The Association between Maternal Knowledge of Malaria Prevention Methods and Malaria Parasitemia among Children Under-Five Years in Malawi
by

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Thesis submitted in partial fulfillment of
the requirements for the degree of
Master of Science in the Graduate Program
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<u>ABSTRACT</u>

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Abstract

Background: Despite increased use of insecticide-treated nets (ITNs) among children under 5 years in Malawi, use of ITNs alone is insufficient to eliminate malaria. Therefore, other prevention methods should be explored to achieve malaria elimination. Previous studies illustrated that mother's knowledge of ITNs positively influenced her child's ITN use. In other settings, mothers' knowledge of ITNs led to increased ITN use and reduced parasitemia among children under 5 years. Therefore, it may be plausible that maternal knowledge of other malaria prevention methods is associated with under-five malaria parasitemia. This study examined whether maternal knowledge of other malaria prevention methods is associated with malaria parasitemia among children under five years in Malawi. I hypothesized that higher levels of maternal knowledge of malaria prevention methods would be associated with lower odds of malaria parasitemia in children under-five.

Methods: The analytic sample included 1,880 children under 5 years of age. Maternal knowledge of malaria prevention methods was assessed using 12 items from the 2017 Malawi Malaria Indicator Survey (MMIS). Each of the 12 items was given either a score of 1 for a correct response or a score of 0 for an incorrect response. All 12 items were added up to create a continuous composite score ranging from a minimum score of 0 (low knowledge) to a maximum score of 12 (high knowledge). I also classified the total score as a 3-level categorical variable: low (score: 0-3), intermediate (score: 4), and high (score: 5-12). For the binary variable, a total score of less than or equal to 4 was considered inadequate knowledge, while a total score of greater than or equal to 5 was considered adequate knowledge. Malaria parasitemia was assessed using positive and negative malaria microscopy test results. I examined the association between maternal knowledge of malaria prevention methods and under-5 parasitemia using weighted multivariable logistic regression models. I also adjusted for sociodemographic characteristics such as mother's highest level of education, ethnicity, type and place of residence, region, child's age, and wealth index.

Results: Maternal knowledge of malaria prevention methods was not found to be a significant predictor of under-5 malaria parasitemia. The survey items used to create the composite score had an alpha value of 0.43 which indicated poor reliability. Of the 1,880 children included in the analytic sample, 67.5% had mothers with only primary school education, 85.7% were from rural areas, and 22.8% were from the poorest wealth index bracket. After adjustment, maternal knowledge of malaria prevention methods as a composite score (adjusted odds ratio [AOR]=1.14, 95% confidence interval [CI]: 0.96, 1.35), as a three-level categorical variable (high knowledge AOR=2.28, 95% CI: 0.63-8.25), or as a binary variable (inadequate knowledge AOR=0.78, 95% CI 0.54-1.14) were not significantly associated with under-five malaria prevalence. Only maternal knowledge of burning leaves was significantly associated with a 5.44 higher odds of malaria parasitemia among children under five years.

Conclusions: In this study, I did not find evidence supporting the hypothesis that higher levels of maternal knowledge of malaria prevention methods is associated with a lower prevalence of under-5 malaria parasitemia in Malawi. This may be because maternal knowledge of malaria prevention methods is not a good indicator of actual practice. Therefore, future studies should explore the relationship between the preventative practices used by mothers and the prevalence of malaria among their children under five years. Future research identifying how alternative malaria prevention practices to ITNs impact under-five parasitemia may help Malawi progress toward malaria elimination.

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List of Abbreviations

Abbreviation	Definition
AOR	Adjusted Odds Ratio
DHS	Demographic Health Survey
ICF	Inner City Fund
IRS	Indoor Residual Spraying
ITN	Insecticide-Treated Net
LLIN	Long Lasting Insecticide Net
MMIS	Malawi Malaria Indicator Survey
OR	Odds Ratio
RDT	Rapid Diagnostic Test
SE	Standard Error
SSA	Sub-Saharan Africa
USAID	United States Agency for International Development
WHO	World Health Organization

Acknowledgements

I would like to thank my committee members Drs. Chenkai Wu, Abu Abdullah, Truls Ostbye, and Myiang Nyunt for their guidance and support in helping me develop this thesis. I would also like to thank Li Ting Chan for her help in my editing my thesis.

1. Introduction

Malaria is caused by *Plasmodium* parasites and transmitted by infected female *Anopheles* mosquitoes. The *Anopheles* mosquito life cycle takes approximately 30 days (1). In that time the mosquitoes progress from eggs to larva to pupa and finally to adult mosquitoes. Adult female *Anopheles* mosquitoes first become infected with *Plasmodium* parasites when taking a blood meal from a human who has malaria parasites in their blood. Then, the parasites undergo several stages of multiplication and morphological transformation in the mosquitoes. When the process is complete, mosquitoes can inject the parasites into humans during their subsequent blood meals. In humans, *Plasmodium* parasites first infect, multiply, and morphologically transform in liver cells. From the liver, the parasites then enter the blood stream where they infect and destroy red blood cells.

Malaria is a serious infectious disease of the blood in humans, involving multiple organ systems. Common symptoms of uncomplicated malaria include periodic fever, chills, rigors, and non-specific symptoms such as headache, muscle aches, joint pain, fatigue, nausea, vomiting and gastrointestinal discomfort. Malaria is a bone marrow depressant, causing a clinically significant decline in platelets, white and red blood cells. Malaria is curable if treated promptly with effective antimalarial drugs. If left untreated or not treated properly, malaria can result in debilitating complications. Severe anemia, blood clotting abnormalities, kidney failure, pulmonary edema, and coma are common manifestations of complicated and severe malaria. The mortality is high in patients with complicated or severe malaria.

In 2018, over 200 million cases of malaria occurred worldwide, resulting in approximately 405,000 deaths (2). Over 90% these cases occurred in the WHO African Region (2). Malawi is among 19 high burden countries in the WHO African Region; it bears about 2% of the global malaria burden, though its population is less than 1% of the world's population (2). In 2017, the incidence of malaria in Malawi was 231 cases per 1,000 person-years, which was above the average incidence (219 per 1,000 person-years) in World Health Organization's (WHO) African region (3,4). In Malawi, malaria cases are primarily caused by *Plasmodium falciparum* parasites, which can be fatal.

As recommended by the WHO, efforts for malaria elimination (where cases are reduced to zero cases of transmission) have focused primarily on two prevention approaches to reduce the global burden of malaria. The first approach involves preventing mosquito bites through insecticide-treated nets (ITNs) or long lasting insecticide nets (LLINs) (5). ITNs/LLINs prevent malaria by acting as both a physical and chemical barrier against mosquito bites. The net itself prevents individuals from being bitten, while the insecticide sprayed on the nets kills the mosquitoes on contact. Previously, the Malawian government distributed ITNs that required retreatment with insecticide every few months, but currently the government only distributes LLINs that can last for several years. Therefore, there is no longer a difference between ITNs and LLINs in Malawi. All nets treated with insecticide are referred to as ITNs. As a prevention tool, ITNs have been shown to effectively reduce malaria incidence by up to 50% in areas of stable transmission as compared to untreated nets (6).

The second recommended malaria prevention tool is indoor residual spraying (IRS). Like ITNs, IRS relies on insecticides to prevent mosquito bites, and refers to the process of applying insecticide to the walls and roofs of houses. When mosquitoes land on these surfaces they are killed or repelled by the insecticides. A study conducted in Tanzania found that using IRS could potentially avert 500 cases of malaria per 1000 persons each year if 80% of the population was covered with this intervention (7). In another study conducted in Northern

Tanzania, researchers found that use of ITNs and IRS decreased indoor mosquito population densities and reduced the prevalence of malaria (8).

In Malawi, use of ITNs is the primary malaria prevention intervention, while IRS is treated as a secondary intervention if it is used at all. For instance, in recent years, the Malawian government downsized its existing IRS program to only one district in the country (9). This is because the WHO does not recommend using IRS in combination with ITNs because of a lack of sufficient evidence of their additive effect (10). They do suggest that IRS can be used in areas of resistance to pyrethroids (the insecticides used on ITNs), but this requires a shift to organophosphate insecticides for IRS use which are more expensive (10,11). In consequence, ITNs are used as the main intervention to achieve Malawi's goal to cut down malaria related morbidity and mortality in half by 2022 (12). After the introduction of mass free ITNs distribution campaigns in 2008, use of ITNs among children under 5 years increased from 56% in 2012 to 68% in 2017 (12). As a result, the prevalence of malaria parasites in children under 5 years decreased from 33% in 2014 to 24% in 2017 (12). Despite an increase in the use of ITNs and a reduction in parasite prevalence, the incidence of malaria still remains high as stated previously (2). In fact, malaria remains a leading cause of morbidity and mortality among children under 5 years in Malawi. Nearly 40% of hospitalized children suffer from the disease (12,13). Additionally in 2018, Malawi had only achieved less than 15% reductions in malaria incidence and mortality (2). Therefore, Malawi is unlikely to meet its 2022 goal to reduce malaria related morbidity and mortality by 50%.

Malawi's slow progress towards its 2022 goal maybe because use of ITNs alone are not sufficient to eliminate malaria. A prior study of the Malawi Malaria Indicatory Surveys (MMISs) found that ITNs were not as important a predictor of under-five malaria parasitemia in 2014 as they had been in 2012 (14). Studies conducted in Ethiopia, Gambia, and Benin found that ITNs and IRS did not reduce malaria incidence levels enough to eliminate malaria when used separately or together (15-17). In addition, in 2017 and 2018, the President's Malaria Initiative reported increasing resistance of *Anopheles* mosquitoes to pyrethroid insecticides, which were used to treat ITNs in Malawi (18,19). Permethrin is one of these insecticides that was used against the predominant malaria vector *Anopheles Funestus* in Malawi. Between 2009 and 2014, Permethrin's ability to kill mosquitoes reduced by nearly 34% in the nation (20). Malaria elimination is further challenged because use of ITNs does not protect individuals from outdoor transmission (21,22). Use of ITNs can only protect individuals when they can effectively kill or repel mosquitoes from biting humans sleeping under the nets. This gap in ITN protection suggests that other prevention methods should be explored to supplement their use.

Possible supplemental interventions include removing stagnant water, screening doors and windows, using mosquito coils, and using other control measures (23). Studies conducted in Ethiopia and Gambia found that screening doors and windows could reduce the population size of indoor mosquitoes by at least 50% (24,25). Another study conducted in Ethiopia demonstrated that environmental control measures such as filling in stagnant waters effectively reduced mosquito density in the intervention village by nearly 50% (26). In Indonesia, use of mosquito coils reduced the prevalence of malaria parasites by 50% (27). These methods primarily prevent malaria among children under 5 years by reducing the mosquito population living near humans. When the mosquito population decreases, the chances of mosquitoes biting children and transmitting malaria parasites also decreases (23). Nevertheless, these interventions are not being utilized as core components of malaria control programs in SSA because successful implementation of these interventions requires mobilization of household members.

In SSA, women act as the primary stewards for their children's health. Prior studies in Nigeria and Zambia illustrated the importance of maternal knowledge in increasing use of ITNs among their household members (28,29). In Uganda, mothers with primary education had a 25% lower odds of their child having malaria parasitemia than mothers with no education (30). In Ethiopia, knowledge of malaria among mothers of children under 5 years was associated with under-five ITN use (31). In Nigeria, despite having poor knowledge of the cause of malaria, mothers used preventive practices such as ITNs and mosquito coils (32). In Madagascar, researchers found that a mother's education level strongly influenced her malaria knowledge and use of prevention efforts (33). In Burkina Faso, scientists found that mothers who had better knowledge about malaria were more likely to use vector control practices such as cleaning surroundings, eliminating breeding sites, and removing objects outside of homes than their less knowledgeable counterparts (34).

Therefore, the aim of this study is to assess whether maternal knowledge of malaria prevention methods is associated with malaria parasitemia among children under 5 years in Malawi. I examined this association using the 2017 Malawi Malaria Indicator Survey (MMIS) dataset. This analysis focused on prevention methods other than ITNs. I expected that higher levels of maternal knowledge of malaria prevention methods would be associated with lower odds of malaria parasitemia among children under 5 years in Malawi.

2. Methods

I performed secondary data analysis using the 2017 MMIS datasets. The description is given below.

2.1 Setting

Malawi is a landlocked country in the southern part of Africa that shares a Northern border with Tanzania, a Western border with Zambia, and a Southern border with Mozambique (35). It is divided into three regions: northern, central, and southern. Malawi's population is approximately 18.2 million people, with nearly 80% of its population living in rural areas (4,36). It is also one of the poorest nations in the world with about 70% of its population making less than $1.90 a day (37). Malaria is endemic in all regions of the country; the peak malaria season occurs from November through April each year (12,38).

The 2017 MMIS is a cross-sectional study funded by the United States Agency for International Development (USAID) as a part of its Demographic Health Survey Program (DHS). The purpose of the survey is to provide nationally representative data on the coverage of core malaria interventions and the existing burden of malaria in the nation. The survey was implemented by Malawi's National Malaria Control Program from April 15, 2017 to June 16, 2017. It follows a two-stage sample design. In the first stage, researchers chose 150 Enumeration areas (EA) or clusters (60 in urban areas and 90 in rural areas) from the 2008 census in Malawi. Researchers deliberately oversampled urban areas in order to create strong estimates for each region in the country. In the second stage, researchers randomly selected 25 households per cluster from a household listing of all 150 clusters, resulting in 3,750 selected households. Of the 3,750 households selected only 3,735 were occupied. Of the 3,735 occupied households, researchers successfully interviewed 3,729 of them, leading to a response rate of 99.8%. Within the interviewed households, 3,861 women aged 15-49 years were eligible for interview. In order to be eligible for interview, women had to be permanent residents or visitors staying in the house at night. Researchers successfully interviewed 3,860 women resulting in a response rate of 100%. Their children aged 6-59 months were also tested for malaria infection. This survey provides estimates on ITN ownership, ITN use, malaria prevalence among children under 5 years, knowledge about malaria (symptoms, causes, and prevention), and other factors related to malaria. More information on the sampling design can be found in the full report (12).

2.2 Participants

This analysis merged the Persons' Recode and Children's datasets from the 2017 MMIS. The Persons Recode dataset contained information on 16,755 household members, while the children's dataset had information on 2,377 children who were present in the household at the time of interview. In order to merge the datasets, children not in the household or were missing a household line number (n=123) were excluded. After merging the datasets, just 2,254 children were matched to their mother's information. Those with a missing or undetermined test result (n=251) and were younger than 6 months or older than 59 months (n=5) were excluded. Also, mothers who answered "don't know" or were missing a response for all malaria prevention method questions (n=118) were excluded. The final sample consisted of 1,880 children (Figure 1).

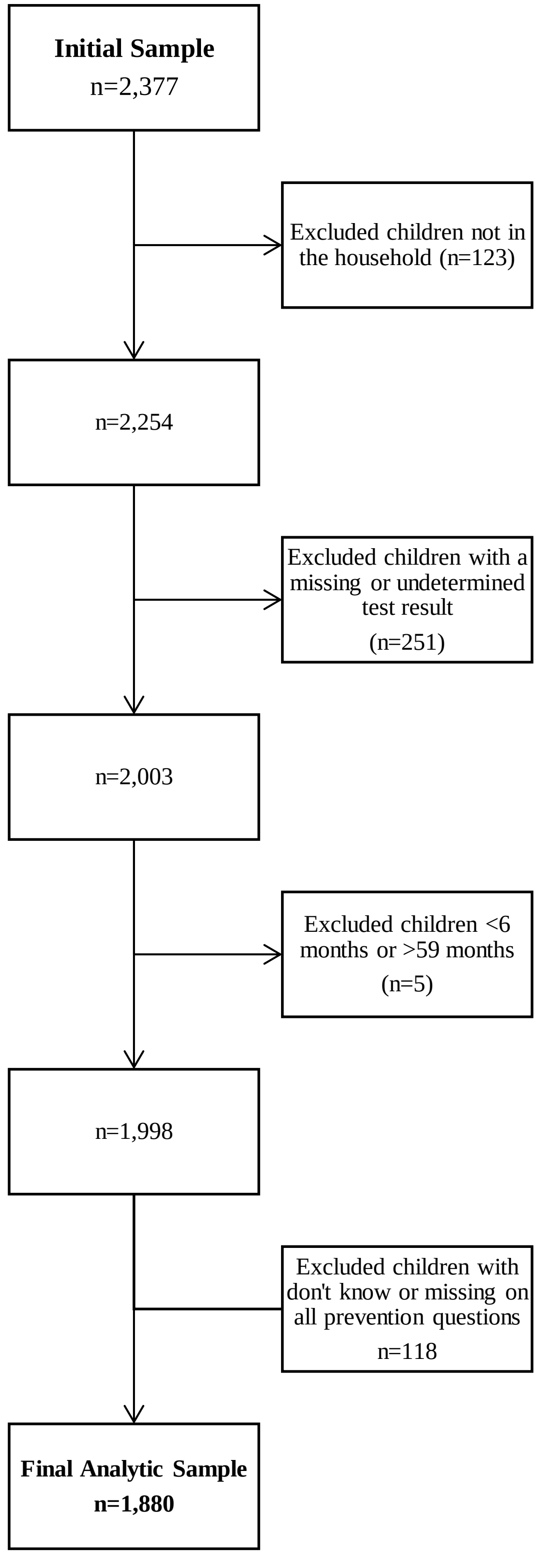

Figure 1: Analytic Sample Flow Chart

2.3 Procedures

The 2017 MMIS received ethical approval from the Inner City Fund (ICF) Institutional Review Board. Prior to each interview, field interviewers obtained informed consent from participating women and from the parent and/or guardian of participating children. I requested and received approval from the DHS program to conduct a secondary data analysis using the 2017 MMIS datasets.

2.4 Measures

The interviewers conducting the 2017 MMIS questionnaires asked women "How can someone protect themselves against malaria?" The interviewer then categorized women's responses into 17 items (Table 1). Of those 17 items, only 12 were used to assess maternal knowledge of malaria prevention methods. The responses on sleeping under a treated net, sleeping under an insecticide-treated net, and using a mosquito net were related to ITN use, so they were excluded. The "other" and "don't know" categories were also excluded because they did not provide any additional information on maternal knowledge of malaria prevention. The remaining 12 items were categorized into eight true prevention methods and four false prevention methods. The true and false methods were determined by using existing evidence in the literature.

Table 1: Malaria Preventative Measures

Excluded Categories (X)	Items
X	Sleep under a treated net
X	Sleep under an insecticide-treated net
X	Use mosquito net
	Take preventative medication
	Spray the house/rooms with insecticide
	Clear weeds around the house
	Use mosquito coils
	Cut grass around house
	Fill in stagnant waters
	Keep surroundings clean
	Burn Leaves
	Avoid drinking dirty water
	Avoid eating bad food
	Put screens on windows
	Avoid getting soaked in the rain
X	Other
X	Don’t know

The true methods were: taking preventative medication, spraying the house/rooms with insecticide, clearing weeds around the house, using mosquito coils, cutting grass around house, filling in stagnant water (puddles), keeping surroundings clean, and putting screens on windows (34,39-41).

The false methods were burning leaves, avoid drinking dirty water, avoid eating bad food, and avoid getting soaked in the rain (42,43).

I first measured maternal knowledge of malaria prevention methods by creating a continuous composite score of the above 12 items. Respondents were given 1 point for each correct response. A higher score meant that mothers were more knowledgeable about malaria prevention methods. The minimum and maximum value for the composite score was 0 and 12, respectively. The frequency distribution illustrates that most mothers' knowledge clustered around scores 4 and 5 (Figure 2).

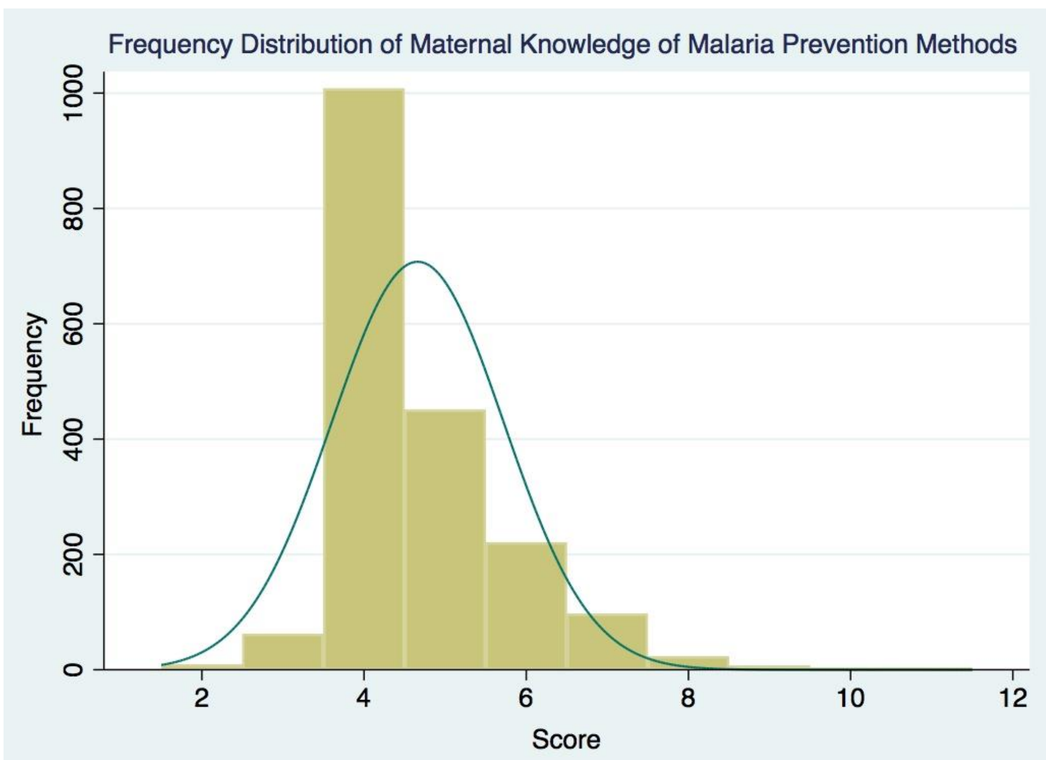

Figure 2: Frequency Distribution of Maternal Knowledge of Malaria Prevention Methods

I then classified maternal knowledge of malaria prevention methods into a three-level categorical variable. Mothers with knowledge scores of 3 or less served as the reference group and were considered to have low knowledge. I set 3 as the cut off value because it reflected that less than 10% of mothers scored higher in malaria prevention methods than the other mothers. Mothers with scores of 4 served as the intermediate knowledge group. I set 4 as a cut-off value because a score of 4 indicated that 50% of children's mothers scored higher in malaria prevention methods than other mothers in the sample. Mothers with scores between 5 and 12 served as the high knowledge group. Mothers with a score of 5 scored higher in malaria prevention methods than 75% of the mothers in the sample.

The composite score was then transformed into a binary variable where mothers who scored 4 or less were categorized as having inadequate knowledge of malaria prevention methods, while mothers who scored 5 or greater were categorized as having adequate knowledge of malaria prevention methods.

2.4.1 Malaria Parasitemia in Children Under Five Years of Age

Malaria parasitemia in children under five years of age was determined using a smear microscopy test. Smear microscopy is the process of spreading blood samples onto microscope slides and staining them to observe whether the organism of interest is present. In this case, smear microscopy helped to identify whether a child under five years of age had *Plasmodium* parasites present in their blood. A positive test indicated the presence of malaria parasites. The survey also measured malaria parasitemia using rapid diagnostic tests (RDTs). A rapid diagnostic test takes only 20 minutes to conduct and works by detecting antigens of *Plasmodium* species in human blood. However, I chose to use a smear microscopy test result from the datasets over a rapid diagnostic test result because of its higher sensitivity (14).

2.4.2 Covariates/Confounders

Covariates included mother's education (no education, primary, or secondary and above), ethnicity (Chewa, Lomwe, Yao, and others), region (north, central, or south), type of place of residence (urban or rural), child's age, and wealth index (poorest, poorer, middle, richer, or richest). The wealth index is a summary score that the DHS program uses to measure a household's standard of living. It takes into account an individual's assets, housing, and access to water and sanitation. Previous studies identified wealth index and the above factors as associated with malaria infection (14,30).

2.5 Statistical Analysis

I first ran the Cronbach's Alpha reliability test to determine the internal consistency of 12 items in measuring the level of maternal knowledge of malaria prevention methods. Alpha values greater than or equal to 0.8 are considered excellent, while alpha values between 0.8 and 0.7 are considered acceptable. Alpha values less than 0.7 are considered unacceptable.

I described the characteristics of the entire sample using means and standard errors (SEs) for continuous variables and counts and proportions for categorical variables. I then compared mothers with inadequate knowledge (score: 0-4) of malaria prevention methods to those with adequate knowledge (score: 5-12) using a two-sample t-test for continuous variables and a chi-squared test for categorical variables. We defined scores of 5-12 as adequate knowledge instead of high knowledge because mothers scores mostly ranged from 5-8. Very few mothers achieved a score of 9 or above.

I also described the characteristics of children's mothers who responded "don't know" to all malaria prevention method items using means and SEs for continuous variables and counts and proportions for categorical variables.

I used logistic regressions to identify the unadjusted and adjusted associations between maternal knowledge of malaria prevention methods and under-five malaria parasitemia. I included mother's education, ethnicity, place of residence, region, child's age, and wealth index in the adjusted models. I modeled maternal knowledge of malaria prevention methods both continuously and in categories (both 2-level and 3-level). Additionally, I used logistic regression to determine the unadjusted and adjusted association between maternal knowledge of each of the 12 malaria prevention methods and under-five malaria parasitemia, separately. I included the same variables in the adjusted models as presented above.

All data analyses were weighted to account for the oversampling of urban areas due to the two-stage cluster sampling design. The significance level was set to $p<0.05$. Statistical analyses were performed with STATA version 16.0.

3. Results

3.1 Cronbach's Alpha Reliability Test

Maternal knowledge of malaria prevention methods as a continuous composite score demonstrated poor internal consistency (reliability); its Cronbach alpha score was only 0.43. The alpha value ranged from 0.31 to 0.44 if an item was removed (Table 2).

Table 2: Cronbach's Alpha Reliability Test

Item	Sign	Item-test Correlation	Alpha
Take preventative medication	+	0.25	0.43
Spray the house/rooms with insecticide	+	0.34	0.40
Clear weeds around house	+	0.51	0.37
Use mosquito coils	+	0.22	0.43
Cut grass around house	+	0.60	0.32
Fill in stagnant waters	+	0.65	0.31
Keep surroundings clean	+	0.54	0.43
Burn leaves	+	0.15	0.43
Avoid drinking dirty water	–	0.22	0.44
Avoid eating bad food	–	0.22	0.43
Put screens on windows	+	0.11	0.43
Avoid getting soaked in the rain	–	0.10	0.43
Test scale			0.43

3.2 Sociodemographic Characteristics

Overall, 1,157 (67.5%) children's mothers had at most a primary school education and 468 (33.5%) of all children's mothers could not read at all. Most mothers lived in a rural residence (1,226 [85.8%]; Table 3). Approximately 22.8% of the children had mothers from the poorest wealth index bracket. A total of 801 children's mothers had adequate knowledge of malaria prevention methods compared to 1,079 children's mothers with inadequate knowledge. Of mothers with adequate knowledge of malaria prevention methods, 451 (62.0%) had at least a primary school education. The majority of them, 476 (79.9%) lived in rural residences. Additionally, 101 (20.4%) of these mothers were from the poorest wealth quintile. In contrast, 706 (70.7%) mothers with inadequate knowledge of malaria prevention methods had at least a primary school education. The majority of them, 750 (89.1%) lived in rural residences. Only 177 (24.2%) mothers with inadequate knowledge of malaria prevention methods came from the poorest wealth quintile.

Table 3: Sociodemographic Characteristics of the Analytic Sample

Characteristics	Overall (n=1,880)	Adequate Knowledge of MPM[a] (n=801)	Inadequate Knowledge of MPM (n=1,079)	P-value[b]
Maternal age in years, mean (SE)	28.2 (0.2)	28.4 (0.3)	28.1 (0.3)	0.545
Education				0.002
No education, No. (%)	178 (14.1)	66 (13.3)	112 (14.6)	
Primary, No. (%)	1,157 (67.5)	451 (62.0)	706 (70.7)	
≥ Secondary[c], No. (%)	545 (18.4)	284 (24.7)	261 (14.7)	
Literacy				0.190
Cannot read at all, No. (%)	468 (33.5)	160 (30.0)	308 (35.5)	
Able to read part, No. (%)	190 (10.1)	92 (11.8)	98 (9.1)	
Able to read whole, No. (%)	1222 (56.5)	549 (58.2)	673 (55.5)	
Religion				0.147
Catholic, No. (%)	315 (16.4)	136 (18.0)	179 (15.5)	
CCAP, No. (%)	280 (12.1)	126 (13.3)	154 (11.4)	
Other Christian, No. (%)	808 (42.4)	336 (39.6)	472 (44.1)	
Muslim, No. (%)	247 (17.0)	91 (14.6)	156 (18.4)	

Other[d], No. (%)	230 (12.0)	112 (14.5)	118 (10.6)	
Ethnicity				<0.000
Chewa, No. (%)	571 (37.1)	229 (37.0)	342 (37.2)	
Lomwe, No. (%)	253 (17.0)	88 (12.5)	165 (19.5)	
Yao, No. (%)	241 (17.1)	76 (12.2)	165 (20.0)	
Other[e], No. (%)	815 (28.8)	408 (38.3)	407 (23.3)	
Region				<0.000
North, No. (%)	573 (10.3)	285 (14.6)	288 (7.8)	
Central, No. (%)	683 (43.9)	308 (51.2)	375 (39.7)	
South, No. (%)	624 (45.9)	208 (34.3)	416 (52.5)	
Type of place of residence				<0.000
Urban (vs. rural), No. (%)	654 (14.3)	325 (20.1)	329 (10.9)	
Wealth index				<0.000
Poorest, No. (%)	278 (22.8)	101 (20.4)	177 (24.2)	
Poorer, No. (%)	314 (24.1)	122 (23.3)	192 (24.6)	
Middle, No. (%)	279 (18.5)	84 (12.4)	195 (22.1)	
Richer, No. (%)	363 (17.4)	162 (20.2)	201 (15.7)	
Richest, No. (%)	646 (17.2)	332 (23.7)	314 (13.5)	
Age of child, months SE	32.7 (0.4)	32.8 (0.6)	32.7 (0.5)	0.936
Sex of child				0.774
Male, No. (%)	963 (51.3)	418 (51.7)	545 (51.0)	
Female, No. (%)	917 (48.7)	383 (48.3)	534 (49.0)	

Abbreviations: MPM, Maternal Prevention Methods; CCAP, Church of Central Africa Presbyterian; SE, standard error;

The two-stage cluster sample design was taken into account when weighting the data. The table displays unweighted counts and weighted percentages rounded to the first decimal place.

[a] Mother’s with adequate knowledge of malaria prevention methods had greater than or equal to 5 correct responses on malaria prevention methods. Mother’s with inadequate knowledge of malaria prevention methods had less than or equal to 4 correct responses on malaria prevention methods.

[b] P-values were obtained using linear regression for continuous variables and chi-squared tests for categorical variables.

[c] Secondary and higher education were collapsed into >=secondary.

[d] Those who identified as having no religion, Anglican, Seventh day advent/Baptist, or other religions were collapsed into the other category.

[e] The Tumbuka, Tonga, Sena, Nkhonde, Ngoni and other ethnicities were collapsed into the other category

Children's mothers who responded "don't know" for all malaria prevention method items were excluded from the analyses (n=41; Table 4). The majority of these mothers (76.5%) had at most a primary school education and (69.8%) of them could not read at all. Compared to mothers included in the analytic sample, those who responded "don't know" had a higher percentage of mothers living in rural areas (99.1% vs. 85.7%) and who were from the poorest wealth quintile (51.8% vs. 22.8%).

Table 4: Sociodemographic Characteristics of Participants with "Don't Know" Compared to the Analytic Sample

Characteristics	Overall (n=1,880)	Don't Know[a] (n=41)
Maternal age in years, mean (SE)	28.2 (0.2)	28.1 (-[b])
Education		
No education, No. (%)	178 (14.1)	9 (23.5)
Primary, No. (%)	1,157 (67.5)	32 (76.5)
≥ Secondary[c], No. (%)	545 (18.4)	0 (0)
Literacy		
Cannot read at all, No. (%)	468 (33.5)	26 (69.8)
Able to read part, No. (%)	190 (10.1)	4 (9.5)
Able to read whole, No. (%)	1222 (56.5)	11(20.7)
Religion		
Catholic, No. (%)	315 (16.4)	10 (20.5)
CCAP, No. (%)	280 (12.1)	3 (8.2)
Other Christian, No. (%)	808 (42.4)	17 (39.8)
Muslim, No. (%)	247 (17.0)	7 (21.5)
Other[d], No. (%)	230 (12.0)	4 (10.1)
Ethnicity		
Chewa, No. (%)	571 (37.1)	21 (57.2)
Lomwe, No. (%)	253 (17.0)	4 (11.7)
Yao, No. (%)	241 (17.1)	5 (15.1)
Other[e], No. (%)	815 (28.8)	11 (16.1)
Region		
North, No. (%)	573 (10.3)	7 (4.4)
Central, No. (%)	683 (43.9)	21(55.4)
South, No. (%)	624 (45.9)	13 (40.2)
Type of place of residence		
Urban (vs. rural), No. (%)	654 (14.3)	1 (0.9)
Wealth index		
Poorest, No. (%)	278 (22.8)	19 (51.8)
Poorer, No. (%)	314 (24.1)	8 (21.7)

Middle, No. (%)	279 (18.5)	8 (16.8)
Richer, No. (%)	363 (17.4)	5 (9.0)
Richest, No. (%)	646 (17.2)	1 (0.9)
Age of child, months SE	32.7 (0.4)	33. 6 (-[f])
Sex of child		
Male, No. (%)	963 (51.3)	19 (52.0)
Female, No. (%)	917 (48.7)	22 (48.0)

Abbreviations: Church of Central Africa Presbyterian; SE, standard error;
The two-stage cluster sample design was taken into account when weighting the data. The table displays unweighted counts and weighted percentages rounded to the first decimal place.

[a] Mothers who had a don’t know response for all malaria prevention method items were excluded from the final analyses.

[b] Standard error cannot be calculated because the stratum has only one sampling unit

[c] Secondary and higher education were collapsed into >=secondary.

[d] Those who identified as having no religion, Anglican, Seventh day advent/Baptist, or other religions were collapsed into the other category.

[e] The Tumbuka, Tonga, Sena, Nkhonde, Ngoni and other ethnicities were collapsed into the other category

[f] Standard error cannot be calculated because the stratum has only one sampling unit

3.3 Association between Maternal Knowledge of Malaria Prevention Methods as a Continuous Variable and Under-Five Parasitemia

In the unadjusted model, every one-unit increase in mothers' knowledge of malaria prevention methods corresponded with a 1% decrease in the odds of child parasitemia (odds ratio [OR] = 0.99; 95% confidence interval [CI]: 0.84, 1.16; Table 5). After multivariable adjustment, every one-unit increase in mother's knowledge corresponded with a 14% (OR=1.14) increase in the odds of child parasitemia (95% CI: 0.96, 1.35). However, these results were not statistically significant.

Table 5: Maternal Knowledge of Malaria Prevention Methods as a Continuous Variable and Under-Five Malaria Parasitemia

	Unadjusted Odds Ratio (95%CI)	Adjusted Odds Ratio (95% CI)
Maternal Knowledge of Malaria Prevention Methods	0.99 (0.84-1.16)	1.14 (0.96-1.35)

The data were weighted to account for the two-stage cluster sampling design. I also adjusted for mother's highest level of education, ethnicity, type and place of residence, region, child's age, and wealth index. The table presents unadjusted and adjusted odd ratios rounded to the second decimal place.

3.4 Association between Maternal Knowledge of Malaria Prevention Methods as a Categorical Variable and Under-Five Parasitemia

In the unadjusted model, intermediate knowledge scores were not associated with under-five malaria parasitemia (OR = 1.93; 95% CI: 0.53, 6.97; Table 6). The unadjusted model for high knowledge scores was also not significant (OR = 1.87; 95% CI: 0.48, 7.22). After multivariable adjustment, intermediate knowledge scores were associated with an 84% higher odds of under-five parasitemia. However, this relationship was not significant. In a similar manner, children whose mothers had high knowledge of malaria prevention methods had a 2.28 higher odds of malaria parasitemia than children whose mothers had low knowledge. Again, this relationship was not significant.

Table 6: Maternal Knowledge of Malaria Prevention Methods as a Categorical Variable and Under-Five Malaria Parasitemia

	Unadjusted Odds Ratio (95%CI)	Adjusted Odds Ratio (95% CI)
Low	Ref.	Ref.
Intermediate[a]	1.93 (0.53-6.97)	1.84 (0.52-6.45)
High[b]	1.87 (0.48-7.22)	2.28 (0.63-8.25)

Low knowledge mothers with scores of 2 or 3 served as the reference group. The data were weighted to account for the two-stage cluster sampling design. I also adjusted for mother's highest level of education, ethnicity, type and place of residence, region, child's age and wealth index. The table presents unadjusted and adjusted odd ratios rounded to the second decimal place.

[a] Mothers with scores of 4.

[b] Mothers with scores of 5-12 .

3.5 Association between Maternal Knowledge of Malaria Prevention Methods as a Binary Variable and Under-Five Parasitemia

In the unadjusted model, inadequate knowledge of malaria prevention methods was not associated with under-five malaria parasitemia (OR = 1.00; 95% CI: 0.71, 1.43; Table 7). After multivariable adjustment, inadequate knowledge of malaria prevention methods was associated with a 22% lower odds of under-five malaria parasitemia, although the association was not significant (95% CI: 0.54, 1.14).

Table 7: Maternal Knowledge of Malaria Prevention Methods as a Binary Variable and Under-Five Malaria Parasitemia

	Unadjusted Odds Ratio (95%CI)	Adjusted Odds Ratio (95% CI)
Adequate knowledge of malaria prevention methods[a]	-	-
Inadequate knowledge of malaria prevention methods[b]	1.00 (0.71-1.43)	0.78 (0.54-1.14)

Mothers with adequate knowledge of malaria prevention methods served as the reference group. The data were weighted to account for the two-stage cluster sampling design. I also adjusted for mother's highest level of education, ethnicity, type and place of residence, region, child's age, and wealth index. The table presents unadjusted and adjusted odd ratios rounded to the second decimal place.

[a] Mothers with adequate knowledge of malaria prevention methods correctly identified 5 or more malaria prevention methods.

[b] Mothers with inadequate knowledge of malaria prevention methods correctly identified 4 or less malaria prevention methods.

3.6 Association between Individual Malaria Prevention Methods and Under-Five Parasitemia

In the unadjusted model, incorrectly identifying burning leaves as a malaria prevention method was not associated with under-five malaria parasitemia (OR = 1.97; 95% CI: 0.31, 12.59; Table 8). After multivariable adjustment, incorrectly identifying burning leaves as a malaria prevention method was significantly associated with a 5.44 higher odds of under-five malaria parasitemia (95% CI: 1.41, 21.04).

Table 8: Maternal Knowledge of Individual Malaria Prevention Methods and Under-Five Malaria Parasitemia

Prevention Methods	Unadjusted Odds Ratio (95%CI)	Adjusted Odds Ratio (95% CI)
Take preventive medication	0.99 (0.41-2.39)	1.02 (0.40-2.55)
Spray the house/rooms with insecticide	2.17 (0.89-5.32)	3.83 (1.72-8.53)
Clear weeds around the house	1.12 (0.72-1.74)	1.50 (0.91-2.49)
Use mosquito coils	1.12 (0.44-2.82)	2.32 (0.80-6.67)
Cut grass around house	1.03 (0.58-1.81)	1.38 (0.80-2.39)
Fill in stagnant waters (puddles)	0.62 (0.43-0.89)	0.82 (0.53-1.26)
Keep surroundings clean	1.01 (0.68-1.50)	1.19 (0.78-1.80)
Put screens on windows[a]	-	-
Burn leaves*	1.97 (0.31-12.59)	5.44 (1.41-21.04)
Avoid drinking dirty water	1.07 (0.51-2.24)	1.13 (0.53-2.39)
Avoid eating bad food	0.44 (0.14-1.44)	0.48 (0.15-1.52)
Avoid getting soaked in rain	0.70 (0.13-3.85)	0.97 (0.70-13.34)

The data were weighted to account for the two-stage cluster sampling design. I also adjusted for mother's highest level of education, ethnicity, type and place of residence, region, child's age, and wealth index. Each variable was coded as 0=no and 1=yes. The table presents unadjusted and adjusted odds ratios rounded to the second decimal place.
[a] The logistic regression failed because not enough mothers whose children tested positive responded that people protect themselves against malaria by screening doors and windows.

4. Discussion

Malaria elimination efforts in Malawi have largely focused on increasing ITN use, but recent studies illustrated that ITNs alone maybe insufficient to eliminate malaria (16,20,22). Alternative interventions such as screening doors and windows, filling in stagnant water, and keeping surroundings clean as well as other control measures may supplement the use of ITNs in malaria elimination programs (23-27). The present study aimed to determine whether maternal knowledge of other malaria prevention methods were associated with malaria parasitemia among children under five years of age in Malawi. I found that maternal knowledge of malaria prevention methods was not significantly associated with malaria parasitemia among children under five years in Malawi. This was contrary to the study hypothesis that higher levels of maternal knowledge of malaria prevention methods would be associated with lower odds of malaria parasitemia among children under five years.

In this study, maternal knowledge of malaria prevention methods was assessed as a composite score with a Cronbach's alpha value of only 0.43, indicating poor internal consistency. In prior studies conducted in Ethiopia and Nigeria, different items were used to assess maternal knowledge of malaria prevention methods and composite scores in all studies were created without rigorous evaluation of the reliability of the scale (31,32,44). In a study conducted in Cambodia, researchers examined the reliability of the scale they created to assess maternal practice of vector control measures. A total of 9 items were included in this scale and the Cronbach's alpha value was 0.63 (45). This alpha value is higher than the one presented in this study, but it is still considered unacceptably low. Despite, the low reliability of the composite score in this study, I assessed its association with malaria parasitemia among children under five years. I found that every unit increase in mothers' knowledge corresponded with a 14% increase in the odds of child parasitemia. However, these results were not statistically significant.

I also modeled maternal knowledge of malaria prevention methods as a three-level categorical variable (low, intermediate, and high). To my knowledge, there are no other studies that evaluated maternal knowledge in this way. This statistical analysis, like the prior one, indicated that increased maternal knowledge was associated with increased odds of child parasitemia. However, no significant association was found between maternal knowledge of malaria prevention methods as a categorical variable and malaria parasitemia among children under five years.

In the present study, approximately 1,079 out of 1,880 (57.4 %) children's mothers had inadequate knowledge (scores of 0-4) of malaria prevention methods. The low level of knowledge I observed in this sample may be, at least partially, due to the fact that nearly 70% of mothers had only a primary school education. This is consistent with previous studies conducted in sub-Saharan Africa where mothers had low knowledge of malaria prevention methods and had limited amounts of formal schooling. In southwest Nigeria, researchers found that nearly 58% of caregivers had poor knowledge (scores of 0-3 out of 6 possible points) of malaria prevention methods (32). In this study, nearly 40% of mothers had at most primary school education or no education at all (32). Similarly, in Burkina Faso, only about 56% of mothers had accurate knowledge of malaria preventative measures, causes, and symptoms, and over 80% of mothers had at most a primary school education or had no education at all (46). I did not find that inadequate maternal knowledge was associated with increased odds of malaria parasitemia among children under five years. I may not be able to detect a difference in malaria parasitemia in this study because I compared children with inadequate knowledge mothers (scores 0-4) to children with adequate knowledge mothers (scores of 5-12). On the contrary, children's mothers with inadequate (or low) knowledge should be compared to children's mothers with high knowledge of malaria prevention methods. However, as previously stated there were very few mothers with high knowledge of malaria prevention methods in this study.

Additionally, I modeled mothers' knowledge of individual prevention methods and under-five malaria parasitemia. After multivariable adjustment, the only significant association I found was burning leaves. One reason for this could be that as a traditional malaria prevention method knowledge of burning leaves is more widespread than the evidence based methods. In the most recent Knowledge, Attitude, and Practice study conducted in Malawi in 1996, researchers found that nearly one third of the population burned leaves or herbs to protect themselves against malaria (47). Therefore, this practice may still be widespread in Malawi despite the lack of conclusive evidence of its effectiveness (48). In this study, identifying burning leaves as a malaria prevention method was associated with an increased odds of under-five malaria parasitemia. This finding was consistent with our hypothesis as burning leaves is an indicator of poor or low malaria knowledge. However, since all the real malaria prevention methods were not significant, this association may be due to chance.

Another reason maternal knowledge of malaria prevention methods was not associated with under-five malaria parasitemia maybe because knowledge does not necessarily translate into action. In Nigeria, researchers found that while nearly 40% of mothers possessed knowledge of using mosquito coils to prevent malaria, less than 20% of mothers actually used mosquito coils in practice (49). Although maternal knowledge is not significantly associated with the presence of under-five parasitemia in our study, action may impact a child's parasitemia status. This is supported by a study in Burkina Faso where mothers who kept their environments free of mosquito breeding sites lowered the odds of under-five malaria prevalence (34). Furthermore, in Cambodia, a mother's malaria preventative actions had protective effects against fever in children, which is a symptom of malaria (45).

4.1 Implications for Policy and Practice

This study indicates that maternal knowledge of malaria prevention methods is not significantly associated with under-five malaria parasitemia. This information is valuable for Malawi and other similar nations, because it highlights that maternal knowledge may not be an area they should focus on in future malaria elimination programs. Policy makers should instead concentrate on improving maternal practice of malaria preventative actions, such as screening doors and windows, filling in stagnant waters, and keeping surroundings clean. One study estimated that mosquito proofing 50% of houses (which includes screening doors and windows) in communities with 80% ITN coverage could potentially interrupt malaria transmission in high transmission settings (1). Filling in stagnant waters, which is a part of a larger strategy known as larval source management, is already recommended by the WHO to be used alongside ITNs in low-and-middle income countries (LMICs) countries where larval breeding sites are easily identifiable (22). Evidence also suggests that mothers controlling mosquito populations by keeping surroundings clean could lead to a nearly 40% reduction in the odds of under-five malaria parasitemia (34).

4.2 Implications for Further Research

Although the results of this study were not statistically significant, it may be due to maternal knowledge of malaria prevention methods being a construct that is not well-defined or consistently measured in the literature. Future research could attempt to standardize the items used to measure maternal knowledge of malaria prevention methods. As knowledge does not necessarily translate to action, future research should also explore maternal practice of vector control methods and malaria parasitemia among children under five years of age. I only identified one study that assessed the association between maternal practice of vector control methods and fever in children (which is an indicator of malaria infection). However, more studies are needed to support the findings that maternal practice of preventative measures reduces under-five malaria parasitemia.

4.3 Study Strengths and Limitations

One strength of this study is that maternal knowledge of malaria prevention methods was assessed as a continuous, categorical, and binary variable. Sometimes when continuous data is transformed into categorical or binary data some of the power to detect a statistical difference is lost. However, in this study the direction of the association remained the same after performing logistic regressions with maternal knowledge as a continuous, categorical, and binary variable. After multivariable adjustment, higher levels of maternal knowledge increased the odds of malaria parasitemia among children under five years while lower levels of knowledge had a protective effect against child malaria, although these results were not significant. This direction of the association is contrary to my hypothesis, but it is likely due to the fact that cross-sectional data were used in these analyses.

This study used a cross-section design, in which exposure and outcome information were collected at the same time. Therefore, it is difficult to establish the causal relationship between the exposure and the outcome. Although this association was not significant, my use of cross-sectional data may explain why higher levels of mothers' knowledge were associated with increased odds of under-five malaria parasitemia. This inverse association was also seen when I assessed maternal knowledge of the individual prevention methods with malaria parasitemia among children under five years. One explanation for these associations could be that mothers may have only started learning about implementing preventative methods after their children had been diagnosed with malaria.

This study has several limitations. Firstly, because of the two-stage cluster sampling design the independence assumption was violated. Multiple children had the same mother in our analytic sample. This was accounted for by weighting the data in all analyses. Secondly, maternal knowledge of malaria prevention methods as a composite score had poor internal consistency. This highlighted the fact that the items used to measure knowledge of prevention methods were not closely related. Therefore, they may not be good indicators of malaria prevention knowledge. Thirdly, I decided the cut-off points for maternal knowledge of malaria prevention methods when treating it either as a categorical or binary variable. This was done by analyzing the frequency distribution of our composite score. Consequently, this may have introduced bias into our study as there is no standard method to classify maternal knowledge of malaria prevention methods. Furthermore, I excluded children whose mothers had a "don't know" response for all malaria prevention method items. These excluded children may have had mothers who were very different from the children's mothers included in this sample. Thus, excluding these children could have biased the study results. However, since only 41 of these children were excluded, it is unlikely the study findings would dramatically change. Additionally, I was not able to account for how knowledge of other family members might contribute to malaria prevention methods. In a study in Eastern Nigeria, a father's education level was significantly associated with ITN use (50). Also, previous studies indicated that knowledge of other household members influences whether mothers seek care for their children with malaria (51,52). Therefore, it is possible that household member knowledge of alternative malaria preventative practices could influence maternal knowledge and consequently child malaria parasitemia. However, the MMIS datasets used in the present study did not measure household member knowledge of malaria prevention methods. Finally, I did not account for multiple-testing because I did these analyses in an exploratory fashion.

5. Conclusion

To my knowledge, this is the first study that investigated the association between maternal knowledge of malaria prevention methods and under-five malaria parasitemia in Malawi. I found no significant association between maternal knowledge of malaria prevention methods and under-five malaria parasitemia in Malawi. However, future studies should explore maternal practice of malaria prevention methods and under-five malaria parasitemia. Obtaining additional evidence on the effectiveness of maternal preventative actions other than ITN use could help bring Malawi closer to eliminating malaria.

Appendix A: Stata Code

```
use "/Users/vivian/Desktop/Malaria/Data
Sets/MW_2017_MIS_01112019_2032_123957/MWKR7IDT/MWKR7IFL.DTA"
rename v001 hv001
rename v002 hv002
rename b16 hvidx
drop if hvidx==0 | hvidx==.
**Deleted children in the KR file do not have information in the
PR file because they live elsewhere (lost 123 kids)
sort hv001 hv002 hvidx
*save "/Users/vivian/Desktop/Malaria/Data Sets/MWKR2017 1.dta"*
clear
use "/Users/vivian/Desktop/Malaria/Data
Sets/MW_2017_MIS_01112019_2032_123957/MWPR7IDT/MWPR7IFL.DTA"
sort hv001 hv002 hvidx
merge m:1 hv001 hv002 hvidx using
"/Users/vivian/Desktop/Malaria/Data Sets/MWKR2017 1.dta"
keep if _merge==3
*save "/Users/vivian/Desktop/Malaria/Data Sets/MWMalaria17 Master
Code Final.dta"*
keep caseid hhid hvidx hc60 hml32 hc51 v003 v005 v022 v021 v012
v101 v102 v106 v130 v131 v155 v190 v460 b4 b8 b19 hml16a s504a
s504b s504c s504d s504e s504f s504g s504h s504i s504j s504k s504l
s504m s504n s504o s504x s504z
drop b8 b19
*Data Management***
recode v101 1=0 2=1 3=2
label define malawi 0 north 1 central 2 south
label values v101 malawi
recode v102 1=0 2=1
label define place 0 urban 1 rural
label values v102 place
recode v130 1=0 2=1 3=2 4=3 5=4 6=5 7=6 96=7
label define bob 0 catholic 1 ccap 2 anglican 3 "seventh day
advent./baptist" 4 "other christian" 5 muslim 6 "no religion" 7
other
label values v130 bob
codebook v130
recode v131 1=0 2=1 3=2 4=3 5=4 6=5 7=6 8=7 96=8
label define sarah 0 chewa 1 tumbuka 2 lomwe 3 tonga 4 yao 5 sena
6 nkhonde 7 ngoni 8 other
label values v131 sarah
recode v190 1=0 2=1 3=2 4=3 5=4
label define bill 0 poorest 1 poorer 2 middle 3 richer 4 richest
label values v190 bill
recode b4 1=0 2=1
```

```
label define jen 0 male 1 female
label values b4 jen
***Restriction***
keep if hml32==0 | hml32==1
drop if hml16a<6 | hml16a>59
drop if s504z==1|s504z==.
drop s504x s504z
drop s504a s504b s504c
***Collapsing Sociodemographic characteristic categories
recode v130 (6/7=6)
recode v130 (2/3=6)
recode v130 (4=2)(5=3)(6=4)
label define v130 0 catholic 1 ccap 2 "other christian" 3 muslim
4 other
label value v130 v130
recode v106 (2/3=2)
label define v106 0 "no education" 1 primary 2 "secondary or
higher"
label value v106 v106
recode v131 (3=8)
recode v131 (5/6=8)
recode v131 (1=8) (7=8)
recode v131 (2=1)(4=2)(8=3)
label define v131 0 chewa 1 lomwe 2 yao 3 other
label values v131 v131
*save "/Users/vivian/Desktop/Malaria/Data Sets/MWMalaria17 Master
Working Dataset Final.dta"*
***Creating Summary Score***
replace s504k=1-s504k
label define patrick 0 yes 1 no
label value s504k patrick
replace s504l=1-s504l
label define dylan 1 no 0 yes
label value s504l dylan
replace s504m=1-s504m
label define savanna 0 yes 1 no
label value s504m savanna
replace s504o=1-s504o
label define mary 0 yes 1 no
label value s504o mary
generate score=s504d+ s504e+ s504f+ s504g+ s504h+ s504i+ s504j+
s504k+ s504l+ s504m+ s504n+ s504o
***Creating Figure 2
hist score, discrete freq
***Making a binary score
gen pmscore=score
recode pmscore (2/4=1) (5/11=0)
```

```
label define pmscore 0 "adequate knowledge of malaria prevention
methods" 1 "inadequate knowledge of malaria prevention methods"
label values pmscore scarlet
***Weighting the data***
generate wgt= v005/1000000
svyset [pw=wgt],psu (v021) strata (v022)
**Cronbach's Alpha Reliability Test
alpha s504d s504e s504f s504g s504h s504i s504j s504k s504l s504m
s504n s504o, item
***Logistic Regression with Continuous Predictor
svy:logistic hml32 score
svy:logistic hml32 score i.v106 i.v131 i.v102 i.v101 i.v190
hml16a
***Logistic Regress with Categorical Predictor (3 categories)
gen cmscore=score
recode cmscore (2/3=0)(4=1)(5/12=2)
svy:logistic hml32 i.cmscore
svy:logistic hml32 i.cmscore i.v106 i.v131 i.v102 i.v101 i.v190
hml16a
***Sociodemographic Characteristics
tab v106
svy: tab v106, col
tab v155
svy: tab v155, col
tab v130
svy: tab v130, col
tab v101
svy: tab v101, col
tab v102
svy: tab v102, col
tab v190
svy: tab v190, col
mean hml16a
svy: mean hml16a
tab b4
tab b4, col
tab v106 pmscore
svy: tab v106 pmscore, col
tab v155 pmscore, col
svy: tab v155 pmscore, col
tab v130 pmscore, col
svy: tab v130 pmscore, col
tab v131 pmscore, col
svy: tab v131 pmscore, col
tab v101 pmscore, col
svy: tab v101 pmscore, col
tab v102 pmscore, col
svy: tab v102 pmscore, col
```

```
tab v190 pmscore, col
svy: tab v190 pmscore, col
tab b4 pmscore, col
svy: tab b4 pmscore, col
svy: regress v012 i.pmscore
svy: regress hml16a i.pmscore
svy: mean hml16a, over (pmscore)
svy: mean v012, over (pmscore)

*** Sociodemographic Characteristics of Participants with Don't
Know
mean v012 if s504z==1
svy: mean v012 if s504z==1
tab v106 if s504z==1
svy: tab v106 if s504z==1, col
tab v155 if s504z==1
svy: tab v155 if s504z==1, col
tab v130 if s504z==1
svy: tab v130 if s504z==1, col
tab v131 if s504z==1
svy: tab v131 if s504z==1, col
tab v101 if s504z==1
svy: tab v101 if s504z==1, col
tab v102 if s504z==1
svy: tab v102 if s504z==1, col
tab v190 if s504z==1
svy: tab v190 if s504z==1, col
mean hml16a if s504z==1
svy: mean hml16a if s504z==1
tab b4 if s504z==1
svy: tab b4 if s504z==1, col

***Logistic Regression with Binary Predictor
svy:logistic hml32 pmscore
svy:logistic hml32 pmscore i.v106 i.v131 i.v102 i.v101 i.v190
hml16a
***Return false measures to adequate
replace s504k=1-s504k
label define s504k 0 no 1 yes
label values s504k s504k
replace s504l=1-s504l
label define s504l 0 no 1 yes
label values s504l s504l
replace s504m=1-s504m
label define s504m 0 no 1 yes
label values s504m s504m
replace s504o=1-s504o
label define s504o 0 no 1 yes
```

```
label values s504o s504o
***Individual malaria prevention methods & under-5 parasitemia
svy:logistic hml32 s504d
svy:logistic hml32 s504d i.v106 i.v131 i.v102 i.v101 i.v190
hml16a
svy:logistic hml32 s504e
svy:logistic hml32 s504e i.v106 i.v131 i.v102 i.v101 i.v190
hml16a
svy:logistic hml32 s504f
svy:logistic hml32 s504f i.v106 i.v131 i.v102 i.v101 i.v190
hml16a
svy:logistic hml32 s504g
svy:logistic hml32 s504g i.v106 i.v131 i.v102 i.v101 i.v190
hml16a
svy:logistic hml32 s504h
svy:logistic hml32 s504h i.v106 i.v131 i.v102 i.v101 i.v190
hml16a
svy:logistic hml32 s504i
svy:logistic hml32 s504i i.v106 i.v131 i.v102 i.v101 i.v190
hml16a
svy:logistic hml32 s504j
svy:logistic hml32 s504j i.v106 i.v131 i.v102 i.v101 i.v190
hml16a
svy:logistic hml32 s504k
svy:logistic hml32 s504k i.v106 i.v131 i.v102 i.v101 i.v190
hml16a
svy:logistic hml32 s504l
svy:logistic hml32 s504l i.v106 i.v131 i.v102 i.v101 i.v190
hml16a
svy:logistic hml32 s504m
svy:logistic hml32 s504m i.v106 i.v131 i.v102 i.v101 i.v190
hml16a
svy:logistic hml32 s504n
svy:logistic hml32 s504n i.v106 i.v131 i.v102 i.v101 i.v190
hml16a
svy:logistic hml32 s504o
svy:logistic hml32 s504o i.v106 i.v131 i.v102 i.v101 i.v190
hml16a
****Frequencies and Relative Frequencies of Malaria Parasatemia
by Prevention Methods
tab s504d hml32
svy: tab s504d hml32, row
tab s504e hml32
svy: tab s504e hml32, row
tab s504f hml32
svy: tab s504f hml32, row
tab s504g hml32
svy: tab s504g hml32, row
```

```
tab s504h hml32
svy: tab s504h hml32, row
tab s504i hml32
svy: tab s504i hml32, row
tab s504j hml32
svy: tab s504j hml32, row
tab s504k hml32
svy: tab s504k hml32, row
tab s504l hml32
svy: tab s504l hml32, row
tab s504m hml32
svy: tab s504m hml32, row
tab s504n hml32
svy: tab s504n hml32, row
tab s504o hml32
svy: tab s504o hml32, row
*** Frequencies and Relative Frequencies of Malaria Prevention
Methods by Knowledge
tab pmscore hml32
svy: tab pmscore hml32, row
```

References

1. Kiware SS, Chitnis N, Tatarsky A, et al. Attacking the mosquito on multiple fronts: Insights from the Vector Control Optimization Model (VCOM) for malaria elimination. *PloS one.* 2017;12(12):e0187680-e0187680.

2. *World Malaria Report 2019.* Geneva: World Health Organization 2019.

3. Incidence of malaria (per 1,000 population at risk). https://data.worldbank.org/indicator/SH.MLR.INCD.P3?name_desc=false, 2019.

4. *World Malaria Report 2018.* Geneva: World Health Organization2018.

5. Ovadje L, Nriagu J. Multi-dimensional knowledge of malaria among Nigerian caregivers: implications for insecticide-treated net use by children. *Malaria journal.* 2016;15(1):516-516.

6. Lengeler C. Insecticide‐treated bed nets and curtains for preventing malaria. *Cochrane Database of Systematic Reviews.* 2004(2).

7. Sherrard-Smith E, Griffin JT, Winskill P, et al. Systematic review of indoor residual spray efficacy and effectiveness against Plasmodium falciparum in Africa. *Nature communications.* 2018;9(1):4982-4982.

8. Protopopoff N, Wright A, West PA, et al. Combination of Insecticide Treated Nets and Indoor Residual Spraying in Northern Tanzania Provides Additional Reduction in Vector Population Density and Malaria Transmission Rates Compared to Insecticide Treated Nets Alone: A Randomised Control Trial. *PloS one.* 2015;10(11):e0142671-e0142671.

9. Mwendera CA, de Jager C, Longwe H, et al. Challenges to the implementation of malaria policies in Malawi. *BMC Health Services Research.* 2019;19(1):194.

10. *Indoor Residual Spraying: An Operational Manual for Indoor Residual Spraying (IRS) for Malaria Transmission Control and Elimination* Geneva, Switzerland: World Health Organization 2015.

11. Chanda E, Mzilahowa T, Chipwanya J, et al. Preventing malaria transmission by indoor residual spraying in Malawi: grappling with the challenge of uncertain sustainability. *Malaria Journal.* 2015;14(1):254.

12. National Malaria Control Programme - NMCP/Malawi, ICF. *Malawi Malaria Indicator Survey 2017.* Lilongwe, Malawi: NMCP/Malawi and ICF;2018.

13. Zamawe COF, Nakamura K, Shibanuma A, Jimba M. The effectiveness of a nationwide universal coverage campaign of insecticide-treated bed nets on childhood malaria in Malawi. *Malaria Journal.* 2016;15(1):505.

14. Zgambo M, Mbakaya BC, Kalembo FW. Prevalence and factors associated with malaria parasitaemia in children under the age of five years in Malawi: A comparison study of the 2012 and 2014 Malaria Indicator Surveys (MISs). *PloS one.* 2017;12(4):e0175537-e0175537.

15. Pinder M, Jawara M, Jarju LBS, et al. Efficacy of indoor residual spraying with dichlorodiphenyltrichloroethane against malaria in Gambian communities with high usage of long-lasting insecticidal mosquito nets: a cluster-randomised controlled trial. *The Lancet.* 2015;385(9976):1436-1446.

16. Loha E, Deressa W, Gari T, et al. Long-lasting insecticidal nets and indoor residual spraying may not be sufficient to eliminate malaria in a low malaria incidence area: results from a cluster randomized controlled trial in Ethiopia. *Malaria Journal.* 2019;18(1):141.

17. Corbel V, Akogbeto M, Damien GB, et al. Combination of malaria vector control interventions in pyrethroid resistance area in Benin: a cluster randomised controlled trial. *The Lancet Infectious Diseases.* 2012;12(8):617-626.

18. *Malawi country profile.* President's Malaria Initiative;2018.

19. *Abbreviated malaria pperational plan FY 2019: Malawi.* President's Malaria Initiative;2019.

20. Riveron JM, Chiumia M, Menze BD, et al. Rise of multiple insecticide resistance in Anopheles funestus in Malawi: a major concern for malaria vector control. *Malaria journal.* 2015;14:344-344.

21. Benelli G, Beier JC. Current vector control challenges in the fight against malaria. *Acta Tropica.* 2017;174:91-96.

22. Killeen GF, Tatarsky A, Diabate A, et al. Developing an expanded vector control toolbox for malaria elimination. *BMJ Global Health.* 2017;2(2):e000211.

23. Williams YA, Tusting LS, Hocini S, et al. Chapter six - expanding the vector control toolbox for malaria elimination: a systematic review of the evidence. In: Rollinson D, Stothard JR, eds. *Advances in Parasitology.* Vol 99: Academic Press; 2018:345-379.

24. Getawen SK, Ashine T, Massebo F, Woldeyes D, Lindtjørn B. Exploring the impact of house screening intervention on entomological indices and incidence of malaria in Arba Minch town, southwest Ethiopia: A randomized control trial. *Acta Tropica.* 2018;181:84-94.

25. Jawara M, Jatta E, Bell D, et al. New Prototype Screened Doors and Windows for Excluding Mosquitoes from Houses: A Pilot Study in Rural Gambia. *The American journal of tropical medicine and hygiene.* 2018;99(6):1475-1484.

26. Yohannes M, Haile M, Ghebreyesus TA, et al. Can source reduction of mosquito larval habitat reduce malaria transmission in Tigray, Ethiopia? *Tropical Medicine & International Health.* 2005;10(12):1274-1285.

27. Syafruddin D, Bangs MJ, Sidik D, et al. Impact of a spatial repellent on malaria incidence in two villages in Sumba, Indonesia. *The American journal of tropical medicine and hygiene.* 2014;91(6):1079-1087.

28. Israel OK, Fawole OI, Adebowale AS, et al. Caregivers' knowledge and utilization of long-lasting insecticidal nets among under-five children in Osun State, Southwest, Nigeria. *Malaria journal.* 2018;17(1):231-231.

29. Pylypchuk Y, Norton SW. Preventing malaria among children in Zambia: the role of mother's knowledge. *Health Economics.* 2015;24(11):1389-1402.

30. Wanzira H, Katamba H, Okullo AE, Agaba B, Kasule M, Rubahika D. Factors associated with malaria parasitaemia among children under 5 years in Uganda: a secondary data analysis of the 2014 Malaria Indicator Survey dataset. *Malaria journal.* 2017;16(1):191-191.

31. Hwang J, Graves PM, Jima D, Reithinger R, Kachur SP, Ethiopia MISWG. Knowledge of malaria and its association with malaria-related behaviors--results from the Malaria Indicator Survey, Ethiopia, 2007. *PloS one.* 2010;5(7):e11692-e11692.

32. Adebayo AM, Akinyemi OO, Cadmus EO. Knowledge of malaria prevention among pregnant women and female caregivers of under-five children in rural southwest Nigeria. *PeerJ.* 2015;3:e792.

33. Clouston SAP, Yukich J, Anglewicz P. Social inequalities in malaria knowledge, prevention and prevalence among children under 5 years old and women aged 15-49 in Madagascar. *Malaria journal.* 2015;13 Suppl 1:499-499.

34. Diabaté S, Druetz T, Millogo T, et al. Domestic larval control practices and malaria prevalence among under-five children in Burkina Faso. *PloS one.* 2015;10(10):e0141784-e0141784.

35. Chitunhu S, Musenge E. Direct and indirect determinants of childhood malaria morbidity in Malawi: a survey cross-sectional analysis based on malaria indicator survey data for 2012. *Malaria Journal.* 2015;14(1):265.

36. Rural Population % of Total Population https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS. Accessed 11/25/2019, 2019.

37. *Malawi Economic Development Document* Washington, D.C. : International Monetary Fund 2017.

38. Nkoka O, Chipeta MS, Chuang Y-C, Fergus D, Chuang K-Y. A comparative study of the prevalence of and factors associated with insecticide-treated nets usage among children under 5 years of age in households that already own nets in Malawi. *Malaria Journal.* 2019;18(1):43.

39. Tusting LS, Ippolito MM, Willey BA, et al. The evidence for improving housing to reduce malaria: a systematic review and meta-analysis. *Malaria Journal.* 2015;14(1):209.

40. Van den Berg H, Van Vugt M, Kabaghe AN, et al. Community-based malaria control in southern Malawi: a description of experimental interventions of community workshops, house improvement and larval source management. *Malaria journal.* 2018;17(1):266-266.

41. Van Eijk AM, Ramanathapuram L, Sutton PL, et al. The use of mosquito repellents at three sites in India with declining malaria transmission: surveys in the community and clinic. *Parasites & Vectors.* 2016;9(1):418.

42. Sabin LL, Rizal A, Brooks MI, et al. Attitudes, knowledge, and practices regarding malaria prevention and treatment among pregnant women in Eastern India. *The American Journal of Tropical Medicine and Hygiene.* 2010;82(6):1010-1016.

43. Legesse Y, Tegegn A, Belachew T, Tushune K. Knowledge, attitude and practice about malaria transmission and its preventive measures among households in urban areas of Assosa Zone, Western Ethiopia. *Ethiopian Journal of Health Development.* 2007;21(2).

44. Oladimeji KE, Tsoka-Gwegweni JM, Ojewole E, Yunga ST. Knowledge of malaria prevention among pregnant women and non-pregnant mothers of children aged under 5 years in Ibadan, South West Nigeria. *Malaria Journal.* 2019;18(1):92.

45. Yasuoka J, Kikuchi K, Nanishi K, et al. Malaria knowledge, preventive actions, and treatment-seeking behavior among ethnic minorities in Ratanakiri Province, Cambodia: a community-based cross-sectional survey. *BMC public health.* 2018;18(1):1206-1206.

46. Yaya S, Bishwajit G, Ekholuenetale M, Shah V, Kadio B, Udenigwe O. Knowledge of prevention, cause, symptom and practices of malaria among women in Burkina Faso. *PloS one.* 2017;12(7):e0180508-e0180508.

47. National Statistical OM, Macro I. *Malawi Knowledge, Attitudes, and Practices in Health Survey 1996.* Zomba, Malawi: National Statistical Office/Malawi and Macro International;1997.

48. World Health O. Smoke and malaria : are interventions to reduce exposure to indoor air pollution likely to increase exposure to mosquitoes and malaria? Geneva: World Health Organization; 2008.

49. Singh R, Musa J, Singh S, Ebere UV. Knowledge, attitude and practices on malaria among the rural communities in aliero, northern Nigeria. *Journal of family medicine and primary care.* 2014;3(1):39-44.

50. Iloh GUP, Amadi AN, Obiukwu CE, Njoku PU, Ofoedu JN, Okafor GOC. Family biosocial variables influencing the use of insecticide treated nets for children in Eastern Nigeria. *J Family Community Med.* 2013;20(1):12-19.

51. Essé C, Utzinger J, Tschannen AB, et al. Social and cultural aspects of 'malaria' and its control in central Côte d'Ivoire. *Malaria Journal.* 2008;7(1):224.

52. Chibwana AI, Mathanga DP, Chinkhumba J, Campbell CH. Socio-cultural predictors of health-seeking behaviour for febrile under-five children in Mwanza-Neno district, Malawi. *Malaria Journal.* 2009;8(1):219.