SCHOOL OF PUBLIC HEALTH

MSc EPIDEMIOLOGY- FIELD EPIDEMIOLOGY

RESEARCH REPORT

Factors associated with the use of insecticide-treated nets among children in Malawi, 2017

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A research report submitted to the Faculty of Health Science, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science Epidemiology

Johannesburg, 2021

Declaration

I, Daniel Denis Mapemba declare that this research report is my unaided work. This dissertation is in partial fulfillment of the Master of Science in Epidemiology (Field Epidemiology) in conjunction with fulfillment of the requirements for the Field Epidemiology Training in the South African Field Epidemiology Training Program. This work has not been submitted before for any degree or examination at any other University.

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Abstract

Malaria is a mosquito vector-borne disease and remains a major public health concern globally especially in Africa. Malawi, like some sub-Saharan African countries, has endemic malaria with an estimated 6 million episodes per year. In Malawi, the burden of malaria is particularly high in children under-five years of age. In 2019, 460/1000 confirmed cases of malaria in Malawi were children under-five years. The primary vector control method in Malawi is the use of insecticide-treated nets (ITN). The National Malaria Control Program (NMCP) set a target of 90% of children under-five years sleeping in an ITN by the year 2022. In 2017, after a series of universal mass ITN distribution campaigns, ITN utilization among children under-five was at 68%. This study aimed to assess factors associated with the use of ITNs among children under-five years of age in households that owned at least one ITN in Malawi to contribute to the available body of knowledge toward achieving the NMCP goal.

We conducted a cross-sectional study using secondary data from a nationally representative survey, Malawi Malaria Indicator Survey-2017. The study population was children under-five years of age in Malawi in 2017 who slept in a household that owned at least an ITN the night before data collection for the parent survey. Firstly, we assessed the distribution of participants by sociodemographic characteristics by calculating proportions for categorical variables and mean and range for continuous variables. Then we fitted univariable logistic regression models with ITN use among children under-five years and each of the child, maternal, and household characteristics. The variables that yielded a p-value ≤ 0.15, in the univariable logistics analysis were included in a multivariable logistic regression model. The main exposure variable was the ratio of household members to ITN. This variable measures household access to bed-nets.

In the multivariable logistic regression analysis, we found that child's age, child's relationship to household head, the ratio of household members to ITN, and alternative use of ITNs at the household level were significant predictors of ITNuse among under-five children. For each year increase in a child's (<5 years) age, his/her odds of sleeping under an ITN decreased by 20%, aOR= 0.8 (95% CI 0.74-0.90). Being a son/daughter/grandchild of the head of household increased the odds of an under-five child sleeping under an ITN by two times compared to being distantly related (nephew/niece) or having no blood relation to the household head (aOR=2.1, CI 1.001-4.32). A unit increase in the ratio of household members to an ITN caused a corresponding 25% decrease in the odds of a child using a bed-net, aOR=0.75 (CI 0.68-0.84. Finally, we found that children who resided in households that reported no alternative use of ITNs(e.g. fishing, windows, gardening, caging livestock, fence, and selling of the ITN for money) had higher odds of sleeping under an ITN than those from households that reported alternative use of bed-nets, aOR=1.75 (CI, 1.09-2.79).

Our study has shown that the ratio of household members to an ITN (household access) is an important factor in ITN use among children under-five years. Increasing household access to ITNs improves the odds of a child using an ITN. However, achieving a good level of access to ITNs by children may be impeded by alternative competing use of the ITNs at the household level. The government of Malawi should identify means to off-set this to improve the availability of the ITN at the household level.

Acknowledgments

I would like to express my deep-felt gratitude to my supervisors for guiding me from the start of this project, the time and effort they put into my work. In particular, Dr. Zodwa Ndlovu, I am grateful for all her guidance and encouragement towards the completion of my project. Dr. Andrew Azman, for the many hours you spent reviewing my work and guiding me, thank you for being my mentor and encouraging me to critically review my work. Dr. Lazarus Kuonza, for the support in my time as a South African Field Epidemiology Resident and support towards my learning.

I would also like to acknowledge the Norwegian Institute of Public Health and for allowing me to study by supporting me financially, administratively, and technically. A special thanks go to Mr. S. Kanyanda for the encouragement and for believing me.

I would also like to thank the staff of the South African Field Epidemiology and Department of Epidemiology and Biostatistics, School of Public Health, University of Witwatersrand, for the support and valuable lessons. In a special way, I also want to thank my classmates at the university, especially, those in my track for the academic and emotional support shown to me through kindness and friendship; Babongile Ndlovu, Bukelani Nyawose, Mojalefa Makae, Shingirai Chikosha, Fhatuwani Gavhi, Mashudu Mashau, Liesl De Boni, Tebogo Matjokotja and Matimba Makhubele.

I would like to thank my family; my mom, dad, and siblings for the support they give me, encouragement, and for believing in me when my faith fails. Thank you for your unconditional love.

Lastly, I thank God the almighty for all of you, for His love and blessings. For the gift of life and health and for enabling all this to happen.

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List of Acronyms

DHS	Demographic and Health Survey
EA	Enumeration Area
IRS	Indoor Residual Spraying
ITN	Insecticide-Treated Bed Net
MMIS	Malawi Malaria Indicator Survey
MPHC	Malawi Population and Housing Census
NMCP	National Malaria Control Program
NSO	National Statistical Office
WHO	World Health Organization

Definition of terms

ITN is any mosquito net including insecticide-treated and untreated mosquito-nets.

CHAPTER 1: INTRODUCTION

Malaria is one of the leading causes of morbidity and mortality among children under five years in some parts of the globe, especially Sub-Saharan Africa (1). One of the widely used vector control methods in the fight against malaria is Insecticide-treated nets (ITNs). The use of these ITNs among children under five is influenced by many factors. In this chapter, we explore the cause of malaria, its transmission, epidemiology, prevention, and policy guidelines underpinning the use of ITNs in Malawi for malaria prevention. We further introduce the problem statement and justification and highlight the aim of the study.

1.1 Background

Malaria is a parasitic infection caused by protozoa of the genus *Plasmodium*. Four species have been known to cause malaria in humans; *Plasmodium falciparum, Plasmodium vivax, Plasmodium malariae and Plasmodium ovale*. Occasionally, *Plasmodium knowlesi*, known to affect non-human primates has been reported to also cause malaria in humans (2).

Figure 1 illustrates the *Plasmodium* life cycle showing stages in both the mosquito vector and the human host (3). Primarily, malaria is transmitted from person-to-person by the female *Anopheles* mosquito (4). When the mosquito bites an infected person, it transfers the *Plasmodium* sporozoites from its saliva to a susceptible human host where it undergoes developmental stages in the blood and liver (2). When a mosquito takes a blood meal from an infected host, *Plasmodium* gametocytes are transferred to the mosquito which develops into sporozoites that can infect other humans and thus continuing the cycle (5).

Malaria transmission is affected by seasons of the year with high transmission occurring in the rainy season when the vector population is high (6,7). Also, vegetation type, high temperatures, and high altitude influence the vector population hence, malaria transmission (6).

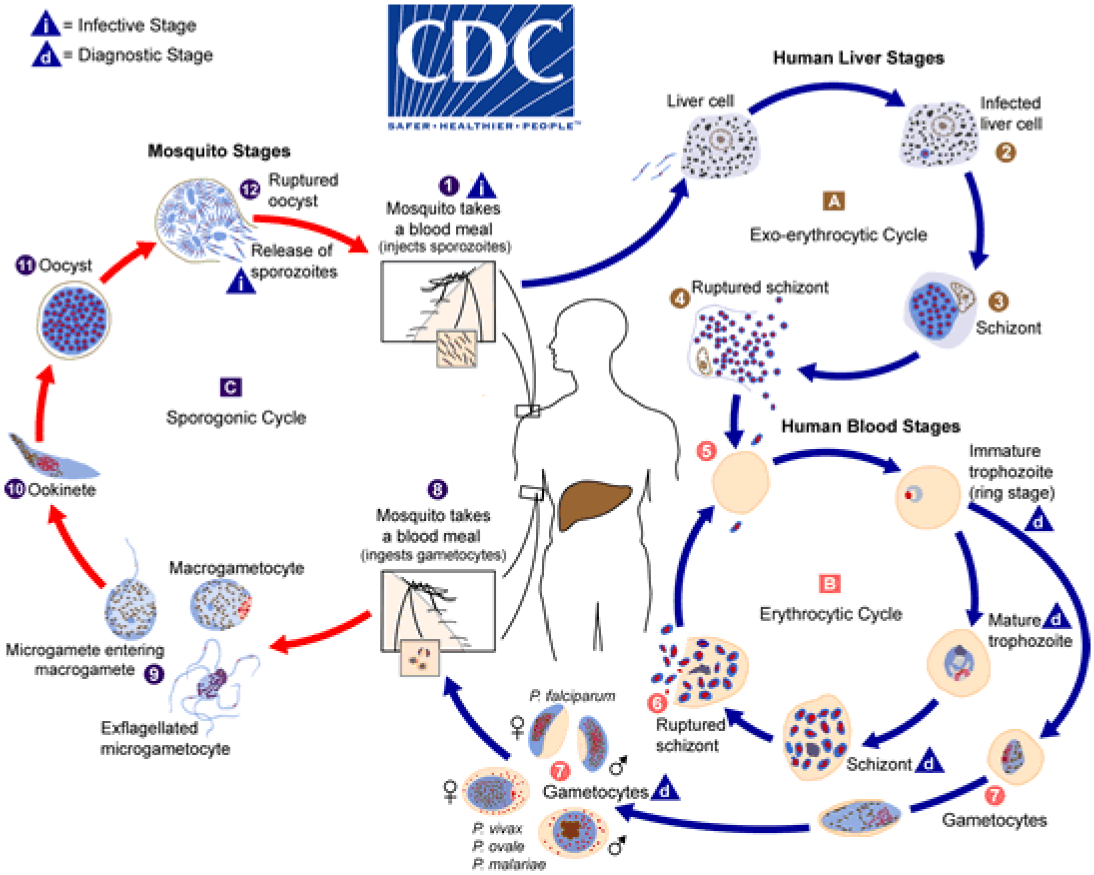

Figure 1.1.1: The life cycle of a malaria-causing Plasmodium. (source: https://www.cdc.gov/malaria/about/biology/index.html).

Malaria incubation period ranges from 7 to 30 days with the shortest period from *Plasmodium falciparum* (7-14 days) (2). The signs and symptoms are similar to many other fibril illnesses, which makes clinical diagnosis difficult. Commonly, a malaria-infected person presents with fever, chills, headache, muscle aches and weakness, vomiting, diarrhea, abdominal pain, and loss of appetite. Malaria infection in young children can cause irritability. Severe cases of malaria infection can lead to death (2).

Malaria has universal susceptibility except for individuals with specific genetic traits like people with sickle-cell disease who are unlikely to be infected with malaria. Malaria is more severe in people with low immunity, children, pregnant women, immunosuppressed people, and the elderly (2).

Malaria remains a major public health concern globally, especially in Africa. In 2017, 87 countries reported locally transmitted malaria (8). Africa reported the highest number of cases. Out of 219 million cases globally reported by the World Health Organization (WHO) in 2017, 200 million cases (91.3%) were in the African Region. The region accounted for 93% of the estimated 435 000 global malaria deaths. Young children are highly susceptible to malaria and the disease remains one of the leading causes of morbidity and mortality among children under five years. Globally, 61% of malaria-related deaths were among children under five years (8).

1.1.1 Malaria prevention and control

Despite malaria's significant contribution to global and local morbidity and mortality, proven preventive measures are readily available (Shretta et al., 2017). Malaria control aims at preventing mosquito bites at the individual level and reducing transmission at the community level. Prevention methods at the individual level include use of mosquito repellents, chemoprophylaxis (taking anti-malarial drugs before exposure to the malaria parasite), use of insecticide-treated bet-nets (ITN) and, behavioral practices such as avoiding being outdoors between dusk and dawn and wearing long covering clothes to avoid exposing skin to mosquitoes (2). At the community level, prevention methods include environmental interventions such as treating mosquito breeding sites with larvacides, in-door residual spraying (IRS) of insecticides and trimming vegetation around dwellings (2).

The main vector control methods adopted in malaria-endemic countries are the use of insecticide-treated nets (ITN) and indoor residual spraying (IRS) with insecticides (9). National malaria control programs focus on a combination of treatment of cases and vector control. Treatment of cases reduces the number of parasite reservoirs and consequently reduces the risk of further spread (10). The WHO provides treatment protocols that inform country-specific treatment guidelines. Treatment varies depending on in-country situations and *Plasmodium* resistance to the range of anti-malarial drugs available (10). Currently, the commonly used antimalarial drug globally is an artemisinin-based combination therapy (10). In other countries, sulfadoxine-pyrimethamine (SP) is used as prophylaxis treatment for targeted population groups like pregnant women due to their high susceptibility to malaria infection and resulting morbidity (10).

Insecticide-treated nets (ITN)

ITNs are mosquito bet nets that have been treated with insecticides to kill mosquitoes and prevent bites (11). Approaches to the distribution of ITNs depends mainly on intervention program priorities. Some countries, like Malawi, provide the nets free of charge through mass distribution campaigns or to targeted population groups through service integration i.e. during antenatal or postnatal clinics (12). Despite various distribution methods, the goal is to ensure the provision, use, and timely replacement of ITNs (1). Malawi targets to conduct a mass ITN distribution campaign every three years (1).

Indoor-residual spraying (IRS)

Indoor-residual spraying involves spraying residual insecticide on walls and surfaces inside of dwelling houses (13). The insecticides kill mosquitoes that rest on sprayed surfaces (14). As much as the strategy may not completely prevent mosquito bites, however, it reduces the risk of transmission from person-to-person as mosquitoes tend to rest on walls (15). Indoor-residual spraying needs to cover 85% of dwellings both for humans and domesticated animals and spraying is repeated at an interval of every three to five years for it to be effective (14). The two vector control methods have proven effective when used individually or in combination (13,16).

Vaccination

The inclusion of a malaria vaccine in routine child vaccination schedules in malaria-endemic regions is being explored (17). In 2019, Malawi and two other countries in Africa launched pilot projects to include malaria vaccination in their routine childhood immunization programs (18). In a phase 3 trial the RTS, S/AS01 malaria vaccine was shown to reduce the occurrence of clinical and severe malaria by approximately 50% within the first year of vaccination among African children aged 5 to 17 months (19).

1.1.2 Malaria in Malawi

Malawi, like some sub-Saharan African countries, has endemic malaria with an estimated 6 million episodes per year. Malaria is responsible for more than 30% of outpatient department consultations and is the third contributing cause of years lost to disability in Malawi (12). In 2017, the prevalence of malaria among children under five years was 24% and 95% of the infection was due to *P. falciparum* (11). In 2019, Malawi reported 5,024,960 confirmed malaria cases from all reporting health facilities and 460.2/1000 confirmed malaria cases were children under-five years (20). In Malawi, Malaria patterns change with seasons, the incidence rises sharply at the beginning of the rainy season and gradually decreases over the entire season, this is associated with an abundance of conducive breeding sites (21).

In Malawi, there is a National Malaria Control Program (NMCP) in the directorate of preventive health services of the Ministry of Health and Population (22). The NMCP is responsible for all malaria prevention interventions, development of policies, stakeholder coordination, and oversight of prevention measures in meeting national strategic objectives (22). The Malawi Malaria Strategic Plan is well aligned with national and international malaria prevention strategies. The NMCP adopted ITN use as the primary vector control strategy in 2015(12). To track progress of the achievements in malaria control the NMCP conducts a scheduled survey called the Malaria Indicator Survey.

1.2 Malawi Malaria Indicator Survey

This sub-section is discourse Malawi Malaria indicator survey (MIS) (11). It is a nationally representative survey designed to provide up-to-date malaria indicators estimates. It is a cross-sectional survey that employed a two-stage stratified sampling design.

In the first stage, 50 enumeration areas (EAs) were selected from each of the three regions of Malawi based on probability proportional to size. Each region was stratified into urban and rural areas which contributed 20 and 30 EA's, respectively. In the second stage, 25 households were randomly sampled from each EA.

Data were collected using three questionnaires which were administered to females aged 15-49 years. Respondents were either permanent residents of the selected households or visitors who stayed in the household the night before the survey. Data were weighted to ensure national representativeness putting into account the study design. The MIS reported descriptive statistics of the finding.

The study found that 82% of households in Malawi owned at least an ITN and 42% had one ITN for every two household occupants (full coverage). The main source of ITNs was the mass distribution campaigns. Accessibility to ITNs within households was at 63% but, only 55% of household members slept in an ITN the night before the survey. Only 68% of children under five years slept under an ITN the night before the survey.

1.3 Problem statement and question

Despite an observable increase in the coverage of ITNs, utilization among children under five years remains suboptimal with only 68% of children under five sleeping under an ITN (11). The target of the government of Malawi, NMCP is to have 90% of children under five years sleeping under an ITN with one ITN for every two household members approach by the year 2022 (22). The low utiliazation of ITN among children under five years may be a major contributor to the high prevalence of malaria, ITN-use being the primary method of malaria vector control in Malawi.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter reviews available knowledge on the use of ITN for malaria prevention among children under five years. Firstly, the impact of ITNs on malaria prevention is discussed before, the factors that are associated with ITN use as reported in the literature are reviewed.

2.2 Impact of ITN on malaria prevention

The evidence available on the impact of ITNs in reducing the mortality and morbidity of malaria makes ITN use a viable option for most malaria-endemic countries (25,26). However, Mwendera, (23) observed that poor/lack of adequate financing for implementation of strategic plans and changes to strategy supported by researched evidence impedes progression from control towards the elimination of malaria in Malawi and other low and middle-income countries.

A meta-analysis that pooled 10 trials on the effectiveness of ITN on malaria incidence, found that the use of ITN reduced malaria incidence by almost 50% among the population who used ITN compared to the population not using ITN (27). In 2018 another meta-analysis, found an average of 56% malaria risk reduction, comparing ITN use and non-use for malaria prevention across 26 studies published from 2000 to 2018 (28). Both papers show that ITN use reduces the incidence of malaria. A study conducted in Malawi found that children under five years from households owning an ITN were less likely to die compared to children from households that owned no nets (hazard ratio: 0.75, 95% CI: 0.62-0.90) (26) this demonstrates the impact of ITNs on child mortality. However, other studies have reported growing mosquito resistance to commonly used insecticides, therefore rendering ITN usage less effective (29).

Despite the observed impact of ITN use on malaria, some countries continue to have suboptimal utilization compared to the WHO target of 80% (9,30). A multi-country study (6 countries) showed that not all bed nets are used in households that owned ITNs (30). The ITN use (proportion of ITNs used the prior night) among children under five years ranged from 27.6% to 71.2% among households owning an ITN (30). Similarly in Malawi, the ITN utilization was 79% in children under five years among ITN owning households in 2017 (11). Several factors have been shown to affect ITN utilization.

2.3 Factors associated with ITN use

Some of the reported factors associated with ITN use include the number of ITNs in a household, household population size, education level of the mother, knowledge of malaria prevention, household wealth, the geographical location of residence (region, state, province, and urbanicity), sex of household head, age and sex of child (31–34). However, these predictors varied by study location.

2.3.1 Household access to insecticide-treated nets

A systematic review of Malaria Indicator Surveys from 15 countries in sub-Saharan Africa showed that intra-household access to ITNs (number of household members per ITN) was an important factor (34). Children from households with better intra-household access to ITNs were 2.1 to 5.5 times more likely to have used an ITN the night before the survey than children in households with poor intra-household access (34). Other studies have also reported the number of nets in a household and household population size as a separate determinant to ITN utilization, comparing households with more nets to those with fewer (24,31,35). Furthermore, children residing in households with fewer members have better odds of ITN utilization controlling for the number of nets and other factors (34).

2.3.2 Child demographic characteristics

In some studies, child demographic characteristics were found to be significantly associated with ITN use among children (24,34,36). A study that compared ITN use determinants between two years found that the odds of ITN use were lower in older children compared to younger ones (one-year-old or less), this was attributed prioritization of the younger children and that breastfeeding children are likely to share sleeping space with their mothers hence gain access to a net (24). However, Ruyange, M. et al, found age to be an insignificant predictor when they compared ITN utilization in under-one-year-olds and over-one-year-olds, adjusting for other individual and household level factors, odds ratio (OR) 1.02 (CI 0.84-1.22) (31). Most papers reviewed consistently reported that the sex of the child was not a predictor for ITN use across Africa (24,31,32,36).

2.3.3 Maternal education level

The mother or child's caregiver educational level is another commonly reported factor. A study in Rwanda found that children whose mothers had no formal education had fewer odds for using an ITN than children whose mothers had some formal education (OR= 0.77) (31). Subsequently, a study conducted in Abuja found that children with educated caregivers had 40% higher odds of using an ITN compared to those whose caregivers were not educated (37). Some studies have consistently reported similar results (34,35). However, a study conducted in Ethiopia found that maternal educational level was not significant after adjusting for other child and household level variables (33).

2.3.4 Household-level characteristics

Household wealth is also a common predictor for ITN use. Some studies have reported that the odds of using an ITN increases with increasing household wealth index. Children from wealthier households are more likely to use ITNs than those from less wealthy households (24,31,32). In contrast, a study in Nigeria found that children from households in the lower wealth quantile had higher odds (OR 1.44, $p<0.01$) of using an ITN than those from the highest wealth quantile (36). Household wealth was found to be insignificantly associated with ITN use post free ITN distribution in 2016 in Malawi (24). Free mass ITN distribution has been shown to improve disparities in ITN ownership (38).

Child health has often been reported to be influenced by the sex of head of household, male-headed household tends to have more resources and better health practices (39). A study in Malawi found that children from female-headed households were less likely to use ITNs compared to those from male-headed households, an odds ratio of 0.8 (24)

2.4 A conceptual framework for factors associated with ITN use among children under-five

This section discusses the conceptual framework which details the idea that informs the interaction of the outcome variable and the exposures. The variables in the framework are shown as reviewed in the literature. The factors can be categorized into three groups, child-level factors, maternal level factors, and household level factors. The child-level factors were the child's age, sex of the child, and child's relationship to head of household. The maternal level factors included the mother's educational level, mother's knowledge of the cause of malaria or prevention. Household-level factors include the number of household members to an ITN ratio (household access), household wealth index, urban/rural residence, sex of household head, age of household head, and alternative use of ITNother than sleeping.

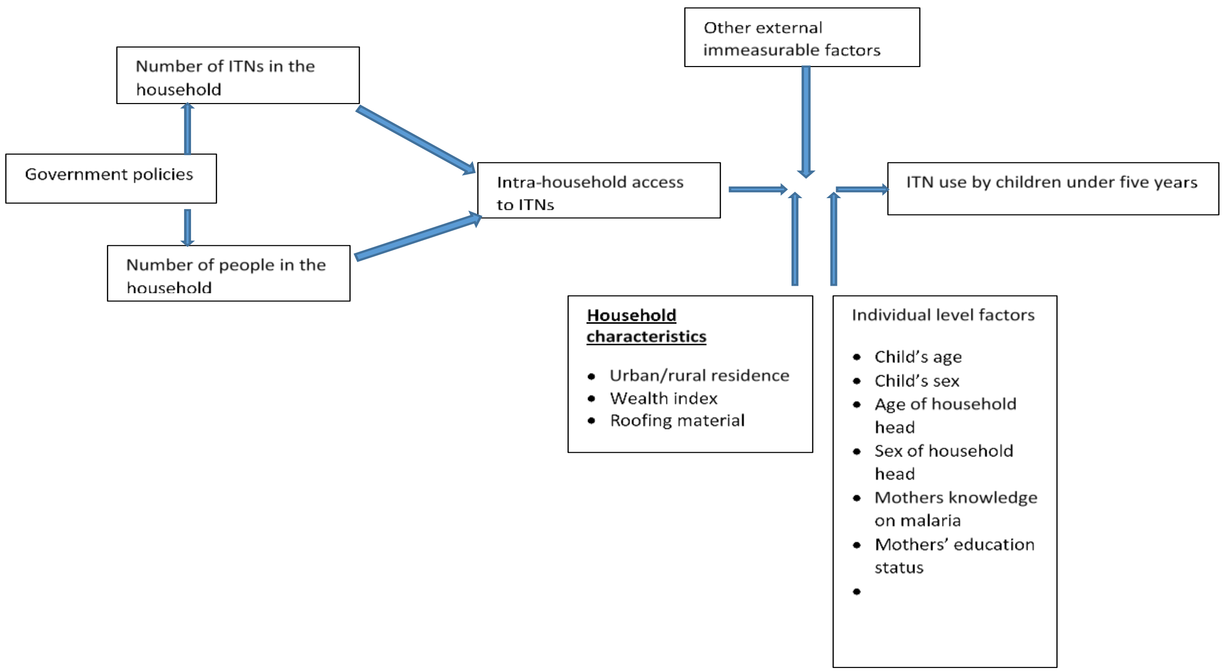

Figure 2.4.1:A conceptual framework of factors associated with the use of ITNs among children under five years.

For an under-five-year-old to use a bed-net, there has to first be access to the bed-net. The ITN access in the household is determined by the number of household members per bed-net, presented as the number of household members to ITN ratio or intra-household access to ITN (34). Conceptually, the number of household members and the number of ITNs variables combine to form the household members to an ITN ratio (composite variable) which directly influences the use of ITNs within the household. However, there are other variables whose interaction with this relationship may modify or confound it. Hence, the framework illustrates the individual-level, the maternal level factors, and the other household-level factors as influencers of the relationship between access to and ITN and its use by an under-five-year-old (figure 2.1). We also appreciate that other elements may have an influence on this relationship but cannot be measured. The framework further appreciates that government policies will influence the availability of ITNs at a household level, for example, the free mass distribution of ITNs to the population. Even family planning policies may influence the household population. Hence, we show government policy as a distal factor but, it is not included in the analysis.

2.5 Justification

This study contributes to the understanding of socioeconomic and sociodemographic factors associated with the use of ITNs among under-five children in Malawi to improve ITN utilization. Other researchers have explored factors contributing to this gap using secondary data from other surveys (24). A review of literature from Malawi showed that factors associated with ITN use evolve from time to time (24). This study used data from a recent nationally representative survey to add to the pool of current knowledge available on the topic.

2.6 Study aims and objectives

The study aimed to assess factors associated with the use of ITNs among children under five years in households that owned at least one ITN in Malawi in 2017.

Specific objectives were to:

3 Compare the sociodemographic characteristics of participants who used ITNs and those who did not use ITNs in ITN owning households.

4 Determine factors associated with ITN usage among children under-five years in bed-net-owning households in Malawi.

CHAPTER 3: METHODS

3.1 Introduction

This chapter outlines the overall methodology that was used in this study. Firstly, there is a description of the study setting then the study design adopted in the present study, sample population, sample power calculation. Lastly, statistical methods were employed to assess for association and estimate effect sizes.

3.2 Study setting

Malawi is located in the sub-Saharan African region. It shares borders with Tanzania, Mozambique, and Zambia. It covers a land area of 118 484 km^2. It has 28 districts that are administratively divided into three regions, namely, Northern, Central, and Southern regions (12). The Northern region has six districts, nine in the Central and thirteen in the South region (22). The country has a population of 17.6 million people with about 2.6 million under-five years (40).

3.3 Study design

The study was a cross-sectional study that used secondary data from the 2017 MMIS.

3.4 Study population

The study population was all children under five years old, who resided in households that were sampled for the MMIS-2017, a night before the survey in Malawi.

3.5 Sample size and power calculation

The sample size was fixed by available observations in the primary survey therefore no sample size calculation was done. A power calculation was conducted to ascertain whether the sample would have enough power to estimate a significant association between ITN utilization among children under five and ITN household access (ratio of household members per bed-net). Based on a previous study, it was assumed that a unit increase in ITN intra-household access led to a 2.2 fold increase in the odds of ITN use among children under five living in households with ITNs (34). With an alpha-level of 0.05 and 2564 children, the sample had more than 99.9% power to detect a significant association. While maintaining the other measures, the sample size was reduced by 200 five consecutive times and power remained at 99.9%.

3.6 Data management

MMIS, 2017, data were requested from the Demographic and Health Survey (DHS) program. Upon acquiring permission, data were downloaded in the Stata data format from the DHS website. The study made use of data from two files that were downloaded from the DHS website. The dataset containing information of all household members (MWPR7IDT) was merged with the dataset containing information for children aged 6-59 months (MWKR7IFL). The merge was performed on two variables of cluster number and household number. After merging, the new data set had 273 variables. First, empty variables were dropped, these were pre-marked as non-applicable in the two datasets. The assessment of variable definitions in the dataset was done to decide on which variables to be used in the analysis based on previously published knowledge. All variables that were not relevant to the analysis were dropped.

The variable on the household wealth index had five categories that were collapsed to three by combining the first two and the last two categories, respectively. This was done because some of the categories had few observations. In the parent study, the household wealth index was generated from a factor score method. The households were scored based on consumer goods that were owned and other household characteristics, such as the source of water and electricity (11). Finally, only children who slept in a household that owned at least an ITN were included in the analysis, and those from households that did not own any ITN were excluded.

3.7 Variables

3.7.1 Outcome variable

The outcome variable was, 'use of ITN,' defined as whether a child under five years of age, who resided in a household that owned at least one net, slept or did not sleep under a bed net on the night before the survey.

3.7.2 Explanatory variables

The primary explanatory variable used in this analysis was household access to an ITN. This variable was defined as the ratio of household members to an ITN in households. Household access has been reported as a consistent predictor of ITN use in literature, whether reported as a ratio (described above) or as separate variables of the number of nets and number of people in a household (34). Furthermore, Household access as a ratio is an important indicator for the NMCP in Malawi with a target of two household members per ITN in every household (11).

Based on the reviewed literature, the following variables were included on the assumption that they could be effect modifiers or confounders: mother's educational level, sex of the child, age of the child, residence (rural/urban), and region of residence. Household-level attributes included household wealth index, sex of household head, and the number of sleeping spaces.

Table 3.1: List of variables and variable definitions used in the analysis

Variable name	Variable definition	Parent variables	Variable type
use of ITN	whether a child under five year of age, who resided in a household that owned at least one net, slept under ITNor not in the night before the survey	Line number (hvidx) and line number of the person who slept in this net (hmla, hmlb,hmlc and hmld)	Binary variable
Household access to ITN	Ratio of household members to an ITN	Number of de-jure members (hv012) and number of mosquito bed nets (hml1)	Continuous variable
Sex of child	Male or female	as coded in the primary dataset	Binary variable
Age of child	Age of child in months	as coded in the primary dataset	Continuous variable
Residence	Rural or urban	as code in the primary dataset	Binary variable
Region of residence	Northern, Central and Southern Regions	as code in the primary dataset	Categorical variable
Sex of household head	Male or female	as code in the primary dataset	Binary variable
Age of household head	Age in years	as code in the primary dataset	Continuous variable
Relationship to the household head	Child's relationship to the household head	collapsed into three categories	Categorical variable
Mother's education level	Mother's highest level of education attended	collapsed into three categories	Categorical variable
Mother's knowledge that mosquito causes malaria	Mother's knowledge of mosquito bite as causes malaria	Cause malaria: mosquito bite	Binary variable
ITNprevents malaria	Mother's knowledge of ITNas main malaria prevention (recoded as a binary variable)	Malaria prevention: use net (s504c), sleep under a insecticide-treated net (s5o4b) and sleep under a treated net (s504a)	Binary variable
Household wealth index	Poor, middle, or rich	collapsed into three categories	Categorical variable
Alternative ITN use	Net used other than sleeping	collapsed into two categories	Categorical variable
Number of separate sleeping spaces	Total count of sleeping spaces in a household	collapsed into two categories	Categorical variable
Number of children under five years	Count of children under five years in the household	as code in the primary dataset	Continuous variable

3.8 Data analysis

Data were analyzed using Stata version 15. Due to the complex study design, weights were used in this analysis. The weights were provided together with the datasets. The weights were computed as inverse values of the products of two probabilities that represented the overall probability of selecting a household in the cluster (i) of stratum (h) (11). The two probabilities were:

1. The probability (P_{1hi}) of selecting a cluster (i) within a stratum (h)
2. The probability (P_{2hi}) of selecting a household within a cluster (i).

The overall probability of selecting a household in the cluster (i) of stratum (h) was:

$P_{hi} = P_{1hi} \times P_{2hi}$

Weights computation (11):

$W_{hi} = {}^{1}/_{P_{hi}}$

The sample weights were calculated and provided in the dataset from the parent survey. The values in the provided weights in the dataset were provided in millions and to generate a usable weight's variable was divided by 1,000,000 as instructed in the Guide to DHS Statistics (41). The analysis was set to survey module in Stata to factor in the weights and account for the complexity of the study design.

3.8.1 Descriptive analysis

Descriptive statistics were done by calculating frequencies and proportional distribution for categorical variables, and mean and 95% confidence interval for continuous variables. Participant characteristics were compared based on whether they slept under an ITN the night before the survey (use of bed-net). Other categorical variables were subjected to a Chi-square test to explore possible associations.

3.8.2 Logistic regression

Univariable logistic regression models were fitted to assess the association of the individual factors with the outcome variable. The measure of association was unadjusted odds ratios. The association estimate was considered statistically significant if the 95% confidence interval did not contain an odds ratio of one or if the p-value was less than 0.05. Afterward, a multivariable logistic regression model was fitted to estimate adjusted odds ratios. All variables that yielded a p-value ≤ 0.15 in the Univariable logistic regression analysis were included in the multivariable logistic regression model. A household population size and number of ITNs in a household were combined to generate the primary exposure variable in the analysis (household access to ITN). The final model contained variables that maintained statistical significance at p-value $\leq$0.05. Model fit was assessed by a goodness-of-fit test for a logistic regression model that incorporates the survey design and weights in the analysis. It uses pseudo-maximum likelihood methods to estimate the deviation of predicted values in the fitted model from the observed values (42). A model is considered to have a good fit if the p-value of the test statistic is greater than 0.05.

3.8.3 Managing missing values

The merged dataset had missing values for three variables (Mothers' educational level, mothers' knowledge of malaria cause, alternative use of ITN at the household level, and mothers' knowledge on ITN as preventing measure) (Table 2). However, only one of these variables (alternative use of ITN at household level) remained in the final model and was missing 11.2% (254/2265) of the observations. The final model was fitted using a complete case analysis technique to manage missing values. This technique implies the exclusions of all observations with missing values within variables (43). However, our data showed that the missing values were missing at random (MAR) because the probability of missing values was partly explained by the other predictors in the model (43) so we conducted a sensitivity test to verify our result.

To test for MAR, we created a dummy binary variable using the variable “alternative use of ITN at household level” in which observation that had missing value were coded “0” and those without missing values were coded “1”. We then run a logistic regression analysis with the dummy variable as the outcome variable using the other predictors to assess if the missinginess could be explained by the other predictors. The assumption was if there is a relationship between the missingness and other observed values then the observed values can be used to impute the missing values. The sensitivity test was carried out by fitting a model using multiple imputations and comparing the estimates with those from the complete case analysis. The results were reported as the percentage differences in the estimates of the two models as suggested by Meeyai (44).

Chapter 4: Results

4.1 Introduction

This chapter presents the results of the analysis. The first section covers the descriptive analysis results (distribution of participants by sociodemographic characteristics). The second section presents results from the logistic regression that tested for association between the outcome and exposure variables.

4.2 Study Participants

The study included 2265 children that met the inclusion criteria, coming from 1765 households (Figure 4.1). After applying the weights to the analysis, the working sample size came to 2365 Out of the weighted sample, 1881 (79.6%) children reported sleeping under an ITN the night before the survey.

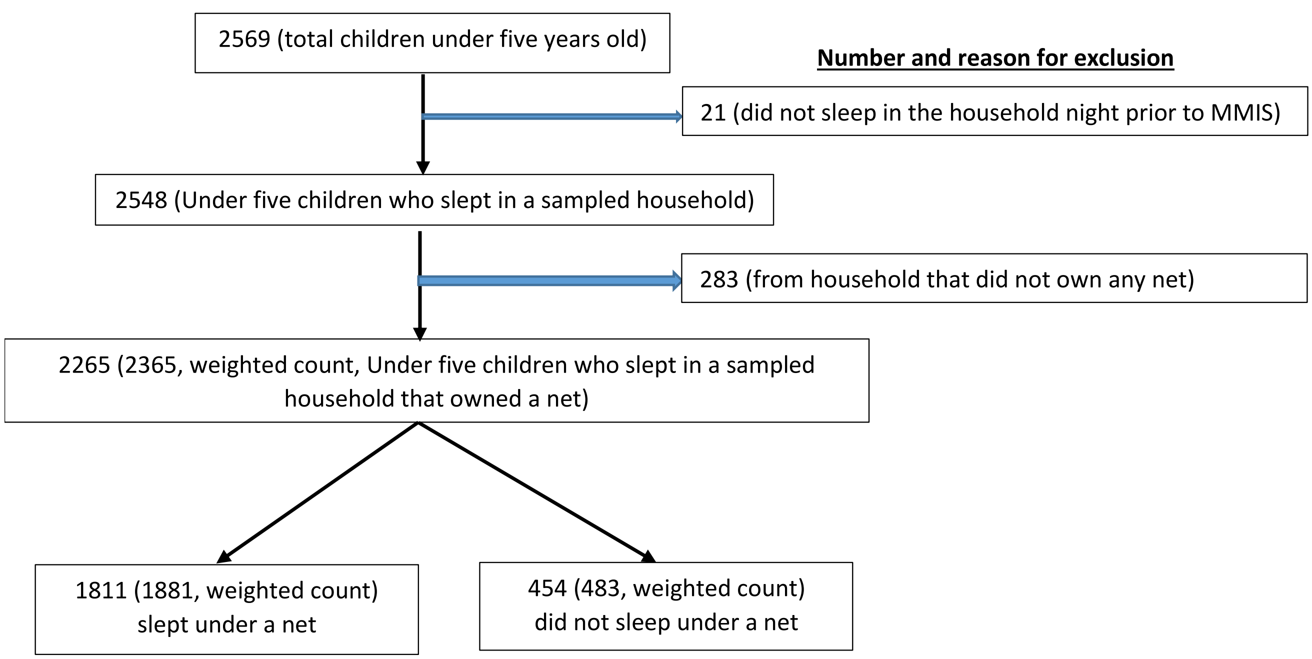

Figure 4.2.1: Inclusion and exclusion criteria for participants (unweighted and weighted counts)

4.2.1 Participant's characteristics

Half of the participants were females, 49.7% (n=1174). The mean ages of the children were 30.8 months: 31.5 and 30.8 for males and females, respectively. Children aged 12 months old or younger accounted for 20% (n=474) of the participants, 13-23 months were 16% (n=379) and almost 64% (n= 1483) were 24 months or older.

Most of the participants resided in rural areas (85.2%, n=2015). A third (67%, n=1405) of participants had mothers whose highest attained education was primary school level. Nineteen percent (19%, n=398) had mothers with secondary education and above and 13.7% (n=286) had mothers without any formal education. The mean age of the head of the household was 37.9 years. Thirty-three percent (33%, n=789) of the children resided in a household whose household head was less or equal to 30 years and 35% were 31-40 years old.

Most of the participants came from poor households (44.5%, n=1053) and 36.1% (n=853) were from rich households, while 19.4% (n=458) came from medium wealth households, and 62%, n=1474 came from a household with a population of more than four members.

Table 4.1: Distribution of socioeconomic and demographic characteristics of participants

Variable	Unweighted count	Unweighted proportion	Weight proportion
Child Level factors			
Sex of child (n, %)			
Male	1343	50.1	50.3
Female	1131	49.9	49.7
Child of age (n, %)			
≤12 months	486	21.4	20.1
13 to ≤23 months	355	15.7	16.0
≥24 months	1424	62.9	63.9
Maternal Level factors			
Mother's education level (n, %)			
No education	182	8.0	12.1
Primary level	1225	54.1	59.4
Secondary level or more	590	26.1	16.8
Missing observations	268	11.8	11.7
Mothers knowledge of malaria			
Mosquito causes malaria (n, %)			
Yes	214	9.5	11.4
No	1878	82.9	80.7
Missing observations	173	7.6	7.9
ITN prevents malaria			
Yes	1832	80.9	77.8
No	60	2.7	3.0
Missing observations	373	16.4	19.2
Household Level Factors			
Residence (n, %)			
Urban	797	35.2	14.8
Rural	1468	64.8	85.2
Region of residence (n, %)			
Northern	757	33.4	11.9
Central	732	32.3	39.0
Southern	776	34.3	49.1
Sex of household head (n, %)			
Male	1797	79.3	78.3
Female	468	20.7	21.7
Age of household head in years (n, %)			
≤30 years	686	30.3	33.4
31-40 years	838	37.0	34.7
41-50 years	343	15.1	15.1
>50 years	398	17.6	16.8
Relationship to household head (n, %)			

Son/Daughter	2136	94.3	94.8
Adopted/Foster child	98	4.3	3.5
Other /no relationship	31	1.4	1.7
Household wealth index (n, %)			
Poor	669	29.5	44.5
Middle	346	15.3	19.4
Rich	1250	55.2	36.1
Household population size (n, %)			
≤ 4 people	824	36.4	37.6
>4 people	1441	63.6	62.4
Number of ITNs per household			
≤2 nets	1431	63.2	71.3
>2 nets	834	36.8	28.7
Alternative ITN use (n, %)			
Bed net for sleeping	1866	82.4	80.6
Other uses	145	6.4	7.7
Missing observations	254	11.2	11.7
Number of separate sleeping spaces			
≤2 sleeping spaces	1265	55.8	62.9
>2 sleeping spaces	1000	44.2	37.1

4.3 ITN Access and Utilization at Household Level

Figure 4.2 shows ITN usage by the ratio of household members to an ITN among urban and rural households. In urban residences, 83% of children and 79% in rural used an ITN on the night before the survey. Of the children who used a bed-net, 97.5% (1835) used an ITN. The mean household population size was 5 and 6 for urban and rural households, respectively. In urban, the mean ratio of household members to ITN was 2.6 (95% CI, 2.4-2.8) and in rural 3.0 (95% CI, 3.1-3.4). A chi-square test showed that there was a significant association between ITN use and the ratio of the household member to an ITN(household access to bed-net), Chi2=128.97, p-value=0.000 (rural, Chi2=87.81, p-value=0.000 and urban, Chi2=58.87, p-value=0.000).

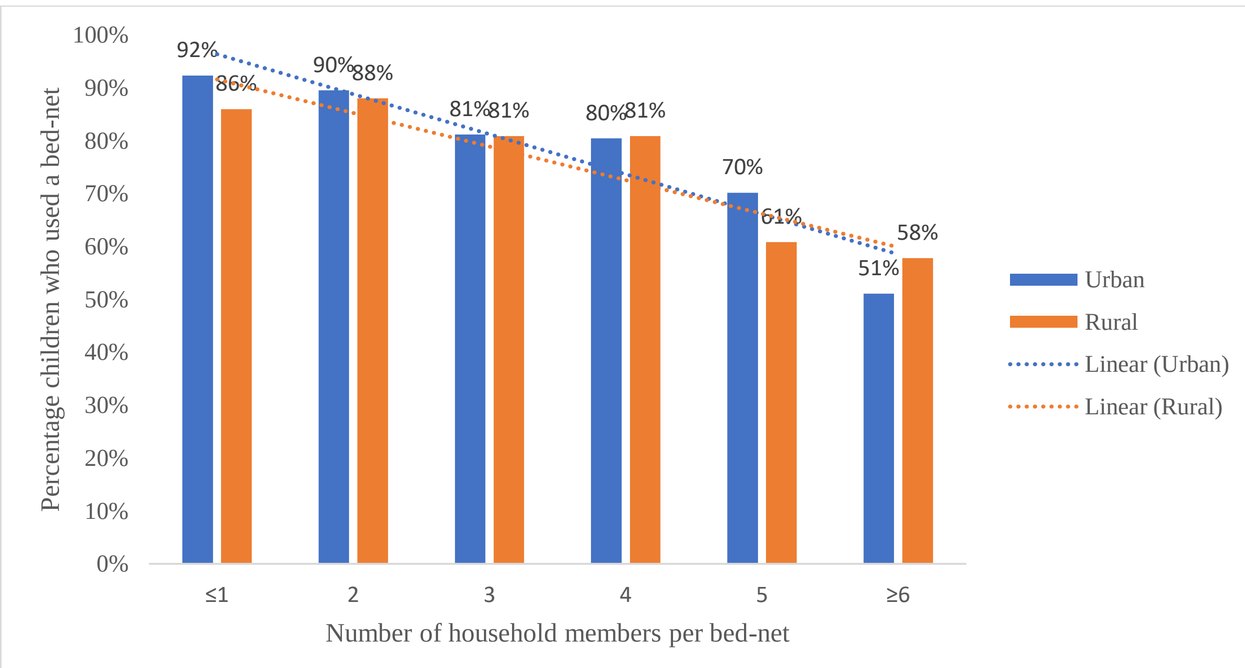

Figure 4.3.1: Distribution of the proportion of children who used ITNs by the ratio of household members to an ITN in households

Distribution of ITN utilization by age of the child

In most age groups, except ≤12 months and 25-36 months, bed net usage was 7% to 8% higher in urban compared to rural areas. Overall, the Chi2 test showed a significant association between ITNuse and a child's age (Chi2=19.56, p-value=0.006). However, sub-group analysis by rural/urban residence showed a significant association of ITN use and child's age among the rural population only (rural, Chi2=, 14.09, p-value=0.013, urban, Chi=4.21, p-value=0.088).

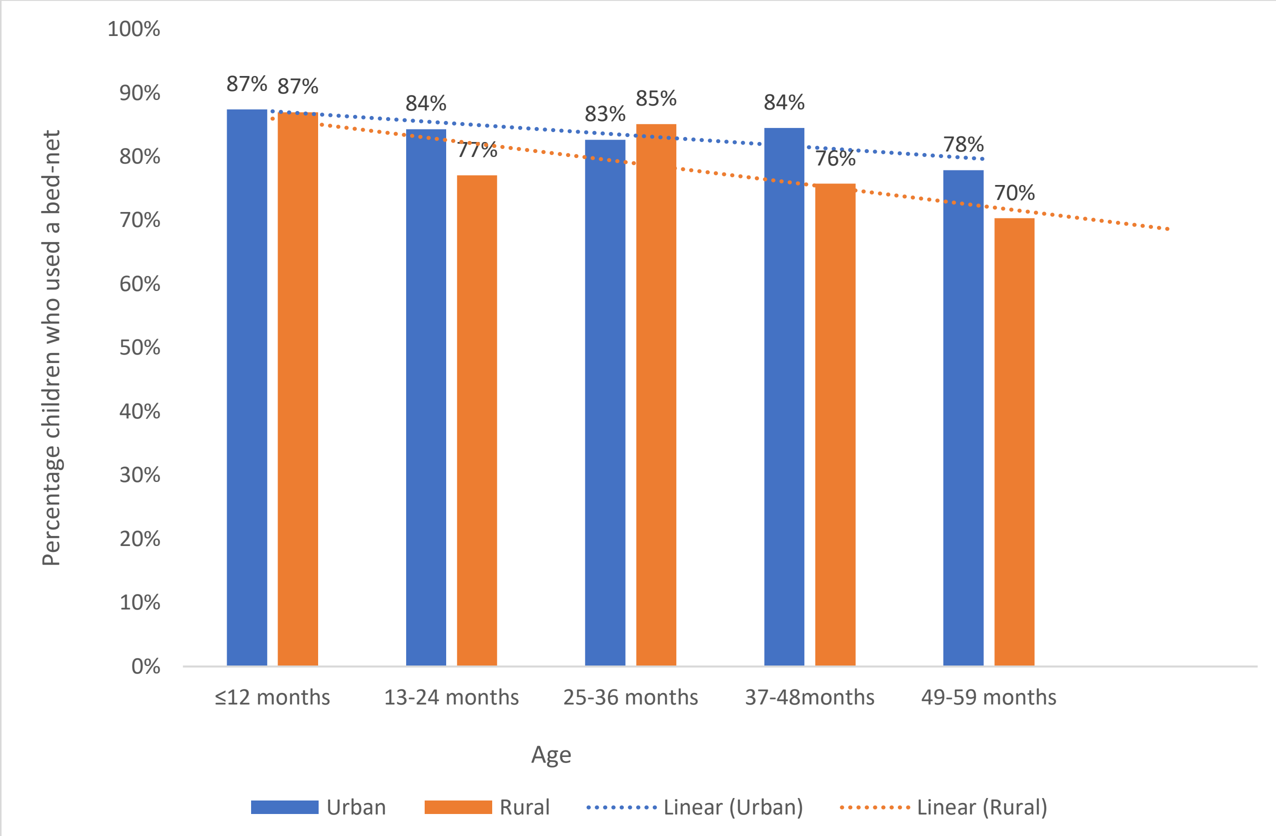

Figure 4.3.2: Distribution of the proportion of children who used ITNs by age of the child in 12 months blocks and a linear trend by residence

4.4 Univariable logistic regression results

Table 4.3 shows results from a Univariable logistic regression analysis. In the analysis, the outcome variable, "use of ITN" was fitted in a model with each of the exposure variables, and the flowing variables were statistically significant at p-value < 0.05; age of child, mothers' educational level being secondary school level or more compared to mother having no formal education, mother's knowledge of mosquito as causing malaria, mothers' knowledge of ITN as a preventive measure against malaria, being a daughter/son of the household head, alternative ITN use at the household level and the ratio of household members to ITN. The age of household head was statistically significant at p-value < 0.05 but the odds ratio was very close to one. Being a rural resident was marginally significant with a p-value of 0.069. The following variables had no association with ITN use: sex of the child, region of residence, and sex of household head. It is important to note that, when the number of ITNs and household population size were treated as separate variables, they both had a statically significant association with ITN use.

4.5 Multivariable logistic regression results

We fitted a multivariable logistic regression model using ITN use as the outcome variable and household members to ITN ratio as the primary exposure variable. Covariates were added to the model if the results of the univariable logistic regression yielded a p-value ≤ 0.15. The model was fitted at two levels and the following covariates were added in the initial model; sex of the child, child's age, mother's education level, mother's knowledge on mosquito as related to malaria cause, mother's knowledge of bet-net as malaria prevention, residence (urban/rural), child's relationship to household head and alternative use of ITNs at the household level. Despite the number of ITNs and household population size meeting the criteria to be included in the multivariable logistic regression model, the two were not included as these were used to generate the primary exposure variable.

The final model retained only the variables that were significantly associated with ITN use. These variables were the ratio of household members to ITN, age of the child, child's relationship to household head, and alternative use of bed-nets. This model was subjected to a goodness of fit test, 'svylogitgof,' and the results showed that there was no evidence that the model was not a good fit for the data, p-value=0.920 (Table 4.2).

Table 4.11: Goodness of fit test results

Model	**F- adjusted test statistic**	**P-value**
Final model	0.51	0.920

Table 4.3 shows the results of the multivariable logistic regression analysis, the child's age was a significant predictor of ITN use among children under-five years, aOR= 0.8 (CI 0.74-0.90). A one-year increase in the age of a child had a corresponding 20% decrease in the odds of a child sleeping under a bed-net. Secondly, being a son/daughter/grandchild of the head of household increased the odds of an under-five child sleeping under an ITN by two folds compared to being distantly related (nephew/niece) or having no blood relation to the household head (aOR=2.1, CI 1.00-4.32).

The ratio of household members to an ITN remained a statistically significant predictor for ITN use by an under-five years old child, aOR=0.75 (CI 0.68-0.84). Thus, a unit increase in the ratio of household members to an ITN showed a corresponding 25% decrease in the odds of an under-five years old child sleeping under an ITN. The study further found that children residing in households that reported no alternative use of ITNs other than sleeping in had 75% higher odds of sleeping under an ITN than children residing in households that reported alternative use, aOR=1.75 (CI, 1.09-2.79) Alternative ITN use includes but not limited to fishing, garden fencing and drying fish.

The sex of child, urban/rural residence, and region of residence remained insignificant at level 0.05 in the adjusted model. Mother's educational level, mother's knowledge of mosquito associated with malaria, mother's knowledge of ITN as a malaria prevention method, and age of household head lost their statistical significance in the adjusted model and were kicked out of the model.

Table 4.12: Factors associated with ITN use among under-five children in Malawi

Variable	Freq.	ITN use(count)	Unadjusted OR (95% CI)	P-value	Adjusted OR (95% CI)	P-value
Sex of child						
Male	1190	955	Ref			
Female	1174	926	0.9 (0.68-1.23)	0.577		
Age of child	2365	1881	0.8 (0.74-0.87)	0.001	0.8 (0.74-.0.90)	<0.001
Mother's education level						
No education	286	217	Ref			
Primary level	1405	1131	1.2 (0.88-2.00)	0.187		
Secondary level or more	398	346	3.2 (1.32-3.40)	0.002		
Mothers' knowledge (frequency, proportion)						
Mosquito causes malaria						
No	364	341	Ref			
Yes	1545	1498	2.1 (1.04-4.36)	0.040		
ITN prevents malaria						
No	427	351	Ref			
Yes	1752	1558	1.8 (1.15-2.69)	0.009		
Residence (n, %)						
Rural	2015	1590	Ref			
Urban	350	291	1.3 (0.98-1.81)	0.067		
Region						
Northern	283	222	Ref			
Central	921	731	1.1 (0.74-1.48)	0.790		
Southern	1161	928	1.1 (0.77-1.52)	0.662		
Relationship to the household head						
Other*/No relationship	41	32	Ref		Ref	

Son/Daughter/Grand child	2241	1795	2.1 (1.15-3.89)	0.016	2.1 (1.00-4.32)	≤0.048
Adopted/Foster child	83	54	1.9 (0.59-5.98)	0.288	1.8 (0.59-5.64)	≤0.291
Age of household head	2365	1881	1.0(0.99-1.0)			
Sex of household head						
Male	1851	1485	Ref			
Female	514	397	0.8 (0.61-1.14)	0.259		
Ratio of household member to a ITN	2365	1881	0.7 (0.67-0.82)	0.001	0.75 (0.68-0.84)	<0.001
Household size	2365	1881	0.8 (0.79-0.90)	0.001		
Number of nets in a households	2365	2044	1.3 (1.1-1.5)	0.012		
Any alternative ITN use?						
Yes	395	346	Ref		Ref	
No	1693	1560	1.7 (1.01-2.69)	0.048	1.75 (1.09-2.79)	≤0.020

*not directly related to the household head, niece, nephew, brother /sister

4.6 Sensitivity test for complete case analysis to the multiple imputation model

Figure 4.4 below shows the Stata logistic regression output of the dummy binary variable for missingness. The results shows that there was significant association between the missing values and other observed values in the other predictors and hence we assumed that the MAR assumption holds.

```
Number of strata   =          6                  Number of obs     =      2,265
Number of PSUs     =        150                  Population size   = 2,364.5081
                                                 Design df         =        144
                                                 F(   5,    140)   =       7.98
                                                 Prob > F          =     0.0000
```

miss514	Odds Ratio	Linearized Std. Err.	t	P>|t|	[95% Conf.	Interval]
use_net						
yes	1.897767	.3899658	3.12	0.002	1.264299	2.848628
pp_itnratio	1.066423	.0773418	0.89	0.377	.9240032	1.230795
hml16a	.9760249	.0043442	-5.45	0.000	.9674759	.9846494
hh_relation						
son/daughter	1.940483	.7833521	1.64	0.103	.8737289	4.30966
adopted/foster child	3.049634	1.734838	1.96	0.052	.9906559	9.387991
_cons	4.57623	2.293679	3.03	0.003	1.699246	12.32422

Figure 4.6.1 Logistics regression analysis output testing for MAR

Then results from the complete case analysis and the multiple imputation model had percentage differences that ranged from 1% to 15%, the confidence intervals overlapped in all the variables. The variable “Relationship to household head” lost its statistical significance in the Multiple imputation model, however, it should be noted that it was marginally significant in the complete case analysis and the lower limit of the confidence interval was approximately one. The final results used the complete case analysis as the difference was considered minimal.

Table 4.13: Difference in estimates for the complete case analysis multivariable logistic regression model and multiple imputed multivariable logistic regression model using the later as the baseline

Variables	**Complete case analysis estimates (adjusted OR)**	**Multiple imputation estimates (adjusted OR)**	**Difference**	**Percentage difference**
Age of child	0.79 (0.72-.0.87)	0.80 (0.73-0.88)	-0.01	1%
Relationship to the household head				
Other/No relationship	Ref		Ref	Ref
Son/Daughter/Grand child	2.08 (1.00-4.32)	1.77 (0.92-3.38)	0.31	15%
Ratio of household members to ITN	0.75 (0.68-0.84)	0.74(0.67-0.87)	0.01	1%
Alternative ITN use				
Yes	Ref		Ref	Ref
No	1.75 (1.09-2.79)	1.76 (1.07-2.89)	-0.01	1%

Chapter 5: Discussion

5.1 Introduction

This chapter discusses the findings of the study in relation to local and international literature. Furthermore, the strengths and limitations of the study and recommendations for ITN use among children for malaria prevention are outlined.

The study aimed to assess the factors associated with the use of ITNs among children under-five years of age in households that owned at least an ITN in Malawi. We examined child, maternal, and household characteristics as factors that influence ITN usage among children. The main findings of this study were that the age of the child, the ratio of household members to ITN, and alternative use of ITNs at household level were significant predictors of ITN use among children under-five years in Malawi. The relationship of the child to the head of the household was a marginally significant predictor. None of the mother's level predictors were significantly associated with ITN use among under-five children in the adjusted model.

The age of the child was a significant predictor of ITN use both in the univariable and multivariable logistic regression analysis. The multivariable logistic regression analysis controlled for the following variables: the ratio of household members to an ITN, alternative use of ITNs at household level, and Relationship of the child to the head of the household. The results showed that an increase in the age of a child led to a decrease in the odds of the child sleeping under an ITN. This coincides with other findings where infants were more likely to sleep under an ITN with their mother compared to older children (34). The same observation is true for Malawi, the young children tend to share sleeping space with the parent/mother hence, share an ITN and as the children grow older, they are weaned and join their peers in the children sleeping quarters. This makes the children lose access to the ITN. Traditionally in Malawi, older children have separate sleeping quarters from the parents and this is mostly practiced in the rural areas where 84% of the population reside (40).

In this study, household access to ITN was measured as the ratio of household members to an ITN. It measured the number of people that are competing to use the same ITN in a household. The adjusted model showed that an increase in the ratio of household members to an ITN corresponded to a decrease in the odds of an under-five sleeping under an ITN. A study by Eisele T. et al, reported similar findings (34). Other studies that modelled the number of people and the number of ITNs in a household as separate predictors found a significant association with the use of ITN by children under-five years. Under the universal coverage of ITNs initiative, Malawi aims to achieve one ITN per every two household members through free national wide mass distribution campaigns of ITNs. However, despite the increase in coverage, there has been a register of alternative use of ITNs other than sleeping in them (11). The alternative use of ITN is detrimental to the coverage hence, the accessibility of ITNs to the targeted users. This may also increase attrition of ITNs to considerably low numbers before the next distribution cycle.

Another significant predictor of ITN use among children under-five is an alternative use of ITNs at the household level. The alternative uses include fishing, windows, gardening, caging livestock, fence, and others reported selling of the ITN for money. Children who lived in houses that reported the use of ITNs for purposes other than sleeping had reduced odds of using an ITN compared to their counterparts. According to the MMIS report, 2017, a high proportion of ITN misuse was reported in the Southern Region of Malawi (11). However, in this study, the region of residence was not a significant factor. A previous study reported a significant difference in ITN usage among children under-five years by region in Malawi (24) but, this was a period before the roll-out of universal mass ITN distribution campaigns.

One unexpected finding was the marginal significance of the relationship of the child to the household head. This study found that the odds of a child sleeping in an ITN were 2.2 folds higher for children who were directly related to the household head (biological child or grandchild) compared to those not directly related to the household head (extended family or adopted). Intra-household relationships have been known to influence child health and access to health where extended family structure is concerned, observed in low resource settings (45). The influence of the relationship to the household head could be offset by increased household access to ITN.

Literature has shown that household socioeconomic status, mother's or child-caregivers education, and knowledge influence health behaviour (39,45). Studies have reported household wealth index and mothers or child-caregivers education and knowledge of malaria as significant factors in the use of ITNs (31,32). A study conducted in Malawi found that in 2010, children from wealthier households were more likely to use an ITN compared to children from poor households (OR 1.2-1.7), and children whose mothers had no formal education or primary education were less likely to use ITNs compared to those whose mothers had secondary education or higher, OR 0.8 and 0.7, respectively. However, this study has found no significant relationship between household wealth index or mother's education status and ITN use among under-five-year-old children (24). Furthermore, there was no significant relationship between a mother's knowledge of mosquito bites as a malaria cause or a mother's knowledge of ITN as a malaria prevention method and the use of ITN by children under-five years.

5.2 Study strengths and limitations

The study had some strengths and limitations. Firstly, the sampling methods allowed for a representative sample of the population under study. However, the data is from a cross-sectional study and cannot infer that the relationship between use of ITN among children under five and the various predictors is consistent at all times. The data was collected from mid-April to mid-June, which coincided with a transition period from hot-rainy season to winter, ITN use may be affected by seasonal weather change hence the associations may not hold for other seasons of the year (limited inference). The responses were self-reported for what may be viewed as desirable health behavior hence may be prone to social desirability bias.

5.3 Conclusion and recommendations

5.3.1 Conclusion

In this study, we conclude that the age of the child, household access to ITN (ratio of household members to an ITN), and alternative ITN use at household level are important predictors of ITN use among children under-five years old in Malawi. Despite age being a predictor, it comes into effect because of the sleeping arrangements that change as a child grows. This can be solved by increasing household access to ITNs by reducing the distribution cycle from three to two years which would ensure availability and access to the ITN is maintained at all ages including the under five children. The effort to improve access is beyond the free provision of the ITNs as alternative household use of the ITNs is also a predictor that off-sets the efforts to improve coverage and access.

5.3.2 Recommendations

National Malaria Control Programmes should continue to work towards universal coverage of ITNs to improve access and maintain access to the ITNs by working on a timely replacement. The universal coverage goal should be combined with health behaviour change communication strategies to educate people on the importance of children sleeping under ITN irrespective of age. Further research should be done to explore more individual behavioural factors that affect the intervention uptake including ways to manage alternative use of the ITNs at the household level.

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Appendices

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UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Mr DD Mapemba

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M181152

NAME: **(Principal Investigator)** Mr DD Mapemba

DEPARTMENT: School of Public Health, Medical School, University

PROJECT TITLE: Factors associated with the use of insecticide-treated nets among under-five children in Malawi in 2017

DATE CONSIDERED: 30/11/2018

DECISION: Approved unconditionally

CONDITIONS:

SUPERVISOR: Ms Z Ndlovu

APPROVED BY: Dr N Naran, Deputy Chairperson, HREC (Medical)

DATE OF APPROVAL: 09/01/2019

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

DECLARATION OF INVESTIGATORS

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

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