 14, $CI_{0.95}$ = [.417, 1.130]. A parent who falls in the richer wealth index category has 66.2% odds of reducing malaria prevalence level among her children than a parent who falls in the poorest wealth index category. Similarly, a parent who falls in the richest wealth index category has 88.6% odds of reducing malaria prevalence level among her children than a parent who falls in the poorest wealth index category. The odds ratios in both the Richer and Richest wealth index categories are statistically significant, ($CI_{0.95}$ = [.185, .617], [.048, .269]).

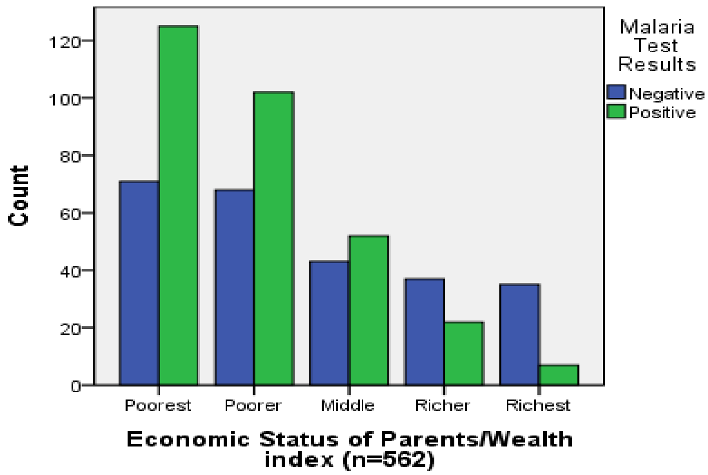

Figure 7. Relationship between Parental Economic Status and Malaria prevalence

As Figure 7 shows, children whose parents were considered poor as defined by wealth index in the LMIS data, had a higher malaria prevalence rate compared to children whose parents were considered richer. The results from this chi-square test as shown in Table 12 and Figure 7 support the alternate hypothesis that there is an association between parental economic status and reduced malaria prevalence among children under the age of 5 years. As a result, the *null* hypothesis was rejected.

RQ4: Among those who own an ITN, is there an association between ownership of structure (beds with posts or mattress that can anchor ITN) and the prevalence of malaria among children under 5 years old?

$H_0$4: There is no association between ownership of structure (beds/mattresses that can anchor ITN) and the prevalence of malaria among children under 5 years old. Let it be noted that 70% of participants with ITN also slept on mattresses or beds with posts that can anchor ITN, and 30% did not.

H_a4: There is an association between ownership of structure (beds with posts that can anchor ITN) and the prevalence of malaria among children under 5 years old.

In research question 4, the goal was to examine whether among those participants who own ITN in addition to a bed or mattress, a structure that supports the proper installation of ITNs, associated with reduced malaria prevalence among children under 5 years old. To address this research question, the dataset (n=562) was filtered to analyze only participants who owned ITN. This produced a sample size of n=328 with which a chi-square test for association was performed between ownership of structure (beds with posts or mattress that can anchor ITN) and malaria prevalence among children under the age of 5 years. All expected cell frequencies were greater than five. There was no statistically significant association between ownership of structure and malaria prevalence among children under the age of 5 years, $\chi^2(1) = 1.667$, $p = .28$, Odds = .770, CI0.95=[.479, 1.238]. This is further shown by the measure of effect between ownership of structure and malaria prevalence among children under the age of 5 years, $\varphi = -.060$, $p = .28$. See Table 15.

Table 15

Chi-square Results for ownership of structure and Malaria prevalence

	Value	P	95% CI	
			Lower	Upper
Pearson chi-square	1.667	.28		
df	1			
Phi	-.060			
Odds	.770		.479	1.238

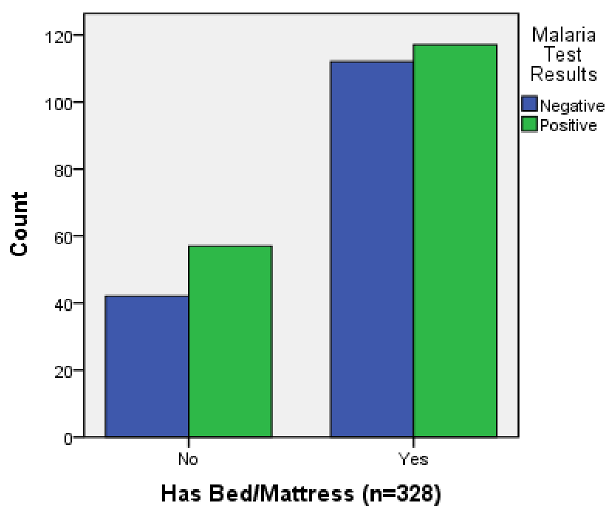

Figure 8. Relationship between Ownership of Structure (bed/mattress) and Malaria Prevalence

As Figure 8 shows, children who owned ITN in addition to a bed/mattress did not experience reduced malaria prevalence level when compared to children who owned ITN but did not own a bed/mattress. The results from this test as shown in Table 15 and Figure 8 support the null hypothesis that there is no association between ownership of structure (bed/mattress) and reduced malaria prevalence among children under the age of 5 years. As a result, we fail to reject the null hypothesis.

Logistic Regression Analysis

As stated previously, logistic regression was used to determine the effects of ITN ownership, parental education, parental economic status, and ownership of structure (bed/mattress) on the likelihood that there would be reduced malaria prevalence among children under the age of 5 years. The regression analysis was conducted for predictor variables in pairs and as a whole.

In the first model, the first predictor, ITN_OWN (ITN ownership) was used. The first logistic regression model was not statistically significant, $\chi^2(1) = .981$, $p = .322$. The model could only explain 0.2% (Nagelkerke R2) of the variance in malaria prevalence among children under the age of 5 years and correctly classify 54.8% of cases. This result is also supported by the Wald statistics which showed that ITN_OWN (Wald = .979, p = .322) do not statistically predict malaria prevalence among children under 5 years old (as shown in Table 16).

Table 16

Logistic Regression predicting likelihood of Malaria prevalence based on ITN ownership

	B	S.E	Wald	*df*	p	Odds Ratio	95% CI for odds Ratio	
							Lower	Upper
ITN_OWN	.170	.179	.979	1	.322	1.186	.846	1.663
Constant	.122	.111	12.18	1	.270	1.130		

In the correlation test performed with chi-square, the results showed that the association between ITN ownership and malaria prevalence was not statistically significant. The chi-square test results appear to align with the regression test results shown in Table 16. However, given the extent to which these results contradict previous results, an additional logistic regression analysis was performed on ITN_OWN (ITN Ownership) that controlled for two confounding factors. The two confounders are parental education level (PARENTAL_KNOW) and ownership of structure (STRUC_BED).

In the model to control the two confounding variables, the model was statistically significant, $\chi^2(2) = 12.311$, $p < .05$. The model could explain only 2.9% (Nagelkerke R2) of the variance in malaria prevalence among children under the age of 5 years and correctly classify 56.6% of cases. As shown in Table 17, both confounding variables could statistically predict malaria prevalence.

Table 17

Logistic Regression predicting likelihood of Malaria prevalence based on Parental education and Ownership of structure

	B	S.E	Wald	*df*	p	Odds Ratio	95% CI for odds Ratio	
							Lower	Upper
PARENTAL_KNOW	**-.282**	**.109**	**6.655**	**1**	**.010**	**.755**	**.609**	**.935**
STRUC_BED	**-.365**	**.183**	**3.964**	**1**	**.046**	**.694**	**.485**	**.994**
Constant	.666	.167	15.880	1	.000	1.946		

When ITN ownership (ITN_OWN) was analyzed with the confounding variables, the model was statistically significant, $\chi^2(3) = 13.071$, $p < .001$. The model could explain only 3.1% (Nagelkerke R2) of the variance in malaria prevalence among children under the age of 5 years and correctly classify 56.6% of cases. Of the main variable (ITN_OWN) and its confounders (PARENTAL_KNOW and STRUC_BED), only PARENTAL_KNOW could statistically predict malaria prevalence, $\chi^2(3) = 13.071$, $p < .001$, Odds = .751, $CI_{0.95}$= [.606, .931] (as shown in Table 18).

Table 18

Logistic Regression predicting likelihood of Malaria prevalence based on ITN ownership, Parental education, and Ownership of bed/mattress

	B	S.E	Wald	*df*	p	Odds Ratio	95% CI for odds Ratio	
							Lower	Upper
PARENTAL_KNOW	**-.286**	**.109**	**6.843**	**1**	**.009**	**.751**	**.606**	**.931**
STRUC_BED	-.348	.184	3.561	1	.059	.706	.492	1.014
ITN_OWN	-.153	.175	.759	1	.384	.858	.609	1.210
Constant	.748	.192	15.106	1	.000	2.112		

In the fourth model, the second predictor, PARENTAL_KNOW (parental education level) was used. The logistic regression model was statistically significant, $\chi^2(1) = 8.316$, p = .004, Odds = .733, $CI_{0.95}$= [.594, .906]. The model could only explain 2% (Nagelkerke R2) of the variance in malaria prevalence among children under the age of 5 years and correctly classify 56.0% of cases. This result is also supported by the Wald statistics which showed that PARENTAL_KNOW (Wald = 8.214, p = .004) did statistically predict malaria prevalence among children under 5 years old (as shown in Table 19).

Table 19

Logistic Regression predicting likelihood of Malaria prevalence based on parental education

	B	S.E	Wald	*df*	p	Odds Ratio	95% CI for odds Ratio	
							Lower	Upper
PARENTAL_KNOW	-.310	.108	8.234	1	.004	.733	.594	.906
Constant	.447	.123	13.085	1	.000	1.563		

The fifth model included all predictors as a whole. The model was statistically significant, $\chi^2(4) = 38.073$, $p < .001$. The model explained 8.8% (Nagelkerke R2) of the variance in malaria prevalence among children under the age of 5 years and correctly classified 60.1% of cases. Sensitivity was 76.3%, and specificity was 40.6%. Like the third model, WEALTH_INDEX (Parental economic status) was the only predictor that was statistically significant, χ^2 (4) = 38.073, $p < .001$, Odds = .659, $CI_{0.95}$= [.557, .780] (as shown in Table 20). In other words, only parental economic status predicted the likelihood of reduced malaria prevalence among children when all the predictors were analyzed together.

Table 20

Logistic Regression predicting likelihood of Malaria prevalence based on ITN ownership, Parental education, Ownership of bed/mattress, and Economic status.

	B	S.E	Wald	*df*	p	Odds Ratio	95% CI for odds Ratio	
							Lower	Upper
ITN_OWN	.170	.179	.869	1	.344	1.185	.834	1.684
PARENTAL_KNOW	-.150	.115	1.703	1	.192	.861	.687	1.078
BED_STRUC	-.149	.213	.490	1	.484	.862	.568	1.307
WEALTH_INDEX	**-.417**	**.086**	**23.614**	**1**	**.000**	**.659**	**.557**	**.780**
Constant	1.240	.260	22.829	1	.000	3.456		

Summary

In this chapter, results from the analysis of secondary data from the 2011 Liberia Malaria Indicator survey were presented. Chi-square for Association and Logistic Regression were the two statistical tests used to derive the following results: a) in RQ1, there was no statistically significant association between ITN ownership and malaria prevalence among children under the age of 5 years after controlling for two confounding variables; b) in RQ2, there was a statistically significant association between parental education level or knowledge and malaria prevalence among children under the age of 5 years; c) in RQ 3, there was a statistically significant association between parental economic status and malaria prevalence among children under the age of 5 years; and d) in RQ4, there was no statistically significant association between ownership of structure and malaria prevalence among children under the age of 5 years. In a test to predict the likelihood of malaria prevalence based on the four independent variables (ITN ownership, parental education/knowledge, ownership of bed/mattress, and parental economic status), only one independent variable (parental economic status) was statistically significant.

In the next and final chapter, the interpretation of the results from the analysis conducted in this chapter will be discussed in light of the research questions. The limitations of this study, recommendations for future study, and implications in terms of positive social change will also be discussed.

Chapter 5: Discussions, Conclusions, and Recommendations

Introduction

The purpose of this quantitative study was to analyze whether the use of ITNs is an effective strategy in reducing malaria prevalence among children under the age of 5 years in Liberia. This study was a cross-sectional design that relied on secondary data from the 2011 LMIS conducted jointly by the Ministry of Health and Social Welfare of Liberia, the LISGIS, and ICF International. The 2011 LMIS survey was sponsored by USAID as part of the Demography and Health Survey Program.

Liberia is a sub-Saharan African nation that is considered malaria hyper-holoendemic (NMCP, 2011). More than 34.6% of hospital out-patient visits and 41% of in-patient deaths were attributed to malaria (NMCP, 2011). Children under the age of 5 years accounted for 19.5% (677,889; WHO, 2013) of the country's population but bear a disproportionate level of the malaria burden (John Hopkins Malaria Institute, 2015; WHO, 2015). Malaria prevalence among children under 5 years of age is estimated at 32% (NMCP, 2011), and a Murray et al. (2012) study estimated that eight children under the age of 5 years die each day as a result of malaria. Since 2006, the primary malaria prevention strategy has centered on the distribution and use of ITNs.

According to the 2011 LMIS, 50% of all households in Liberia own at least one ITN, and only 37% of children under the age of 5 years slept under an ITN the night prior to the survey (NMCP, 2011). In 2007, 655,860 ITNs were distributed to households with children, 1,221,700 ITNs distributed in 2009 and 883,400 ITNs distributed in 2010 (WHO, 2014c). In 2012, 1,185,780 ITNs were distributed to households with children

(MOHSW, 2012). With such moderate to high level of ITN ownership among Liberian households, the corresponding statistics on malaria deaths among children is alarmingly high.

Since the reintroduction of the distribution of ITNs in Liberia in 2006 following 14 years of civil conflict, this is the first study in the post conflict nation to analyze the effectiveness of ITNs in controlling malaria among children based on the following social attributes: ITN ownership, parental education/knowledge, parental economic status, and ownership of structure (sleeping bed/mattress).

A sample of 562 participants from the 2011 LMIS was analyzed using chi-square for association and logistic regression to address the following four research questions:

RQ1: Is there an association between ITN ownership and malaria prevalence among children under 5 years old?

RQ2: Is there an association between parental education and the prevalence of malaria among children under 5 years old?

RQ3: Is there an association between the economic status of parents and the prevalence of malaria among children under 5 years old?

RQ4: Among those who own an ITN, is there an association between ownership of structure (beds with posts or mattress that can anchor ITN) and the prevalence of malaria among children under 5 years old?

A summary of the findings from the data analysis is as follows: (a) the association between ITN ownership and reduced malaria prevalence among children was not statistically significant, (b) the association between parental education and reduced malaria prevalence among children was statistically significant, (c) the association between parental economic status and reduced malaria prevalence among children was statistically significant, and (d) the association between those who own an ITN in addition to bed/mattress and reduced malaria prevalence among children was not statistically significant. The interpretation of these findings is presented in the next section.

Interpretation of Findings

The first findings on malaria prevalence among children in Liberia who are younger than 5 years relate to the following question: Is there an association between ITN ownership and reduced malaria prevalence among children under 5 years old? In both the crude and adjusted analyses, the results revealed that children who own an ITN are not less likely to contract malaria than children who do not own an ITN. This finding is similar to an evidence-based assessment of the efficacy of ITNs in controlling malaria conducted by Fullman et al. (2013). The Fullman et al. study is part of a growing body of literature that suggests that malaria vectors are becoming resistant to the chemicals (deltamethrin, pyrethrins, and pyrethroids) used in the construction of ITNs. In the Fullman et al. study, the effectiveness of the combination of two intervention strategies–ITNs and indoor residual spraying (IRS)–and the effectiveness of a single strategy–ITNs or IRS, were assessed. The study was conducted among children less than 5 years old in 17 Sub-Saharan African countries. The study revealed a significant protection against malaria infection when a combined intervention was used compared to a single intervention (ITN or IRS). This does not mean that ITNs do not provide protection against malaria. On the contrary, there are results from other studies that link reduced malaria prevalence to ITN use (Eisele et al., 2010; Strode et al., 2014; Tokponnon et al., 2014). One factor that could have contributed to the current findings may be the fact that heads of household or older age groups tend to allocate ITNs to themselves, sleeping under the bed net (Graves et al., 2011) as an honor according to cultural tradition, leaving children who are most vulnerable to sleep on mats on the floor without bed nets, thus exposing children to mosquito bites. This is especially common when there are too fewer ITNs in the household (Lam et al., 2014). Another factor that may contribute to this finding is revealed in studies that show that while households may own ITNs, they do not necessarily know how to properly use them (Esimai, & Aluko, 2014; Kyu et al., 2013; Ordinioha, 2012).

To further understand the impact of ITN use on malaria prevalence among children, the role of parental education was explored with the following question: Is there an association between parental education and the prevalence of malaria among children under 5 years old? The results revealed that the higher the educational level of the parent, the more likely there will be a reduced prevalence of malaria among their children. The odds were even greater the higher the education the parent attained. This finding aligns with numerous other studies linking parental education and knowledge to reduced malaria prevalence among children (Esimai & Aluko, 2014; Ezire et al., 2015; Sichande et al., 2014). In the Sichande et al. (2014) study that was conducted in the sub-Saharan country of Zambia, education was an influencing factor in health seeking behaviors. Children whose parents had attained education beyond secondary school were

1.7 times more likely to use ITNs as a protection against malaria compared to children whose parents did not go to school or attained primary education (Sichande et al., 2014).

Additional findings on malaria prevalence among children were derived with the following question: Is there an association between the economic status of parents and the prevalence of malaria among children under 5 years old? The results revealed that the higher the economic status of the parent, the more likely there will be a reduced prevalence of malaria among their children. This means children whose parents are wealthy may have other means of malaria prevention. Other malaria control methods available to children of wealthy parents may include better treatment options, better housing, and living in communities with higher socioeconomic status (Houngbedji et al., 2015), and thus better houses with little or no exposure to malaria infected mosquitoes. This finding aligns with numerous research studies that showed that the heaviest malaria burdens are borne by the poorest regions of the world particularly in sub-Saharan Africa (de Castro & Fisher, 2012; Krefis et al., 2010; Ricci, 2012; Sonko et al., 2014). In Liberia, for example, 83.8% of the population has a poverty headcount ratio of $1.25 a day (Purchasing Power Parity; UNDP, 2014). Though ITNs are distributed free of charge to the population by nonprofit international organizations, unfortunately, community health workers sell the ITN to villagers (Tuba, Sandoy, Bloch, & Byskov, 2010), thereby limiting ITN ownership to those who can afford it. This undermines the widespread use of ITNs by the majority of the population, enough to achieve herd immunity and thus protect the very few who do not sleep under an ITN. In Liberia, for example, people in poor communities to whom ITNs are distributed free of charge are selling them to purchase other items such as food (Genoway, 2015).

In addition, most Liberians in the rural parts of the country live far away from health facilities or ITN distribution points (NMCP, 2011). The physical demand of walking 2 to 3 hours to the nearest health center to receive an ITN is a cost barrier. In a study by Larson et al. (2012) conducted in the sub-Saharan country of Malawi on the influence of distance on ITN ownership, the researchers found that people living closest to ITN distribution points or health facilities were most likely to have an ITN compared to people who live far away from ITN distribution points. These findings also apply to Liberia where fewer health facilities and ITN distribution points were largely far away from the communities they serve (NMCP, 2011).

To understand whether the proper installation of ITN had an impact on malaria prevalence, this final question was examined: Among those who own an ITN, is there an association between ownership of structure (beds with posts or mattress that can anchor ITN) and the prevalence of malaria among children under 5 years old? In both the crude and adjusted analyses, the results revealed that children who owned an ITN and also own a bed or mattress was not less likely to contract malaria than children who owned an ITN but did own a bed or mattress.

A predictive likelihood of malaria prevalence based on the independent variables (ITN ownership, parental education/knowledge, ownership of bed/mattress, and economic status) was also conducted. The results revealed that of the four predictors as a whole, only parental economic status significantly predicted malaria prevalence among children.

Findings in Relation to the Health Belief Model (HBM)

This study was based on the HBM. This theory was developed by Irwin Rosenstock, Godfrey Hochbaum, and Stephen Kegels in the 1950s to explain and predict health behaviors (Glanz et al., 2008). Perceived benefit, perceived susceptibility, and perceived barrier are the three HBM constructs that are relevant to this study.

Perceived benefit refers to the benefits of avoiding a disease threat (Glanz et al, 2008). It is the belief that any measure recommended to prevent or reduce a disease threat can actually prevent or reduce the disease threat (Glanz et al, 2008). ITNs may provide the ability to avoid a disease threat. However, the inadaptability of ITNs in all environments where children play and sleep challenges their benefits. For example, ITNs are only useful and most effective in the bedroom during bed time. They cannot be used outdoors when children and families are more likely to be exposed to malaria vectors (Sangaré et al., 2012). This may explain the chi-square results that revealed that there is no statistically significant association between ITN ownership and malaria prevalence among children in Liberia.

Perceived susceptibility refers to the vulnerability to a disease threat that one feels (Glanz et al, 2008). Such feeling of vulnerability to a disease threat allows a person to take the necessary preventive actions. The motherly instinct to protect one's child from illnesses and disease threats appear to support the perceived susceptibility construct of HBM. According to the 2011 LMIS, 90% of parents were aware that the malaria disease can be prevented, and 75% identified ITNs as a means of protection against malaria (NMCP, 2011).

Perceived barrier refers to the cost involved when one undergoes prevention practices such as the ownership of an ITN (Glanz et al, 2008). These costs are both tangible and psychological. For example, rural villages in Liberia are isolated and far removed from health centers that distribute ITNs (NMCP, 2011). The physical demands of walking about 2 to 3 hours to the nearest health center to obtain an ITN present an obvious barrier. Requirements for the proper setup of an ITN present another barrier. For instance, beds with posts or mattresses provide a grounding anchor for ITNs (Sangaré et al., 2012). Rural families who cannot afford beds or mattresses but are accustomed to using floor mats as beds may stay away from using ITNs (Sangaré et al., 2012). High economic status can overcome these perceived barriers. Results in this study revealed that there is an association between the economic status of parents and malaria prevalence among children. The results also revealed that the economic status of parents can be used to predict the likelihood of malaria prevalence among children.

Limitations of the Study

In this study, I used secondary data to analyze the association between the independent and dependent variables. As such, the limitations incumbent in using secondary data do apply to this study: (a) The purpose and collection method of the original data was not influenced by the current research topic; as a result, some data were incomplete or missing for the current research topic, and (b) the format of the dataset–scale of measurement and label categories–differed from the format suitable for this study. Additional data manipulation was required that could lead to errors and can jeopardize the validity of the study results. To mitigate this threat, extra care was taken by using a scientifically-proven method such as dropping the four cases that contained missing data.

This analysis was conducted using survey data that was collected in 2011. The current circumstances regarding the malaria status of children may have changed since the survey was conducted. As a result, the findings in this study may be slightly different from the current malaria status among children in Liberia.

In assessing the independent variable, ownership of structure, the data indicated that 70% of participants with an ITN also slept on mattresses or beds that can anchor an ITN, while 30% of participants did not sleep on mattresses. It is possible that the 30% of participants who did not have beds or mattresses used other resources or means to properly anchor their nets. Those resources or means were not investigated in this study.

In this study, I did not seek cause and effect outcome, but rather an association between variables. Therefore, internal validity and its threats were not examined. However, 562 samples were analyzed, a sample size that was large enough to mitigate threats to external validity.

Finally, the focus of this study and the data used are specific to the malaria epidemic in Liberia. Though most countries in sub-Sahara Africa face similar malaria crises, the results cannot be generalized to other malaria endemic countries.

Recommendations

This study used a quantitative methodology to examine the association between owning ITN and malaria prevalence. The results revealed that the association was not statistically significant. Parental education/knowledge, parental economic status, and ownership of structure (bed/mattress) were also examined. There are other factors that pose a challenge to the effectiveness of ITNs in controlling malaria among children. Further research is needed to examine those other factors in the context of the results of the present study. It is also recommended that government focuses on literacy training that will build the economic capacity of the population. As this study results revealed, parental education and economic status are associated with malaria prevalence.

Most countries that have managed to eliminate malaria as a public health concern did not do so relying on ITN alone. Mosquito larvae elimination, indoor and outdoor insecticide praying, massive education and awareness, and economic capacity building were part of a comprehensive strategy used to eliminate malaria in countries like Morocco, Turkmenistan, the United States, and Ecuador (WHO, 2012; CDC, 2010; Pinault & Hunter, 2012). Thus, an integrated approach with a comprehensive strategy to address the malaria situation in Liberia is recommended.

Implications for Social Change

The results from this study suggest that using ITN alone as a primary malaria control strategy may not be as effective. The study results may assist in fostering social change by helping policymakers and public health authorities in Liberia integrate the use of ITN as part of a comprehensive approach to malaria control and not the primary approach. Massive community awareness and economic capacity building can empower malaria endemic communities with the understanding that the disease can be rapidly reduced with other robust strategies other than the sole reliance on ITNs. Malaria has been shown to have a direct association with poverty, as elegantly demonstrated by Gallup and Sachs (2001). The poor in Liberia and the rest of sub-Saharan Africa bear the brunt of the malaria burden (de Castro & Fisher, 2012; Krefis et al., 2010; Ricci, 2012; Sonko et al., 2014; UNDP, 2014). There is evidence that sub-Saharan African countries affected by the malaria endemic lost billions of dollars annually due to lost productivity and expenditures on malaria treatment (World Bank, 2013a). A comprehensive malaria control regime can promote positive social change by focusing on improving the quality of life of the poorest, poverty reduction, and investment in other social development initiatives such as housing, sanitation, roads, and schools. These strategies, if implemented, will relieve the emotional and financial burdens of families often affected by malaria and its fatal consequences. It will also enable policymakers and public health authorities in Liberia to prudently allocate limited resources to other pressing health concerns.

Conclusion

Growing up in Liberia, there has never a time where malaria was not considered a public health challenge. Malaria was a common disease in my household and in the community. We slept under bed nets to prevent mosquito bites. Forty years later, children in most Liberian communities still sleep under ITNs. The malaria disease that we attempted to prevent by sleeping under ITNs still remains alarmingly high to the extent that it kills an estimated eight children under the age of 5 years each day in Liberia (Murray et al., 2012). In this study, the effectiveness of ITN in controlling malaria among children in Liberia was analyzed. The findings of this study revealed that ITN ownership did not lead to reduced malaria prevalence among children. This finding highlights the disparity between ITN ownership and actual use of ITN in a proper manner, or allowing vulnerable children under 5 to actually sleep under ITN for protection, instead of heads of households The fact that in many research studies, mosquitoes are becoming resistant to the chemicals used in ITN (Temu et al., 2012; Tokponnon et al., 2014), changing their feeding habits (Sougoufara et al., 2014), and ITNs are being sold by people in poor communities to buy much needed items such as food (Genoway, 2015), could be contributing factors to these findings.

As this study results also revealed, parental education and economic status are associated with malaria prevalence. It is therefore important for the government's malaria control strategy to focus on literacy training that will build the economic capacity of the population.

The sole reliance on ITN use as a primary malaria control strategy is to wave a flag of surrender and accept that humans and insects will coexist in the private space of humans. Most countries that have managed to eliminate malaria as a public health concern did not do so relying on ITN alone. Larvae elimination, ITN use, indoor and outdoor insecticide spraying, massive education and awareness, and economic capacity building were part of a comprehensive strategy used to eliminate malaria in Morocco, Turkmenistan, the United States, and Ecuador (CDC, 2010; Pinault & Hunter, 2012;

WHO, 2012). In the United States, for example, the use of the chemical DDT was an effective insecticide for the eradication of malaria in the southern United States (CDC, 2010). The chemical was banned in the United States in 1972 and other parts of the world due to its purported impact on the ecosystem, without an effective alternative to control mosquitoes in the highly malaria endemic countries of sub-Saharan Africa, thus derailing the WHO Malaria Eradication efforts in those parts of the world. However, with restricted use, Stockholm Convention and the WHO in 2011 granted exemption for the production of DDT for public health use indoor applications (WHO, 2011). Similar strategy used to eliminate malaria in developed countries must be adopted to effectively combat and control malaria in Liberia, and indeed in the entire sub-Saharan Africa, where the greatest burden of Malaria still remains today.

References

American Psychological Association. (2015). Work, stress, and health & socioeconomic status. Retrieved from http://www.apa.org/pi/ses/resources/publications/factsheet-wsh.aspx

Baden, J., & Moss, C. (2014, August 20). Ebola is not God's wrath. *Slate*. Retrieved from http://www.slate.com

Banek, K., Kilian, A., & Allan, R. (2010). Evaluation of Interceptor long-lasting insecticidal nets in eight communities in Liberia. *Malaria Journal*, 9, 84. doi:10.1186/1475-2875-9-84

Blagoveschensky, D., Bregetova, N., & Monchadsky, A. (1945). An investigation of new repellants for the protection of man against mosquito attacks. *Transactions of the Royal Society of Tropical Medicine and Hygiene, 34*, 147-150.

Centers for Disease Control and Prevention. (2012). Malaria treatment. Retrieved from http://www.cdc.gov/malaria/diagnosis_treatment/treatment.html

Challoner, K. R., & Forget, N. (2011). Effect of civil war on medical education in Liberia. *International Journal of Emergency Medicine*, 4, 6. doi:10.1186/1865-1380-4-6

Chareonviriyaphap, T., Bangs, M. J., Suwonkerd, W., Kongmee, M., Corbel, V., & Ngoen-Klan, R. (2013). Review of insecticide resistance and behavioral avoidance of vectors of human diseases in Thailand. *Parasites & Vectors*, 6, 280. Doi:10.1186/1756-3305-6-280

Checchi, F., Durand, R., Balkan, S., Vonhm, B. T., Kollie, J. Z., Biberson, P., … Guthmann, J. P.(2002). High plasmodium falciparum resistance to chloroquine and sulfadoxine-pyrimethamine in Harper, Liberia: Results in vivo and analysis of point mutations. Transactions *of the Royal Society of Tropical Medicine & Hygiene*, 96 (6), 664-669. doi:10.1016/S0035-9203(02)90346-9

Chen, L. Y. (2014). Does Plasmodium falciparum have an Achilles' heel? *Malaria Chemotherapy, Control & Elimination*, *3*(1), 114. doi:10.4172/2090-2778.1000114

Cheng, H. G., & Phillips, M. R. (2014). Secondary analysis of existing data: opportunities and implementation. *Shanghai Archives of Psychiatry*, *26*(6), 371–375. doi:10.11919/j.issn.1002-0829.214171

Cox, F. (2010). History of the discovery of the malaria parasites and their vectors. *Parasites & Vectors*, 3,5. doi:10.1186/1756-3305-3-5

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (Laureate Education, Inc., custom ed.). Thousand Oaks, CA: Sage Publications.

De Castro, M. C., & Fisher, M. G. (2012). Is malaria illness among young children a cause or a consequence of low socioeconomic status? Evidence from the United Republic of Tanzania. *Malaria Journal*, 11, 161. Doi:10.1186/1475-2875-11-161

Demographics and Heath Survey Program. (n.d.). Liberia: Malaria Indicator Survey (MIS), 2011. Retrieved from http://www.dhsprogram.com/what-we-do/survey/survey-display-361.cfm

Eisele, T. P., Larsen, D., & Steketee, R. W. (2010). Protective efficacy of interventions for preventing malaria mortality in children in plasmodium falciparum endemic areas. *International Journal of Epidemiology*, *39*(Suppl 1), i88–i101. doi:10.1093/ije/dyq026

Esimai, O., & Aluko, O. (2014). Determinants of use of insecticide treated bednets among caregivers of under five children in an urban local government area of Osun state, South-Western Nigeria. *Global Journal of Health Science,* 7 (2): 20-7. doi:10.5539/gjhs.v7n2p20

Ezire, O., Adebayo, S. B., Idogho, O., Bamgboye, E. A., & Nwokolo, E. (2015). Determinants of use of insecticide-treated nets among pregnant women in Nigeria. *International Journal of Women's Health*, *7*, 655–661. doi:10.2147/IJWH.S77807

Fink, A. (2010). *Conducting research literature review from the internet to paper* (3rd ed.). Thousand Oaks, CA: Sage.

Frankfort-Nachmias, C., & Nachmias, D. (2008). *Research methods in the social sciences* (7th ed.). New York, NY: Worth.

Fullman, N., Burstein, R., Lim, S. S., Medlin, C., & Gakidou, E. (2013). Nets, spray or both? The effectiveness of insecticide-treated nets and indoor residual spraying in reducing malaria morbidity and child mortality in sub-Saharan Africa. *Malaria Journal*, *12*, 62. doi:10.1186/1475-2875-12-62

Gallup, J. L., & Sachs, J. D. (2001). The economic burden of malaria. *American Journal of Tropical Medicine and Hygiene,* 64(1), 85-96. Retrieved from http://www.ajtmh.org/content/64/1_suppl/85.full.pdf+html

Genoway, E. (2015, May 24). Donated mosquito nets peddling in the streets of Monrovia. Frontpageafricaonline. Retrieved from http://www.frontpageafricaonline.com

Glanz, K., Rimer, B. K., & Lewis, F.M. (2002). *Health behavior and health education. Theory, research and practice.* San Francisco, CA: Wiley & Sons.

Glanz, K., Rimer, B., & Viswanath, K. (2008). *Health behavior and health education – Theory, research, and practice* (Fourth Edition). San Francisco, CA: John Wiley & Sons, Inc.

Govoetchan, R., Gnanguenon, V., Ogouwalé, E., Oké-Agbo, F., Azondékon, R., Sovi, A., … Akogbéto, M. (2014). Dry season refugia for anopheline larvae and mapping of the seasonal distribution in mosquito larval habitats in Kandi, northeastern Benin. *Parasites & Vectors*, 7, 137. doi:10.1186/1756-3305-7-137

Graves, P. M., Ngondi, J. M., Hwang, J., Getachew, A., Gebre, T., Mosher, A. W., … Richards, F. O. (2011). Factors associated with mosquito net use by individuals in households owning nets in Ethiopia. *Malaria Journal*, *10*, 354. doi:10.1186/1475-2875-10-354

Griffin, J., Hollingsworth, D., Okell, L., Churcher, T., White, M., Hinsley, W., …Ghani, A. (2010). Reducing Plasmodium falciparum malaria transmission in Africa: A model-based evaluation of intervention strategies. PLoS Medicine 7(8): e1000324. doi:10.1371/journal.pmed.1000324

Houngbedji, C. A., N'Dri, P. B., Hürlimann, E., Yapi, R. B., Silué, K. D., Soro, G., … Raso, G. (2015). Disparities of *Plasmodium falciparum* infection, malaria-related morbidity and access to malaria prevention and treatment among school-aged children: a national cross-sectional survey in Côte d'Ivoire. *Malaria Journal*, *14*, 7. doi:10.1186/1475-2875-14-7

Institute of Medicine. (2004). *Saving lives, buying time: Economics of malaria drugs in an age of resistance*. Washington, D.C: The National Academies Press, doi:10.17226/11017

Jones, C. M., Sanou, A., Guelbeogo, W. M., Sagnon, N., Johnson, P. C., & Ranson, H. (2012). Aging partially restores the efficacy of malaria vector control in insecticide-resistant populations of *Anopheles gambiae s.l.* from Burkina Faso. *Malaria Journal*, *11*, 24. doi:10.1186/1475-2875-11-24

Kamareddine, L. (2012). The biological control of the malaria vector. *Toxins*, *4*(9), 748–767. doi:10.3390/toxins4090748

Kariuki, S. K., Njunge, J., Muia, A., Muluvi, G., Gatei, W., ter Kuile, F., … Shi, Y. P. (2013). Effect of malaria transmission reduction by insecticide-treated bed nets (ITNs) on the genetic diversity of *Plasmodium falciparum* merozoite surface protein (MSP-1) and circumsporozoite (CSP) in western Kenya. *Malaria Journal*, *12*, 295. doi:10.1186/1475-2875-12-295

Koenker, H. M., Loll, D., Rweyemamu, D., & Ali, A. S. (2013). A good night's sleep and the habit of net use: perceptions of risk and reasons for bed net use in Bukoba and Zanzibar. *Malaria Journal*, *12*, 203. doi:10.1186/1475-2875-12-203

Kitchen, L. W., Lawrence, K. L. & Coleman, R. E. (2009). The role of the United States military in the development of vector control products, including insect repellents, insecticides, and bed nets. *Journal of Vector Ecology*, 34: 50–61. doi:10.1111/j.1948-7134.2009.00007.x

Krefis, A. C., Schwarz, N. G., Nkrumah, B., Acquah, S., Loag, W., Sarpong, N., … May, J. (2010). Principal component analysis of socioeconomic factors and their association with malaria in children from the Ashanti Region, Ghana.*Malaria Journal*, *9*, 201. doi:10.1186/1475-2875-9-201

Kyu, H. H., Georgiades, K., Shannon, H. S., & Boyle, M. H. (2013). Evaluation of the association between long-lasting insecticidal nets mass distribution campaigns and child malaria in Nigeria. *Malaria Journal*, 12, 14. doi:10.1186/1475-2875-12-14

Lam, Y., Harvey, S., Monroe, A., Muhangi, D., Loll, D., Kabali, A., & Weber, R. (2014). Decision-making on intra-household allocation of bed nets in Uganda: do households prioritize the most vulnerable members? *Malaria Journal*, 13, 183. doi:10.1186/1475-2875-13-183

Langkamp, D. L., Lehman, A., & Lemeshow, S. (2010). Techniques for handling missing data in secondary analyses of large surveys. *Academic Pediatrics*, 10(3), 205–210. doi:10.1016/j.acap.2010.01.005

Larson, P. S., Mathanga, D. P., Campbell, C. H., & Wilson, M. L. (2012). Distance to health services influences insecticide-treated net possession and use among six to

59 month-old children in Malawi. *Malaria Journal*, 11, 18. doi:10.1186/1475-2875-11-18

Liberia Institute of Statistics and geo-Information Services. (2009). *2008 Population and housing census final results*. Retrieved from http://www.emansion.gov.lr/doc/Population_by_County.pdf

Loll, D. K., Berthe, S., Faye, S. L., Wone, I., Arnold, B., Koenker, H., … Weber, R. (2014). “You need to take care of it like you take care of your soul”: perceptions and behaviours related to mosquito net damage, care, and repair in Senegal. *Malaria Journal*, 13, 322. doi:10.1186/1475-2875-13-322

McDonald, J.H. 2014. Handbook of Biological Statistics (3rd ed.). Sparky House Publishing, Baltimore, Maryland.

Minakawa, N., Dida, G. O., Sonye, G. O., Futami, K., & Kaneko, S. (2008). Unforeseen misuses of bed nets in fishing villages along Lake Victoria. *Malaria Journal*, 7, 165. doi:10.1186/1475-2875-7-165

Ministry of Health and Social Welfare. (2012). *Ministry of Health and Social Welfare 2012, annual report*. Retrieved from http://www.mohsw.gov.lr/documents/MOHSW%20Annual%20Report_2012_2.pdf

Murray, C.J.L., Rosenfeld, L.C., Lim, S.S., Andrews, K.G., Foreman, K.J., Haring, D.H., … Lopez, A.D. (2012). Global malaria mortality between 1980 and 2010: a systematic analysis. *The Lancet,* 379, 9814. doi:10.1016/S0140-6736(12)60034-8

National Institutes of Health. (2012). Life cycle of the malaria parasite. Retrieved from http://www.niaid.nih.gov/topics/malaria/pages/lifecycle.aspx

National Malaria Control Program [Liberia], Ministry of Health and Social Welfare, Liberia Institute of Statistics and Geo-Information Services, and ICF International. (2012). Liberia Malaria Indicator Survey 2011. Monrovia, Liberia: NMCP, LISGIS, and ICF International

Nilsson, S. K., Childs, L. M., Buckee, C., & Marti, M. (2015). Targeting human transmission biology for malaria elimination. *PLoS Pathogens*, *11*(6), e1004871. doi:10.1371/journal.ppat.1004871

Ricci, F. (2012). Social implications of malaria and their relationships with poverty. *Mediterranean Journal of Hematology and Infectious Diseases*, *4*(1), e2012048. doi:10.4084/MJHID.2012.048

Roll back Malaria Partnership. (2011). *Progress and impact series: A decade of partnership and progress*. Retrieved from http://data.unicef.org/corecode/uploads/document6/uploaded_pdfs/corecode/Malaria_report8-Eng_48.pdf

RTI International. (2012). *LIBERIA: National policy and strategic plan on integrated vector management*. Retrieved from http://pdf.usaid.gov/pdf_docs/PA00J21W.pdf

Sangaré, L. R., Weiss, N. S., Brentlinger, P. E., Richardson, B. A., Staedke, S. G., Kiwuwa, M. S., & Stergachis, A. (2012). Determinants of use of insecticide treated nets for the prevention of malaria in pregnancy: Jinja, Uganda. *PLoS ONE*, *7*(6), e39712. doi:10.1371/journal.pone.0039712

Sichande, M., Michelo, C., Halwindi, H., & Miller, J. (2014). Education attainment of head of households associated with insecticide-treated net utilization among five to nineteen-year old individuals: evidence from the malaria indicator survey 2010 in Zambia. *Malaria Journal*, *13*, 378. doi:10.1186/1475-2875-13-378

Smith, A. K., Ayanian, J. Z., Covinsky, K. E., Landon, B. E., McCarthy, E. P., Wee, C. C., & Steinman, M. A. (2011). Conducting high-value secondary dataset analysis: An introductory guide and resources. *Journal of General Internal Medicine*, *26*(8), 920–929. doi:10.1007/s11606-010-1621-5

Sonko, S. T., Jaiteh, M., Jafali, J., Jarju, L. B., D'Alessandro, U., Camara, A., … Saho, A. (2014). Does socio-economic status explain the differentials in malaria parasite prevalence? Evidence from The Gambia. *Malaria Journal*, *13*, 449. doi:10.1186/1475-2875-13-449

Sougoufara, S., Diédhiou, S.M., Doucouré, S., Diagne, N., Sembène, P., Harry, M., … Ndiath, M.O. (2014). Biting by anopheles funestus in broad daylight after use of long-lasting insecticidal nets: a new challenge to malaria elimination. *Malaria Journal*, 13,125 doi:10.1186/1475-2875-13-125

Strecher and Rosenstock (1997). *Cambridge handbook of psychology, health and medicine*. Cambridge University Press. New York, New York

Strode, C., Donegan, S., Garner, P., Enayati, A. A., & Hemingway, J. (2014). The Impact of Pyrethroid Resistance on the Efficacy of Insecticide-Treated Bed Nets against African Anopheline Mosquitoes: Systematic Review and Meta-Analysis. *PLoS Medicine*, *11*(3), e1001619. doi:10.1371/journal.pmed.1001619

Suresh, K., & Chandrashekara, S. (2012). Sample size estimation and power analysis for clinical research studies. *Journal of Human Reproductive Sciences*, *5*(1), 7–13. doi:10.4103/0974-1208.97779

Temu, E. A., Maxwell, C., Munyekenye, G., Howard, A. F. V., Munga, S., Avicor, S. W., … Ranson, H. (2012). Pyrethroid Resistance in *Anopheles gambiae*, in Bomi County, Liberia, Compromises Malaria Vector Control. *PLoS ONE*, *7*(9), e44986. doi:10.1371/journal.pone.0044986

The World Bank. (2013a). *Malaria*. Retrieved from http://www.worldbank.org/en/topic/health/brief/malaria

The World Bank. (2013b). *Liberia*. Retrieved from http://www.worldbank.org/en/country/liberia

Tokponnon, F. T., Ogouyémi, A. H., Sissinto, Y., Sovi, A., Gnanguenon, V., Cornélie, S., … Massougbodji, A. (2014). Impact of long-lasting, insecticidal nets on anaemia and prevalence of Plasmodium falciparum among children under five years in areas with highly resistant malaria vectors. *Malaria Journal*, *13*, 76. doi:10.1186/1475-2875-13-76

Tuba, M., Sandoy, I., Bloch, P. & Byskov, J. (2010). Fairness and legitimacy of decisions during delivery of malaria services and ITN interventions in Zambia. *Malaria Journal*, 9**,**309, doi:10.1186/1475-2875-9-309

United Nations Development Program. (2014). *Human development report 2014*. Retrieved from http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/LBR.pdf

University of Southern California. (n.d.). Organizing your social sciences research paper. Retrieved from http://libguides.usc.edu/content.php?pid=83009&sid=818072

Watanabe, N., Kaneko, A., Yamar, S., Leodoro, H., Taleo, G., Tanihata, T., … Larson, P. S. (2014). Determinants of the use of insecticide-treated bed nets on islands of pre- and post-malaria elimination: an application of the health belief model in Vanuatu. *Malaria Journal*, *13*, 441. doi:10.1186/1475-2875-13-441

World Bank. (2015). *Liberia dashboard*. Retrieved from http://sdwebx.worldbank.org/climateportalb/home.cfm?page=country_profile&CCode=LBR

World Health Organization. (2011). *The use of DDT in malaria vector control*. Retrieved from http://apps.who.int/iris/bitstream/10665/69945/1/WHO_HTM_GMP_2011_eng.pdf

World Health Organization. (2014a). *Country cooperation strategy at a glance*. Retrieved from http://www.who.int/countryfocus/cooperation_strategy/ccsbrief_lbr_en.pdf

World Health Organization. (2014b). *World malaria report - Liberia*. Retrieved from http://www.who.int/malaria/publications/country-profiles/profile_lbr_en.pdf

World Health Organization. (2014c). *Liberia malaria analytical summary*. Retrieved from http://www.aho.afro.who.int/profiles_information/index.php/Liberia:Analytical_summary_-_Malaria

World Health Organization. (2015). *Malaria facts*. Retrieved from http://www.who.int/mediacentre/factsheets/fs094/en/

World Health Organization. (2013). Neonatal and child health profile. Retrieved from http://www.who.int/maternal_child_adolescent/epidemiology/profiles/neonatal_child/lbr.pdf

Appendix A: Authorization to Use Data

DHS Download Account Application

[redacted] Jan 29

To [redacted]

See Attached.

You have been authorized to download data from the Demographic and Health Surveys (DHS) Program. This authorization is for unrestricted countries requested on your application.

The data should only be used for the purpose of the registered research or study. To use the same or different data for another purpose, a new research project request should be submitted. This can be done from the "Create A New Project" link in your user account.

All DHS data should be treated as confidential, and no effort should be made to identify any household or individual respondent interviewed in the survey.

The data sets must not be passed on to other researchers without the written consent of DHS. Users are requested to submit a copy of any reports/publications resulting from using the DHS data files. These reports should be sent to: [redacted]

To begin downloading datasets, please login at:
http://www.dhsprogram.com/data/dataset_admin/login_main.cfm

Once you are logged in, you may also edit your contact information, change your email/password, request additional countries or Edit/Modify an existing Description of Project.

If you are a first time user of DHS Data, please view the following videos on downloading and opening DHS data:
http://www.dhsprogram.com/data/Using-DataSets-for-Analysis.cfm#CP_JUMP_14039

Additional resources to help you analyze DHS data efficiently include: http://dhsprogram.com/data/Using-Datasets-for-Analysis.cfm, a video on Introduction to DHS Sampling Procedures - found at: http://youtu.be/DD5npelwh80 and a video on Introduction to Principles of DHS Sampling Weights - found at: http://youtu.be/SJRVxvdIc8s

The files you will download are in zipped format and must be unzipped before analysis. Following are some guidelines:

After unzipping, print the file with the .DOC extension (found in the Individual/Male Recode Zips). This file contains useful information on country specific variables and differences in the Standard Recode definition.

Please download the DHS Recode Manual: http://dhsprogram.com/publications/publication-dhsg4-dhs-questionnaires-and-manuals.cfm

The DHS Recode Manual contains the documentation and map for use with the data. The Documentation file contains a general description of the recode file, including the rationale for recoding; coding standards; description of variables etc. The Map file contains a listing of the standard dictionary with basic information relating to each variable.

It is essential that you consult the questionnaire for a country, when using the data files. Questionnaires are in the appendices of each survey's final report: http://dhsprogram.com/publications/publications-by-type.cfm

We also recommend that you make use of the Data Tools and Manuals: http://www.dhsprogram.com/accesssurveys/technical_assistance.cfm

DHS statistics can also be obtained using the STATcompiler tool:

Appendix B: NIH Training Certificate

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Taiyee Quenneh** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 06/15/2013

Certification Number: 1198250