Title

Attempting to understand the knowledge,perspectives, and practices of people living in Chilinza,Malawi on the topic of malaria

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Attempting to understand the knowledge, perspectives, and practices of people living in Chilinza, Malawi on the topic of malaria

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Abstract

This study addresses the issue of malaria in the village of Chilinza in the country of Malawi. The goal of this study is to better understand the knowledge, practices, and perspectives of people living in Chilinza regarding malaria - specifically, using a community-centered approach, 1) learning to understand the problem through the eyes of the locals 2) identifying "positive deviance" or successful practices in use that could be replicated or amplified and 3) potential obstacles that the people of Chilinza have that prevent them from utilizing resources (cultural, practical, religious, etc.). This study utilizes quantitative preliminary surveys and qualitative in-depth interviews. The hypothesis is that there are households within the community that are already adopting "best practices," and identifying and replicating these best practices can help reduce malaria cases. The findings of this study indicate that there are solutions from within the community for combating malaria transmission including using insecticide treated bed nets (ITBNs) regularly, typing up the ITBN during the daytime to preserve the net, and using *mphungabwi* as a natural mosquito repellent. Although the findings of this study may be difficult to directly apply to other villages or countries, it can provide greater insight on how to effectively eradicate malaria from Chilinza and lessen malaria in other countries.

Keywords: Malawi, Malaria, Positive Deviance

Introduction

My research aims to identify solutions to malaria from within the community of Chilinza in Malawi. In Malawi, malaria is a disease caused by the parasite *Plasmodium falciparum (P. falciparum)* which is transmitted to the human host when one is bit by an infected female *Anopheles* mosquito. Malaria is not spread through human-to-human transmission but instead through contact with an infected mosquito. When a female *Anopheles* mosquito bites a person who already has malaria, the parasite is then spread to the mosquito, who can now infect more humans (Milner, 2018). Malaria can cause flu-like symptoms, which include chills, body aches, nausea, vomiting, and, more dangerously, anemia because of a loss of red blood cells. *P. falciparum* invades and reshapes human red blood cells, which effectively renders the red blood cell useless. As more and more red blood cells are infected, the infected human loses more and more functioning blood cells, which can often lead to death (Mohandas & An, 2012).

According to the World Health Organization (WHO), the African Region carries a disproportionately high share of global malaria cases. As of 2020, there were 241 million reported cases of malaria globally and 627,000 deaths due to malaria (World Health Organization, 2020). The African region was home to 95% of global malaria cases and 96% of global malaria deaths. Children under 5 years of age accounted for approximately 80% of all malaria deaths in the African Region (*Fact Sheet about Malaria*, n.d.). The COVID-19 pandemic has also disrupted attempts to deliver malaria services, contributing to the 14 million malaria cases and 69,000 deaths seen globally in 2020 (Amimo et al., 2020). From 2019 to 2020, there was an estimated 12 percent increase in malaria deaths in Sub-Saharan Africa. In light of

COVID-19, there is an even greater urgency to develop methods to eradicate malaria from countries, especially in Sub-Saharan Africa.

One of the countries within Sub-Saharan Africa is Malawi, which is a landlocked country in Sub-Saharan Africa (Figure 1).

Figure 1: Map of Malawi (Encyclopedia Britannica 2022)

Malawi accounts for 2% of global malaria cases and deaths and is among the top 15 countries with a high malaria burden. As of 2019, 23% of all outpatient visits in Malawi stemmed from malaria, with 5.2 million confirmed cases. Malawi is one of the world's least developed countries. Out of 195 countries, Malawi's GDP (Gross Domestic Product) is ranked 145th (*Malawi Overview: Development News, Research, Data | World Bank*, n.d.). Malawi's economy heavily depends on agriculture; 80% of the population work in agriculture, contributing to 30%

of the country's GDP. This dependence is at risk as, in recent years, there have been extended periods of the rainy season causing the destruction of crops. According to some reports, one-fourth of the population runs out of food just five months after their annual harvest, which is well before their next harvest. When people are malnourished, they are more at risk for developing severe illnesses such as those from malarial infections (Milner, 2018). In addition, children are more likely to miss school when they contract malaria, which lowers their chances of completing primary school and moving on to secondary school and university. Malaria is most prevalent in rural villages outside of the cities in Malawi. There, the problems of poor nutrition, limited or no access to healthcare, and reluctance to use insecticide-treated bed nets (ITBN) are most pronounced.

Although malaria is a deadly disease, it is preventable. Malaria prevention practices that are globally recognized and applied include using ITBNs at night when sleeping, using insecticide repellent, practicing vector control, ingesting antimalarial drugs, and, more recently, vaccinating children against malaria. There are challenges, however, to implementing these techniques, especially in more rural areas and communities.

Literature Review

Challenges

Since the 50s, there have been many attempts to eradicate and prevent malaria over the past decades. In 1955 the Global Malaria Eradication Program (GMEP) was established to eradicate

malaria worldwide. However, due to the economic and financial crisis during the 1970s and 1980s, support for GMEP declined. One of the main lessons learned during this period was that "no single strategy can be applicable everywhere and that a long-term commitment with a flexible strategy that includes community involvement, integration with health systems, and the development of agile surveillance systems is needed" (Najera et al., 2011). In 2007 there was another global call to eradicate malaria but with little success. Instead, countries decided to focus on malaria control rather than eradication. Then in October 2021, Mosquirix, a malaria vaccine, was approved by the World Health Organization for broad use in children. While this was a historic achievement, researchers found through phases and testing that the vaccine would only prevent 4 in 10 cases of malaria (Laurens, 2020). While this is an improvement in reducing malaria cases, these results also make clear that the Mosquirix is not the single solution to the eradication of malaria. In addition, the vaccine requires 4 doses which is unrealistic to execute in more rural communities such as those in Sub-Saharan Africa. Mosquirix, although a huge achievement in science and health, is not the final solution to the problem of malaria. In addition to Mosquirix, techniques and methods like case management and mosquito vector control with the use of insecticide repellent and ITBNs have been utilized in an attempt to eradicate malaria. In this next section we will break down 3 different approaches to the problem at hand.

Case Management

Currently, one of the two strategies being implemented in Malawi is case management which includes diagnostic testing and the prescribing of anti-malarial drugs to children with positive malaria tests. This strategy is referred to as the Italian and Dutch Schools of thought, which advocates for locally designed programs based around case management and environmental

sanitation (Mathanga et al., 2012). However, in the rural primary health facilities in Chikhwawa Malawi, a study found that stock outs and prompt care seeking were challenges to effective malaria case management. In particular, the study found that parents in Chikhwawa would have a "wait and see" policy when the child had a fever. Only when the fever was serious and persisted did the guardians seek medical attention for their child (Klootwijk et al., 2019). The researchers emphasized that further work focused on prompt health seeking behavior was necessary. Another research study conducted nationwide in 2011 found that 83% of health workers had received training on malaria case management. However, only 67% of patients were diagnosed correctly. In addition, 19% of the 107 facilities surveyed did not have artemisinin-based combination therapy (ACT) stocked. The study estimated that 1.5 million out of 4.4 million malaria patients seen in Malawian public facilities annually received incorrect treatment and an estimated 2.7 million patients without malaria were incorrectly given an ACT (Steinhardt et al., 2014). While case management can be effective, if people are not prompt at seeking healthcare when ill and when the healthcare system is ill equipped to diagnose and treat malaria, the method is ineffective in preventing malaria related complications and deaths.

Mosquito Vector Control - Indoor Residual Spraying (IRS)

The second strategy being implemented in Malawi to address malaria is preventing malaria vector mosquitoes through the use of indoor residual spraying (IRS) and insecticide treated bed nets (ITBNs). IRS in combination with ITBNs have proven to be effective in reducing malaria transmission via mosquitoes (*Malaria Vector Control*, n.d.). A 2019 study in Tororo, Uganda demonstrated dramatic reductions in the incidence of malaria after IRS spraying (Musiime et al., 2019). Between December 2014 and October 2018, 6 rounds of IRS were conducted. The

researchers found a decline of female *Anopheles* mosquitoes biting rate (19.6 to 2.3) per house per night. They concluded that the distribution of ITBNs and the 6 rounds of IRS decreased the mosquito vector intensity and as a result, a decrease in malaria transmission. However, because of a dependence on the IRS, there has been an increase in insecticide resistance. As a result, the effectiveness of the IRS has decreased. In addition, the researchers noted that "single vector control tools" are not sustainable. Instead, combined control tools are more effective and sustainable. Another issue with IRS is the cost - compared to ITBNs, IRS are more expensive. Specifically, in Malawi, the IRS program is uncertain because of limited funding (Chanda et al., 2015).

Mosquito Vector Control - Insecticide Treated Bed Nets (ITBNs)

Another method of mosquito vector control is the use of insecticide-treated bed nets (ITBNs). Multiple studies have found that the consistent and correct use of ITBNs help reduce the number of malaria-related deaths. Between 2000 and 2015, ITBNs averted 68% of malaria cases in Africa alone (Bhatt et al., 2015). Another study from 2018 compared the effectiveness of malaria prevention measures globally through a systematic literature review (PubMed, Cochrane Central, Embase, and Web of Science). The study found that although there are many malaria control measures that are important in eliminating malaria, ITBNs are more resource effective based on the statistical evidence that was gathered (Wangdi et al., 2018). Another study from 2016 studied the effectiveness of a nationwide campaign of ITBNs for children in Malawi. However, the results found that despite a slight increase in households with ITBNs, the prevalence of malaria actually increased. In particular, their results found that an under-utilization of ITBNs was a contributor to the increase of malaria prevalence (Zamawe et al., 2016). Since as early as 1988,

studies have shown that the incorrect and inconsistent use of ITBNs contributes to ineffective reduction in malaria morbidity. However, there has been little research on how to understand the inconsistent use of ITBNs.

Positive Deviance

There have been numerous studies on the effectiveness of malaria prevention techniques in Malawi (ITBNs, mosquito larval vector control, and case management), as well as improvements in vaccine technology. But one aspect that has yet to be studied, from recent or past research, is 1) identifying people who are already practicing effective malaria preventative techniques and 2) understanding why those people choose to actively practice malaria prevention.

This strategy, called positive deviance, is drawn from Jerry Sternin who was a public health officer focused on malnutrition in children for Save the Children in Vietnam during the 1990s. Sternin decided to look for positive deviants - successful practices already in use that can be replicated or amplified - in the communities (Marsh et al., 2004). With the help of local village mother's, Sternin measured and weighed every child in the village to identify children who were healthier, based on body mass index (BMI) percentile, than the other children. They found a select group of children who were in the healthy BMI range, leading Sternin to believe that if a handful of children could stay healthy despite poor sanitation, poverty, and a lack of clean water, every child could be healthy. The next step was to talk with the guardians of these healthier children and identify any diet or meal practices that were unconventional or different from what most other families were doing. Sternin discovered that the children who were healthier had different styles of eating, more amounts of meals but in smaller quantities, and had a more

diverse diet (the mothers would collect tiny shrimp and crab which weren't deemed food for kids and add sweet potato greens which were considered lowly food). These discoveries were eventually passed to other families through active practice and community groups to help enforce these techniques. The ultimate result was a 65% decrease in malnutrition rates. In this case-study, the solutions came from the community, with local members armed with the solutions to address malnutrition on their own. This study seeks to take the principles from Sternin's experience in Vietnam and transfer them to the problem of malaria in a community of Malawi. No studies so far have attempted to look at malaria preventative practices already in place that have yet to be transferred to the entire community.

The importance of this study is that the findings can be used to find more effective ways of addressing malaria in the village of Chilinza. The study itself will most likely not be able to be applied globally or even nationally. But there may be certain practices and approaches that could potentially be applied to other villages or other countries. If this is the case, and the strategies and approaches used in this study are applied successfully in other villages and countries, then there could be large implications in the eventual eradication of malaria in Chilinza, Malawi, and globally. This study would be a small step in that direction as without a true understanding of the people of Chilinza, a lasting impact can't be made.

Methods

Study design and setting

This is a cross-sectional study using quantitative method surveys and qualitative method interviews. The research was conducted solely in Chilinza, TA Malili, Malawi (Figure 2).

Map ID	Name
1	TA Khongoni
2	TA Chitukula
3	SC Mtema
4	TA Kabudula
5	TA Chimutu
6	SC Chitekwele
7	Lilongwe City
8	SC Njewa
9	SC Tsabango
10	TA Kalolo
11	TA Mazengera
12	TA Malili
13	TA Kalumba
14	TA Kalumbu
15	TA Chadza
16	TA Chiseka

Figure 2: Map of TA Malili, Chilinza - Map ID 12 (GADM 2022)

Chilinza is home to 207 households (as of July 2022). Most people in Chilinza work as farmers who sell their maize for income. Diets mainly consist of maize (eaten in the form of a paste

called *nsima)* with other local vegetables. The homes in Chilinza are almost all made of bricks and none of the houses have running water or electricity. Instead, there are 2 water boreholes situated across the village that residents walk to and pump their water (Figure 3). Latrines and bathhouses are located around the homes and can be shared between multiple households.

Figures 3, 4, & 5: Moments of daily life in Chilinza, Malawi (Abrahan Echeverria 2017)

The study took place over the course of 6 weeks between June 11th, 2022 - July 20th, 2022 and consisted of a preliminary survey followed by interviews that were asked by a team of African Bible College students fluent in English and Chichewa (the national language of Malawi). I was introduced to my team through a local NGO called Live Love Malawi, that works directly with the people of Chilinza (Live Love Malawi, 2021).

My team and I already had established relationships with some of the Chilinza locals, including the acting chief of Chilinza. In Malawi, the chief title is passed down to the nephew of the previous chief. Because the current Chief Chilinza is of old age and dealing with health issues, his nephew is the acting chief and was the liaison between myself and the people of Chilinza.

In 2017, teams of 2-3 college students went from household to household, over the course of two weeks, conducting a basic demographic survey. However, minimal data was obtained specific to malaria. Because of low access to technology, going household to household was still the most effective way to gather data for this research project. The study was separated into three phases - 1) learning to understand the problem through the eyes of the locals 2) identify “positive deviants" or successful practices in use that could be replicated or amplified and 3) potential obstacles that the people of Chilinza have that prevent them from utilizing resources (cultural, practical, religious, etc.).

Study Population

The study population included families with children between the ages of 0-17 years. Households without children were excluded from the study because of minimal time on the ground and because children are more vulnerable to malaria.

Participant Recruitment

Before I arrived, the local NGO (Live Love Malawi) staff informed the acting chief of Chilinza about the availability of the research. Recruitment and subject permission took place via public announcement and word of mouth from the acting chief of Chilinza. Participation in the study was completely voluntary, and any household in Chilinza with children was eligible for participation in this study.

Data Collection

Surveys

The first and second phase of this study was conducted in the form of surveys. The survey was recorded via RedCap, a protected and encrypted, wifi-less app. In addition, consent forms were read to participants, in the native language Chichewa, through a translator. Because some of the subjects are educationally disadvantaged, verbal consent was gathered for the surveys, interviews, and for recorded conversations. I visited every household with children and with the help of a team of translators asked questions about diet, frequency of illness, and usage of ITBNs. Because children had school, the survey was conducted after school ended, between the hours of 12PM-5PM Monday through Friday. Since the surveys were conducted during the daytime when the male guardians were out working, those surveyed were almost all women. The

surveys lasted around 15 minutes each (questions as well as height and weight collections). In addition, the local NGO warned against conducting surveys on Saturdays and Sundays because many people worked side jobs on Saturdays away from the village and people were away for church all day on Sundays.

The children in the households also had their height and weight measured in order to calculate BMI (body mass index) which can be used as a reflection of better nutrition. With the information from this survey I hoped to identify positive deviants - households that have children with BMI higher than the average as well as those who are less frequently ill. Once these households were identified, in-depth interviews took place in these households. Families that had children whose BMI fell within the 5th and 85th percentile for their age as well as low prevalence of illness were deemed "healthy." However, most children measured were within the healthy BMI range based off their age and sex. Instead, there were differences in the frequency and consistency of people's ITBN usage. As a result, I used the different categories of net usage to identify positive deviants. Once the surveys were completed and positive deviants were established, identifiable data was de-identified and assigned code with a key only accessible by me and the Faculty Sponsor.

Interviews

Phase three of this study was conducted through in-depth interviews. The interviewees were divided into five sections - households where everyone uses a mosquito net every day, households where only the parents use their net everyday, households where only children use their net everyday, households who do not have any mosquito net, and households who

sometimes use their mosquito nets. In addition, similar to the surveys, those interviewed were almost all women. The goal of the interviews would allow me to gain a better understanding if there were certain practices and perspectives regarding ITBN usage and malaria prevention practices. Questions regarding malaria, mosquito breeding patterns, ITBNs, and other malaria preventive practices were asked. The interviews, which lasted about 45 minutes each, were recorded via an audio device and stored in an encrypted file within my password-protected computer. Interviews were conducted outside the home, typically while everyone was sitting on the ground or on a bamboo mat.

Data Analysis

The last aspect of this study was analyzing the data and sharing the findings with the community. While in Malawi, the survey data was analyzed and categorized using R and Excel. Once interview data was analyzed and understood, the information gathered was shared through meetings with the village committees and acting chief. However, the findings were not completely integrated into people's practices because of limited time. In addition I went into classrooms to teach primary school students about the importance of ITBN usage and how to properly take care of their nets.

Ethical Considerations

Ethical approval for this study was obtained from the Institutional Review Board (IRB) (CPHS Protocol number: 2022-03-15097)

Findings

Through the surveys and interviews, I was able to 1) identify people who are positive deviants or those who are practicing malaria preventative techniques and 2) understand why those people choose to actively practice malaria prevention. My findings are split into four sections - strengths, weakness, opportunities, and threats identified (SWOT)(Ghazinoory et al., 2011).

My sample demographic population primarily included households from a rural village community in Malawi. All the survey respondents live in Chilinza, TA Malili, Malawi. For this study, I successfully enrolled 160 households which had anywhere between 1-6 children. All 372 children (under the age of 18 years) in Chilinza were measured and weighed. Most of the heads of households are farmers who make a small profit off selling maize, except for around 10 people who are builders employed by the local primary school. The highest level of education for the heads of households (mothers and fathers) is secondary school. Due to limited time in Chilinza, Malawi, and because children are most impacted by malaria, households with children were the only ones included in this study.

Strengths

Through surveys and interviews, I was able to gain a better understanding of people's knowledge, perspective, and understanding of malaria, mosquitoes and ITBNs. Originally, I had hypothesized that there would be greater variations in nutritional habits and knowledge on mosquito breeding patterns. This was based on experience from two previous trips to Chilinza, Malawi. While working in the medical clinic in 2017 and 2019, the doctors reported cases of

stunting and malnutrition amongst children. However, excluding 49 of the 372 children measured and weighed, all the other children in Chilinza were within the 5th-85th percentile body mass index (BMI) for their age and sex, which is a healthy BMI according to the Center for Disease and Control (CDC, 2022) and within the 3rd-97th percentile z-score which is healthy for children under the age of 2 (NIHR, 2022). In addition, there was very little variation in nutritional habits and the number of meals being consumed. The average number of meals that children were eating on average was 2.46 meals a day. 337 out of 372 children were eating 2-3 meals a day (Figure 6).

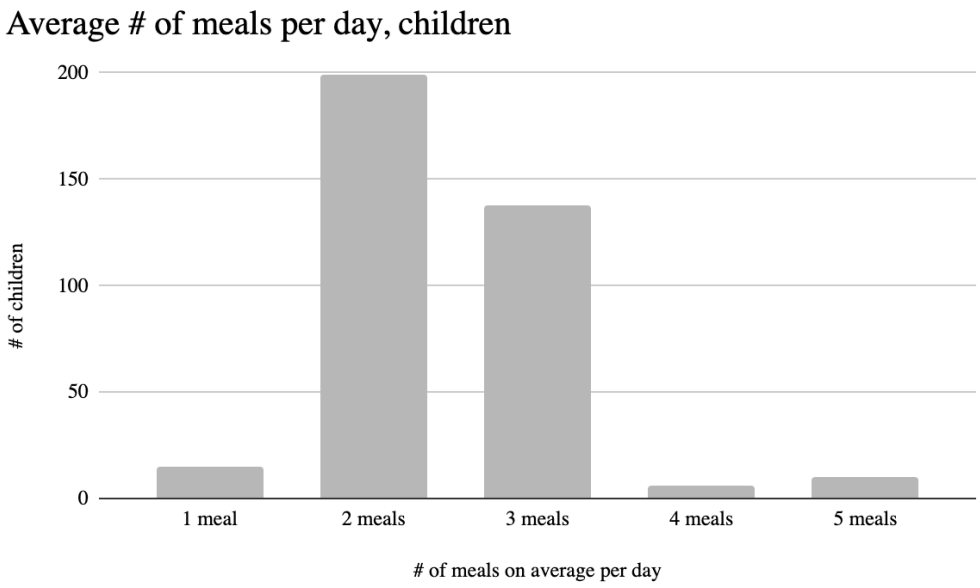

Figure 6: Average number of meals per day, children

These food included, *nsima, nkhwani* (pumpkin leaves), *nyemba* (beans), *rape* (rapeseed), *soya* (soy beans), and *mpilu* (mustard leaves) to name a few. Some families included chicken, fish, and eggs, but these families were exceptions. These households had family members that worked

at the school for construction and or cleaning. For this reason, those families were not considered as positive deviances. In addition, there were families that were eating 1 meal a day without much variation in nutrients. However, because these were not habits with positive effects, these cases were categorized as outliers but not positive deviants. While wealth can dictate access to better health outcomes, wealth level as a preventative measure was not included. Instead, the level of knowledge and understanding was focused on.

In addition, all of the 20 households interviewed, regardless of whether or not they owned or used an ITBN, knew that mosquitoes breed in stagnant water. All 20 households shared similar techniques for removing stagnant water - either they built drainage systems, or they did their laundry on a slope so that water drained better. One household in particular mentioned that their house was strategically built on a slant so that laundry could be done by the house without having to worry about stagnant water. Another household also said they “sprinkled the water” so that the water spreads out and dries faster and did their laundry at the nearby stream instead of near the house to prevent occurrences of stagnant water. These methods were all positive practices that contributed to preventing mosquito breeding and therefore malaria transmission.

Weaknesses

Weaknesses were also identified; it became clear that knowledge was dictating actions. More specifically a lack of knowledge was impacting decisions that negatively affected families. Households that did not have a clear understanding of how malaria was transmitted were often the families that were not using their ITBNs regularly. Some beliefs that reduced the usage of ITBNs included that malaria was spread when warm clothes were not worn or that malaria was

spread when someone coughed on another person. One distinction that is important to make is that many colds and flus are often assumed to be malaria. Unless families get tested at the hospitals or clinics, many families assume that symptoms of colds and flus are malaria. This was identified in a previous survey done in 2017 when respondents from Chilinza claimed suffering from malaria monthly (Mosaic, 2017). Because it is difficult for the people in Chilinza to get tested at the medical clinic every time they feel ill, it is not plausible to know the actual number of cases of malaria that occur. In addition, because cold-like symptoms are often perceived to be malaria, some households in Chilinza do not perceive malaria as a huge threat, nor a preventable threat. The fear and threat of malaria is not as present or imminent.

From interviews, it was clear that misconceptions of how malaria is transmitted translated into misuse of ITBNs. Some households that did not have a clear understanding of malaria transmission reported using their nets for other circumstances. One family that was interviewed has one net that is used just by the parents. This family of 5 people lives furthest away from the main road and in a moderately sized one room brick home. At the time of the interview, the mother was pregnant and she was told by the doctor at the nearby clinic that she had to sleep under an ITBN in order to protect the fetus. The mother and father shared that originally the entire family, including their 3 sons, were all sleeping under an ITBN. However after their 10 and 12 year old sons used the net to go fishing in an attempt to catch and sell the fish for extra money, the nets were damaged and became unusable. It is relatively common for people to use ITBNs as fishing nets not just in Chilinza but also in Malawi which is an issue that stems from food insecurity and poverty (Berthe et al., 2019). When asked how malaria was transmitted, both the mother and father answered not eating good food and sleeping in a “cold place.” The 10 year

old son who was sitting down with us during the interview, said quietly that mosquitoes transmitted malaria. Once the parents heard the son's answer, they changed their response and stated that mosquitoes were the cause of malaria transmission. When asked where all the information was heard from the parents and the son said that they learned malaria related facts from school. While it was not clear if the 10 year old knew the information about how malaria is transmitted before he and his brother went fishing, in Malawian culture, parents are the authority figures and thus the decisions of parents outweigh the knowledge that children may have. This household highlights two weaknesses that were discovered - the effects of inaccurate information spreading which can result in practices that do not prevent malaria transmission and that earning money outweighs the threat of malaria transmission via mosquitoes.

Another family shared that they had used their nets to store and collect maize. Usually maize is stored in a cylindrical thatched granary called a *nkhokwe* (Figure 7), but in this case the family had extra and needed a place to store their maize that would be protected from pests and animals. The ITBN then was used to cover and contain the extra maize. This family demonstrates another dilemma - the perceived threat is ultimately food insecurity or a lack of food and as a result, malaria is not considered as a high priority. Because the Malawian agriculture system is so dependent on rainfall (maize requires large amounts of water), seasons of prolonged droughts or flooding greatly impact food production and security. As a result, the people of Chilinza's focus is more on having enough food rather than malaria, which seems like a more removed issue. Food is an immediate and visible threat, whereas malaria is not.

Figure 7: *Nkhokwe* (CorpsAfrica 2018)

Another weakness that was identified was access to ITBNs. One household that was interviewed was in another village visiting family when the government handed out ITBNs in Chilinza. The mother explained that there is no place to buy ITBNs close by. This household was a family of 5, with 3 children all under the age of 10. The father had a small plot of land where he grew maize and other vegetables. The mother identified that mosquitoes and also "eating bad food" can cause malaria. To prevent malaria, she made sure that the utensils were clean and that the food that they ate was clean. The combination of lack of access to ITBNs as well as the misconception of how malaria is transmitted contributes to the prevalence of malaria in Chilinza.

All the households that were interviewed shared that they learned how malaria was transmitted through school. This stressed the importance of what information was being spread as well as how well the information was presented in a way that stuck with the community. 13 out of the 20 households did not have a clear understanding of how malaria is transmitted, which emphasizes the importance of the accuracy of information being spread as well as the engagement level.

Opportunities Identified - Positive Deviants

ITBN

One household, in particular, stuck out as positive deviants - through careful observation and trial and error, they came to the conclusion that using ITBNs was a vital part of preventing malaria. This family grows maize that is sold and also beans and pumpkins for their own consumption. With the help of my translator, we gathered that they were not considered well off compared to other households in Chilinza. For breakfast, the children would drink tea (if they could afford to purchase tea leaves that week). Usually, their first meal was lunch, when they would eat a simple meal of *nsima* (maize flour paste) and cooked vegetables (tomatoes, pumpkin leaves, okra, and rape). They would eat the same thing again for dinner but with a variation in the type of vegetable.

This household has a firm understanding of what malaria is and how it is transmitted. When asked what malaria was and how it was spread, the mother answered -

"Malaria is a parasite that comes with mosquitoes. Malaria is spread by mosquitoes especially during rainy seasons."

The mother said that she learned this information from school but also from observations over the years - she noticed that during the rainy season, members of her family were more likely to be bitten by mosquitoes and end up sick with malaria. Studies have found malaria patterns

associated with the rainy season in Malawi and other African countries (Kalinga-Chirwa et al., 2011) (Mburu et al., 2019) (Fosah et al., 2022).

What was most interesting about this household was that in the previous year (2021) they did not have nor use ITBNs and during the rainy seasons the four children frequented the medical clinic to be tested and to receive medication for malaria. The mother and father decided that investing in an ITBN was worth the money if it meant that the children wouldn't have to travel around 2 kilometers to go to the nearest clinic and 5 kilometers to the nearest hospital. They purchased 2 ITBNs for the children (1 per two children) which cost around 2,500-4,000 Malawian Kwacha or 3-4 USD per net. With the new ITBN, during this past rainy season, the children were not sick as often and did not frequent the hospital as often. The mother said that this little "study" that her family did was a clear indicator that the use of ITBNs resulted in less sick days and less malaria related hospital visits. She also identified that children are more impacted by malaria than adults because during the rainy seasons, the children were ill more frequently than she and her husband. She said that she is an advocate of ITBNs for her neighbors and tells them that the ITBNs can prevent malaria infection.

This household in particular was essential in understanding the aspects that are necessary for positive changes in behavior. The combination of accurate information about the spread of malaria as well as an urgency to protect themselves from mosquitoes helped convince this family that ITBNs were necessary to prevent malaria despite the monetary investment and the hassle of sleeping in a net. These two aspects are echoed in a research study done during the COVID-19 pandemic. A study in Italy found that perceived likelihood of contracting the virus as well as

knowledge of the spread of the virus influenced people's decisions to social distance (Savadori & Lauriola, 2021). Essentially understanding the imminent risk and having a firm understanding are vital to see positive changes in behavior (Chang et al., 2014). This household was vital in understanding that in order to see positive change in behaviors with ITBN usage, highlighting the risks and accurate information is one potential key to improve upon.

This household was 1 of 3 households that had a very clear understanding of what malaria was and how it was transmitted and dedicated and consistent use of ITBNs, especially during the rainy season in Malawi. The two other households, similar to this household, are not by any means wealthier than other families in Chilinza. Their choice to use ITBNs consistently, especially for their children stems from an understanding that mosquitoes are the transmitters of malaria. These households demonstrate that an understanding of transmission of malaria is vital in order to see positive changes in behavior.

ITBN - Day Time Practices

One issue that prevents people from using ITBNs is bed bugs. One of the interview questions was "Why do you think people aren't using their mosquito nets?" Out of the 20 households that were interviewed, 6 households answered bed bugs and one respondent even answered that their household had to burn their ITBNs because of bed bugs. The overall consensus from these 6 households was that ITBNs attract bed bugs.

This issue is not only experienced in Chilinza. Since 1968, bed bug infestations have caused issues in malaria eradication programs (Fourie & Crafford, 2018). In other parts of the world,

bed bugs have been found to gather on ITBNs in the morning (*Mosquitoes and Bed Bugs – Unfortunate Bedfellows in the Fight against Malaria*, n.d.). In addition, a study in 2018 found that participants in the Balaka district in Malawi also said that bed bugs were a common and ongoing concern in malaria elimination. People would alleviate their discomfort by sleeping outside of their ITBNs and not on their mats, which undermines malaria prevention practices. In addition, during the day, bed bugs hide in cracks and crevices and come out at night, attracted to the warmth of the human body and carbon dioxide. Bed bugs are not attracted to ITBNs, unlike what was gathered from the interviews I conducted (Fourie & Crafford, 2018). Instead the bed bugs are attracted to the humans under the ITBN, not the net itself.

Solutions to bed bugs gathering in and on ITBNs were identified in households. Out of the 15 households with nets that were interviewed, 6 families tie their ITBNs during the day and hang them to prevent any insects from entering the net during the daytime and to keep the bedroom space cleaner and neater. The other 9 households either leave the net as is during the day, fold the net, or hang the net, but do not tie the net.

While interviewing one household, the mother demonstrated with her hands how she ties up her net in her home - she gathers the bottom of the net, twists it tightly, ties it into a knot, and hangs the net over a wire that is against the wall. She also specified that before the sun sets for the day, she prepares the net for the evening. Because almost all households have no electricity, setting up the net before the sun sets allows her to ensure the ITBN is set up properly before it becomes pitch dark. In this home, like all other households that were surveyed and interviewed, the families sleep on bamboo mats on the floor. This was one of the few houses that I entered and sat

in; it is a small one room home with no electricity or running water. Like most homes in Chilinza, there are no windows, and the only source of light during the day comes through the open front door (Figure 8). At night, there is no source of light. The floor was covered in concrete and a mat of bamboo covered part of the floor where the family sleeps. The ceiling is supported by wooden planks which are covered by sheets of metal. Some homes that cannot afford slabs of metal opt for straw roofs. When the nets are hung from the ceiling, they come all the way down to the floor and surround the mats. By tying up the net during the daytime, the ITBN is not in the way during daily activities to be moved, dirtied, or damaged. This household purchased their ITBNs and so the mother wants the nets to last as long as possible, which requires taking care of the ITBN and preventing damage or dirtiness to the net. While the mother did not explicitly state where she learned these techniques, she said that she started doing this and does this consistently in order to keep their house more neat which as a result helps prevent bed bugs. As a result, she has not had to remove or burn her ITBN because of bed bugs.

Figure 8: An example of the inside of a home in Chilinza. Unlike most homes in Chilinza, this house has windows. (Meredith Morris, 2017)

While this method of tying up the ITBN has not been tested scientifically, preventing bed bugs does require one to maintain a clean space. In addition, the WHO recommends tying up the ITBN during the daytime to promote long lasting use (World Health Organization, 2011). In addition, by tying up the net and hanging, bed bugs are less likely to enter underneath the net. The practice of tying up the ITBN during the day time was advocated for after this information was discovered in Chilinza. This information was shared with the village committee, village chief, as well as the students at Chilinza Primary School through demonstrations with the ITBN (Figure 9). While the households that tied up their nets did so to prevent mosquitoes from entering the daytime and to keep their space clean, this method could also help address the issue

of bed bugs which is one factor that is preventing people from owning and using their ITBNs consistently.

Figure 9: Teaching at Chilinza Primary School about ITBNs
(Tiger Souvannakoumane 2022)

Mphungabwi

Another solution that arose from the community is the use of *mphungabwi* (an herb in the basil family classified as *Ocium Americanum L.*) (*World Bank, Mpungabwi*, n.d.), a plant that is a natural mosquito repellent. One household that we interviewed had nets that were used everyday and by everyone although the mother noted that the nets had some holes. She identified that malaria is transmitted by mosquitoes and so as an extra precaution she and her household gathered *mphungabwi* and put the leaves around the bed to prevent mosquito bites. The leaves could be used for up to 3 days. The mother shared that she gathers the leaves, especially during the rainy season, to better protect against mosquitoes. This family lived closer to the main road

where the *mphungabwi,* grows on the side similar to a weed. When asked where this practice was learned, she shared that she had learned from her parents since mosquito nets can be expensive. This family that used *mphungabwi* reported that the son, who is 11 years old, only missed 1 day of school on average per month. Out of the 312 children that were part of this study and school / preschool aged, only 96 children missed less than 2 days of school per month (Figure 10). While I did not ask specifically if malaria was the illness that caused children to miss school, a previous survey done in the same village found that malaria to these villagers is any fever, cough, and cold. For that reason, missing school due to illness was not specified as malaria.

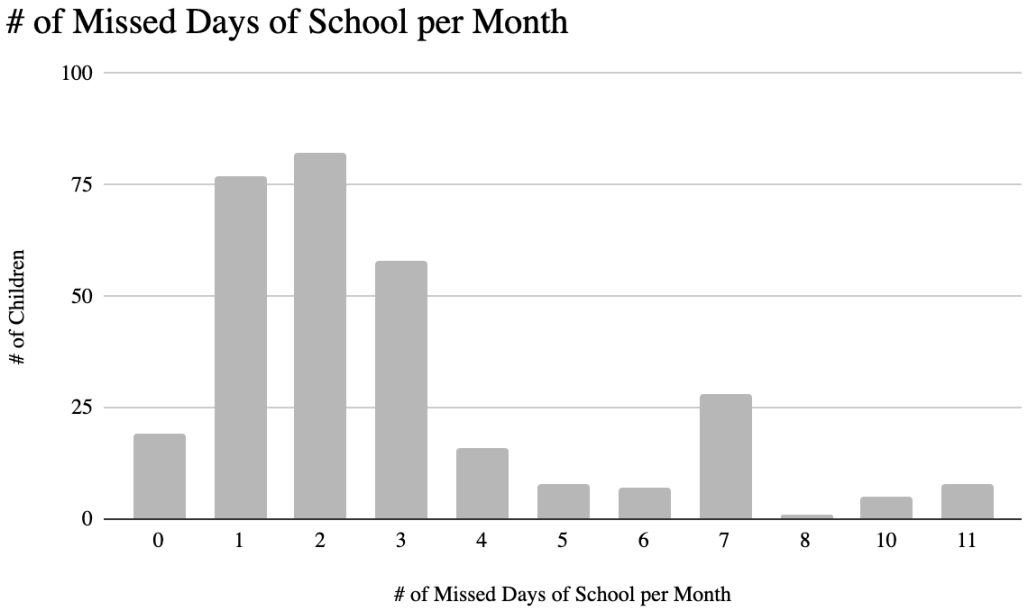

Figure 10: # of Missed Days of School per Month

The second household that mentioned *mphungabwi,* was Chief Chilinza's nephew, the acting chief of Chilinza. My interview with the acting chief was the only interview conducted inside a home with a meal of *nsima* and *nkwhani* (pumpkin leaves), prepared by his wife. When asked if there were any medicinal plants, he mentioned *mphungabwi,* but stated that they were not used in

his household because of the plant's proximity. He sent his 15 year old son to go grab some *mphungabwi* to show us the plant. 30 minutes later his son came running back holding a knife and the leaves. Because of the far distance, his family does not use *mphungabwi.* Unlike the other family that lives near the main road, Mr. Munghape's household is further away from the main road, making access to *mphungabwi* harder and more inconvenient. The distance of the *mphungabwi,* from households is a deterring factor for using *mphungabwi* as a mosquito repellent.

Throughout the 20 interviews conducted, these were the only two households that mentioned *mphungabwi* as a malaria preventative practice. When this malaria preventative practice was brought up to the village committee, many of the members knew what *mphungabwi* was and where one could find the herb. However, the overall consensus was that the herb was not being used as a mosquito repellent.

The only literature specific to *mphungabwi* is a 2004 report from the World Bank cited *mpungabwi* (note a slightly different spelling) as an "effective mosquito repellent" (*World Bank, Mpungabwi*, n.d.). The World Bank also noted that *mpungabwi,* is an effective measure for mosquito control, although amongst more literate communities, this method is seen as "unmodern." In addition, there is research that *Ocium Americanum L.* is an effective mosquito repellent (Tisgratog et al., 2016).

Mphungabwi as a solution for malaria demonstrates the importance of identifying and understanding traditional knowledge. There are already solutions to malaria prevention in

Chilinza and rather than forcing Western solutions, integrating the different spheres is an important step in preventing malaria for future generations.

Threats

Although malaria is a threat to the health and wellness of the people of Chilinza, their greatest concern is food insecurity. In February 2022, it was reported that over 5.4 million Malawians (33% of the population) faced moderate or severe chronic food insecurity (ReliefWeb, 2022). Specifically in Chilinza, families can go up to 4 months without a stable source of food. Despite improvements in the economy over the last decade, Malawi is still very dependent on rainfed agriculture, and as such, is vulnerable to climate irregularities such as prolonged dry seasons or flooding. And with over 80% of Malawians being smallholder farmers, droughts and weather changes greatly impact the majority of the population. As a result, malaria is not as immediate of a concern and instead is put on the back burner in many people's minds. Until food insecurity is no longer an immediate concern, malaria and malaria prevention will be pushed to the side. In order to fully address malaria prevention, food insecurity also has to be addressed.

Results and Conclusions

My findings show that there are solutions within the community of Chilinza for combating malaria transmission. These solutions ultimately stem from a knowledge and understanding of malaria and how it is transmitted. Solutions include using ITBNs regularly, tying up the ITBN during the daytime to preserve the net, and using *mphungabwi* as a natural mosquito repellent. The data I gathered supports the idea that solutions within the community are effective and can be practiced by other households. The results also show that wealth is not the only predictor of

malaria prevention - wealth and accuracy of knowledge is an indicator of who is actively practicing malaria prevention techniques and who is not. For those that were not able to purchase ITBNs either due to finances or access, certain families that were identified as positive deviants found other ways to protect themselves and their families from malaria.

Implications and Next Steps

As a result of this study, it has been determined that within Chilinza, there is a need for better access to ITBNs, separate from government aid, as well as education. After going through the interview and survey data, I felt there was a need to share how malaria is transmitted, especially amongst children as they are the future generation.

The importance of this study is that the findings can be used to find more effective ways of addressing malaria in the village of Chilinza. The study itself will most likely not be able to be applied globally or even nationally. But there may be certain practices and approaches that could potentially be applied to other villages or other countries. If this is the case, and the strategies and approaches used in this study are applied successfully in other villages and countries, then there could be large implications in the eventual eradication of malaria in Chilinza, Malawi, and globally. This study would be a small step in that direction as without a true understanding of the people of Chilinza, a lasting impact can't be made.

Limitations and Future Research

Although this research project was carefully constructed and carried out, there are limitations to this study that can be addressed in future research.

Firstly, no households with only adults were surveyed or interviewed. For the sake of time, these households were not included in this study. However, in future research it would be important to include those households because there might be other methods or understandings amongst the singles and childless couples of Chilinza. In addition, there were a handful of older people that live alone and there may be more indigenous knowledge and practices amongst these households that was not explored in this study.

Another limitation was the collection of height and weight of all the children. Because the heights and weights were collected at individual's homes, there was less consistency of the surface on which children were being measured. Because none of the ground is paved or flat near or around homes I attempted to measure and weigh children on as flat a surface as possible. However, there may be some inconsistencies and inaccuracies from the height and weight collection because of the uneven surfaces.

In addition, one discovery was that ultimately malaria is not perceived as large of a threat because food insecurity is a more pressing issue. Future research on if there are solutions for addressing food insecurity within Chilinza should be explored.

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Availability of data and materials

Data will be made available on reasonable request to Sayana Lee.

Appendix

Appendix A: Preliminary Survey Questions

(All questions and answers will be in a protected and encrypted wifi-less app)

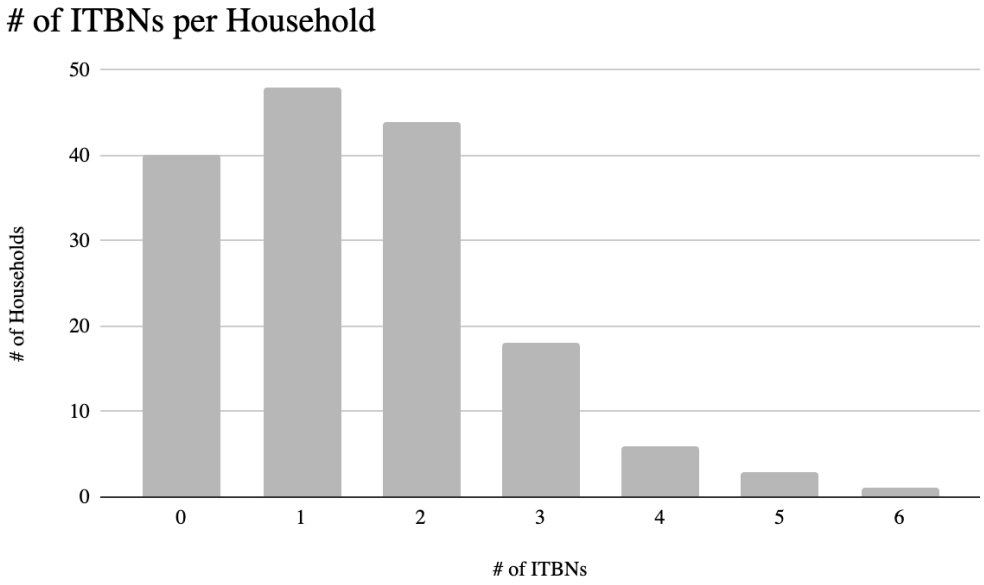
1. Guardian's name
    a. DOB
2. Guardian's name
    a. DOB
3. Adult's name
    a. DOB
4. Adult's name
    a. DOB
5. Child's name
    a. DOB
    b. Height
    c. Weight
    d. Sex
6. Child's name
    a. DOB
    b. Height
    c. Weight
    d. Sex
7. Child's name
    a. DOB
    b. Height
    c. Weight
    d. Sex
8. Child's name
    a. DOB
    b. Height
    c. Weight
    d. Sex
9. Child's name
    a. DOB
    b. Height
    c. Weight
    d. Sex
10. How many mosquito nets do you own?

11. How often do you use your mosquito net a week?
12. How often do your child(ren) get sick a month (having to skip school)?
13. How many meals do your children eat a day on average?
14. What foods are a consistent part of your child(ren)'s diet?

Appendix B: In-depth Interview Questions

1. Do you know what transmits malaria?
2. What do you do to make sure that you and your family can prevent contracting malaria?
3. If you use your mosquito net regularly, why do you choose to use your mosquito net? Why do you think people aren't using their mosquito nets?
4. Do you know how stagnant water increases your chances of contracting malaria?
5. What do you do to make sure to prevent stagnant water?
6. How do you get your food?
    a. Do you buy it or do you grow it?
        i. Vegetables, fruits, maize, rice, beans, fish, chicken, eggs, other meats
    b. What foods are you growing? Which of these foods are you consuming and which are you selling?
7. How often do you eat each type of food?
    a. Vegetables, fruits, nsima, rice, beans, fish, chicken, eggs, other meats
    b. How are you eating these foods? Any raw fruits or vegetables? Steaming vs. boiling vs. frying?
8. Is there anything you feel like your household does that's different and could positively impact your family's health?

Appendix C: Distribution of ITBNs in Chilinza, Malawi



References

1. "About Child & Teen BMI." *Centers for Disease Control and Prevention*, Centers for Disease Control and Prevention, 24 Sept. 2022, https://www.cdc.gov/healthyweight/assessing/bmi/childrens_bmi/about_childrens_bmi.html.
2. Amimo, F., Lambert, B., & Magit, A. (2020). What does the COVID-19 pandemic mean for HIV, tuberculosis, and malaria control? *Tropical Medicine and Health*, *48*(1), 32. https://doi.org/10.1186/s41182-020-00219-6
3. Berthe, S., Harvey, S. A., Lynch, M., Koenker, H., Jumbe, V., Kaunda-Khangamwa, B., & Mathanga, D. P. (2019). Poverty and food security: Drivers of insecticide-treated mosquito net misuse in Malawi. *Malaria Journal*, *18*(1), 320. https://doi.org/10.1186/s12936-019-2952-2
4. Bhatt, S., Weiss, D. J., Cameron, E., Bisanzio, D., Mappin, B., Dalrymple, U., Battle, K. E., Moyes, C. L., Henry, A., Eckhoff, P. A., Wenger, E. A., Briët, O., Penny, M. A., Smith, T. A., Bennett, A., Yukich, J., Eisele, T. P., Griffin, J. T., Fergus, C. A., … Gething, P. W. (2015). The effect of malaria control on Plasmodium falciparum in Africa between 2000 and 2015. *Nature*, *526*(7572), 207–211. https://doi.org/10.1038/nature15535
5. Chanda, E., Mzilahowa, T., Chipwanya, J., Mulenga, S., Ali, D., Troell, P., Dodoli, W., Govere, J. M., & Gimnig, J. (2015). Preventing malaria transmission by indoor residual spraying in Malawi: Grappling with the challenge of uncertain sustainability. *Malaria Journal*, *14*(1), 254. https://doi.org/10.1186/s12936-015-0759-3

6. Chang, S. J., Choi, S., Kim, S.-A., & Song, M. (2014). Intervention Strategies Based on Information-Motivation-Behavioral Skills Model for Health Behavior Change: A Systematic Review. *Asian Nursing Research*, *8*(3), 172–181. https://doi.org/10.1016/j.anr.2014.08.002
7. *CORPSAFRICA*, https://www.corpsafrica.org/blog/archives/05-2018.
8. Echeverria A. (2017).
9. *Fact sheet about malaria*. (n.d.). Retrieved August 31, 2022, from https://www.who.int/news-room/fact-sheets/detail/malaria
10. Fosah, S., Mbouna, A. D., Efon, E., Achu, D. F., Andre, L., & Dikande, A. M. (2022). Influences of Rainfall and Temperature on Malaria Endemicity in Cameroon: Emphasis on Bonaberi District. *Journal of Geoscience and Environment Protection*, *10*(03), 46–66. https://doi.org/10.4236/gep.2022.103004
11. Fourie, J., & Crafford, D. (2018). The Bed Bug Resurgence in Africa. In S. L. Doggett, D. M. Miller, & C.-Y. Lee (Eds.), *Advances in the Biology and Management of Modern Bed Bugs* (pp. 87–94). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119171539.ch8
12. Ghazinoory, S., Abdi, M., & Azadegan-Mehr, M. (2011). SWOT methodology: a state-of-the-art review for the past, a framework for the future. *Journal of business economics and management*, *12*(1), 24-48.
13. Kalinga-Chirwa, R., Ngongondo, C., Kalanda-Joshua, M., Kazembe, L., Pemba, D., & Kululanga, E. (2011). Linking rainfall and irrigation to clinically reported malaria cases in some villages in Chikhwawa District, Malawi. *Physics and Chemistry of the Earth, Parts A/B/C*, *36*(14–15), 887–894. https://doi.org/10.1016/j.pce.2011.07.053

14. Heath, C., & Heath, D. (2010). Switch : How to Change Things When Change is Hard. Broadway.
15. Klootwijk, L., Chirwa, A. E., Kabaghe, A. N., & van Vugt, M. (2019). Challenges affecting prompt access to adequate uncomplicated malaria case management in children in rural primary health facilities in Chikhwawa Malawi. *BMC Health Services Research*, *19*(1), 735. https://doi.org/10.1186/s12913-019-4544-9
16. Laurens, M. B. (2020). RTS,S/AS01 vaccine (Mosquirix™): An overview. *Human Vaccines & Immunotherapeutics*, *16*(3), 480–489. https://doi.org/10.1080/21645515.2019.1669415
17. Live Love Malawi. (June 9, 2021). https://www.livelovemalawi.com/
18. *Malaria vector control*. (n.d.). Retrieved September 18, 2022, from https://www.who.int/teams/global-malaria-programme/prevention/vector-control
19. "Malawi." *Encyclopædia Britannica*, Encyclopædia Britannica, Inc., https://www.britannica.com/place/Malawi.
20. "Malawi IPC Chronic Food Insecurity Report, February 2022 - Malawi." *ReliefWeb*, 20 May 2022, https://reliefweb.int/report/malawi/malawi-ipc-chronic-food-insecurity-report-february-2022#:~:text=The%20February%20Malawi%20IPC%20Chronic,No%2FMinimal%20chronic%20food%20insecurity.
21. *Malawi Overview: Development news, research, data | World Bank*. (n.d.). Retrieved September 14, 2022, from https://www.worldbank.org/en/country/malawi/overview#1
22. Marsh, D. R., Schroeder, D. G., Dearden, K. A., Sternin, J., & Sternin, M. (2004). The power of positive deviance. *BMJ*, *329*(7475), 1177–1179.

https://doi.org/10.1136/bmj.329.7475.1177

23. Mathanga, D. P., Walker, E. D., Wilson, M. L., Ali, D., Taylor, T. E., & Laufer, M. K. (2012). Malaria control in Malawi: Current status and directions for the future. *Acta Tropica*, *121*(3), 212–217. https://doi.org/10.1016/j.actatropica.2011.06.017
24. Mburu, M. M., Mzilahowa, T., Amoah, B., Chifundo, D., Phiri, K. S., van den Berg, H., Takken, W., & McCann, R. S. (2019). Biting patterns of malaria vectors of the lower Shire valley, southern Malawi. *Acta Tropica*, *197*, 105059. https://doi.org/10.1016/j.actatropica.2019.105059
25. Milner, D. A. (2018). Malaria Pathogenesis. *Cold Spring Harbor Perspectives in Medicine*, *8*(1), a025569. https://doi.org/10.1101/cshperspect.a025569
26. Mohandas, N., & An, X. (2012). Malaria and human red blood cells. *Medical Microbiology and Immunology*, *201*(4), 593–598. https://doi.org/10.1007/s00430-012-0272-z
27. Morris M. (2017).
28. Mosaic. (2017). *Chilinza Survey.*
29. *Mosquitoes and bed bugs – unfortunate bedfellows in the fight against malaria*. (n.d.). Retrieved October 10, 2022, from https://agriculture.basf.com/global/en/business-areas/public-health/stories_partnership_countries/stories/mosquitos-and-bed-bugs.html
30. Musiime, A. K., Smith, D. L., Kilama, M., Rek, J., Arinaitwe, E., Nankabirwa, J. I., Kamya, M. R., Conrad, M. D., Dorsey, G., Akol, A. M., Staedke, S. G., Lindsay, S. W., & Egonyu, J. P. (2019). Impact of vector control interventions on malaria transmission intensity, outdoor vector biting rates and Anopheles mosquito species composition in

Tororo, Uganda. *Malaria Journal*, *18*(1), 445. https://doi.org/10.1186/s12936-019-3076-4

31. "Percentiles and Z-Scores." *DAPA Measurement Toolkit*, https://dapa-toolkit.mrc.ac.uk/anthropometry/anthropometric-indices/growth.
32. Savadori, L., & Lauriola, M. (2021). Risk Perception and Protective Behaviors During the Rise of the COVID-19 Outbreak in Italy. *Frontiers in Psychology*, *11*, 577331. https://doi.org/10.3389/fpsyg.2020.577331
33. Souvannakoumane T. (2022).
34. Steinhardt, L. C., Chinkhumba, J., Wolkon, A., Luka, M., Luhanga, M., Sande, J., Oyugi, J., Ali, D., Mathanga, D., & Skarbinski, J. (2014). Quality of Malaria Case Management in Malawi: Results from a Nationally Representative Health Facility Survey. *PLoS ONE*, *9*(2), e89050. https://doi.org/10.1371/journal.pone.0089050
35. Tisgratog, R., Sanguanpong, U., Grieco, J. P., Ngoen-Kluan, R., & Chareonviriyaphap, T. (2016). Plants traditionally used as mosquito repellents and the implication for their use in vector control. *Acta Tropica*, *157*, 136–144. https://doi.org/10.1016/j.actatropica.2016.01.024
36. Wangdi, K., Furuya-Kanamori, L., Clark, J., Barendregt, J. J., Gatton, M. L., Banwell, C., Kelly, G. C., Doi, S. A. R., & Clements, A. C. A. (2018). Comparative effectiveness of malaria prevention measures: A systematic review and network meta-analysis. *Parasites & Vectors*, *11*(1), 210. https://doi.org/10.1186/s13071-018-2783-y
37. *World Bank, Mpungabwi*. (n.d.). Retrieved October 3, 2022, from https://documents1.worldbank.org/curated/en/517231468271540257/text/393410MW0Medicinal0plant01PUBLIC1.txt
38. World Health Organization. (2011). *Guidelines for monitoring the durability of*

long-lasting insecticidal mosquito nets under operational conditions. *WHO/HTM/NTD/WHOPES/2011.5*, 44.

39. World Health Organization. (2020). *World malaria report 2020: 20 years of global progress and challenges*. World Health Organization. https://apps.who.int/iris/handle/10665/337660
40. Zamawe, C. O. F., Nakamura, K., Shibanuma, A., & Jimba, M. (2016). The effectiveness of a nationwide universal coverage campaign of insecticide-treated bed nets on childhood malaria in Malawi. *Malaria Journal*, *15*(1), 505. https://doi.org/10.1186/s12936-016-1550-9