# A SOCIAL MODEL OF HEALTH APPROACH TO UNDERSTANDING THE INTERACTIVE RELATIONSHIP AMONG DETERMINANTS OF ITN USE: AN EXPLORATION OF MALARIA INTERVENTION STRATEGY AMONG HOUSEHOLD MEMBERS IN GHANA.

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Spring2022

This thesis is submitted in partial fulfilment of the requirements for the degree of MPhil (Hons) in Global Development Theory and Practice at the Department of Health Promotion and Development of the University of Bergen

## ACKNOWLEDGEMENT

My sincere gratitude goes to my supervisor, Helga Bjørnøy Urke (Ph.D.), who dedicated her time and efforts throughout this thesis leading me to complete this project successfully. Also, my appreciation to the DHS Office who provided me with their approval to utilize their dataset for this master's project. I would like to say to everyone else who in some form helped shape this project a big thank you!!!.

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## ABSTRACT

This study aims to explore the context-specific factors associated with ITN use that focuses on the interactive relationship among determinants of ITN use. The study adopts the social model of health as a conceptual approach to explore the interplay among determinants of ITN use at the individual, net, household, and community levels. This conceptual approach is developed to test the moderating influence of net-level factor (i.e., the number of ITNs) on the relationship between the number of children under five years and household members' ITN use.

The thesis involved a sample size of 10,977 based on a nationally representative sample of Ghanaian households drawn from the Ghana Demographic and Health Survey (DHS) - 2020 dataset. A single-level moderation model was appropriate for the data analysis method. From the results of the data analysis, the main predictor variable the number of children under five years was positively associated with household members' ITN use (OR = 0.29, $p < .001$). A moderation effect of the number of ITNs ((OR = -.05, $p < .001$) on the relationship between the number of children under five years and household members' ITN use was reported. The key finding of the study is that the number of children under five years influenced household members' ITN use, but this relationship was determined by the number of ITNs in the household. The proportion of the number of children under five years and ITN use is moderately different for a high and low number of ITNs in the household with the former decreasing ITN use and the latter increasing ITN use.

The results of the thesis indicate a critical consideration for the complex interplay of determinants of ITN use which reveal the significant connection between the individual, net, household, and community-level factors shaping ITN use. The interaction between individual and net level factors on household members' ITN use is relevant to the social model of health that implies adequate access to health services towards supporting health-related behavior and better health outcomes.

The thesis provides a conceptual approach to malaria intervention that engages a comprehensive discussion of health promotion action. This considers a review of extensive theoretical and empirical literature in outlining practical implications and proposes outlooks for future research in engaging more scientific and evidence-oriented health action toward malaria prevention in Ghana.



**Keywords**: Household members' ITN use, malaria intervention, moderation, number of children under five years, number of ITNs

# CHAPTER ONE: INTRODUCTION

## 1.1. Background

Malaria is a global life-threatening disease that generally affects vulnerable individuals and groups and disproportionately infects regions particularly the sub-Saharan Africa region. The World Health Organization-WHO (2021), defines malaria as an acute febrile illness caused by Plasmodium parasites, which are spread to people through bites of the female Anopheles mosquitoes. Among these parasites exist two particular species - *P. falciparum and P. vivax* – that pose the greatest threat. *P. falciparum* is considered the deadliest malaria parasite and the most prevalent on the African continent. Although this disease is life-threatening, it is preventable and curable. According to the World Malaria Report (2021), there was an estimated 241 million cases of malaria globally with malaria-related deaths at 627 000 in the same year. The sub-Saharan African region carries the excess share of the global malaria burden with 95 percent of malaria cases and 96 percent of malaria deaths (World Health Organization-WHO, 2021). Children under five years account for the majority of malaria deaths in the region with an estimated 80 percent of malaria mortality rate (World Health Organization-WHO, 2021).

Studies have described the malaria epidemic in the sub-Saharan African region as a major development challenge where malaria endemicity in these areas has several implications for global sustainable development (e.g., Gallup and Sachs, 2001; Sachs and Malaney, 2002). These implications are experienced in poor health outcomes for a substantial proportion of the population with the cost of treating and curing the disease increasing poverty in the region. Albeit, over the years, several attempts have been made globally, regionally, and at the country, level to reduce, control and eliminate malaria. This was in large part due to a significant global investment in malaria control and elimination efforts which exceeded USD$ 2.7 billion in 2013 (World Malaria Report, 2014). In sub-Saharan Africa, considerable efforts on an intensive scale-up of malaria prevention and control interventions include insecticide-treated nets (ITNs), indoor residual spraying (IRS), intermittent preventive treatment during pregnancy (IPTp), and prompt diagnosis and treatment (Yé Y et al., 2017). These interventions feature vector control which is a highly effective method for reducing malaria transmission and a vital component of malaria control and elimination strategies in highly endemic malaria areas in the region (World Health Organization-WHO, 2022). Among these vector control are ITNs which are considered the most effective

malaria prevention strategy (World Health Organization-WHO, 2022). ITN is a mosquito bed net that provides a physical barrier between the user and mosquito vectors and repels or kills mosquito vectors upon contact with the insecticide (Thiévent et al., 2018).

It is estimated that since 2000, more than 2 billion ITNs have been delivered to malaria-endemic countries (World Health Organization-WHO, 2022) and 69% of the 663 million cases averted in sub-Saharan Africa between 2000 and 2015 were attributed to ITNs (Bhatt et al, 2015: 2). Moreover, from 2000 to 2019, the percentage of the population with access to an ITN increased from 3% to 52% (World Health Organization-WHO, 2021). These have major impacts on the population, especially for vulnerable groups such as children under five years. Lengeler (2004) and Eisele et al., (2010) indicate that in high endemic areas which are characterized by stable malaria transmission all year round, ITNs have the potential to reduce severe malaria mortality by at least 45% and malaria-related mortality in children under five years up to 55%. As noted by Binka et al., (1998), when ITNs are easily accessible and available across the population, they not only provide effective protection from malaria infection for those who use them but also prevent malaria transmission to non-users in the community.

The effectiveness of ITNs as a malaria prevention intervention and a cost-efficient vector control has gained a strong desire among national malaria programs for rigorous evaluation and scaling up to tackle malaria-related mortality and morbidity (World Malaria Report, 2014; Yé Y et al., 2017). This is supported by the World Health Organization's recommendation for mass campaigns for ITN distribution to the general population, and regular distribution targeting pregnant women during antenatal care (ANC) visits and children under five years during immunizations, to ensure at least one ITN for every two persons in each household (World Health Organization, 2017). Based on the World Health Organization's (2015) Global Technical Strategy (GTS) for malaria 2016-2030, ITN distribution targets for universal coverage aim to achieve at least 80% coverage for ITN ownership and use. Current estimates of ITN access and use show significant progress in reaching the target with most endemic countries in sub-Saharan Africa having considerable access—3% to 52% between 2000 and 2019, and use—2% to 46% in the same period (World Malaria Report, 2021). Regardless of these improvements in household ITN ownership and use over the years, household ITN ownership and use have stalled in the past few years (World Malaria Report 2021). A survey on ITN use shows that only 50% of the population at risk in sub-Saharan

Africa slept under an ITN the previous night indicating huge gaps in ITN use and ownership (Koenker and Kilian, 2014). This highlights the barrier to malaria prevention activities.

A review of malaria intervention research involving ITN use indicates that although the availability of ITNs in a household is a prerequisite for use, it does not determine the effective use of ITNs (Pulford et al., 2011). Rather, determinants of ITN use are a result of the complex interplay of factors at the individual, household, community, and net level (Graves et al., 2011; Ngondi et al., 2011). These determinants can explain the health-related behavior choices of ITN use. Scott et al., (2021) indicate that the heterogeneity of determinants of ITN use in different settings is further compounded by the shifting epidemiology of malaria over time. Thus, they suggest the need to understand the context-specific factors associated with ITN use which is vital for achieving universal ITN coverage and reducing the malaria burden (Scott et al., 2021).

Accordingly, this study seeks to present a contextual understanding of determinants of ITN use by exploring how the number of children under five years influence household members' ITN use. Specifically, it examines the interplay of the number of ITNs in the household and other factors at the individual, household, community, and net level associated with household members' ITN use. In general, this study aims to provide an in-depth understanding of context-specific factors associated with ITN use to address the gap in ITN ownership and use towards malaria prevention and control efforts within sub-Saharan Africa focusing on Ghana.

### 1.2. Determinants of ITN use in Ghana

ITN use determinants in Ghana involve an understanding of malaria transmission dynamics which is based on the seasonal variability of malaria infection across the country. Previous research on determinants of ITN use indicates a strong influence of environmental factors which affected malaria mortality risks such as proximity to health facilities and potential breeding areas for mosquitoes (Binka et al., 1998). Few studies in Ghana have examined the trends in ITN use, focusing on areas with high malaria endemicity and prevalence of infection, among children under five years and pregnant women (e.g., Azabre et al., 2013; Amedo, 2016; Axame et al., 2016). In a particular study, they found that several households were not utilizing ITNs due to poverty, inconvenience, and the belief that ITNs are not effective for controlling malaria (Azabre et al., 2013). Most households instead used traditional malaria intervention strategies, including drinking local herbs, and not eating sweets which have no association with malaria control (Azabre et al.,

2013). In another study conducted in a high malaria-endemic region in Ghana—Hohoe municipality, they discovered that although ownership of ITN per household is high—80.7%, utilization was much lower—41.7% (Konlan et al., 2019: 2). Others explain that the proper utilization of ITNs among high-risk groups is lower and that increase in ITN ownership does not equal an increase in ITN utilization (e.g., Mba and Aboh, 2007; Axame et al., 2016).

Moreover, research on ITN use in Ghana has identified a strong relationship between behavioral factors and indicators of use (e.g., Adongo et al., 2005; Diema et al., 2017). Behavior predictors including health knowledge and perceptions about illness and diseases impact the effectiveness of ITN use. People's utilization of ITNs is dependent on their knowledge of the consequences of non-use (Diema et al., 2017). Again, Konlan et al. (2019) suggests that ITN use among children under five years is strongly influenced by the individual characteristics of the caregiver—age, education, gender, employment status, health behavior, and group belief. These factors are positively associated with ITN use, especially among households with children under five years.

Recent studies have explored ITN use determinants to understand the gap between ITN access and use in households (e.g., Ahorlu et al., 2019; Ricotta et al., 2019). These studies show a strong association between increased exposure to malaria knowledge and increased ITN use. They mention that ITN use is conditional on access, which is affected by household factors including wealth index, household composition (i.e., number of children), sleeping rooms, and place of residence—rural, or urban (Ricotta et al., 2019). Hence, it is relevant to identify the interactions among determinants at the different levels to explain their effect on ITN use in the household.

### 1.3. Research Objectives

Drawing from the above background, the general objective of this thesis is to explore the interaction of individual factor (i.e., number of children under five years) and net level factor (number of available ITNs) on household members' ITN use. This is assessed by using a sample from the Ghana Demographic and Health Survey 2020 on malaria indicators. Subsequently, these are the specific research objectives:

1. To examine the relationship between the number of children under five years and ITN use among households with ITN ownership.
2. To test the moderating influence of the number of ITNs in the household on the relationship between the number of children under five years and household members' ITN use.

### 1.4. Malaria Prevalence and Endemicity in Ghana

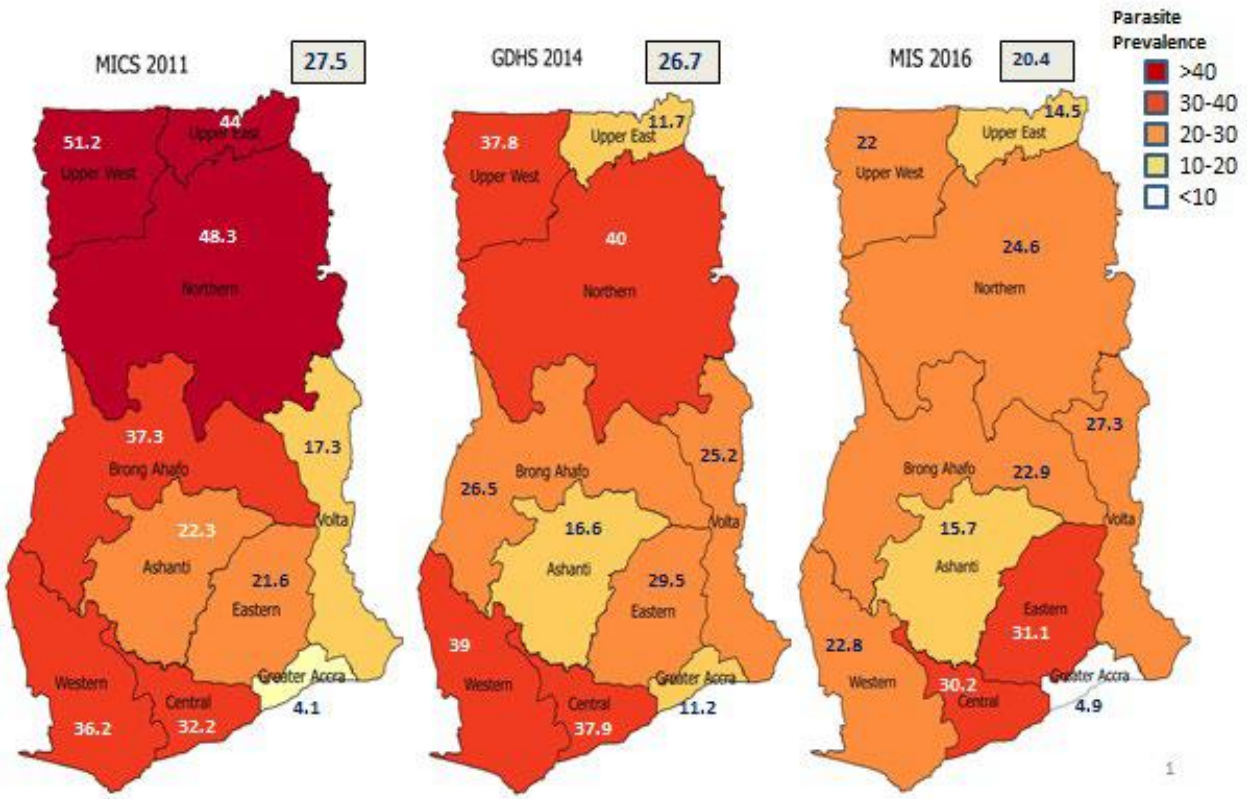
Malaria continues to be a leading health problem in Ghana which affects a significant proportion of the population. From 2008 to 2019, malaria mortality in Ghana has been most prevalent among children under five years, followed by people between the ages of 15 to 49 years old (Sasu, 2022). Malaria continually affected a large number of people over the years, causing roughly 21.6 thousand deaths in 2019 (Sasu, 2022). Among the highest risk and most vulnerable groups to malaria infection in Ghana are children under five years and pregnant women due to their lowered immunity (Ghana Statistical Service-GSS and ICF, 2020). Although over the years there have been huge improvements in malaria prevention and control which has led to a substantial decrease in malaria-related deaths, it has remained one of the leading causes of illnesses and deaths in the country (World Health Organization-WHO, 2021).

Malaria is endemic and perennial in Ghana, with pronounced seasonal variations in the northern part of the country (U.S. President's Malaria Initiative-PMI, 2020). The length of malaria transmission varies by geographical region in Ghana and depends on the length of the dry season (December-March), during which there is little transmission (U.S. President's Malaria Initiative-PMI, 2020). In Ghana, there are two major transmission patterns—a six to seven month transmission season in a larger part of the north of the country and a shorter three to four-month transmission in the upper part of the north, with the highest number of cases occurring between July and November (U.S. President's Malaria Initiative-PMI, 2020: 9). In the southern part of Ghana, the transmission season occurs between nine months or more, with a small peak from May to June and a larger peak from October to November (U.S. President's Malaria Initiative-PMI, 2020). The progress in malaria prevention and control in Ghana has been steady over recent years and is poised to start stratifying malaria risk at lower levels (i.e., district and sub-district) and target malaria interventions based on epidemiological and entomological data (U.S. President's Malaria Initiative-PMI, 2020; World Malaria Report, 2021). Nationwide malaria prevalence in children declined from 48 percent in 2011 to 28 percent in 2016 (U.S. President's Malaria Initiative-PMI, 2020), however, there remain large variations and significant decreases in prevalence within and between regions as illustrated in Figure 1.

Moreover, previous research conducted on malaria at the district and sub-district level revealed that factors perceived as contributing to the high malaria prevalence in the country are malnutrition, excessive heat, excessive drinking, fatigue, dirty surroundings, unsafe water, bad air,

and poor hygiene (Asenso-Okyere, 1994). They also mention that the prevalence of malaria within the districts and sub-districts in Ghana was largely attributed to low and lack of adequate knowledge about the mode of transmission and symptoms (ibid.).

**Figure 1: Malaria Parasite Prevalence among Children Under Five Years of Age by Geographic Area in Ghana**




Source: U.S. President's Malaria Initiative–PMI, (2020)

## 1.5. Management of Malaria in Ghana

Ghana's attempt at controlling the transmission of malaria began in the 1950s, which involved the eradication of massive drain construction, chloroquine impregnated salts, aerial spraying, and weekly swallowing of daraprim called "*Sunday Sunday*" medicine as preventive care (Ghana Health Service-GHS, 2022). Despite government efforts between 1960 and 2000, malaria continued to be one of the leading causes of premature deaths in the country (Ghana Health Service-GHS, 2022). The government launched an aggressive Roll Back Malaria (RBM) initiative in 1999 that emphasized the strengthening of health services through multi and inter-sectoral partnerships and making treatment and prevention strategies more universally accessible (Ghana

Health Service-GHS, 2022). In 2000, the first National Malaria Control Strategic Plan—NMCP, (2000-2010) was developed to reduce malaria-specific morbidity and mortality by 50 percent by the year 2010 (Ghana Health Service-GHS, 2022). A key goal of this strategy was the promotion of ITN use which was adopted in 2001. The strategy was focused on making affordable ITNs universally accessible through the commercial sector, both at commercial prices and subsidized prices through direct government subsidies to vulnerable groups. Since 2005, there have been significant improvements in expanding malaria control interventions in the country due to huge donor investments mainly from the Global Fund to Fight Aids Tuberculosis and Malaria (GFATM) (Ghana Health Service-GHS, 2022).

In 2014, the Ghana Malaria National Control Strategic Plan (NMCP) was extended through to 2020. The goal was to reduce malaria morbidity and mortality by 75 percent from the 2012 plan by 2020 across all regions in the country (U.S. President's Malaria Initiative-PMI, 2020). This plan aimed to consolidate the recent gains and accelerate malaria control in the high transmission areas to further reduce the malaria burden and move towards establishing lower-transmission areas in Ghana by the end of 2020 (U.S. President's Malaria Initiative-PMI, 2020). Although the NMCP has achieved this goal with an 85 percent reduction in malaria deaths from 2012 (2,275) to 2018 (417), malaria morbidity remains high nationally with geographic variability, particularly in the Northern regions (U.S. President's Malaria Initiative-PMI, 2020: 13). The 2014-2020 NMCP specific objective includes protecting at least 80 percent of the population at risk by universal coverage of ITNs, through the mass campaign and continuous distribution, including other vector control.

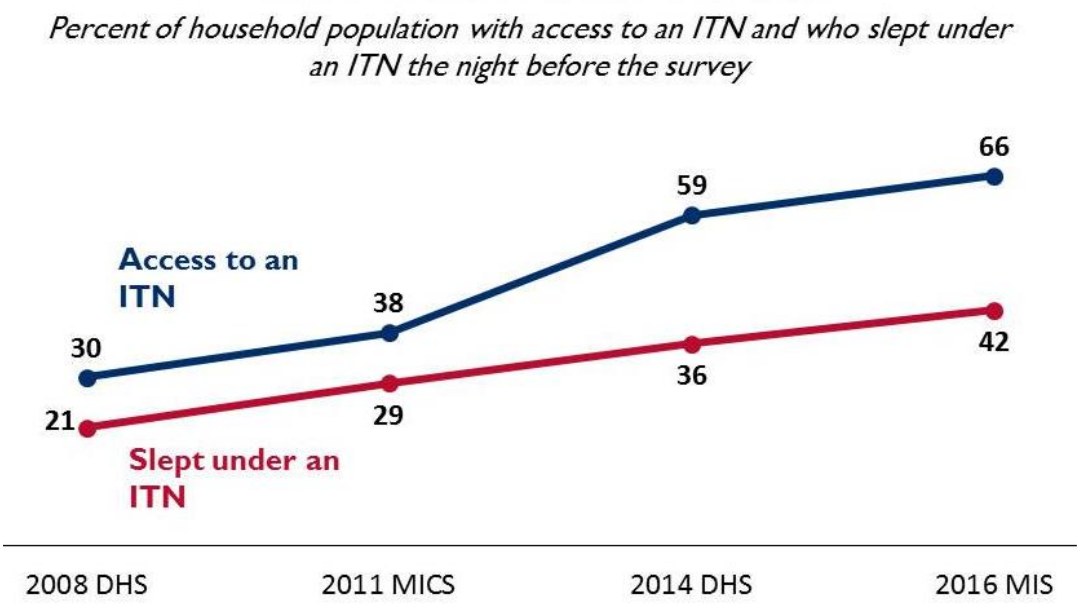
### 1.6. ITNs distribution and coverage in Ghana

ITN distribution in Ghana is guided by the 2014-2020 National Malaria Control Plan—NMCP, to sustain universal coverage by distributing a sufficient number of ITNs to cover all household members (Ghana Statistical Service-GSS and ICF, 2020). This indicator is operationalized as one ITN per two persons. ITNs in Ghana are primarily distributed through mass distribution campaigns, visits to antenatal care (ANC) clinics and child welfare clinics (CWCs), and at primary schools (NMCP, 2019). ITNs in Ghana are regularly distributed with the most recent mass distribution campaign in 2018 aimed at providing ITNs to 90 percent of the registered population (Ghana Statistical Service-GSS and ICF, 2020: 26). Mass distribution of ITNs occur at the regional, district, and sub-district level respectively.

According to the 2019 Ghana Malaria Indicator Survey (GMIS) results, 74 percent of households in Ghana own at least one ITN and 52 percent of households have at least one ITN for every two persons who stayed in the household the night before the survey, whilst 26 percent do not own any ITNs. ITN ownership has increased gradually from 42 percent in 2008 and is higher in rural households (85%), than in urban households (64%) (Ghana Statistical Service-GSS and ICF, 2020: 26).

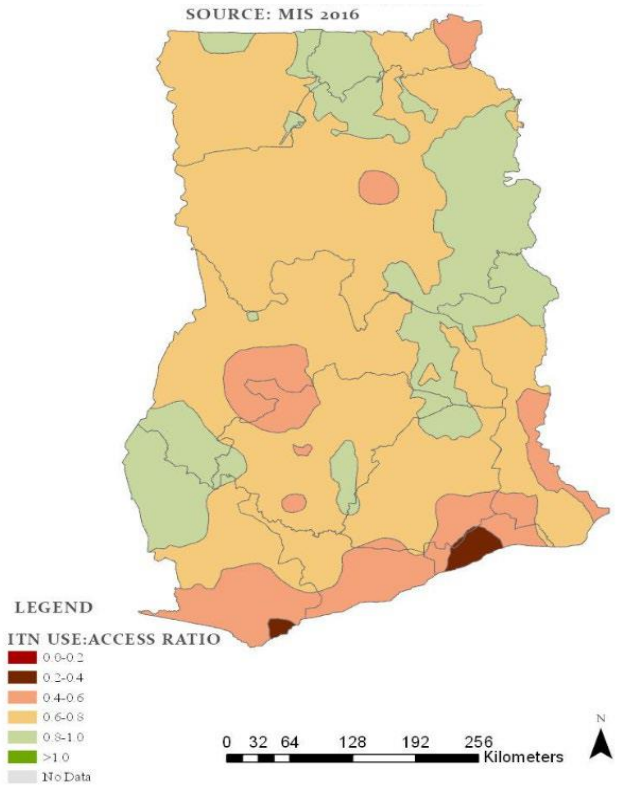
Universal coverage of ITNs is based on the indicator of access to an ITN and is measured by the proportion that could sleep under an ITN if each ITN in the household were used by up to two people. It is estimated that the percentage of the household population with access to an ITN in Ghana is 66 percent while ITN use is 42 percent (Ghana Statistical Service-GSS and ICF, 2020: 28). The trends in ITN access and use are an indicator of the behavior gap where available ITNs are not being used as shown in Figure 2. Moreover, ITN access and use in Ghana varies by region which is largest in Greater Accra and Eastern region and smallest in Upper West Region, as shown in Figure 3.

**Figure 2: Trends in ITN access and use**




Source: U.S. President's Malaria Initiative–PMI, (2020).

**Figure 3: Geographical variation of ITN Access and Use in Ghana**

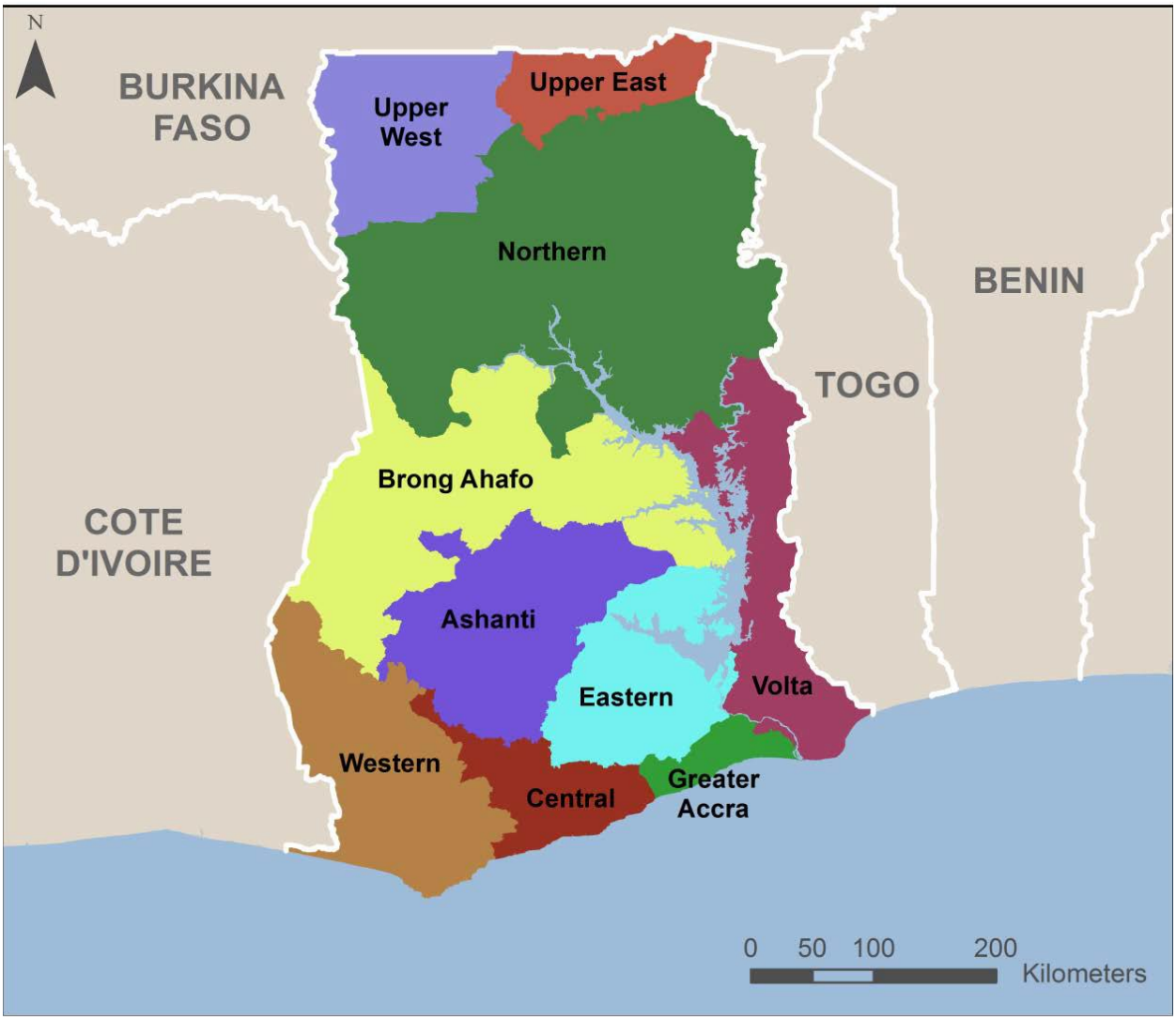



Source: U.S. President's Malaria Initiative–PMI, (2020).

### 1.7. Demographic profile of Ghana

According to the 2021 population census, Ghana's population is approximately 31 million (Ghana Statistical Service-GSS., 2021). The population based on sex comprises 50.5% females and 49.5% males (Ghana Statistical Service-GSS., 2021). Ghana has 16 administrative regions and is a multilingual country with about eighty languages being spoken, with English and lingua franca as the official language (Eberhard et al., 2022). Ghana is made up of a multi-ethnic and multicultural society with more than seventy ethnic groups. The major ethnic groups include the Akan (48%), Mole-Dagbon (17%), Ewe (14%), Ga-Adangme at (7%) percent, and others (Ghana Statistical Service-GSS et al., 2018). Ghana's population in terms of urban-rural ratio is 56 percent and 44 percent respectively (Ghana Statistical Service–GSS et al., 2018). The main religions in Ghana are Christianity (60%), Islam (20%), Traditional (16%), and others (Ghana Statistical Service-GSS et al., 2018). Based on the access and distribution of resources in Ghana, the urban areas generally have more access to resources including health care and other basic amenities which causes the rural population to experience severe poverty due to differential resource access. Figure 4 below shows the geographical map of Ghana including the administrative regions as the study context.

**Figure 4: Map of Ghana showing the study context**




Source: Ghana Statistical Service-GSS and ICF, (2020)

### 1.8. Study Contribution

The objective of this thesis is to examine the interaction among determinants of ITN use that are associated with health-related behavioral choices for adopting malaria interventions. Extant literature on the study area has contributed to theorizing a complex interplay among determinants of ITN use in malaria intervention (e.g., Pulford et al., 2011; Graves et al., 2011). Determinants of ITN use are conditional on access which involves a multi-level interaction among individual, household, community, and net-level factors (Ricotta et al, 2019). The interplay among these determinants is shaped contextually, such that ITN use is determined by context-specific factors (Scott et al., 2021). By utilizing the social model of health as a holistic theoretical approach, this

thesis presents a contextual understanding of the factors that are associated with household members' ITN use among households with ITN ownership.

In analyzing the moderating influence of the number of ITNs in the household, this thesis extends the assumption of a moderating effect on the relationship among ITN use determinants which extends the view of the social determinants of health in health promotion discourse. Hence, it emphasizes the interrelationship among various social and environmental conditions for health, beyond the individual characteristics of behavior. This notion represents a core basis in health promotion (Green et al., 2015; Naidoo and Willis, 2016). Adopting this conceptual approach supports health promotion practice by providing an empirical and theoretical grounded study that enhances health action through a holistic understanding of health interventions. The thesis is relevant from a health promotion perspective as it aids a multi-level approach to analyzing health action.

### 1.9. Organization of The Study

The organization of this thesis is divided into six chapters. Chapter one presents the introduction involving the study background that describes the malaria topic and malaria intervention strategies such as ITN use, including study objectives, justification, and main research problems.

In chapter two, the theoretical model of the thesis is described, and this includes the scientific perspectives involving social health determinants associated with ITN use. In expounding on the theoretical framework, the social model of health is used to identify the various levels of influence: individual, net, household, and community levels as significant factors. This includes the level-specific factors: the number of children under five years and the number of ITNs in the household. Accordingly, the social model of health is considered a holistic theoretical framework that provides a multilevel approach to understanding the determinants of ITN use.

Chapter three provides an extensive range of relevant empirical literature on malaria interventions regarding ITN use which follows to combine the literature systematically, identification of gaps, and develop hypotheses that are grounded in theory as well as methodologically feasible as drawn from the extant literature. This chapter sets the tone for which appropriate statistical analysis can be undertaken and guides the overall thesis.

Chapter four outlines in detail the appropriate methodological approach adopted for examining the research objectives and developing the research model. This consists of the philosophical foundation, research design, data structure, and analytical estimation procedures. Also, a discussion of the moderation model and regression analysis procedure are included.

Chapter five presents the results from the data analysis, and this includes the descriptive statistics, Pearson and Polychoric correlations, and multiple linear regression estimates. Inferences are drawn from the stated hypotheses formulated in chapter three.

Finally, chapter six offers a theoretically and empirically in-depth discussion based on the results in the previous chapter. Also, a general discussion of the overall research entailing implications for research and practice, thesis strengths and limitations, and directions for future health promotion research. The chapter ends with a conclusion.

# CHAPTER TWO: THEORETICAL FRAMEWORK

## 2.0. Introduction

In this chapter, I first identify the range of empirical and theoretical underpinnings associated with ITN use in the household after which I provide the theoretical framework for this thesis. A compilation of the existing literature describes the main driver of ITN use as access to an ITN, explaining that people are not able to use an ITN unless one is available (e.g., Graves et al.,2011; Koenker and Kilian 2014; Ricotta et al., 2019; Scott et al., 2021). Moreover, a range of factors at the individual, household, community, and net levels have been noted to influence ITN use. These factors contribute to a socio-ecological approach in analyzing malaria intervention, underpinning ITN use within a multi-level framework which determines malaria prevention outcomes.

### *2.1.1 Individual factors*

Within health promotion, individual-level factors are conceptualized based on a biological perspective, describing the genetic and psychosocial aspects associated with one's health and well-being (Green et al.,2015). Studies have expounded on the psychosocial dimensions and their relationship to health outcomes (e.g., Durch et al., 1997; Martikainen, Bartley and Lahelma, 2002; Ansari et al., 2003). For instance, Martikainen, Bartley, and Lahelman (2002) explain that psychosocial factors in the health context involve two streams: mediating the effects of social structural factors on individual health outcomes, and conditioned, and modified by social structures and contexts in which they exist. In other words, they address the broader social structural forces in a context and their influence on individual characteristics associated with health. Moreover, Ansari et al., (2003), argue that psychosocial factors are encompassed in the broader context of social determinants of health: social determinants (age, gender, education), psychosocial determinants (social support, self-esteem, chronic stress, isolation), and community/societal determinants (income inequality, social capital, level of trust). For example, few studies conducted in some African countries found that health interventions in the case of malaria vector control are determined by age, gender, education, and belonging to a vulnerable group such as children under five years and pregnant women (e.g., Toé et al., 2009; Allai et al., 2003; Dunn, et al., 2011; Hwang et al., 2010).

Several psychosocial theories have been applied to explain health-related behavior choices which focus on individual-level factors. These theories which are commonly referred to as social

cognition models focus on beliefs and attitudes as the proximal determinant of behavior (Sutton, 2002). Theories such as the Health Belief Model (Becker, 1977), the theory of reasoned action (Ajzen and Fishbein, 1980), and the social cognitive theory (Bandura, 1986) assume that health outcomes are determined by individual actions and attitudes. Thus, health behavior is an outcome of individual decision-making (Sutton, 2002). Moreover, these theories explain how health outcomes at the individual level constitute psychosocial processes such as socioeconomic status, social capital, stress, security, and autonomy which shape health behaviors and lifestyles (Marmot et al., 1991; Marmot and Wilkinson, 1999).

Research on malaria prevention has focused extensively on health-related behavior among other individual-level factors in analyzing malaria prevention outcomes (e.g., Tweneboah-Koduah et al., 2012; Owusu Adjah and Panayiotou, 2014; Baume and Franca-Koh, 2011). Similar studies point to individual knowledge, beliefs, attitudes, and perception of ITNs, as significant to malaria prevention outcomes (e.g., Ahorlu et al., 1997; Dunn et 2011; Nganda et al., 2004; Koenker et al., 2012). For example, a study in Tanzania found the use of ITN by pregnant women was conditioned by the knowledge of malaria transmission (Nganda et al., 2004). However, the complexity of health behavior, linked to the relationship between social determinants and health conditions, has broadened the focus of health beyond the individual level to include the broader social and cultural context of health determinants. Indeed, health determinants encompass the psychosocial, material, and socio-economical and the interrelatedness of these factors to health behaviors and health outcomes (Ansari et al., 2003).

### *2.1.2. Social factors*

Social determinants of health constitute socio-cultural and structural factors that interact to shape individuals' and groups' adoption of health-related behaviors and their associated health outcomes. Studies on malaria prevention have described the influence of socio-cultural determinants on health-related behavior in ITN use (Beiersmann et al., 2007; Oberländer and Elverdan, 2000; Strachan et al., 2016). For instance, the decision-making role which is a characteristic of the household is identified as influential in adopting malaria intervention strategies regarding household members sleeping under ITNs (Oberländer and Elverdan, 2000). Cultural norms including local community perceptions of malaria are considered a major barrier to malaria intervention in some contexts (e.g., Adongo et al., 2005; Beiersmann et al., 2007). The influence of structural factors (e.g., social capital and social gradient/socioeconomic status) has been well

examined in health promotion research (e.g., Marmot and Wilkinson, 1999; Kawachi et al., 1997; Kawachi and Berkman, 2000). Structural factors here describe the set of forces and systems that directly shape individual daily live conditions and influence health outcomes (Wilkinson et al., 1998). Within social level factors, structural factors depict the wider set of forces that characterize individuals' health behavior in group settings such as the household and community. It includes the relationship between individuals and social mechanisms that generate stratifications and social class divisions in society defining their socio-economic position within hierarchies of power, prestige, and access to resources (World Health Organization-WHO, 2010). Thus, structural factors are important predictors of health outcomes as they explain how individuals' health behaviors are shaped by their social contexts like living standards and environmental and cultural influences (World Health Organization-WHO, 2010).

Theories such as empowerment (Kabeer, 1999; 2005), gender and power (Connell, 2013), and social capital (Antonovsky, 1996) have been applied in health promotion research from the social determinants of health perspective. Empowerment theory in health promotion involves the interplay between aspects of the individual's life course (sense of control, knowledge, and awareness, self-efficacy and self-esteem, and a greater sense of support) in influencing their capabilities for health-related behavior choices and positive health outcomes (Green et al., 2015). Also, the social capital theory underlies the significance of social influences (family, community) which exerts influence on an individual intention to adopt or reject health interventions (Green et al., 2015).

An evaluation of the social-level health determinants as a framework for explaining individuals' adoption of health-related behavior considers the interaction between proximal (family, friends, peer groups) and distal (community and social norms, cultural context) factors as major influences on individual health-related decisions and health outcomes. Indeed, this perspective is fundamental to malaria-related behavior which as noted by Dunn et al., (2011) is rooted in the wider aspects of local livelihoods and socio-cultural beliefs and practices. An appreciation of the social factors implies a broader inclusion beyond individual factors which are embedded within and are the result of a multi-level social health system (Green et al., 2015).

In identifying the dimensions of health-related behavior related to malaria prevention, this study aims to follow a holistic approach to account for the complexities of health as it concerns individual

and group behavioral choices and decisions regarding adopting health interventions. As explored by several studies on malaria intervention (e.g., Graves et al., 2011; Koenker et al., 2012; Tassembedo et al., 2020; Scott et al., 2021), a contextual analysis involving the interplay between individual and social-level factors is important to understanding malaria intervention as it relates to health promotion. Guided by the extant literature and supported by extensive empirical evidence, this study develops a conceptual model to contextually explain the mechanisms of malaria intervention. I draw on the socio-ecological theory as a framework to examine the interplay of factors associated with ITN use among household members. The socio-ecological theory of choice adopted is Dahlgreen and Whitehead's (1991) social model of health.

### 2.2. Socio-ecological Model (SEM): The Social Model of Health

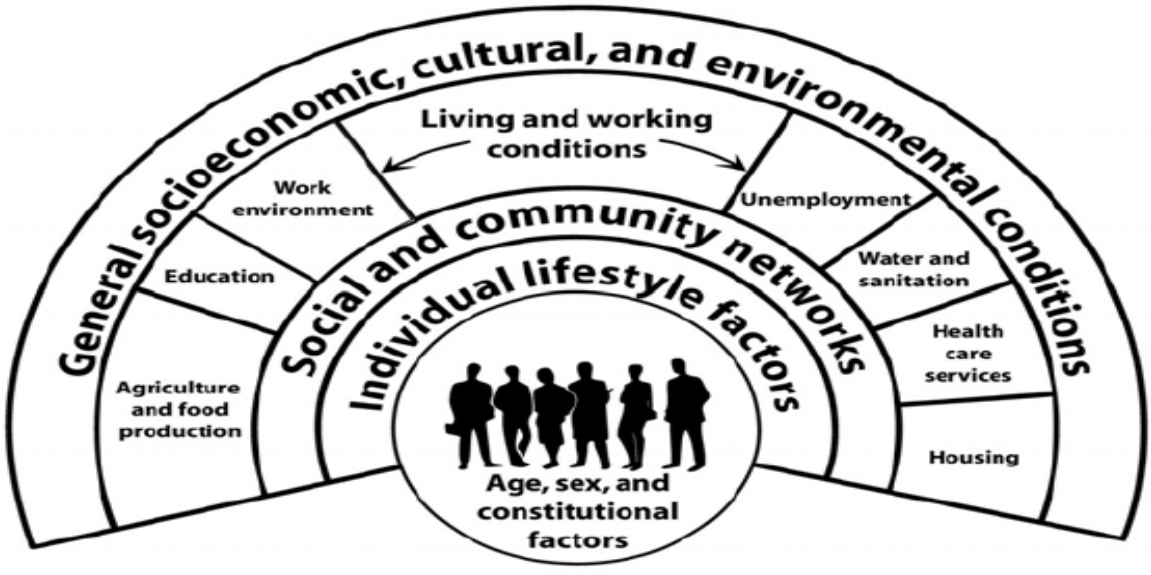
The social-ecological model (SEM) helps to understand a complex range of factors affecting behavior within specific social environments. It emphasizes multiple levels of influence—individual, interpersonal, community, and social, and the idea that behaviors both shape and are shaped by the social environment (Glanz et al., 2008: 18). Studies applying this model have acted to establish health and health behaviors in the context of people, social and political environments (e.g., Krieger, 2001; Poundstone et al., 2004; Robinson, 2008; Townsend and Foster, 2013).SEM was initially introduced as the ecological systems model by Urie Bronfenbrenner in the 1970s for understanding human development and later formalized as a theory in the 1980s (Bronfenbrenner, 1989). As argued by Bronfenbrenner (1989), the ecological system model involves nesting circles that place the individual at the center within a composition of various systems. Bronfenbrenner's (1989) model at its core involves biological and genetic aspects of human development.

The SEM in later development is based on the settings approach—i.e., the impact of the relationship between individuals and the environment on their health. The settings approach was advocated for in the Ottawa Charter for health promotion which forms the basis of the socio-ecological model for health promotion (World Health Organization-WHO, 1986). The SEM involves two key concepts—behavior affects and is affected by multiple levels of influence; and individual behavior shapes and is shaped by the social environment—reciprocal causation (Stokols, 1996). SEM focuses definitively on the social, institutional, and cultural contexts of people-environment relations (McLaren and Hawe, 2005). This perspective emphasizes the

"multiple dimensions—e.g., physical, social, and cultural environment, personal attributes; multiple levels—e.g., individuals, groups, organizations; and complexity of human situations—e.g., objective, and subjective qualities, various scales of immediacy, the cumulative impact of an event over time" (McLaren and Hawe, 2005: 12). In line with this, Stokols (1996) argues that a strong association between individuals and the environment is deemed an important predictor of well-being. In other words, SEM highlights the interaction between, and interdependence of factors within and across all levels of health behavior, indicating that most public health challenges are too complex to be understood and decisively addressed from a single-level approach (Stokols, 1996).

Dahlgren and Whitehead (1991) conceptualize the socio-ecological model of health as a broad interrelationship of micro and macro determinants which they frame in a nesting circle—depicting the interaction between individual, their environment, and disease. Their SEM of health shows the multidimensionality of health entailed by four core elements—lifestyle, environment, human biology, and healthcare organizations, as discrete entities. These are nested within the main health determinants—individual/intrapersonal, interpersonal/relationships, social/community, and societal conditions. The diagrammatic representation of the SEM as framed by Dahlgreen, and Whitehead (1991) is illustrated in Figure 5.

**Figure 5: The Main Determinants of Health**




Source: Dahlgreen and Whitehead, (1991).

At the core of the model represents individual characteristics such as age, gender, education, income, and health history. This is attributed to the individual lifestyle factors and involves the immediate influence of the individual characteristics on behavior such as knowledge, attitudes, beliefs, and personal traits. Malaria intervention at this level is related to the individual attitudes, beliefs, and risk perceptions about malaria, and prevention action generally entails adequate knowledge of ITNs and their uses through education and skills training (e.g., Baume and Marin, 2007; Toé et al., 2009; Graves et al., 2011, Azabre et al., 2013).

The second level is the interpersonal domain and involves the individual relationship such as friends, family members, and partners, all of whom influences behavior and contribute to their experiences. These relationships form the primary groups of the individual which shape their social identity, support, and role definition and directly impact health and wellbeing. Malaria intervention herein involves intrahousehold relationships associated with ITN use and their effect on household members' health-related behavior choices toward malaria prevention (e.g., Toé et al. 2009; Ngondi et al., 2011; Konlan et al., 2019; Ricotta et al., 2019).

The third level refers to the community domain and explores the settings in which people have wider social interactions, such as schools, workplaces, and neighborhoods, and attempts to identify the characteristics of these settings that affect health. This level within malaria intervention includes the impact of the community as a social factor influencing ITN use and aspects of the wider social environment in affecting healthy cultures in malaria prevention (e.g., Wiseman et al., 2007; Dunn et al., 2011; Tassembedo et al., 2020; Koenker et al., 2019).

The fourth level focuses on the living circumstances and working conditions which may constrain or promote healthy behaviors and wellbeing. These refer to factors determined by social policies which affect health such as unemployment, housing, education, access to health care services, and the physical environment. This level considers social structures that shape healthy activities such as access to ITNs and behavior change communication strategies for consistent ITN use (e.g., Graves et al., 2011; Hetzel et al., 2012; Koenker and Kilian, 2014; Scott et al., 2021).

The fifth level features societal conditions that affect health. These include the general socio-economic, cultural, and environmental conditions and their impact on health. This describes the social, political, and economic structures such as strategies for disease prevention and management of health interventions. Malaria intervention herein involves the social context (society) in which

people live and how it influences their health-related behavior in malaria prevention (e.g., Wiseman et al., 2011; Graves et al., 2011; Koenker and Yukich, 2014; Tassembedo et al., 2020).

In understanding the main determinants of health as a multi-dimensional approach to conceptualizing health based on the hierarchical set of levels nested within the framework. This study is framed based on the levels discussed—individual-level factors (age, gender, number of children under five years); household-level factors (relationship to household head, gender of household head, age of household head, number of household members, number of rooms for sleeping, wealth index,) net-level factors (number of ITNs, source of ITNs, net age) and community-level factors (region, type of place of residence).

# CHAPTER THREE: LITERATURE REVIEW

## 3.0. Introduction

In this section, I review relevant existing literature analyzing malaria interventions focusing on factors associated with ITN use and the significance of ITNs in malaria prevention. I complete the chapter by presenting the theoretical framework for this thesis.

## 3.1. Literature Search Strategy

The literature search strategy for this thesis involved an electronic search for academic journals including the terms "ITN utilization", "ITN access and ITN ownership" and "malaria intervention and prevention" from PubMed, National Center for Biotechnology Information (NCBI), Biomed and PsycInfo. A search in these databases was conducted through the authors' university library system (Oria). Due to the scope of the study, exclusion and inclusion criteria was established which involved a selection of only published research articles that are peer-reviewed. Academic articles not published in English were not selected and thus excluded. In terms of year of articles, there were no year criteria for the published articles.

In selecting the articles included for the review, certain criteria were followed. i. Keywords such as "correlates of ITN use", "determinants of ITN use" and "factors associated with ITN use" were highlighted to address the study objectives and included. ii. The articles included had to focus on individuals and households with access to ITNs or with ITN ownership. iii. Also, the focus of the study should be on malaria-endemic regions (e.g., Africa and Southeast Asia). These criteria allowed the search results to be filtered to identify the most relevant articles for the study in analyzing the interrelationship between factors associated with ITN use.

## 3.2. Literature Review Synthesis: Issues and Gap Identification

ITNs as a core malaria intervention strategy have generated several interests in public health and health promotion research and continue to dominate the malaria prevention discourse. A key aspect of this discourse is the gap between ITN ownership and ITN use. Several studies have attempted to address this issue by exploring the multidimensional interaction between factors associated with ITN use considering the availability of ITNs and articulating the need for more research in similar contexts on this dimensionality (e.g., Graves et al., 2011; Pulford et al., 2011; Koenker and Yukich,

2017; Ahorlu et al., 2019; Scott et al., 2021). For example, Graves et al., (2011) note for more research to focus on net characteristics such as ITN ownership period among other net characteristics for analyzing ITN use. While some studies have focused on net characteristics in explaining why households with ITN ownership use fewer ITNs (e.g., Pulford et al., 2011; Baume and Franca-Koh, 2011; Koenker and Yukich, 2017); these factors interact with individual and household factors which can explain the trends in ITN use. As indicated by Ngondi et al., (2011:10), the factors affecting ITN use are more complex than just the level of household ITN ownership. They propose more research into ITN use after mass distribution campaigns which is crucial to understanding and mapping the gap between ITN ownership and ITN use (Ngondi et al., 2011). Several studies on ITNs follow a multilevel approach in examining ITN ownership and use due to the complexity of the phenomenon (Hwang et al., 2010; Wiseman et al., 2007; Ngondi et al., 2011; Graves et al., 2011; Tassew et al., 2017; Tassembedo et al., 2020). A key aspect of ITN use that dominates the literature is malaria-related behavioral choices and decisions. This has often been explored as the primary driver of malaria prevention and control with previous studies identifying factors greatly influencing malaria-related behavior (e.g., Adongo et al., 2005; De la Cruz et al., 2006; Beiersmann et al., 2007; Hwang et al., 2010; Fuge et al., 2015). Indeed, the concept of health-related behavior is intricate and considering the connection between health behavior and health intervention, a comprehensive approach is significant (Naidoo and Willis, 2016). Hence, it is imperative to outline the interplay of the different determinants of health in addressing the phenomenon.

A synopsis of literature (e.g., Toé et al. 2009; Adongo et al., 2005; Alaii et al., 2003; Baume and Marin, 2007; Wiseman et al., 2007; Hwang et al., 2010; Dunn et al., 2011; Koenker and Yukich, 2017; Olapeju et al., 2018) have examined individual-level factors associated with ITN use. Other studies (e.g., Iwashita et al., 2010; Keating et al., 2005; Wiseman et al., 2007; Dunn et al., 2011; Baume et al., 2009; Ng'ang'a et al., 2021) have examined household-level factors in ITN use. Few studies (e.g., Graves et al., 2011; Koenker et al., 2019; Ricotta et al., 2019; Tassembedo et al., 2020) have included community-level health determinants in analyzing ITN use. While some previous studies (e.g., Ngondi et al., 2011; Graves et al., 2011) have also examined all the three levels and including net characteristics (i.e., number of nets/net density, net age, net physical condition) to highlight the multi-level interactions between individual, household, community, and net level factors. These interaction terms are yet to be explored in other contexts with high malaria

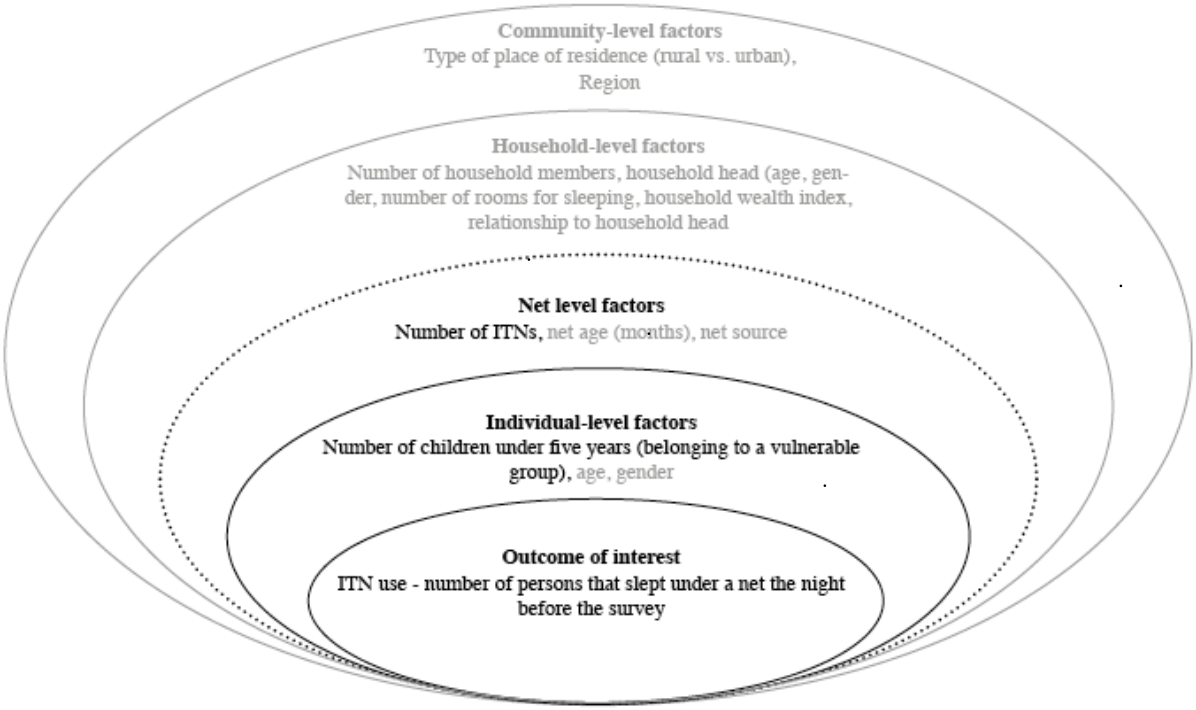
endemicity. Some previous studies on ITN use have explicitly focused on high-risk groups (e.g., children under five years, and pregnant women) since they are at higher risk of malaria illness (e.g., Baume et al., 2009; Wanzira et al., 2014; Fuge et al., 2015; Admasie et al., 2018).

In a study, where Graves et al., (2011) examined the multi-level interaction between factors associated with ITN use, net level factors were included to determine the interactions among other level factors. Therefore, this thesis adds to the literature by contextually analyzing the interactions between individual and net-level factors associated with ITN use. The premise of this analysis is based on Pulford et al., (2011) indication of the need for a greater understanding of the determinants of ITN use and the complex relationship between them, such as moderation effects in determinants of ITN use.

### 3.3. Theoretical Model for the Study

Exploring the interplay of factors associated with ITN use, this thesis conceptualizes a model—Figure 6, based on the main determinants of health conceptual framework to illustrate a multi-level system of the various levels in the analysis. The model is adapted from Graves et al., (2011), and modified to include the specific net level factors to explore a moderation effect. The five distinct levels demonstrated in the model represent the theoretical and methodological perspectives that some empirical studies applied in investigating ITN use. To establish and present a holistic approach to identifying the context-specific factors associated with ITN use and the interaction among various level factors, the theoretical model generates an in-depth analysis in examining ITN use. Accordingly, this study intends to contextually theorize based on previous analysis of ITN use to determine the interplay of individual, household, community, and net level factors in ITN use. This is necessary to understand the gap between ITN ownership and ITN use, for effective malaria intervention. Drawing on Pulford et al's (2011), systematic review of ITN ownership and use research , there has been minimal research attention on the aftermath of mass distribution of ITNs in explaining why households with ITN ownership choose not to use them. Also, understanding the gap between ITN access and ITN use involves a contextual lens due to the heterogeneity of determinants of ITN use across different contexts (Scott et al., 2021).

**Figure 6: Social Model of Health in the Study of Determinants of ITN Use**




Source: Adapted from Graves et al., (2011).

### 3.4. Individual-level factors assessed

Individual-level factors in ITN use are mapped as the most focused layer of malaria-related behavior. The relationship between individual characteristics such as age, gender, vulnerable/risk group (children under five years), and ITN use is well established in malaria prevention research and considered critical in malaria intervention (e.g., Baume and Marin, 2007; Toé et al. 2009; Wiseman et al. 2007; Hwang et al., 2010). Several studies have identified factors including educational attainment, age, gender, and children under five years as strongly influencing ITN ownership and use (e.g., Wiseman et al., 2007; Noor et al., 2009; Quive et al., 2015; Fokam et al., 2017; Olapeju et al., 2018). In a study by Noor et al., (2009) on ITN use in 18 malaria-endemic countries in Africa, ITN use was significantly associated with age in all the surveyed countries, with the use of ITNs highest among children under five years. Children and adolescents over five years were found less likely to sleep under a net compared to children under five years (e.g., Noor et al., 2009; Storey et al., 2018). Some empirical studies have drawn an association between individual health behaviors and malaria-related health choices such as knowledge, perceptions, and practices regarding malaria transmission and prevention which influence ITN use (e.g., Ahorlu et al., 1997; De la Cruz, et al., 2006; Ahorlu et al., 2019). Few empirical studies on ITNs have

employed behavioral theories to analyze the relationship between individual-level determinants and ITN use, making a strong association between individual behaviors such as risk perception and proper knowledge of malaria disease and consistent ITN use (e.g., Hwang et al., 2010; Ngondi et al., 2011; Graves et al., 2011; Storey et al., 2018). A study by Hwang et al., (2010), found that ITN ownership was associated with women's knowledge of malaria which determined ITN use. Also, household members' ITN use was associated with women's risk perceptions and having children under five years in a household, since they are the most susceptible to malaria infections (Hwang et al., 2010). This implies the individual health behavior concerning knowledge about malaria and their vulnerability to the illness.

Moreover, individual perceptions of malaria are a result of a complex mix of beliefs about the cause and prevention of the illness which influence ITN ownership and use (Agyepong and Manderson, 1999). Despite these indications, some studies suggest that greater knowledge about malaria is not always translated to improved ITN use and that these factors are linked with culturally related perceptions about malaria intervention practices (e.g., Adongo et al., 2005; Deressa et al., 2004; Agyepong and Manderson, 1999). For instance, studies on ITN use in Ghana, Burkina Faso and Tanzania have all shown a strong link between local knowledge regarding malaria and individual health choices about the malaria intervention (e.g., Ahorlu et al., 1997; Beiersmann et al., 2007; Nganda et al., 2004) In other words, individuals' ITN use given the availability of ITNs is linked to several factors influencing their choice of use which is primarily determined by malaria knowledge and its associated effect on behavior regarding the intervention. Guided by this empirical evidence, I formulate a hypothesis for this thesis based on a direct relationship between individual-level factors and ITN use. Thus, I hypothesize that:

H1: The number of children under five years is positively associated with household members' ITN use among households with ownership of at least one ITN for sleeping.

### 3.5. Net-level factors assessed

Within the net-level, factors associated with ITN use involve the net characteristics themselves, influenced by access and ownership of ITNs. Recent studies suggest that ITN access and ITN use are highly correlated (e.g., Koenker et al., 2016; Koenker and Kilian, 2014; Ricotta et al., 2019). According to a study in Ghana on determinants of ITN use, ITN use was conditional on access which is affected by other factors such as place of residence (urban or rural) and wealth index for

instance (Ricotta et al., 2019). Graves et al., (2011) highlight that net-level factors are moderators in ITN use due to their effect on other determinants, in terms of net conditions and net physical characteristics (cost, size, shape, color) and perceived durability of ITNs which directly influence ITN use. Moreover, net-level factors are found to significantly interact with the individual, household, community, and environmental factors in complex ways to determine attitudes and behavior towards ITN use and its feasibility for individuals in the household (Graves et al., 2011). In a study by Baume et al., (2009), they indicated that net factors such as net shape influence ITN use such that conical nets are more used in households than rectangular nets due to the ease of hanging for sleeping, which is also determined by individual knowledge about ITN use. Other studies have reported similar results where the shape of the nets influences ITN use such as the inconvenience of hanging, and other net issues like heat discomfort from sleeping under an ITN due to limited airflow (e.g., Hetzel et al., 2012; Fokam et al., 2017; Storey et al., 2018).

Storey et al., (2018) in their study reported that the number of ITNs in the household was associated with ITN use, such that owning three or more ITNs in the household increased the likelihood of household members sleeping under ITNs almost three times compared to one or two ITNs. Furthermore, the net source is a positive predictor of ITN use such that knowing where to obtain ITNs increases ITN use (Storey et al., 2018). Another study by Ngondi et al., (2011) in Ethiopia indicates that decreased ITN use was associated with increased net age, increased damage of ITNs, and a high number of ITNs among other factors. Hence, net-level factors (e.g., length of ITN ownership, number of ITNs) may interact with individual factors such as age, gender, and children under five years. Results from a study in several African countries showed that among children under five years who sleep under ITNs, a higher proportion of male children slept under ITNs compared to females in most of the surveyed countries with no difference in other countries (Noor et al., 2009). Moreover, results from a study on ITN ownership and use in Cameroon highlight that the number of ITNs and children under five years had a strong impact on ITN use in the household (Storey et al., 2018). This has been theorized based on the household sleeping arrangement and household structure in African countries (Iwashita et al., 2010). That is, in African households, infants often share the same bed space with their breastfeeding mothers while older children usually sleep in separate rooms without their mothers (Alaii et al., 2003). Also, ITN distribution to households often targets children under five and their mothers because they are the most vulnerable to malaria thus influencing the number of ITNs in the household and ITN use (Iwashita

et al., 2010). Scott et al., (2021) explain that the reason for low ITN uses among children over five years is because this age group is considered the least vulnerable within a household compared to children under five years and as such not given priority in the household ITN allocation for sleeping. Following these notions, this study adopts the above theoretical perspective in analyzing the relationship between the number of ITNs and the number of children under five years in ITN use. Hence, I hypothesize that this net factor influences the relationship between the number of children under five years and household members' ITN use:

H2: The number of ITNs in the household moderates the relationship between the number of children under five years and household members' ITN use such that the relationship is weaker for households with a fewer number of ITNs.

### 3.6. Household-level factors assessed

Malaria interventions at the household level recognize individuals interacting as a social unit to engage in health-related behavior choices. Household-level factors such as the number of rooms for sleeping, relationship to household head, gender of household head, and household wealth index are associated with ITN use based on the existing literature (e.g., Alaii et al., 2003; Wiseman et al. 2007; Toé et al. 2009; Dunn et al., 2011). Much of the household-level factors are based on the socio-demographic, economic, and cultural aspects of everyday life which influence health-related behaviors regarding ITN use (Dunn et al., 2011).

Toé et al. (2009) imply that in households with fewer spaces for sleeping, ITN use can be a burden and difficult to use since it is bulky to hang up and down and poses a fire risk. Other studies have pointed out that household size and structure influence ITN use among households with ITN ownership (e.g., Wiseman et al., 2007; Baume et al., 2009; Iwashita et al., 2010; Storey et al., 2018; Scott et al., 2021). For example, Iwashita et al., (2010) in their study of ITN use in villages along Lake Victoria, highlight that ITN use is affected by household sleeping arrangements, with most residents unaware of this factor as a reason for ITN non-use. Some studies have focused on the socio-demographic characteristics of households related to ITN use. For instance, a study in Ethiopia found that household size less than or equal to five members were more likely to have their under five years old children use ITNs than those with more than five household members (Admasie et al.,2018). In contrast, a study in Burkina Faso found no significant association

between household size and ITN use by children under five years (Souleymane et al., 2014). A study in Kenya highlights that the gender of a household head especially female heads improves the consistent use of ITNs compared to male household heads (Geraldine and Urbanus, 2018). Conversely, studies in Ethiopia found a significant association between male household heads and household members' ITN use (e.g., Astatkie and Feleke, 2010; Abraham et al., 2015). Several studies have also analyzed the relationship between household wealth index and ITN use (e.g., Allai et al., 2003; Nganda et al., 2004; Ngondi et al., 2011; Noor et al., 2007; Hwang et al., 2010; Ricotta et al., 2019). They found household wealth status to be significantly associated with ITN use whereby households with a higher wealth index used ITNs more often since higher socioeconomic status (SES) is associated with educational level (Ngondi et al., 2011). Higher SES leads to better knowledge which improves the health behavioral choice for ITN use in households (Hwang et al., 2010). Yet, a study has shown that the household wealth index is not a consistent determinant of ITN use (e.g., Eisele et al., 2010). Overall, household-level factors impact health-related behavior and affect ITN use. The household-level factors in this research (*see* Figure 6) are assessed as covariates in the hypothesized model to explain the interaction between household, individual, net, and community-level factors on ITN use (*see* Model 3).

### 3.7. Community-level factors assessed

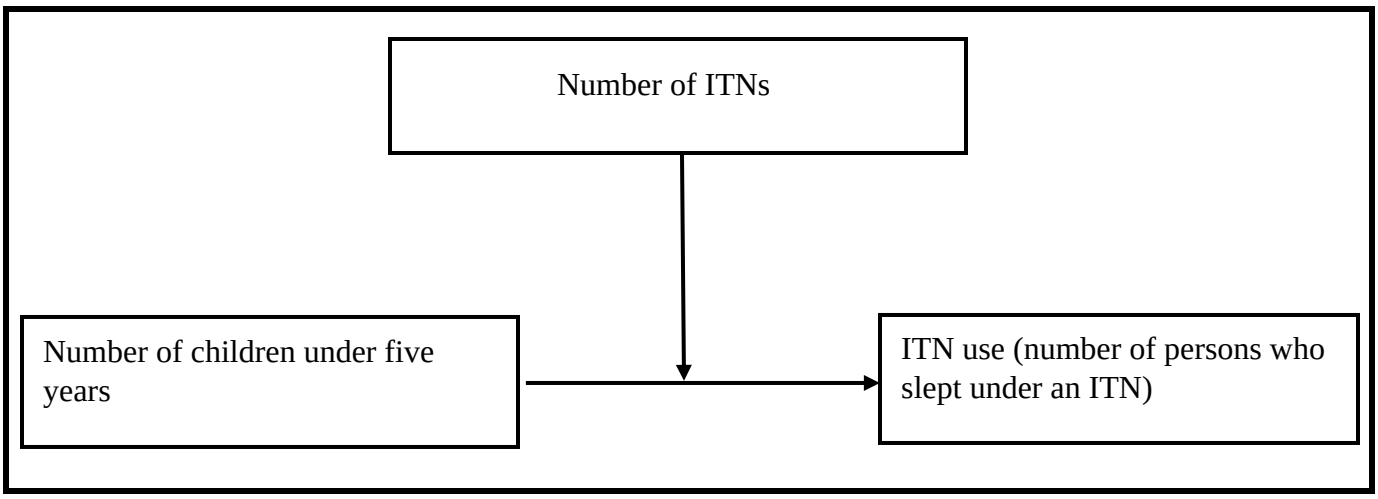
Community-level factors in malaria intervention address the broader socio-cultural aspects of health behavior involving social norms and values, cultural beliefs, and practices that interplay with individual and household factors in determining ITN use. The relevance of community-level factors has been substantiated in several studies assessing ITN use (e.g., Wiseman et al., 2007; Graves et al., 2011; Tassembedo et al., 2020; Koenker et al., 2019). In the findings of a study on ITN use in Burkina Faso, both the place of residence and region were significantly associated with ITN use based on malaria prevalence (Tassembedo et al., 2020). For example, ITN use was higher in households located in urban areas compared to rural areas, as well as higher in regions of low malaria prevalence compared to those with the highest malaria prevalence (Tassembedo et al., 2020). A different study indicates that the settings (either urban or rural) play a role in ITN use and interacts with other factors in determining ITN use (Ricotta et al., 2019). That is, wealthier and more urban households are less likely to use ITNs even when available (Ricotta et al., 2019).

Koenker et al, (2019) report that ITN use is influenced by the region due to seasonal variation which is dependent on factors such as climate (rainfall, temperature), and mosquito abundance. In this case, ITN use is more likely higher in arid climates and less pronounced in humid climates where rainfall is relatively constant throughout the year (Koenker et al., 2019). This condition implies that ITN use is influenced by seasonal variation based on regional differences. Community-level factors assessed in this thesis are the place of residence (rural and urban) and the region which are analyzed as control variables as guided by empirical studies examining ITN use (e.g., Graves et al., 2011; Koenker et al., 2019).

### 3.8. Summary of Overall Research Model

This study adopts the social model of health theory to develop a theoretical model that explains the number of ITNs influencing the relationship between the number of children under five years and ITN use as illustrated in Figure 7. Based on empirical evidence from extant literature, the possible likely moderating role of the number of ITNs is analyzed to address the existing gap between ITN ownership and ITN use. Various control variables including age, gender, number of rooms for sleeping, place of residence, region, relationship to household head, net age, net source, age of household head, gender of household head, and wealth index as potential predictors of ITN use are factored in the overall research. Given the relevance of the interaction of determinants of ITN use in shaping malaria intervention activities, this study may support knowledge for local, national, and international health practitioners undertaking health promotion programs designed to eradicate malaria and improve community health outcomes in malaria-endemic areas.

**Figure 7: Single-level Research Model**



# CHAPTER FOUR: METHODS

## 4.0. Introduction

This chapter follows the theoretical and empirical framework and research hypothesis detailed in chapters two and three by describing the appropriate methodological framework adopted to undertake the research. The methods discusses the philosophical foundation, research design, and the analytical approach utilized for the study.

## 4.1. Philosophical Foundation

A philosophical foundation or 'paradigm' is a general organizing framework for scientific research that involves the research formulation, design, methods, data collection, findings, and the general research process (Punch, 2014). The philosophical foundation adopted for this research is the positivist paradigm. The Positivist Social Science (PSS) position in scientific research is a dominant standpoint that underlines quantitative research. Neuman (2014) defines positivist social science or 'positivism' as a philosophical framework that is positioned on the assumption that scientific knowledge is a direct cause and effect. In Neuman's (2014: 17) definition, it is an "organized method for combining deductive logic with accurate empirical observations of human behavior to identify and validate a set of probabilistic laws for predicting universal patterns of human actions". This allows the possibility to make informed and concrete explanations regarding the cause and effect of human behavior. Positivists' value in social science research is proving causal relationships—providing probable explanations on the cause and effect of human action. The principle of establishing causal laws is based on an explanation of social theory using a realist ontological lens— "the reality is out there and waiting to be discovered" (Neuman, 2014: 98). The practical application of the positivist paradigm involves an understanding of the tenets of social science research which includes distinguishing positivism from other research paradigms like constructivism and interpretative. Thus, justification for this philosophical paradigm including the epistemological, ontological, and methodological assumptions is outlined.

Ontology explains "the issue of what exists, or the fundamental nature of reality" (Neuman, 2014: 93). The ontological assumption of the positivist paradigm is that the world can be understood from a realist view, such that what exists is what we see as it happens. Within a realist view, the world is organized into pre-existing categories waiting to be discovered (Neuman, 2014). Punch (2014: 31) suggests that the realist view in research provides an objective account of the world and

that the basis of science is to develop a descriptive explanation in the form of universal laws. The practical application of ontology in this thesis is the analytical assumption established—the relationship between variables of interest can be expressed through equations and estimated.

Epistemology on the other hand is "the issue of how we know the world around us or what makes a claim about it true" (Neuman, 2014: 95). Epistemological assumption deals with objectivity—that empirical reality is investigated to distinguish factual from non-factual evidence to produce objective knowledge (Neuman, 2014). Positivists engage in deductive reasoning through testing existing data about reality against empirical data. Positivist social science in this case provides a generalist approach to the research—seeking out general rules that optimally pertain to an extremely large number of phenomena, people, settings, and times (Hudson and Ozanne, 1988). This thesis infers from the deterministic assumption based on the causal relationship between objects—the relationship between the number of children under five years and household members' ITN use. Thus, a quantitative approach is appropriate for this thesis.

### 4.2. Research Design

The research design is the basic framework for exploring the study phenomenon in order to focus on the research objectives and address the research hypotheses. The research design directs the overall research process—i.e., data collection, analyzing collected data, interpretation of data, and producing the research (Creswell and Poth, 2018). According to Punch (2014: 206), the research design is the fundamental plan for the research which involves four primary concepts: "research strategy, conceptual framework, sampling of data, and research procedure". A good research design minimizes bias and maximizes the reliability of data collected and analyzed, ensuring coherence, fit to research purposes, and conceptual and theoretical framework (Punch, 2014: 114).

The research design utilized in this thesis is cross-sectional design and relies on secondary data from the 2019 Ghana Demographic and Health Survey (GDHS). This research design is appropriate in making an inference on whether there is a statistically significant relationship between the variable of interest in the study. Cross-sectional research is a scientific process "that examines information on many cases at one point in time" (Neuman, 2014: 44). This design is appropriate for identifying associations between variables in a study that can be a useful tool to guide further experimental studies on the subject (Levin, 2006). A key advantage of this design in

public health research is the applicability of study findings to an unobserved population (Levin, 2006). Thus, it provides a scientific process that is both conceptual and evidence-based and can be applied to various social contexts and settings involving large populations.

### 4.3. Ghana Demographic and Health Survey (GDHS)-2020 Dataset

The GDHS is based on the DHS research process that collects in-depth information on a wide range of topics from a representative sample of the population in Ghana. The dataset is based on lengthy surveys that collect, process, tabulate and publish a report describing the living conditions and the demographic and health situation in the country. The GDHS dataset is derived from the global DHS program established by the US Agency for international development in 1984 (Croft et al., 2018). This project measures public health topics such as malaria, HIV and nutrition, anaemia childhood mortality, child health, maternal mortality, and maternal health, among others. The program also measures indicators related to the sustainable development goals such as wealth index, gender, and education. Since its introduction, the DHS program has conducted more than 400 surveys in over 90 countries (see[1] for a complete overview).

The GDHS, a nationally representative survey, is implemented by the Ghana Statistical Service (GSS), the Ghana Health Service (GHS), and the National Public Health Reference Laboratory (NPHRL), a division of the GHS (Ghana Statistical Service-GSS et al., 2015). These surveys, conducted in phases provide reliable and recent data on health topics, particularly information on malaria treatment, prevention, and prevalence among children and women and other health-related topics (e.g., family planning, HIV prevalence, etc.). Key indicators on demographic characteristics involving individual respondents, households as well as socioeconomic status index are collected (Ghana Statistical Service-GSS et al., 2015). The 2019 Ghana Malaria Indicator Survey (GMIS) published in 2020 is the most recent series of the GDHS and is the primary data source for analysis in this thesis.

### 4.4. Ghana Malaria Indicator Survey (GMIS)-2019

The 2019 GMIS is the second in the series of the GMIS—the first conducted in 2016. The GMIS dataset is based on a nationally designed survey to obtain population-based estimates of malaria indicators that are used to inform strategic planning and evaluation of the Ghana Malaria Control

[1] Comprehensive guide to DHS Data https://dhsprogram.com/

Programme (Ghana Statistical Service-GSS and ICF, 2020: ix). The dataset provides information on malaria prevention, treatment, and prevalence in Ghana. The survey collects data on global malaria measures such as ownership and use of ITNs, assessed coverage of intermittent preventive treatment (IpT) to protect pregnant women against malaria, identified practices and specific medications used to treat malaria, measured indicators of malaria knowledge and communication messages (Ghana Statistical Service-GSS and ICF, 2020).

GMIS data collection involves two phases. The first phase comprises the household listing exercise (200 cluster areas), which were visited, and the data was recorded on structures, names of the head of households, and the Global Positioning System (GPS) coordinates of clusters. The second stage involves interviews of households and eligible women aged 15-49, and children aged 6-59 months are tested for anaemia and malaria with consent from guardians or parents. Finally, the data collected is via computer-assisted personal interviewing (Ghana Statistical Service-GSS and ICF, 2020). Thus, this dataset is suitable for analysis in this thesis based on the demographic and malaria indicators measured in the survey.

## 4.5. Data

### *4.5.1. Sampling*

The sampling strategy for the 2019 GMIS follows a random sample of clusters based on the 10 administrative regions of Ghana. The sampling frame is a complete list of all census enumeration boundaries defined according to the 2010 Population and Housing Census (PHC). It contains information about the enumeration areas (EA) location, type of residence (urban or rural), the estimated number of residential households, and the estimated population (Ghana Statistical Service-GSS and ICF, 2020: 1). The sample was stratified and selected from the sampling frame in two phases. In the first phase, 200 EAs (97 in urban areas and 103 in rural areas) were selected using a random sampling selection in each sampling stratum (Ghana Statistical Service-GSS and ICF, 2020: 2). The survey for the final GMIS data uses four questionnaires: the Household Questionnaire, the Woman's Questionnaire, the Biomarker Questionnaire, and the Fieldworker Questionnaire. The questionnaire was adapted to reflect issues relevant to Ghana.

The 'Household Questionnaire Forms' lists all the usual members in the selected household including the characteristics of each household member such as age, sex, and relationship to the head of household (*see* Croft et al., 2018). Additionally, the 'Household Questionnaire Forms'

contain information on characteristics of the household including the number of sleeping rooms, ownership, and use of ITNs. Given the primary objective of the survey and the indicators available, the 'Household Questionnaire Forms' is the focus of this thesis (*see* Croft et al., 2018). The 'Household Questionnaire Forms' are used to select women and men eligible for individual interviews. Women and men aged 15-49 and 15-59 respectively are interviewed using the 'Woman's and Man's Questionnaire Forms'. A sample of 5,799 households from a selected 6,002 households was successfully interviewed yielding a response rate of 99 % (Ghana Statistical Service-GSS and ICF, 2020: 5). In the interviewed households, 5,181 women out of 5,246 selected were successfully interviewed, yielding a response rate of 99% (Ghana Statistical Service-GSS and ICF, 2020: 5).

#### *4.5.2. Sample*

The study sample is the Household Members (or Persons—PR) Recode Unit of analysis dataset retrieved from the DHS 2020 database. The PR dataset contains completed household and individual household members interviews—household characteristics, individual men and women, and biomarker rosters. (Croft et al., 2018). Specifically, the PR data contains information on characteristics of household members including age, sex, marital status, education, as well as biomarker measurement information (Croft et al., 2018). The dataset includes both 'de facto' and 'de jure' household members— "the former describes the group of people that stayed in the household the previous night whiles the latter describes the people that usually live in the surveyed households also known as usual residents" (Croft et al., 2018: 57). The type of household appropriate for analysis by the DHS is the 'de facto' household population. The total number of the defacto household population interviewed in the GMIS 2019 was 23,713. Thus, the dataset chosen for the thesis analysis both describes the household characteristics (household composition and structure) as well as the household members (women and men individually). The PR dataset is appropriate for the thesis as it contains accurate information on household members and household characteristics that are relevant for analysis on the issue of malaria prevention.

#### *4.5.3. Data Quality*

According to Croft et al., (2018), the DHS data is of high quality and provides accurate measurement of indicators due to multiple steps in data processing and data reporting. A data editing process is applied to the data where incorrect or incomplete reporting such as date of birth or important event dates are handled appropriately in the final dataset. This is explained thoroughly

in the DHS guide (*see* Croft et al., 2018). Data handling in the DHS deals with issues such as 'not applicable' and 'missing values' and 'other special codes'. The DHS program uses a process of data editing and imputation to input exact information such as important dates. Data quality assessment reports conducted on the DHS have supported the authenticity of the dataset, confirming it to be of high quality (Pullum, 2019). The DHS guide provides a detailed procedure for data collecting and analysis as part of the data quality assurance (Croft et al., 2018)[2].

#### *4.5.4. DHS Data Access and Authorization*

Access to the DHS data was by a letter to the DHS office via email requesting permission to use the data for a Master thesis research. This involved a detailed description of the purpose of the data use and the research objectives that will be explored. Successful approval based on the research description was granted on 16th March 2021 (*see* Appendix A for approval letter). As stated in the letter, the data is available for use only for the registered project, and redistribution of data is not permitted.

### 4.6. Data Measures

This section describes the variables in the DHS dataset that is used and the handling of the scale items into composite variables for analysis.

#### *4.6.1. Outcome Variables*

***Use of ITNs by persons in the household****:* According to the Guide to DHS Statistics (Croft et al., 2018) the measure of use of ITNs by persons in the household is based on the Household survey indicator regarding Malaria Control Indicator four—i.e., the proportion of the household population that slept under an ITN the previous night. It measures the use of ITNs as a malaria intervention strategy among the WHO 100 Core Health Indicators (Croft et al., 2018). The use of ITNs is defined as "the percentage of the household population who slept the night before under an ITN, and among the population in households with at least one ITN, the percentage who slept under an ITN the night before the survey" (Croft et al., 2018: 473). It is an index of five self-reported items used to measure the number of 'de facto' household population that slept under an ITN the night before the survey. The maximum number of persons sleeping under one ITN is set to five (5+) since the survey provides an index of up to five different persons (ICF, 2018).

[2] See for an overview of DHS data quality procedures https://dhsprogram.com/data/Data-Quality-and-Use.cfm/

### *4.6.2. Independent Variables*

***Number of children under five years***: It describes the total number of children five years and under in a household. This is part of the 'Household Questionnaire' forming the household schedule and indicates the question: "*What is the number of all children aged 0-5 ?"* The response is factored as a continuous variable with the value ranges *0, 1, 2, 3, 4, 5, 6, 7, 8,* and *11*.

***Number of insecticide-treated bed nets (ITNs)***: This variable is included in the 'Household Characteristics' and measures household ownership of ITNs as part of the indicators for malaria prevention. The variable is based on the response to the question "*How many mosquito bed nets does your household have ?*". The variable is counted as continuous with the given value ranges *1, 2, 3, 4, 5, 6, 7(+)*. The last value is based on the survey response which indicates that if 7 or more nets, record '7'(Ghana Statistical Service-GSS and ICF, 2020).

### *4.6.3. Socio-Demographic Control Variables*

Following the theoretical and empirical framework, review of relevant literature described above, and prior studies utilizing the DHS dataset, the following demographic variables were included as socio-demographic control variables: age, gender, place of residence, and region. The age range in the subsample was from 15-49 years and was defined as a continuous variable. Gender/sex as represented in the DHS data is a dichotomous variable of either female or male. Place of residence was defined as a categorical variable of urban and rural. Urban areas are described as areas with a population size of 5,000 and above (Songsore, 2009). Region of residence was a categorical variable that is defined for every cluster in the sample design. A total of 10 administrative regions were selected from which the clusters for the survey were drawn. Also, a list of several other explanatory variables included as covariates are discussed.

### *4.6.4. Other Covariates*

***Net age (in months):*** This describes the number of months the ITN was obtained and owned by the household. It forms part of the indicator of household net ownership in the malaria indicator survey. This variable is based on the question: "*How many months ago did your household get the mosquito bed net ?"*. The response is treated as a categorical variable (nominal) in the following categories *0, 13, 25, and 37(+)* months respectively .

***Source of ITNs:*** It assessed the percent distribution of ITNs by the source of the net. According to the 2019 GMIS, the main source of ITNs in Ghana was the 2018 mass national distribution campaign, which accounted for 67% of household nets (Ghana Statistical Service-GSS and ICF, 2020: 28). Based on the DHS guide, the variable is an index of four items on the source of ITNs owned by surveyed households: *i.* Mass Distribution Campaign, *ii.* Antenatal care clinic, *iii.* immunization visit, and *iv.* school district distribution. The survey questionnaire asks: "*Did you get the net through the 2018 mass distribution campaign, during an antenatal care visit, during an immunization visit, or during a school distribution ?*" The respondent answers *yes* to one of the four items. For instance, *yes* to item *i* if that was the source of ITN or *yes* to item *ii,* and so on. If none of the four main sources was used by the household, then the response was no (*0*). A (*0)* response is the baseline of the source of ITNs if the ITNs were not accessed through the four main sources—"*Where did you get the net* ?" (*1*) Private Health Facility, (*2*) Pharmacy/Chemist/Drugstore, (*3*) Shop/Market, (*4*) Religious Institution, (*5*) NGO, (*6*) Community Based Agents, (*7*) Petrol Station/ Mobile Mart (CBAs), (*8*) Prior Mass Distribution Campaign, (*96*) Other (Ghana Statistical Service-GSS and ICF, 2020: 105). This variable was recoded into a binary variable: campaign distribution which includes all the four main sources of ITNs (i.e., mass campaign distribution, antenatal care clinic, immunization, and school visit) with the variable value of (*1* ) and other sources with a variable value of (*0*).

***Wealth index:*** The wealth index measures the household wealth by residence (Ghana Statistical Service-GSS and ICF, 2020). This involves the percent distribution of the 'de jure' population by wealth quintiles—poorest/lowest, poorer/second, middle, richer/fourth, richest/highest (Ghana Statistical Service-GSS and ICF, 2020). The wealth index factor is calculated as the percentage of households possessing various household effects (radio, television, mobile phone, computer, refrigerator), means of transportation (bicycle, car, boat), agricultural land, and livestock/farm animals, according to residence (Ghana Statistical Service-GSS and ICF, 2020). Few studies in the sub-Saharan region have applied the wealth index in their analysis of the household economic status and malaria prevention (e.g., Rutstein and Johnson, 2004; Taylor et al., 2017). The wealth index provides information that may be relevant for malaria control indicators regarding the proportion of household ITN ownership, and the number of rooms used for sleeping. The items in the wealth index have the value range of 1-5 based on the categories: *poorest, poorer, middle,*

*richer, and richest* respectively.

***Number of household members***: It measures the total 'de jure' household population during the survey. This involves the response to the question *"What is the total number of persons in the household ?"* The response is measured as a continuous variable with the values *1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, and 38*.

***Number of rooms for sleeping***: It measures the total number of rooms used for sleeping as part of the household characteristics. This is part of the 'Household Questionnaire' which indicates the question: *"How many rooms in the household are used for sleeping?"* The response is factored as a continuous variable with the values *1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 22, and 24*.

***Relationship to head of household****:* This describes each 'de jure' and 'de facto' household member's relationship to the head of household. It measures the relationship to the household head as part of the 'Household Schedule': *"What is the relationship of (NAME) to the head of the household ?"* The response is factored as a nominal variable in the following categories: Head (*1*), Wife or Husband (*2)*, Son or Daughter (*3*), Son-in-law or Daughter-in-law (*4*), Grandchild (*5*), Parent (*6*), Parent-in-law (*7*), Brother or Sister (*8*), Other relative (*9*), Adopted/Foster/Stepchild (*10*), Not related (*11*), (ICF., 2018). However, for the analysis, this variable was recoded into only 4 nominal categories namely Head (*1*), wife or husband (*2*), son or daughter (*3*), and other relatives (*4*) (combines all the items previously 4-11 into one item ).

***Age of household head***: This describes the age in years of the head of household interviewed. This is part of the 'Household Questionnaire' describing the head of the household. The response is factored into a continuous variable. The age values are from 0 to 95 years.

***Gender of household head***: This describes the gender of the head of each household interviewed. This is part of the 'Household Questionnaire' describing the head of the household. The response is factored as a binary variable with the categories: male(*1*) and female (*2*).

## 4.7. Analytical Approach

Data analysis was conducted using Stata 16—Stata Corporation, College Station, Texas. The thesis analysis consists of a descriptive analysis of the data, bivariate analysis to assess the association between the independent and the dependent variables, and multivariate logistic regression models to examine the extent of the correlation among the variables. All analyses involved the survey sampling design and sampling weights.

### *4.7.1. Data Examination*

Data examination is a statistical process of checking for the accuracy of the data and consistency of the measures (data cleaning) for data analysis (Neuman, 2014). Data examination and data cleaning are vital processes before statistical analysis (Creswell and Poth, 2018). First, a preliminary assessment is made to understand the data structure, to know how missing values are labeled, the total number of observations regardless of the missing values, the total number of variables, and the type of variables—i.e., categorical, and continuous, that are necessary (Punch, 2014). Data cleaning involves identifying and addressing the errors in data inputs in a dataset. Thus, data examination and cleaning represent an intensive data analysis step that allows one to responsibly proceed with accurately analyzing, interpreting, and reporting quantitative data.

These issues are vital in preliminary data analyses which influence estimation bias, and the statistical power of the model if not addressed (Tabachnick and Fidell, 2007). For example, with smaller datasets, careful proofreading of all data variables is recommended but for larger datasets, analyzing descriptive statistics and graphic representations of variables is efficient in ensuring appropriate value ranges—e.g., possible minimum and maximum values (Tabachnick and Fidell, 2007). The preliminary steps to be addressed in this thesis include handling missing data and detecting outliers (extreme values) and normality.

The issue of missing data is the most common in quantitative research. For instance, it is essential to first identify the extent of missing data such as the patterns of missing data and the amount of data missing, and the reasons why the data may be missing to reduce bias (Tabachnick and Fidell, 2007). On the other hand, outliers/extreme values distort sample statistics—i.e., can lead to either stating there is an association or correlation when there is not one or failing to identify a cause and effect when there is one and interfere with generalizability (Tabachnick and Fidell, 2007).

Appropriate techniques must be applied to address these issues which determine the reliability and validity of data. Addressing missing values could for instance be conducted by substituting the mean with an overall sample mean or a subsample mean or using multiple imputations (Tabachnick and Fidell, 2007). Regarding outliers, such extreme values may be excluded from the data analysis. In effect, data examination and cleaning techniques are utilized to correct erroneous and extreme values to minimize bias and increase the data quality (Tabachnick and Fidell, 2007).

#### *4.7.2. Issues Addressed: Missing Values, Outliers, Normality*

Data examination and cleaning for the thesis involved running a descriptive analysis for the various continuous variables to obtain descriptive statistics, such as central tendency—mean and standard deviation, normality, missing values, range (minimum and maximum values), and checking for the normal value ranges based on the variable coding process (value labels). Also, a frequency distribution model (estimates) was run for the categorical variables.

In the Guide to DHS Statistics, specific rules are provided on handling missing values and other special categories of data values. For instance, codes like "missing", "don't know", "inconsistent" and "not applicable" (or "blank") are assigned special responses (see[3] for a comprehensive review of handling missing values and other exceptions).

Incomplete data issues in multilinear data analyses are considered in both the independent variables and dependent variables which in principle require non-missing data values regarding all observations (Frost, 2019). Observations with missing values in the predictors are handled in the data analysis by listwise deletion. This can be easily done but could produce bias in the model depending on the type of observation with missing values—i.e., in cases where the missing values are not completely random and missingness is dependent on another variable's value (Frost, 2019). For this thesis, missing values are determined to be random— i.e., not related to the missing data, but some of the observed data, and do not pose any major concern to the data analysis. Grund et al., (2016) suggest that listwise deletion can be an ideal method for addressing incomplete values especially when the variance of the slopes is large. Listwise deletion provides complete information on each observation, such observations with some missing or incomplete information on any variable are excluded (Grund et al., 2016).

[3] https://www.dhsprogram.com/data/Data-Processing.cfm#CP_JUMP_5191/

In the thesis, listwise deletion was applied to the sample of 23,713 observations which resulted in 12,736 observations dropped. The final sample utilized after addressing missing values and outliers was 10,977 with complete observations, which is suitable and relevant for multilinear modeling and to decrease estimation errors (Tabachnick and Fidell, 2007).

#### *4.7.3. Bivariate Analysis*

For the data analysis, the relationship between the dependent variable and the various independent variables was assessed in a multivariate setting. In the first analysis, correlations between the variables were examined. Regarding the continuous variable, Pearson Product-Moment Coefficient was applied to determine the associations. For categorical and binary variables, Polychoric and biserial correlations were used accordingly.

#### *4.7.4. Regression Analysis*

A linear regression modeling (i.e., multiple linear regression) was applied in the study due to the number of observations and to detail the relationship between data variables (Tabachnick and Fidell, 2007; Pallant, 2010). Multiple linear regression is a type of linear least-squares method for estimating the parameters for a particular level of a set of exploratory variables by the principle of minimizing the sum of the squares of the differences between the observed dependent variable (Frost, 2019). A basic assumption of this method is that the smaller the differences in the dependent variable of the sum of squared distances of the independent variables, the better the model fits the data (Pallant, 2010). A linear model is suitable for the regression analysis because the dependent variable is continuous thus minimizing bias (Snijders and Bosker, 2012). Moreover, multiple linear models allow us to specify the relationship between the levels of random effects and factorial interactions on the dependent variable for a given set of individuals (Frost, 2019). As a cross-sectional study, this procedure is methodologically appropriate (Snijders and Bosker, 2012; Frost, 2019). Multiple linear regression models have been used in health promotion research in determining the relationship among various independent variables on a continuous dependent variable (e.g., Liu et al., 2015; Kurnia et al., 2017; Pelikan et al., 2018).

#### *4.7.5. The Moderation Model*

This study utilizes the moderation theory and methods developed by Preacher, Rucker, and Hayes (2007). The moderation model tests whether the prediction of a dependent variable, from an independent variable, differs across levels of a third variable (Fairchild and MacKinnon, 2009: 89). According to Preacher, Rucker, and Hayes (2007), moderation is significant in determining

the relationship between two variables where the correlation between the outcome variable and independent variable is dependent on a third variable. “Moderator variables affect the strength and or the direction of the relation between a predictor (IV) and an outcome (DV)—i.e., *enhancing*, where the effect of the predictor on the outcome increases with an increase in the model, *reducing*, where an increase in the moderator would decrease the effect of the predictor on the outcome or *changing*, where an increase in the moderator would alter the effect of the predictor on the outcome” (Fairchild and Mackinnon, 2009: 89). In line with this, the study is focused on the moderation effect of the *number of ITNs* on the relationship between the number of children under five years and household members’ ITN use. Moderation effects in this thesis are tested on a single moderation model where both predictor variables and their relationship to the outcome variable are observed before the model estimation.

#### *4.7.6. Model estimation*

Four models were estimated (i.e., Model 1, Model 2, Model 3, Model 4). Since the analysis was at a single analytical level (i.e., household members), the null model was not applied (Tabachnick and Fidell, 2007). The outcome variable was measured at a single level (i.e., each variable measured has a different intercept coefficient and different slope coefficients. In Model 1, the direct effect of the number of children under five years on household members’ ITN use was analyzed, representing hypothesis 1 (Base Model). The moderation effect (i.e., number of ITNs in the household) was introduced in Model 2 representing hypothesis 2. In Model 3, the moderation effect was reintroduced, including the control variables to form the final model. Hence, the final model shows the interaction between the number of children under five years, the number of ITNs in the household, and covariates that were examined for the final model. Model 4 was a robustness check of Model 3 using the White test to produce more robust results.

#### *4.7.7. Robustness check*

A robustness check is performed to assess whether a statistically significant relationship remains across different model estimations. “Robustness check’ is where the researcher examines how certain “core” regression coefficient estimates behave when the regression specification is modified by adding or removing regressors (Lu and White, 2014: 194). Robustness is necessary for valid causal inference such that coefficients of the critical core variables should be insensitive to adding or dropping variables, under appropriate conditions (Lu and White, 2014). Robustness test such as the White test is a significant diagnostic test that check for heteroscedasticity (i.e.,

differing variance) in regression data analysis as a way of improving research practice (Sajwan and Chetty, 2018). If heteroscedasticity is present in the data, the variance differs across the values of the explanatory variables and violates the assumption, making the OLS estimator unreliable due to bias (Sajwan and Chetty, 2018). The White test was performed after the final model to apply corrective measures to the results for data validity (*see* Appendix C for analysis of the White test).

### 4.8. Ethical considerations

The ethical procedure in this research followed the ethical guidelines in scientific research—i.e., informed consent, anonymity, and no harm (Oancea, 2014). Ethical concerns and ethical behavior were undertaken extensively as part of the DHS research mandates (*see* Ghana Statistical Service –GSS, and ICF, 2020). As part of the ethical procedure in Norway, ethical clearance must be sought from the Norwegian Centre for Research Data (NSD), but this was not applicable since the secondary data used for this research was sourced from outside of Norway. Other specific guidelines in conducting research in Norway were followed based on the NSD guideline, which represents the institution mandated with Data Protection for Research undertaken in all Norwegian universities. The Ghana DHS was approved by the Ghana Health Service Ethical Review Committee and the Inner-City Fund's (ICF) Institutional Review Board. The survey further complies with the US Department of Health and Human Service regulations for the protection of human subjects. The institutional review board responsible for the ethical protocol in Ghana ensured that the survey complies with the laws and norms of the Ghanaian society[4].

### 4.9. Informed Consent

The DHS and ICF had clear protocols for the 2019 GMIS. The risks and benefits of participation in the survey were explained to respondents (Ghana Statistical Service-GSS and ICF, 2020). Participation in the survey was voluntary. Informed consent was sought directly from eligible respondents before the various questionnaires (e.g., Household or Woman) were administered. Data regarding children involved requesting informed consent from parents or guardians (Ghana Statistical Service-GSS and ICF, 2020). All data and other relevant information collected were confidential. Respondent's names and identification numbers were removed from the final data sets before analyses were conducted (*see*, Ghana Statistical Service – GSS and ICF, 2020).

[4] See, The DHS Program - Protecting the Privacy of DHS Survey Respondents for a comprehensive overview

# CHAPTER FIVE: RESULTS

## 5.0. Introduction

This chapter presents the results of the statistical analyses conducted to test the hypotheses in the study. Firstly, descriptive statistics and correlations for the study variables are reported. Secondly, drawing on the theoretical and methodological framework in chapters two and four respectively, model estimates are reported and analyzed for best fitted and final model selection. Lastly, the selected final model is used to address the research objectives and hypotheses.

## 5.1. Descriptive Statistics

Descriptive statistics is a preliminary analysis of data to describe and report the characteristics of the sample of a study in a valid process (Punch, 2014). It includes the mean, standard deviation, range of scores, skewness, kurtosis, observation missingness, and how they are flagged and handled (*see* Appendix for descriptive statistics). In this thesis, a univariate analysis was performed to observe normality patterns, outliers—i.e., unique observations of respondent's background on multiple dimensions used in the study; and are reported. Table 1 presents the descriptive statistics of means, standard deviation (SD), and percentage distribution for each variable under study.

### *Final sample*

The final study sample utilized as discussed in the methodology chapter after addressing missingness and incomplete data was 10,977 with complete observation, which is appropriate and desirable for regression analysis and to reduce estimation complexities.

### *Household Socio-Demographic characteristics*

In terms of household demographic characteristics, the mean age of the sample was 24.7 years (SD = 21.51) with the distribution of the household members as 0-95 years. The age distribution for the household head ranged from 16-95 years with a mean of 48.3 years (SD = 15.6). The age ratio with the place of residence was evenly distributed. In terms of gender, 46.10 percent of the sampled household members were male, and 53.9 percent were female. Also, the gender of the household head if male or female was 73.4 and 26.6 percent respectively which was unevenly distributed. The average household size in the sample is six (SD = 3.3) with household members ranging from one to 38 for a given household. About 26.9 percent of the sampled households resided in the urban areas while 73.03 percent resided in the rural areas. The region of sampled households involved a mean of 6.13 (SD = 2.9) ranging from one to 10. The distribution of the region of the sampled households was evenly distributed across nine of the 10 regions.

**Table 1: Descriptive characteristics of study variables for household members GMIS 2019/ Ghana DHS 2020**

| Variable. | Variable type | (%) | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|---|
| Age (years) | Continuous | | 10,977 | 24.67 | 21.51 | 0 | 95 |
| Household members | Continuous | | 10,977 | 6.12 | 3.29 | 1 | 38 |
| Children under five years | Continuous | | 10,977 | 1.20 | 1.21 | 0 | 11 |
| Household Head (age) | Continuous | | 10,977 | 48.26 | 15.58 | 16 | 95 |
| Number of rooms for sleeping | Continuous | | 10,977 | 2.46 | 1.71 | 1 | 24 |
| Number of ITNs | Continuous | | 10,977 | 3.14 | 1.60 | 1 | 7 |
| ITN use | Continuous | | 10,977 | 2.28 | .92 | 1 | 4 |
| Wealth index | Ordinal | | 10.977 | 2.19 | 1.25 | 1 | 5 |
| Poorest | | 40.11 | | | | | |
| Poorer | | 24.63 | | | | | |
| Middle | | 18.38 | | | | | |
| Richer | | 10.24 | | | | | |
| Richest | | 6.63 | | | | | |
| Gender | Nominal | | 10,977 | | | | |
| Male | | 46.10 | | | | | |
| Female | | 53.90 | | | | | |
| Household head (gender) | Nominal | | 10,977 | | | | |
| Male | | 73.39 | | | | | |
| Female | | 26.61 | | | | | |
| Net age (in months) | Nominal | | 10,977 | | | | |
| 0 months | | 55.89 | | | | | |
| Up to 13 months | | 30.42 | | | | | |
| Up to 25 months | | 6.53 | | | | | |
| Up to 37 months (3 years+) | | 7.16 | | | | | |
| Relationship to Household head | Nominal | | 10,977 | | | | |
| Head | | 22.43 | | | | | |
| Wife/husband | | 14.11 | | | | | |
| Son/daughter | | 42.67 | | | | | |
| Other relatives | | 20.79 | | | | | |
| Type of place of residence | Nominal | | 10,977 | | | | |
| Urban | | 26.97 | | | | | |
| Rural | | 73.03 | | | | | |
| Region | Nominal | | 10,977 | | | | |
| Western | | 8.95 | | | | | |
| Central | | 8.80 | | | | | |
| Greater Accra | | 3.57 | | | | | |
| Volta | | 10.39 | | | | | |
| Eastern | | 6.77 | | | | | |
| Ashanti | | 9.20 | | | | | |
| Brong Ahafo | | 11.17 | | | | | |
| Northern | | 15.07 | | | | | |
| Upper East | | 14.21 | | | | | |
| Upper West | | 11.87 | | | | | |
| Net source | Nominal | | 10.977 | | | | |
| Campaign distribution | | 80.01 | | | | | |
| Other source | | 19.99 | | | | | |

*N* = 10,977

In terms of region as measured in the sample, Greater Accra accounted for 3.57 percent of the sample representing the lowest proportion of the 10 administrative regions sampled. The Northern region, Upper East and Upper West accounted for 15.07, 14.21, and 11.87 percent respectively, representing the highest percentages of the sample. The remaining six regions accounted for values between 6,.77 percent, and 11.17 percent of the sample. The wealth index in this study is measured as an ordinal variable—i.e., poorest, poorer, middle, richer, and richest categories. Among these categories, 40 percent of the sample were in the poorest category of the wealth index. 25 percent of the sample were in the poorer category. 18 percent of the sample were measured in the middle category. 10 percent of the sample represented the richer category whilst the richest category accounted for seven percent of the sample. Both the richer and richest categories combined represented 19 percent of the sample, of which approximately 72 percent resided in the urban centers. Thus, the data shows that regarding household wealth index, there is a wide inequality between urban and rural households.

*ITN use*

This measure is a continuous variable that represents the indicator of the use of ITNs by persons in the household: reflecting the *number of persons that slept under a net the previous night before the survey*. Regarding this measure, the mean value for the number of persons who slept under a net per household is two with a minimum and maximum value of one and four respectively. 22 percent of the sample reported one person slept under an ITN the previous night. 40 percent reported two persons slept under an ITN the previous night. 28 percent reported three persons slept under an ITN the previous and 10 percent reported four persons sleeping under an ITN the previous night. The number of persons who slept under ITNs differed significantly between urban and rural households with as much as 80 percent of the sample accounting for more persons sleeping under ITNs in rural households. Hence, the sample can be assumed to be unevenly distributed in terms of ITN use across the type of place of residence.

*Number of children under five years*

This variable is represented as a continuous variable with a mean score of 1.20 (SD = 1.21, range 1-11). 32 percent of households in the survey reported having no children under five years. 33.5 percent of households reported having one child under five years. 23 percent of the household reported having two children under five years old in the household. Seven percent of the household sample reported having three children under five years. Two percent of the household sample had

four children under five years old. One percent of the sample had five children under five years old. The remaining number of children *6, 7, 8,* and *11* accounted for 0.52 percent of the household sample. Hence the sample can be said to be unevenly distributed in terms of the proportion of children under five years in the household.

*Number of ITNs in the household*

The mean score for the number of ITNs in the household is 3.14 (SD: 1.60, range 1-7). 12 percent of the sample reported owning at least one ITN. 28 percent of the sample reported owning two ITNs. 24 percent of the sample reported owning three ITNs. 19 percent of the sample reported owning four ITNs. Eight percent of the sample reported owning five ITNs. Four percent of the sample reported owning six ITNs and five percent of the sample reported owning seven ITNs or more.

*Net source*

As stated in the methodology chapter, this variable was recoded into a binary scale— campaign distribution and other sources. The mean score for the source of the net was .80 (SD: .40, range 0-1). 80 percent of the sample reported campaign distribution as their source of the net. 20 percent reported other sources.

*Net age (in months)*

Net age consists of four categories describing the age of the net in months based on the period the household obtained the ITNs. This variable is measured on a nominal scale with a mean score of 8.23 (SD: 11.10, range 0-37). 56 percent of the sample reported obtaining the net less than a month ago. 30 percent reported obtaining the net up to13 months ago. Seven percent reported obtaining the net up to 25 months ago. Seven percent reported obtaining the net for up to 37 months or more.

**5.2. Bivariate Analysis**

In the following, correlation coefficients for the associations between variables under study are presented. Table two reports Pearson correlation coefficients between continuous variables and Polychoric correlations between categorical variables. The bivariate analysis includes weak to moderate correlations obtained between the independent variables and the dependent variable. Overall, the main study variables of interest were significantly correlated ($p < .05$). The correlation results are discussed in detail in the following section.

*Relationship among main study variables*

The number of children under five years and ITN use were positively correlated, and this association was statistically significant (r= .33, p < .05). Number of ITNs was negatively related to ITN use (r= -.06, p < .05) and was positively associated with number of children under five years (r= .23, p < .05).

*Relationship between explanatory variables and main study variables*

Gender was associated with ITN use (r =.07, p < .05), number of children under five years (r = .03, p < .05) and negatively associated with number of ITNs (r = -.02, p < .05). Age was negatively associated with ITN use ( r = -.40, p < .05), number of children under five years ( r = -.24, p < .05), and number of ITNs (r = -.03, p < .05). Wealth index was negatively associated with ITN use (r= -.10, p < .05), number of children under five years ( r = -.11, p < .05) and number of ITNs (r= -.04, p < .05). Region was not significant with ITN use (r = .02). but significantly associated with number of children under five years (r = .12, p < .05) and number of ITNs( r = .10, p < .05). Place of residence was associated with ITN use (r = .10, p < .05), number of children under five years ( r = .10, p < .05) and number of ITNs ( r = .06, p < .05). The detailed relationship among all the variables in the study are illustrated in Table 2.

**Table 2: Bivariate association of potential predictors with reported household ITN use. GMIS 2019/ Ghana DHS 2020.**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ITN use (1) | 1 | | | | | | | | | | | | | | |
| Children under five years (2) | .33* | 1 | | | | | | | | | | | | | |
| Number of ITNs (3) | -.06* | .23* | 1 | | | | | | | | | | | | |
| Gender of household members (4) | .07* | .03* | -.02* | 1 | | | | | | | | | | | |
| Age of household members (5) | -.40* | -.24* | -.03* | .08* | 1 | | | | | | | | | | |
| Net source (6) | .02* | .08* | .06* | .01 | -.03* | 1 | | | | | | | | | |
| Net age (in months) (7) | -.02* | -.04* | .0 | -.01 | .03* | -.40* | 1 | | | | | | | | |
| Relationship to household head (8) | .22* | .20* | .20* | .10* | -.60* | .02* | -.10 | 1 | | | | | | | |
| Gender of household head (9) | -.04* | -.11* | -.11* | .16* | .02* | .04* | -.06* | .10* | 1 | | | | | | |
| Age of household head (10) | -.20* | -.10* | .23* | .01 | .30* | -.02 | .04* | .11* | .10* | 1 | | | | | |
| Number of household members (11) | .23* | .64* | .53* | -.0 | -.15* | .03* | .01 | .30* | -.20* | .21* | 1 | | | | |
| Number of rooms for sleeping (12) | -.04* | .34* | .50* | -.03* | .02* | -.02 | .02 | .20* | -.20* | .31* | .70* | 1 | | | |
| Wealth index (13) | -.10* | -.11* | -.04* | .03* | .01 | -.01 | -.10* | -.10* | .12* | -.10* | -.20* | -.13* | 1 | | |
| Region (14) | .02 | .12* | .10* | -.02 | -.02* | - .10* | .14* | .10* | -.20* | .03* | .22* | .24 | -.44* | 1 | |
| Place of residence (15) | .10* | .10* | .06* | -.02* | -.0 | .05* | .10* | .02* | -.12* | .05* | .10* | .10* | -.60* | .20* | 1 |

Notes: * $p < 0.05$

## 5.3. Model Estimation and Selection

### *5.3.1. Base model estimation (Model 1)*

In Model 1, only the predictor variable was estimated with the dependent variable to assess the coefficient as a base for the regression analysis. The main predictor variable *number of children under five years* was significant and positively associated with ITN use as the dependent variable; (OR = 0.25, $p < 0.001$). Regarding the control variables, none were included in the analysis of model 1, purposely to use the model as a base for comparison to subsequent models where the model complexity increases. The model comparison presents a yardstick for a statistical check to validate the final model selection.

### *5.3.2. Review model estimation (Model 2)*

With the Model 2 estimation, Model 1 was replicated, and the moderator variable of the number of ITNs in the household was introduced. The analysis results show no significant relationship between the number of ITNs and ITN use (OR = 0.01). The main predictor variable *number of children under five years* was still significantly associated with the dependent variable *ITN use* (OR = 0.56, $p < .001$). The interaction between the predictor variable number of children under five years and the number of ITNs shows a significant negative moderation effect on the dependent variable *ITN use* (OR = -0.07, $p < 0.001$). The control variables were not included in Model 2 as well to test the interaction between the main predictor variable and an explanatory variable of interest. This model will further serve as a statistical check on the final model selection as it builds on the base model by introducing a moderator on the predictor variable.

### *5.3.3. Final model estimation (Model 3)*

Model 3 as the final model is more complex as it introduces the control variables. Model 2 was replicated in Model 3 in addition to introducing several control variables: *relationship to household head, number of household members, number of rooms for sleeping, gender of household head, net age, net source, gender of household members, wealth index, age of household members, region, and place of residence*. The main predictor variable *number of children under five years* was still significantly associated with ITN use (OR = 0.29, $p < .001$). The number of ITNs was significantly associated with *ITN use* (OR = -.04, $p < .001$). There was still a significant moderation effect of the number of ITNs on the relationship between the number of children under five years

and ITN use (OR = -.05, p < .001). *Relationship to household head, number of household members, rooms used for sleeping, gender of household head, net age, gender, wealth index, age, and region* were significant control variables. Other control variables, *net source, and place of residence* were not significant. Hence, Model 3 is selected as the final model and is used to address the research hypotheses and make statistical estimations on the data.

## 5.4. Regression Results

A linear regression model was applied where the analysis carried out at a single level, was used to estimate the coefficients of the predictor variables and other explanatory variables on the dependent variable. The regression model was used to estimate the independent association of the predictor variables *number* of *children under five years* and *number of ITNs* on the outcome variable *ITN use*. Estimates reported in the model for the predictor variables and other explanatory are in ordinary least squares. Based on the unit of analysis, the single-level analysis approach is significant. Model 3 (Table 3) shows the final estimates used to address the research hypothesis and to compute marginal effects to interpret the research hypothesis 2.

### *5.4.1. Model 4(Robustness check for Final model estimation)*

As part of robustness checks for Model 3 estimates, the White test was estimated and reported as Model 4. This included an estimate of the standard errors and confidence intervals of the Model 3 estimates. Overall, the comparison of both model estimates shows consistency in terms of statistical significance and the magnitude effect in ordinary least squares.

### *5.4.2. Direct Effect of Number of Children Under Five years*

In the results reported in Table 3, the research hypothesis 1, which that illustrates the number of children under five years is positively associated with ITN use is statistically significant (p<.001) and supported. That is, for one unit increase in the number of children under five years in each household, the probability of more household members sleeping under an ITN, compared with the middle and lower probability of ITN use is .29 times greater, holding other factors constant. The result indicates that households with a higher number of children under five years are more likely to have an increased number of household members sleeping under an ITN than those without or with a lower number of children under five years.

**Table 3: Results of single-level moderation: moderation effect of the number of ITNs on the association between the number of children under five years and household members' ITN use. Ghana DHS 2019**

| Dependent variable: ITN use (number of persons who slept under an ITN the previous night before the survey) | | | | |
|---|---|---|---|---|
| | Single-level linear regression | | | White test (Robustness check) |
| **Variables** | **Model 1** | **Model 2** | **Model 3** | **Model 4** |
| **Number of Children under five years** | 0.25*** | 0.56*** | 0.29*** | 0.29*** |
| | (37.11) | (36.48) | (19.01) | [17.78] |
| **Number of ITNs in household** | | 0.01 | -0.04*** | -0.04*** |
| | | (1.81) | (-6.16) | [-6.32] |
| **Number of Children under five years x number of ITNs** | | -0.07*** | -0.05*** | -0.05*** |
| | | (-20.49) | (-13.74) | [-13.14] |
| **Relationship to household head** | | | | |
| ***Head (reference category)*** | | | - | |
| ***Wife/husband*** | | | 0.26*** | 0.26*** |
| | | | (9.10) | [9.37] |
| ***Son/daughter*** | | | -0.02 | -0.02 |
| | | | (-0.57) | [-0.56] |
| ***Other relatives*** | | | -0.08** | -0.08** |
| | | | (2.71) | [-2.67] |
| **Number of household members** | | | 0.10*** | 0.10*** |
| | | | (23.53) | [20.98] |
| **Number of rooms for sleeping** | | | -0.11*** | -0.11*** |
| | | | (-16.43) | [-13.90] |
| **Gender of household head** | | | | |
| ***Male (reference category)*** | | | - | |
| ***Female*** | | | 0.04* | |
| 0.04* | | | | |
| | | | (2.11) | [2.08] |
| **Net age** | | | | |
| ***Less than 1 month (reference category)*** | | | - | |
| ***Up to 13months*** | | | 0.01 | 0.01 |
| | | | (0.54) | [0.55] |
| ***Up to 25 months*** | | | -0.01 | -0.01 |
| | | | (-0.44) | [-0.43] |
| ***Up to 37 months*** | | | -0.07* | -0.07* |
| | | | (-2.15) | [-2.10] |
| **Net source** | | | | |
| ***Other source (reference category)*** | | | - | |
| ***Campaign*** | | | -0.04 | -0.04 |
| | | | (-1.75) | [-1.77] |
| **Gender of household member** | | | | |
| ***Male (reference category)*** | | | - | |
| ***Female*** | | | 0.08*** | 0.08*** |
| | | | (4.75) | [4.65] |
| **Wealth index** | | | | |
| ***Poorest (reference category)*** | | | - | |
| ***Poorer*** | | | -0.05* | -0.05* |
| | | | (-2.50) | [-2.48] |
| ***Middle*** | | | -0.06* | - 0.06* |
| | | | (-2.50) | [-2.58] |
| ***Richer*** | | | -0.14*** | -0.14*** |
| | | | (-4.47) | [-4.54] |
| ***Richest*** | | | -0.20*** | -0.20*** |
| | | | (-5.09) | [-5.52] |
| **Age of household members** | | | -0.01*** | -0.01*** |
| | | | (-27.10) | [-27.14] |
| **Region** | | | -0.02*** | -0.02*** |
| | | | (-4.89) | [-4.94] |
| **Place of residence** | | | | |
| ***Urban (reference category)*** | | | - | |
| ***Rural*** | | | 0.02 | 0.02 |
| | | | (1.07) | [1.09] |
| **_cons** | 1.975*** | 1.870*** | 2.286*** | 2.286*** |
| | (169.65) | (75.70) | (41.87) | [42.14] |
| ***N*** | 10977 | 10977 | 10977 | 10977 |

**t statistics in parentheses**

*** p < 0.05, ** p < 0.01, *** p < 0.001**

### 5.5. Interactions and Marginal effects

Regression coefficients and p-values were estimated based on Model 3 to make inferences on the relationship between the predictor variables and other explanatory variables on the dependent variable. The p-value in the analysis tests each predictor variable on the null hypotheses (Model 1) to determine its significance with the dependent variable (Frost, 2019). The coefficient value indicates how much the mean of the dependent variable changes given a one-unit shift in the independent variables while holding other variables in the model constant (Model 3). The introduction of control variables in Model 3 is significant as it assessed the effect of each variable independent of the others (Frost, 2019). To make valid inferences about the statistically significant moderation effect from a linear regression model, marginal effects are especially useful as it provides more information by interpreting the results from a linear regression model as the difference in probabilities (Lüdecke, 2021). In this thesis, the marginal effect is used to interpret the change in the effects of the number of children under five years on household members' ITN use at a single level for a given moderator. Based on the statistical analysis software, the Stata 16[5] command 'margins' is a numerical method that computes a probabilistic statistic (i.e., the margin of responses) based on predictions from Model 3 by manipulating the values of the covariates of interest. As such, the 'predictive margins' applied to estimate marginal effects allow for two covariates to be varied (i.e., number of *children under five years*, *number of ITNs*) and all control variables to be constant. The theoretical reasoning is, that it allows for comparison between two respondents similar in many aspects but differ along with a given moderator variable. Therefore, the interaction terms from Model 3 can be interpreted based on a probability scale that is significant and descriptive.

An overview of the Stata 16 'margins' procedure is as follows. First, the hypotheses predictions are estimated based on derivatives of increasing small changes in the number of children under five years. Next, Stata takes the average of predictions from step 1 so the marginal effects of the number of children under five years are the numerical derivative for given values of the moderator variable (low vs high; $(-)(+)1SD$ about the mean). See Appendix F for the graph plot illustrating step 2 for the moderator variable analyzed in the study. In the final step 3, the difference in predictive margins, which analyzes whether the effect of the number of children under five years changes for low (i.e. -1*SD* below the mean) and high values (+1*SD* above the mean) of the

[5] StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC.

moderator variable is significant and computed. The Stata software 'marginsplot 'command is used to visualize variance in predictive margins of the number of children under five years for the moderator variable (at low and high values: 1 *SD*−+ about the mean) as reported in Figures 8 and 9.

*Interaction effect of number of ITNs in the household*

To discuss hypothesis 2, Figure 8 illustrates how the effect of the number of children under five years on ITN use depends on the number of ITNs in the household. The result shows that the effect of the number of children under five years seems to be stronger for households with a fewer number of ITNs at all levels of the outcome variable *ITN use,* and the difference is statistically significant. Interpreting the marginal effect of the number of children under five years at the outcome levels 0(*-1SD below the mean*), 1( *1SD about the mean ),* and *2(+1SD above the mean )* as illustrated in Figure 8, there is a change in the effect of the number of children under five years at the three outcome levels. That is, the effect of the number of children under five is lower among households with a higher number of ITNs (i.e., the slope is lowest for the number of children under five years at +1*SD* from the mean on number of ITNs at outcome 2) and increases as the number of ITNs decreases (i.e., the slope is highest at -1*SD* from the mean on the number of ITNs at outcome 0). Thus, it can be inferred that the relationship between the number of children under five years and ITN use is strongly significant among households with a fewer number of ITNs. Hence, my hypothesis 2 was not supported based on the results.

**Figure 8: Average Marginal Effects of Number of Children Under Five years with 95% CIs**

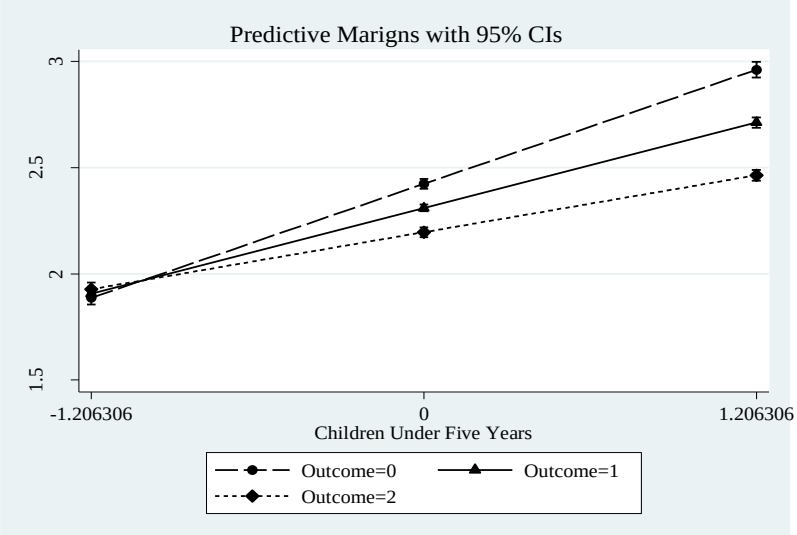
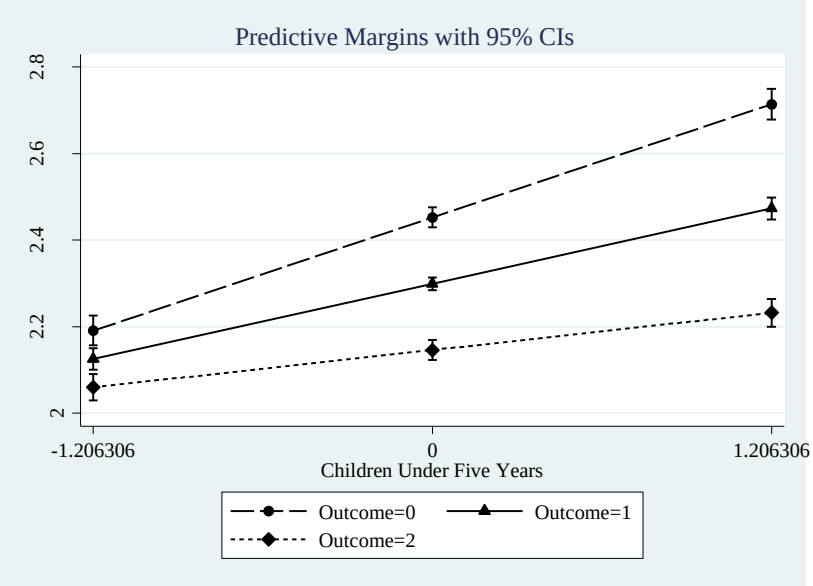


Figure 9 illustrates the marginal effects of the number of children under five years including additional covariates analyzed in the final model (Model 3). Figure 9 shows similar marginal effects at the three outcome levels, although the slopes are slightly changed but have the same magnitude of direction. In the illustration, the effect of the number of children under five sharply increases at -1*SD* from the mean on the number of ITNs, even though the prediction is lower at the y-axis (y-axis = 2.8) for the outcome 0. Again, the slope for outcome 2 is slightly lower at the y-axis but in the same direction.

**Figure 9: Average Marginal Effects of Number of Children Under Five Years with additional Covariates with 95% Cis**




## 5.6. Robustness Check

To ensure the robustness of Model 3 estimates, the White Test as a robustness check tool in regression analysis was estimated and reported as Model 4 in Table 4 illustrated. The White test estimates of the regression model are consistent in terms of the ordinary least squares values and statistical significance of the coefficients as well as magnitude effects.

# CHAPTER SIX: DISCUSSION

## 6.0. Introduction

This chapter presents a discussion of the study findings, which includes a theoretical interpretation of the main research objectives, its implications for health promotion practice, strengths and limitations of the study, and an overall discussion of the study concerning future health promotion research. Finally, a conclusion of the study is drawn to end the chapter.

## 6.1. Study Findings

The primary objectives of this thesis were to, first of all, examine the relationship between the number of children under five years and household members' ITN use among households with ITN availability. Also, to test the moderating influence of the number of ITNs in the household on the relationship between the number of children under five years and household members' ITN use. From the results reported in chapter five, the main predictor variable *number of children under five years* was positively associated with *ITN use* among household members, implying that the higher number of children under five years residing in a household, the higher ITNs are used by household members. The results also showed a significant moderation effect on ITN use such that the average marginal effects of the proportion of the number of children under five years are moderately different for a high and low number of ITNs in the household. However, the change in the likelihood of an outcome in ITN use slightly varied between outcome levels 0, 1, and 2. This indicates that household members' ITN use is influenced by the moderating role of the number of ITNs in the household. In the illustrated Figures 8 and 9, representing the different slopes of marginal effects, the difference in slopes implies that given households associated with outcome level 0 of ITN use (i.e., *number of household members that slept under an ITN the previous night*), the interaction effect of children under five years and number of ITNs is associated with an increase in the likelihood of more household members ITN use. The interaction between the number of children under five years and the number of ITNs on the likelihood of more household members sleeping under ITNs is lower for households associated with subsequent higher-level outcomes (i.e., outcome levels 1 and 2). An intuitive explanation could be other moderating factors in the household including but not limited to sleeping room capacity for instance.

Therefore, the study findings show that the number of ITNs in the household is a significant moderator that impacts the predicted positive relationship between the number of children under

five years and household members' ITN use. Low availability and less ownership of ITNs significantly influence ITN use since strategies for ITN access and ownership primarily focus on mass distributions of ITNs rather than on targeted distribution based on intra-household factors including rooms available for sleeping, household size, and composition, household relationship structure among other factors. For instance, targeted distribution of ITNs has been shown to effectively increase ITN use especially among children under five years; in central Uganda which increased ITN use among households with children under five years up by 40% (11% -51%) as found by Wanzira et al., (2014). The study findings here make a theoretical and empirical attempt to elucidate contextually, the existing gap in ITN ownership and use to address malaria interventions.

*Role of number of children under five years in ITN use*

The thesis findings show the role of the number of children under five years in the household as a significant predictor of household members' ITN use. As reported earlier, there was a positive association between the number of children under five years and household members' ITN use. ITNs at the household level are widely recommended for use by all individuals in a household as the most effective way to ensure malaria prevention (World Health Organization- WHO, 2015). The findings indicate that the number of children under five years in a given household promotes the positive health behavior of sleeping under ITNs. This is justified by the fact that they are the most vulnerable group among household members to malaria infections and have the highest risk of malaria mortality (World Health Organization-WHO, 2022). Children under five years have been found in several studies as the age group that generally sleeps under an ITN compared to other household members (e.g., Thwing et al., 2008; Noor et al., 2009; Atieli et al., 2011; Hetzel, 2012; Wanzira et al., 2014; Storey et al., 2018). This is linked to increased household ITN ownership through mass distributions which they indicate increases ITN use especially among children under five years (e.g., Hetzel, 2012; Olapeju et al., 2018). From a social model of health standpoint, the findings are theoretically grounded in that vein. The social model of health which analyses health as a multi-level interaction focuses on individual characteristics (i.e., age, gender, constitutional factors) as the core factors primarily influencing health and this represents the theoretical framework of this thesis. The thesis findings thus explicate how the number of children under five years in the household influences household members' ITN use by interacting with other factors to that effect, holding other factors constant. The finding can be explained within

other psychological theories such as the Health Career Model (e.g., Green et al., 2015; Tones and Tilford, 2001), which theorizes individual characteristics as representing the central core and influences a person's health status at the different stages of their life span and also in identifying opportunities for intervention. Individual characteristics are an important aspect in understanding health-related behavior and act as a key influence on health through interacting with other factors at the different levels of a person's health course. Previous research by García-Basteiro et al., (2011) in a cross-sectional survey among households in Equatorial Guinea, found a positive association between the number of children under five years and ITN use in households with ITN ownership. In the study context of Ghana, Konlan et al., (2019) found ITN use to be positively associated with caregivers of children under five years by at least 49 percent which was statistically significant. This further supports the findings, that ITN use in the household was significantly increased as a result of the number of children under five years. Accordingly, individual-level factors in health promotion influence health intentions, attitudes, and behaviors which represent an influential determinant of health action (Green et al., 2015). From a health promotion perspective, individual characteristics serve as a primary driver toward health action and adopting health behaviors that have overarching influences on healthy lifestyles (Naidoo and Willis, 2016). Hence, individual-level factors are essential within the health determinants and facilitate the adoption of healthy behaviors, in this case influencing health interventions regarding ITN use.

*Number of ITNs in the household as a moderating factor*

An understanding of ITN use among household members suggests the availability and access to ITNs for every individual in the household. From the thesis findings, the number of ITNs in the household is a moderating factor that has a changeable effect on the outcome of ITN use at the low and high outcome levels (*see* chapter five). This coincides with previous studies that identified net-level factors as modifying ITN use (e.g., Baume et al., 2009; Ngondi et al., 2011; Graves et al., 2011; Koenker and Yukich, 2017). As discussed by several studies, access to ITNs is a prerequisite to ITN use (e.g., Pulford et al., 2011; Graves et al., 2011; Ngondi et al., 2011; Ricotta et al., 2019; Scott et al., 2021). Although access to ITNs is an important determining factor in individual behavior regarding ITN use, this relationship is not direct as the thesis findings have shown and are conditional on other factors at the different levels of health determinants. The number of ITNs was not associated with ITN use from the thesis findings and was consistent with the findings from other studies (e.g., Ricotta et al., 2019; Koenker et al., 2019). Yet, the findings contradict other

studies that suggest the increased number of ITNs increases household members' ITN use (e.g., Olapeju et al., 2018; Storey et al., 2018). A considerable explanation here is the contextual differences in intra-household access to available ITNs which significantly determine use patterns. Another explanation could be the geographical differences in malaria vector control such that ITNs are the primary malaria intervention in some contexts due to the geographical location and climate compared to others as cited by one study (Olapeju et al., 2018). Thus, although ITNs are a major intervention tool in Ghana, it may be the case that they are used less in some areas of the country due to other interventions such as indoor spraying among others due to household preferences. In a similar study in Ghana using DHS data, they report that ITN ownership and ITN use are influenced by a complexity of individual and household factors and are also spatially dependent on several conditionalities such as region and place of residence (Ricotta et al., 2019). Considering a multi-level interaction as theorized by the literature, examining the number of ITNs as observed in the study was approached concerning the interplay with individual factors which showed a significant association with ITN use. The social model of health, which advocates for a systematic approach such that health should be considered as a cumulative effect of different levels of influence, was significant in testing the moderation influence of the number of ITNs on the number of children under five years and household members' ITN use. The complex interaction between the different levels of influence is indicative of a broad interrelationship between the various determinants of health (Dahlgren and Whitehead, 1991 cited in Green et al., 2015).

From a theoretical standpoint, the moderation by the net-level factor on the relationship between the individual-level factor and the health behavior outcome of ITN use shows the influence of the number of ITNs on the predictive association between the number of children under five years and household members' ITN use. Indeed, the thesis findings support a holistic approach to health behavior interpretations in determining the availability of ITNs in the household and household members' ITNs use, with implications for healthy action. The interplay of these factors is important, as it can provide insight into how the various determinants of ITN use, dynamically shape malaria interventions and the health behavioral implications underlying these conditions.

Despite, the findings suggesting the number of ITNs not significantly associated with ITN use in a direct relationship effect, there is however an important consideration of access to ITNs to enable health behavior choices on household members' ITN use. This has been explicitly discussed by

studies examining ITN access and ITN use (e.g., Eisele et al., 2010; Graves et al., 2011; Ngondi et al., 2011; Pulford et al., 2011; Ricotta et al., 2019; Scott et al., 2021). From a holistic outlook, access to ITNs is fundamental to the overall increase in malaria prevention since it increases community-wide coverage of ITNs which promotes the general socio-economic, cultural, and environmental conditions. In line with this, studies have found that individuals not sleeping under ITNs but living in areas with high ITN access and coverage, have been observed to be at decreased risk of infection due to the resulting reduction in overall malaria transmission (e.g., Howard et al., 2000; Killeen et al., 2007). Moreover, the lack of access to ITNs in households creates a significant barrier to health action such that individuals are not exposed to malaria intervention strategies and are unable to adopt such interventions which have severe implications for malaria prevention. This is explicitly stated by Singh et al., (2013), that the primary barrier to ITN use is the insufficient supply and availability of ITNs in the household. In that case, increased access to ITNs can provide the necessary resource to influence health behavior change by ensuring equitable distribution of ITNs based on household characteristics for optimal coverage. This is relevant in addressing the differential access to ITNs for use among household members as few studies have shown (e.g., Iwashita et al., 2010; Babalola et al., 2016; García-Basteiro et al., 2011).

ITN availability in the household is conditional on access which can influence health decision-making in the household in terms of who sleeps under an ITN, what ITNs are being used, and how many sleep under ITNs. Studies by Korenromp et al, (2003) and Eisele et al., (2010) indicate that the more ITNs available in the household, the more likely a child under five years will sleep under an ITN. Yet, studies by Baume and Franca-Koh (2011) and Ngondi et al, (2011) both mentioned that the more ITNs available in the household, the lower likelihood of use for individual ITNs. However, both studies' unit of analysis was at the net level which looked at net characteristics such as shape, size, color, and net physical condition in predicting whether an ITN was used or not used. Although this thesis includes net-level factors in its analysis (see chapter three), the main unit of analysis is the household members, and thus of particular interest is the interplay between net-level factors and individual-level factors on the outcome of household members' ITN use which makes the result of the number of ITNs relevant. Within a health promotion interpretation, this thesis is linked to the Health Action Model which identifies individual decision-making on two major aspects— that is, systems that contribute to behavioral intention, and the factors that determine the likelihood that the behavioral intention is being translated into practice. In other

words, access to an ITN represents the system that enables the behavior intention of adopting malaria intervention (i.e., sleeping under an ITN) while the number of ITNs interacts with the number of children under five years to determine the likelihood of household ITN use every night. Hence, household members' ITN use is conditional on access which influences the availability of ITNs such that the number of ITNs moderates the significant association between the number of children under five years and household members' ITN use.

Drawing on the social model of health, the interaction between individual and net level factors (i.e., access to ITNs as access to healthcare services) is theoretically relevant. In this case, the influence of the healthcare system (i.e., universal coverage of ITNs) on the relationship between individual characteristics and health behavioral choices (i.e., sleeping under an ITN) is supportive of the theory underpinning this thesis. The assumption of the number of ITNs as a moderating factor is intuitively based on the broader influence of the social, economic, and cultural environment (i.e., knowledge and attitudes, risk perceptions, access to healthcare services, housing characteristics, and living conditions). Hence, the number of ITNs as a moderating factor seems to affect the individual factor of the number of children under five years and the health-related behavior action of household members' ITN use which is valid based on the theoretical foundation of this thesis.

*Other covariates*

In the findings reported in Chapter Five, several control variables were introduced after the moderator *number of ITNs* was analyzed with the number of children under five years and ITN use which still showed a significant result in the final model. Almost all the covariates excluding net source and place of residence were significantly associated with ITN use. Particularly, the covariates at the individual level such as age and gender were significantly associated which ITN use. These variables have been extensively reviewed in the literature as having a significant association with ITN use. Considerably, gender as an individual-level factor is a strong predictor of ITN use such that women in the household are more likely to sleep under an ITN, and also female caregivers have a greater likelihood of sleeping under an ITN with their infant children. This is reflected in several studies (e.g., Konlan et al., 2019; Hetzel et al., 2012; Babalola et al., 2016; Hwang et al., 2010; Olapeju et al., 2018). For instance, Babalola et al., (2016) in their study report that the relationship between age and ITN varies with sex. In other words, the association of age with ITN use was moderated by sex, such that men, older children, and teenagers were less

likely to sleep under an ITN compared to women and children under five years. Also, a female caregiver's perceived severity of malaria, perceived efficacy to detect malaria, and exposure to community campaigns on Malaria strongly influenced her household's ITN use (Babalola et al., 2016). In a study by Thompson et al., (2016) they note that gender can be a strong influence on access to healthcare services such that women are more likely to engage in health-related behavior due to their perceived risks to health conditions. Again, one study found that the odds of using an ITN were higher among females than males in households with not enough ITNs but then the odds were comparable when households have enough ITNs available (Olapeju et al., 2018). In that case, one can argue that women's health-related behavior in ITN use is strongly influenced by their perceptions of malaria risks as well as their strong desire to promote healthy action based on their gender. Also, mass distribution of ITNs mainly targets women, specifically pregnant women, through their visits to antenatal clinics and become more exposed to malaria communication messages promoting ITN use behavior which could explain the strong association between gender and ITN use.

Drawing on health promotion theories such as the social determinants of health, an individual's gender strongly influences their health outcome (Marmot et al., 2008). For example, gender can influence health through decision-making power which allows the possibility for women to make their own choices and that of their household (Marmot et al., 2008). As one study found, gender may influence ITN use within households, due to the different roles dictating different sleeping patterns for men and women (Toé et al., 2009).

Age was positively associated with ITN use which corresponds with the reviewed empirical literature. Age and gender as individual factors strongly interact with each other, and this has been reported in a previous study. For, example, a woman's age has been reported to influence her knowledge about malaria which influences her using an ITN (Babalola et al., 2016). Other studies have on the other hand found no association between age and gender in ITN use (e.g., Atieli et al., 2011; Berkessa et al., 2015). Again, a study found that the age of a mother or female caregiver is significantly associated with ITN use by children under five years (Admasie et al., 2018) A possible explanation for these variances is the contextual differences in factors associated with ITN use which highlights the importance of context in understanding health-related behavior and addressing health challenges which is the basis of the social determinants of health theory.

Among the net factors analyzed, age of net was only significantly associated with ITN use at up to 37 months. Net age is negatively associated with ITN use when ITNs available in the household are more than three years old. This finding confirms other studies where net age was explored (e.g., Ngondi et al., 2011; Graves et al., 2011). In those studies, net age was analyzed as older than six months; and older than 12 months which found that ITN use was one-third as likely if all the ITNs in the household were more than a year old. Given the thesis findings, it can be argued that when net age increases over three years, ITN use decreases. Thus, the optimal use span of ITNs in a Ghanaian household is three years and this is consistent with the WHO analysis that indicates the median lifespan of ITNs in a household to be three years (World Health Organization-WHO, 2013). Possible explanations are that older ITNs could be in poor condition (worn out) and considered less effective in protecting against mosquitoes, or insecticide chemicals in the nets could be assumed weak after three years of use, and also lower risk perceptions due to constant use of nets for a lengthy period. However, the reason for newer ITNs not being used could not be determined in the analysis since it is beyond the scope of the study.

All household-level covariates in the thesis were significantly associated. Regarding household size and the number of rooms for sleeping, several studies have found a significant association between these variables and ITN use (e.g., Hwang et al., 2010; Storey et al., 2018; Iwashita et al., 2010; Ng'ang'a et al., 2009; Admasie et al., 2018). In this thesis, household size and sleeping rooms were positively and negatively associated with ITN use respectively. In terms of age and gender of household head, relationship to household head, and household wealth index, several studies have explored these factors in ITN use. Age and gender of the household head were found to be significantly associated with ITN use across different contexts (e.g., Noor et al., 2009; Geraldine, 2013; Tassembedo et al., 2020; Pooseesod et al, 2021; Scott et al., 2021). In terms of relationship to household head, there is strong evidence of a significant association with ITN use. For instance, household members who are immediately related to the household head are more likely to sleep under an ITN (e.g., Wiseman et al., 2007). The household wealth index in this thesis was significantly associated with ITN use in the richer and richest categories compared to the poorer and middle categories which is consistent with another study in Ghana. In that same study, increasing wealth was associated with decreased ITN use compared to the poorest categories among households with ITN access (e.g., Riccotta et al., 2019). This is because, in urban households, there is increased use of alternative malaria interventions such as indoor spraying,

mosquito coils, and window screens (over 80 percent of urban households in Ghana have window screens) (Ricotta et al., 2019). The findings are also consistent with studies in other contexts (e.g., Ngondi et al., 2011; Koenker et al., 2019; Tassembedo et al., 2020).

Community-level factors as covariates in this thesis: the place of residence and region, have been examined in the reviewed literature. In a few studies, place of residence was significantly associated with ITN use (e.g., Tassembedo et al., 2020; Ricotta et al., 2019; Graves et al., 2011; Wiseman et al., 2007). For example, a study found that people living in rural areas had a lower odds of ITN use compared to urban areas (Tassembedo et al., 2020). In the study context of Ghana, a previous study found that rural residents were more likely to use ITNs compared to urban areas (Ricotta et al., 2019). In this thesis, however, place of residence was not associated with ITN use. A probable reason is the increased coverage of ITNs, especially in rural households in Ghana which improves access to ITNs and therefore not affected by the type of dwelling. Also, the cost and affordability of ITNs are not a factor in rural households due to this condition. The region was significantly associated with ITN use in this study which is consistent with evidence from other studies (e.g., Tassembedo et al., 2020; Babalola et al., 2016). Hence, the covariates examined in this thesis are theoretically and empirically grounded and relevant considering the reviewed literature. The thesis findings have expounded contextually on the interplay among individual, net, household, and community-level factors affecting household members' ITN use.

## 6.2. Methodological Issues

The thesis objective to explore household members' ITN use among those with available ITNs in the household, has made a substantial contribution to understanding this dimension within a contextual lens, although with some limitations. Considering these limitations, the study findings should be interpreted within the outlined methodological issues presented next.

### *6.2.1.Limitations*

*Omitted variable bias*

Omitted variable bias refers to a condition whereby one or more variables are not included in a statistical model and are correlated to the independent variables included in the model and a determinant of the dependent variable. In this thesis, the analysis involved the use of secondary data which is data collected from a nationally representative sample. Hence, a major limitation is that the thesis objectives and hypothesis is based on the available secondary data, and no

consideration is given in the design of the DHS; a basic concern in utilizing the existing dataset (Cheng and Phillips, 2014). Hence, some explanatory variables as possible predictors were omitted. The omission of a significant predictor can produce correlations between the error term and the independent variables (Cheng and Phillips, 2014; Baldwin et al., 2022). Following the theoretical framework (see chapter two), this thesis's inclusion of variables for analysis is theoretically and empirically guided with consideration of the study scope. Although the variables analyzed are significant predictors of ITN use, few other relevant variables including educational level, degree of control over household decision-making, occupation/livelihood, social and cultural norms, behavioral change communications, and malaria knowledge explored in ITN research (e.g., Hwang et al., 2010; Tassembedo et al., 2020; Ricotta et al., 2019; Wiseman et al., 2007; Toé et al., 2009; Dunn et al., 2011); are not included in the thesis data analysis.

*Survey design*

The secondary data utilized in this thesis was cross-sectional design— i.e., correlational study, which limits the opportunity for making causal inferences, especially in psychological research (Wilms et al., 2021). Therefore, the basis for the interpretation of the data analysis results is based on the confidence of the authors' examination of the theoretical model hypothesis which addresses confounding variables. To establish causality, a more accurate measurement of techniques, specification of measurement techniques, longitudinal design, or repeated measures are significant. Possibly, this can provide more insights into the phenomenon and alternative explanations on the study topic. According to Taris et al., (2021:1) the downside of cross-sectional research design especially in psychology is the "inability to separate between a presumed cause and its possible effect—i.e., two concepts may well correlate significantly, but it does not mean that one cause the other". In the least, there should be empirical evidence of the direct relationship over time such that the "cause" precedes its "outcome" in time (Taris et al., 2021).

*Validity of Self-Reported- Malaria Behavior – Use of ITN the previous night*

The outcome of "*How many people slept under an ITN?*" is based on self-reporting and may have validity issues as cross-sectional surveys are periodic and have the potential to influence the reported ITN use behavior depending on the perceived malaria risk of the surveyed respondents. In the thesis, the outcome "*How many people slept under an ITN the previous night?*" is self-reported with responses only capturing a cross-section of ITN use at a specific night in time and does not provide an explicit measure of ITN use consistently over time. Moreover, studies that rely

on self-reporting about health behaviors face a risk of social desirability bias (Krumpal, 2013). As described by Krumpal, (2013) social desirability bias is the tendency of survey respondents to report answers that are socially acceptable by over-reporting desirable behaviors which can interfere with the interpretation of individual differences. This poses serious problems to the validity of statistical results. Given the global attention on malaria intervention and the mass coverage of ITNs, households will probably overreport the number of household members sleeping under ITNs in the survey.

*Theoretical limitations*

The social model of health encompasses a broad theoretical approach to understanding and interpreting the complex dimensions of health. Although the thesis utilizes this theoretical model, the analysis involves a single-level moderation model and does not completely address in detail the multi-level framework in the theoretical model. This is due to the use of a secondary dataset as the primary data source. The thesis focused on the main levels of health influence as described in the model. However, the interactions at the broader levels (e.g., employment, education, social and community networks, and the general socio-economic, cultural, and environmental conditions) were not explored (*see* Chapter Two). Hence, given the scope of the study as a master thesis research, the model was not extensively applied as a broad framework.

## 6.3. Strengths

*Extension on the moderation analysis in determinants of ITN use*

Undertaking this thesis within the health promotion field acknowledges the importance of developing knowledge that supports the understanding of individual and group behaviors for promoting health (Green et al., 2015). The thesis findings add to the literature by extending the perspective of a complex interaction of determinants of ITN use such as net-level factor influence on the association between individual characteristics and household members' ITN use. This thesis undertakes a moderation analysis of the number of ITNs on the relationship between the number of children under five years and household members' ITN use thus enhancing the understanding of health behavior regarding ITN use. A moderation analysis in ITN research has been given little attention, and to the best of my knowledge, this is the first study that investigates a moderation effect within the study context.

*Holistic approach to the conceptualization of household members ITN use*

The thesis findings contribute to the empirical literature by modeling a conceptual framework to interpret the interaction of individual and net-level factors thereby justifying the moderation analysis. The theoretical model applied in the thesis: the social model of health provides a comprehensive theoretical approach that underlines the multi-level interaction between determinants of health which supports the moderating factor of the number of ITNs on the relationship between the number of children under five years and household members' ITN use. The thesis provides empirical evidence of the social model of health for future research in the study context.

*Generalizability of study findings (external validity)*

The generalizability of study findings is part of the quality assessment indicator in quantitative research. It describes the extent to which the results obtained from research can be applied to other study contexts or a larger population (Coughlan et al., 2007). According to Murad et al., (2018: 17), the primary concern of health research is the ability to draw inferences from the study sample which is a problem of applicability. This can be evaluated by determining how similar the sample population is to the general population in terms that affect outcomes (Murad et al., 2018). Primary methods used to evaluate the generalizability of a quantitative study are sample selection method (random sampling) and sample size selection (Murad et al., 2018). A more common instrument used to evaluate generalizability is Firestone's (2003), statistical generalization which involves an inference based on the sample population.

This thesis uses the DHS dataset which draws from a sample of household members (men, women, and children under the ages of five) and is representative of households in Ghana (Ghana Statistical Service-GSS, and ICF, 2020). Utilizing this data, there is a higher potential to make an inference that the thesis findings can be generalizable. This is due to the thesis utilizing a statistically comprehensive dataset that follows a methodological process and applies to various geographical contexts and other study populations. Yet, in acknowledging the issue of 'directness' as a central concern of applicability, it is important to consider that the thesis findings are not directly transferrable even if the contexts are similar (Murad et al., 2018:18).

The thesis findings, in the context of Ghana, provide a comprehensive understanding of malaria intervention at the household level. This may support evidence for health policy that can be adopted in other sub-Saharan countries based on geographical, socioeconomic, cultural, and

environmental similarities. Future research in the study area can be undertaken in other contexts, where DHS datasets are available which will ensure the use of similar analysis for replication studies.

### 6.4. Implications for health promotion practice

Drawing on the tenets of health promotion through empirical evidence on malaria intervention and prevention, this thesis provides several implications for health promotion practice. Health promotion tenets central to this thesis are access, equity, and empowerment. To address existing health conditions, health needs should be assessed to develop suitable models and frameworks to guide health action (Naidoo and Willis, 2016). Health-promoting activities should be guided by the concept of empowerment such that it enables individuals and communities, to take control over the conditions influencing their health (Naidoo and Willis, 2016: 265). Moreover, it should be equitable and guided by concern for social justice. Also, it should be participatory, involving all concerned in every stage of the process of development and evaluation (Naidoo and Willis, 2016). Reflecting on the concepts described, the thesis undertaken provides a focal point for understanding health promotion through a behavioral lens by utilizing psychological theories such as the social model of health (*see* Chapter Two). The application of the social model of health supports the approach of assessing health needs through systematically identifying the gap between existing health conditions (malaria prevalence) and the desired health outcome (malaria prevention). Utilizing this theoretical framework shows evidence of the relationship between individual characteristics and health-related behavior action. Based on the thesis findings, an inference can be made that access to and availability of ITNs in the household shape household members' ITN use. Access and use of health services that prevent or treat diseases influence our health (World Health Organization-WHO, 2017). The concepts of access and empowerment are interrelated as access to health services, influences the ability to make decisions and control resources which is vital for positive health outcomes such as disease prevention (Green et al., 2015: 6).

Given the circumstance that the effect of the number of ITNs varies according to households' having fewer or more available ITNs, shows the magnitude of a multi-level effect of health determinants beyond the measure of access and use in understanding health behavior. Although access and availability of ITNs are vital for malaria prevention, they may also constrain the practice of ITN use due to several factors at the household and community level. Thus, the nature of health

determinants and their broad interactions are relevant and should be considered within the settings in which they occur (Green et al., 2015; Naidoo and Willis, 2016).

Implications for health promotion practice in terms of addressing the gap between ITN ownership and ITN use require more substantial attention to the moderating factors at the net level and their interaction with the individual, household, and community-level factors in all contexts. These levels are especially fundamental as they directly shape the immediate health choices and decisions as well as influence the conditions for which health is addressed. Household-level factors are especially relevant as they shape group behavior in terms of promoting social action and group perceptions regarding health choices. Health policies should focus more on the household level to assess the intra-household characteristics such as the age groups of household members, gender of household head and household gender composition, and sleeping arrangements, among other household-level factors. Identifying the interactions between these factors in ITN use can be relevant in mapping households' ITN use trends, to enhance optimal ITN coverage for consistent use. As this study has shown, higher ITN ownership does not cause an increase in household members' ITN use specifically involving children under five years. What this implies for health promotion planning is more household ITN-related 'needs assessment' that requires further understanding of the health needs and experiences to be able to determine the health-related behaviors of household groups systematically (Naidoo and Willis, 2016: 269).

## 6.5. Systematic approach to malaria intervention activities for health promotion planning

### *6.5.1. Level-specific interventions*

A key aspect of interpreting the thesis findings involves an outline of level-specific interventions within a systematic approach to health promotion planning. Several health promotion planning approaches such as horizontal and vertical programs exist (Green et al., 2015; Naidoo and Willis, 2016). These strategies are systematic and involve a step-by-step process aimed at identifying health action goals and the most effective means of achieving them (Green et al., 2015: 160). Based on the theoretical model of this study, the level-specific interventions that are discussed follow an ecological planning approach (Green et al., 2015). "An ecological planning approach highlights health action that is grounded in theory and is consistent with a multi-level, multi-sectoral analysis" (Green et al., 2015: 177). This approach consists of three stages: *theory of the problem*: an analysis of problems and the intrapersonal, interpersonal, organizational, community, cultural and public factors that produce and maintain them; *theory of intervention*: a state-of-the-art view of the

relative effectiveness of different interventions; and *understanding the context of practice*: interventions to be matched to the local community or organizational context (Green et al., 2015: 177). Guided by this approach, the level-specific interventions are outlined.

*Individual-level*: Health promotion practitioners should engage in more needs assessments that will help increase direct health promotion activities such as encouraging all age groups and gender on the importance of sleeping under an ITN not just emphasizing vulnerable groups (children under five years and pregnant women). An emphasis on only high-risk groups, for instance, leads to a few household members using ITNs. However, focusing more on all household members using ITNs will enhance protection against malaria for all household members. The goal of health promotion is to ensure that every individual has the right access to resources to enable them to make decisions to promote their health (Green et al., 2015). More holistically, at the individual level, involves the core influences on health behavior which is key to understanding the health behavior process and can help in identifying pathways to effective health action policies in malaria intervention. While the thesis focuses on children under five years, as the main predictor, other individual factors such as age and gender were equally significant in the final model.

*Household-level*: Health promotion action taken at the household level should be aimed at addressing the interpersonal relationships and conditions that lead to household members adopting healthy choices and decisions regarding consistent ITN use. Health promotion practitioners should focus on facilitating social change through addressing household structures such as differential access to resources, and the decision-making process that shapes household ITN use. Also, addressing the resource constraints such as poor sleeping arrangements and lack of sleeping spaces by increasing knowledge on the versatility of ITN use in malaria control.

*Community-level*: Health promotion practitioners should introduce more policies aimed at improving health conditions and healthy environments by increasing awareness of the environmental and geographical determinants of health as it relates to ITN use. Based on the thesis findings, the *region* is significantly associated with ITN use, and an understanding of why and how this determines ITN use is relevant for malaria intervention. Although some understanding of this is clear, a more fundamental notion will be assessing the interaction between region and other determinants at the individual and household level to get a comprehensive effect of this influence. Furthermore, increasing community awareness of ITNs by incorporating cultural aspects into the

practice of ITN use and supporting cultural knowledge in ITN use practices. Accordingly, a health promotion approach that takes into consideration these ecological factors aims to provide a better health policy action toward malaria prevention.

### 6.6. Possible Implications and Outlook for Future Health Promotion Research

This section suggests possible implications and an outlook for future research. These suggestions address the research limitations and the identified research gaps within the study area.

*Potential study variables(decision-making process, cultural beliefs and practices, gender norms)*

Potential variables of interest that could be analyzed in the study context for deeper insights into the behavioral choices of individuals in the household regarding ITN use are the household decision-making process, cultural beliefs and practices, and gender norms. These variables could extend future research into determining the social conditions and influences on the health behavior of individuals as a group. This thesis thus proposes future research specifically in the same context to consider an analysis of these potential variables to expand the empirical evidence presented in this thesis beyond the DHS indicators. An examination of variables such as the household decision-making process as it specifically relates to malaria intervention such as *How decisions regarding who sleeps under an ITN and how many people sleep under an ITN based on the household proportion of ITNs,* addresses the intra-household dynamics which can provide a more in-depth understanding of household members' sleeping behavior patterns. For instance, this variable has been analyzed in previous research by Wiseman et al., (2007) as a determinant of ITN use and could be equally relevant in the study context. Although the household decision-making process (i.e., control of decision making) was included in the DHS dataset, it was not assessed in the malaria survey, and this could be further explored in an analysis of household members' ITN use.

Cultural beliefs and practices in terms of local knowledge and attitudes regarding malaria have been associated with behavioral choices of individuals regarding ITN use (e.g., Toé et al., 2009; Hwang et al., 2010; Adongo et al., 2005). Cultural beliefs particularly relating to malaria knowledge can influence behavior in terms of the perceived benefit of ITNs and the cultural influence in decisions on whether to use ITNs. Thus, future research can examine this factor further by focusing on the extent to which cultural beliefs and practices interact with other variables at the individual and household levels to determine ITN use.

Further, gender norms could be a potential factor in future research on ITN use as it defines gender

attitudes and roles which may provide a deeper understanding of gender relations, particularly on how and why being female or male affects ITN use. Previous research by Dunn et al., (2011) has considered this factor but at a general socio-cultural level. A more specific analysis of this factor following the conceptual framework and theoretical model of this thesis could be considered to deepen insights into households' ITN use.

*Moderation model*

The thesis proposes that future research in the same context focus on extending the analysis on ITN use using a moderation analysis by expanding on the study variables and possibly introducing other potential moderation models. As stated earlier, there is little evidence of research applying a moderation method, especially in the study context and this could be extended to provide a more comprehensive understanding of the complex interactions among the determinants of ITN use to improve malaria intervention.

*Longitudinal study*

Based on the thesis's use of secondary data from the DHS dataset, the study is limited from utilizing a correlational analysis method which does not imply causations and is a major disadvantage with correlational studies. Thus, the thesis recommends future research in longitudinal studies. The use of DHS surveys does not provide a repetition of the same persons observed even though they are periodic surveys.

*Mixed Methods*

This thesis adopts a quantitative methodology and the research questions examined used a deductive approach to objectively test and fit indices that scientifically supported or rejected the hypotheses. As such the thesis results have implications for further studies with a qualitative research approach. Morgan (2014) suggests that qualitative research could supplement the results from quantitative research by *investigating*: which pursues further examination of the results through interpreting specific patterns in the data. Thus, undertaking qualitative research is motivated by seeking further explanations for how and why a particular set of results occurred (Morgan, 2014). This could be extremely useful in understanding household members' ITN use. The use of both approaches in further research will complement each other allowing a combination of both methodologies to effectively address the methodological limitations and gaps. Hence, a triangulation of data from both approaches can effectively increase the internal and external validity of the data measures as well as reduce measurement errors.

## 6.7. Conclusion

The primary objective of this thesis was to examine the interplay among determinants of ITN use by analyzing the interaction between individual and net level factors on household members' ITN use. The thesis adopted the social model of health, as a theoretical model to expound on the interactive relationship between the number of children under five years and the number of ITNs in the household within a multilevel approach in determining household members' ITN use. In other words, the thesis follows a conceptual framework based on a theoretical understanding of the social determinants of health to illustrate the moderating factor of the number of ITNs in the household on the relationship between the number of children under five years and household members ITN use. A moderation model as utilized in this thesis is based on empirical evidence of the interrelationship among determinants at the individual, household, community, and net levels which has not been extensively examined in the study context. By including net-level factors, the thesis attempted to address a research gap involving ITN ownership and ITN use.

The thesis methodological approach involves a single-level regression model with a sample of 10,977 household members. The thesis uses secondary data from a nationally representative sample from the Ghana Demographic and Health Survey 2020 dataset. The thesis's main finding is that the number of children under five years significantly affects the number of household members using ITNs and this relationship is moderated by the number of ITNs in the household. The results show that the number of ITNs in the household was not significantly associated with ITN use and only significantly related to the number of children under five years. Specifically, for households with a fewer number of ITNs, the relationship between the number of children under five years and ITN use was stronger compared to households with more ITNs in the household. Hence, the results imply that although the availability of ITNs in the household is important for use; it does not predict ITN use. This is highly relevant from a social health standpoint as it shows the cumulative effect of social factors influencing health. In this case, the availability of ITNs in the household does not entirely affect health behavior in terms of sleeping under ITNs but rather influences other factors in predicting the health behavior of ITN use. Given the extensive empirical literature on malaria interventions, this thesis contributes to the existing literature by addressing the gap between ITN access and use by utilizing a conceptual approach that comprehensively connects the various levels of health determinants regarding ITN use. This approach provides a social health dimension that is an important lens for identifying and understanding health behavior.

Furthermore, the thesis findings extend the empirical perspective of health behavioral choices as explicated by a multilevel framework with the individual level factors representing the core of a health behavior process. In the thesis, some limitations and implications for future research were highlighted and this was discussed following a review of the theoretical and methodological approaches undertaken. Overall, the thesis sought to provide a contextual analysis of ITN use among household members as a malaria intervention strategy which is useful for health promotion practitioners in reorienting malaria interventions for improving malaria prevention outcomes. Health promotion planners in the study context should consider these findings based on the conceptual approaches utilized which makes a theoretical and empirical deduction to indicate a contextual difference in determinants of ITN use. This is necessary for future action in improving program efforts targeting increased universal coverage of ITN which can significantly influence ITN use. Finally, attention should be given to the interactive relationship among various other determinants of ITN use particularly at the household level that could predict ITN use within a comprehensive outlook which could further help improve our understanding as to why certain household members with increased access to available ITNs in the household do not consistently use them. This could be of great importance to reshaping thinking on malaria intervention strategies and help to effectively address malaria prevention efforts.

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# APPENDICES

## APPENDIX A : Approval Letter from DHS Office

Mar 16, 2021

Kelvin Awoonor-Williams
University of Bergen
Norway
Phone: +47 98002582
Email: Kelvin.Williams@student.uib.no
Request Date: 03/15/2021

Dear Kelvin Awoonor-Williams:

This is to confirm that you are approved to use the following SPA Datasets for your registered research paper titled: "A CONTEXTUAL UNDERSTANDING OF HEALTHCARE SEEKING BEHAVIOR IN PREDICTING HOUSEHOLD HEALTH OUTCOMES":

**Ghana**

To access the datasets, please login at: https://www.dhsprogram.com/data/dataset_admin/login_main.cfm. The user name is the registered email address, and the password is the one selected during registration.

The IRB-approved procedures for DHS public-use datasets do not in any way allow respondents, households, or sample communities to be identified. There are no names of individuals or household addresses in the data files. The geographic identifiers only go down to the regional level (where regions are typically very large geographical areas encompassing several states/provinces). Each enumeration area (Primary Sampling Unit) has a PSU number in the data file, but the PSU numbers do not have any labels to indicate their names or locations. In surveys that collect GIS coordinates in the field, the coordinates are only for the enumeration area (EA) as a whole, and not for individual households, and the measured coordinates are randomly displaced within a large geographic area so that specific enumeration areas cannot be identified.

The DHS Data may be used only for the purpose of statistical reporting and analysis, and only for your registered research. To use the data for another purpose, a new research project must be registered. 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. Also, be aware that re-distribution of any DHS micro-level data, either directly or within any tool/dashboard, is not permitted. Please reference the complete terms of use at: https://dhsprogram.com/Data/terms-of-use.cfm.

The data must not be passed on to other researchers without the written consent of DHS. However, if you have coresearchers registered in your account for this research paper, you are authorized to share the data with them. All data users are required to submit an electronic copy (pdf) of any reports/publications resulting from using the DHS data files to: references@dhsprogram.com.

Sincerely,

*Bridgette Wellington*

Bridgette Wellington
Data Archivist
The Demographic and Health Surveys (DHS) Program

**APPENDIX B: Descriptive statistics of main study variables**

Number of persons who slept under a net

| Percentiles | | Smallest | | |
|---|---|---|---|---|
| 1% | 1 | 1 | | |
| 5% | 1 | 1 | | |
| 10% | 1 | 1 | Obs. | 10,977 |
| 25% | 2 | 1 | Sum of Wgt. | 10,977 |
| 50% | 2 | | Mean | 2.279585 |
| | | Largest | Std. Dev. | .9184572 |
| 75% | 3 | 4 | | |
| 90% | 4 | 4 | Variance | .8435637 |
| 95% | 4 | 4 | Skewness | .2400311 |
| 99% | 4 | 4 | Kurtosis | 2.225505 |

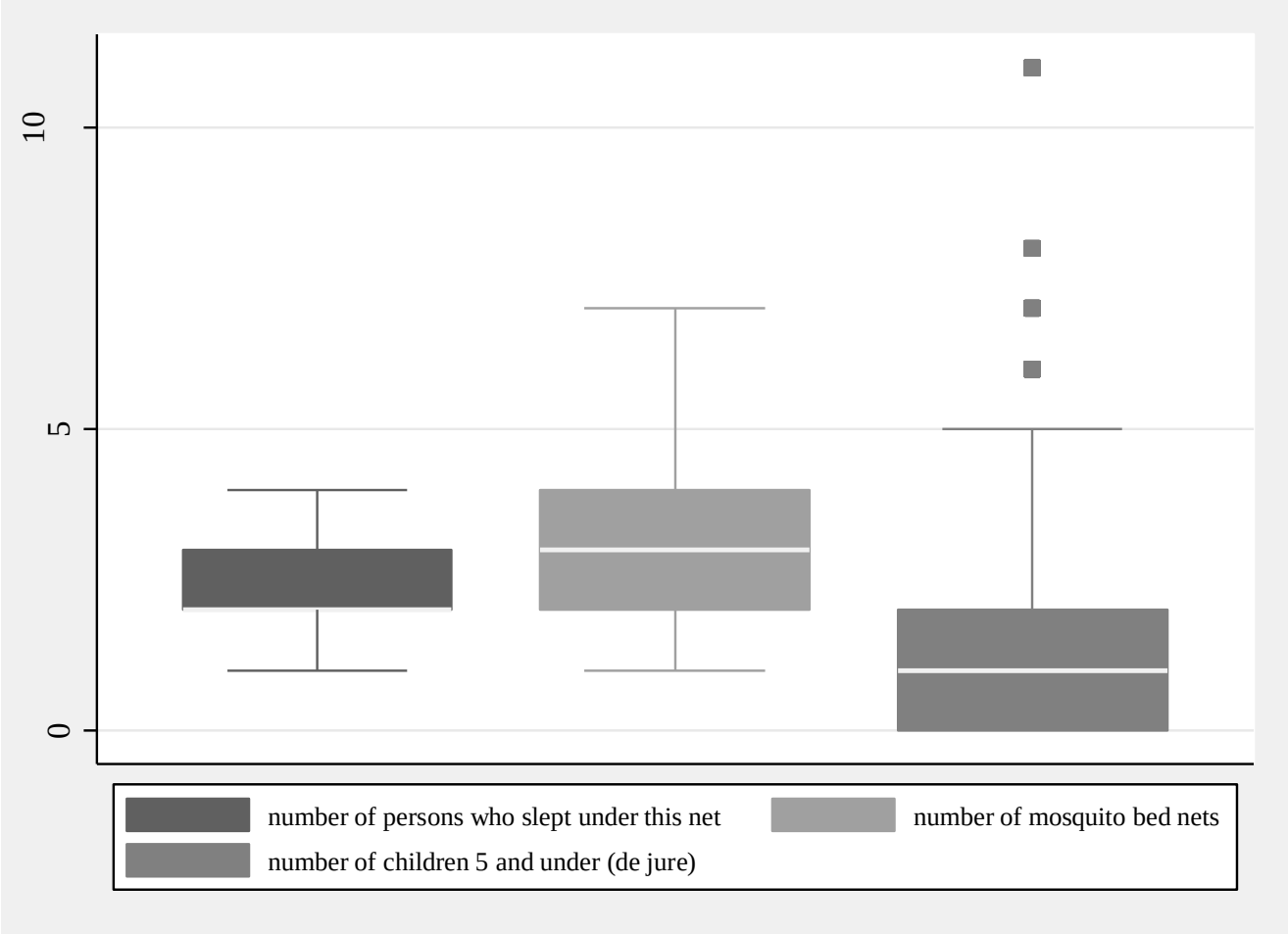
Number of children under five years

| Percentiles | | Smallest | | |
|---|---|---|---|---|
| 1% | 0 | 0 | | |
| 5% | 0 | 0 | | |
| 10% | 0 | 0 | Obs. | 10,977 |
| 25% | 0 | 0 | Sum of Wgt. | 10,977 |
| 50% | 1 | | Mean | 1.197231 |
| | | Largest | Std. Dev. | 1.206306 |
| 75% | 2 | 11 | | |
| 90% | 3 | 11 | Variance | 1.455175 |
| 95% | 3 | 11 | Skewness | 1.819259 |
| 99% | 5 | 11 | Kurtosis | 10.9282 |

Number of mosquito bed nets

| Percentiles | | Smallest | | |
|---|---|---|---|---|
| 1% | 1 | 1 | | |
| 5% | 1 | 1 | | |
| 10% | 1 | 1 | Obs. | 10,977 |
| 25% | 2 | 1 | Sum of Wgt. | 10,977 |
| 50% | 3 | | Mean | 3.14248 |
| | | Largest | Std. Dev. | 1.558304 |
| 75% | 4 | 7 | | |
| 90% | 5 | 7 | Variance | 2.428313 |
| 95% | 7 | 7 | Skewness | .7426504 |
| 99% | 7 | 7 | Kurtosis | 3.04836 |

**APPENDIX C: BOX PLOT SHOWING THE DISTRIBUTION OF MAIN STUDY VARIABLES**



**APPENDIX D : Descriptive statistics for socio-demographic variables**

Sex of household member

| Percentiles | | Smallest | | |
|---|---|---|---|---|
| 1% | 1 | 1 | | |
| 5% | 1 | 1 | | |
| 10% | 1 | 1 | Obs. | 10,977 |
| 25% | 1 | 1 | Sum of Wgt. | 10,977 |
| 50% | 2 | | Mean | 1.539036 |
| | | Largest | Std. Dev. | .4984966 |
| 75% | 2 | 2 | | |
| 90% | 2 | 2 | Variance | .2484988 |
| 95% | 2 | 2 | Skewness | -.1566227 |
| 99% | 2 | 2 | Kurtosis | 1.024531 |

Age of household members

| Percentiles | | Smallest | | |
|---|---|---|---|---|
| 1% | 0 | 0 | | |
| 5% | 1 | 0 | | |
| 10% | 2 | 0 | Obs. | 10,977 |
| 25% | 7 | 0 | Sum of Wgt. | 10,977 |
| 50% | 18 | | Mean | 24.66703 |
| | | Largest | Std. Dev. | 21.50997 |
| 75% | 38 | 95 | | |
| 90% | 57 | 95 | Variance | 462.6788 |
| 95% | 68 | 95 | Skewness | .92054 |
| 99% | 83 | 95 | Kurtosis | 2.998343 |

Region

| Percentiles | | Smallest | | |
|---|---|---|---|---|
| 1% | 1 | 1 | | |
| 5% | 1 | 1 | | |
| 10% | 2 | 1 | Obs. | 10,977 |
| 25% | 4 | 1 | Sum of Wgt. | 10,977 |
| 50% | 7 | | Mean | 6.132185 |
| | | Largest | Std. Dev. | 2.885371 |
| 75% | 9 | 10 | | |
| 90% | 10 | 10 | Variance | 8.325364 |
| 95% | 10 | 10 | Skewness | -.3843013 |
| 99% | 10 | 10 | Kurtosis | 1.897479 |

Type of place of residence

| Percentiles | | Smallest | | |
|---|---|---|---|---|
| 1% | 1 | 1 | | |
| 5% | 1 | 1 | | |
| 10% | 1 | 1 | Obs. | 10,977 |
| 25% | 1 | 1 | Sum of Wgt. | 10,977 |
| 50% | 2 | | Mean | 1.730254 |
| | | Largest | Std. Dev. | .4438479 |
| 75% | 2 | 2 | | |
| 90% | 2 | 2 | Variance | .197001 |
| 95% | 2 | 2 | Skewness | -1.037584 |
| 99% | 2 | 2 | Kurtosis | 2.07658 |

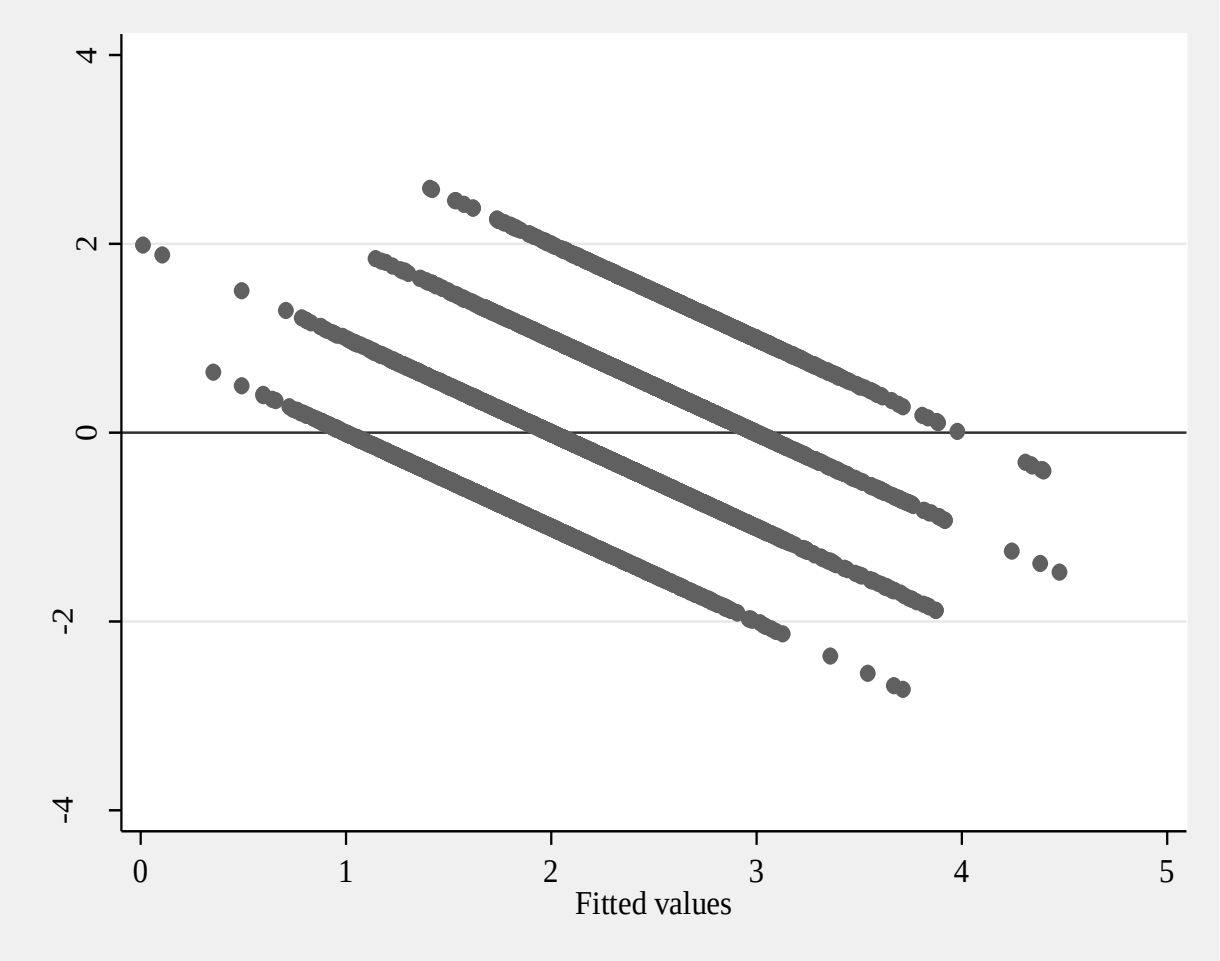
## APPENDIX E: White test for Heteroscedasticity

```
White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(223)     =   1149.57
         Prob > chi2   =    0.0000

Cameron & Trivedi's decomposition of IM-test
```

| Source | chi2 | df | p |
|---|---|---|---|
| Heteroskedasticity | 1149.57 | 223 | 0.0000 |
| Skewness | 452.15 | 21 | 0.0000 |
| Kurtosis | 71.18 | 1 | 0.0000 |
| Total | 1672.90 | 245 | 0.0000 |



**APPENDIX F: Predictive margins of Number of ITNs in the household with 95% CIs**