Analysis of the Effectiveness of Community-Based Interventions for Climate-Resilient Malaria Control in Busia County, Kenya

By

Mercy Monden

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First Supervisor: Prof. Dr. Walter Leal

Second Supervisor: Prof. Dr. York F. Zöllner

DECLARATION

This is to declare that this thesis is my original work, and it has not been presented for a degree or any other award in any institution of higher learning in Germany and across the world. Acknowledgements have been made concerning texts which have previously been used. Also, no part or whole of this work must be used for any purpose without my permission

DEDICATION

This thesis is dedicated to my family whose unwavering support, encouragement and love have been a constant source of strength throughout this journey. I also dedicate this work to my supervisors, mentors and friends who inspired and guided me along the way.

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List of Abbreviations and Acronyms

WHO: World Health Organization

MIS: Malaria Indicator Survey

CBIs: Community-Based Interventions

CRMC: Climate-Resilient Malaria Control

EAC: East African Community

LMICs: low and middle-income countries

IRS: Indoor Residual Spraying

ITNs: Insecticide Treated Nets

BCC: Behavioral Change Communication Programs

CHWs: Community Health Workers

SPSS: Statistical Package for the Social Sciences

R-Studio: An integrated development environment for R

Operational Definitions

- **Malaria:** a serious and sometimes fatal disease that is spread by female anopheles' mosquitos through bites and the introduction of parasites into the bloodstream
- **Malaria Control Interventions:** well-established methods used to prevent and treat Malaria, such as insecticide-treated bed nets, indoor spraying, and access to antimalarial medication
- **Community-Based Interventions (CBIs)**: community-level remediation used in effective control, management, or reduction of the impact of malaria infections
- **Climate resilience:** the ability of a system, in this case, malaria control efforts, to adapt to and withstand the impacts of climate change
- **Climatic-Resilient Malaria Control Strategies:** strategies designed to combat Malaria in a way that considers the changing climate. They are always effective even as weather patterns, temperature, and rainfall fluctuate.

Abstract

Background: Malaria continues to be a major global public health threat, affecting countless lives worldwide. According to the World Health Organization (WHO), in 2022, there were an estimated 249 million clinical malaria cases and 608,000 malaria-related deaths. Alarmingly, approximately 95% of these deaths occurred in the African Region. Like many other regions globally, malaria is highly prevalent in Kenya's Lake Region counties, including Busia County. The sustained high cases of Malaria have been associated with constant climatic changes that affect the effectiveness of the implemented interventional measures, highlighting the need to adopt community-based and climate-resilient malaria control strategies.

Objective: This study aims to analyze the effectiveness of community-based interventions for climate-resilient malaria control in Busia County, Kenya.

Research Methodology: A cross-sectional methodological approach was adopted and data collection was done through questionnaires that targeted 300 respondents from the eight sub-counties of Busia Country. The participants included public health officers, nurses, medical practitioners, Community health workers (CHWs) and other healthcare personnel who participated in malaria control initiatives. 279 of 300 distributed questionnaires, representing a 93% response rate, were returned. The collected quantitive data was analyzed using the R-Studio software.

Results: Findings indicated that RDTs and antimalarial treatments((*Total effectiveness 100%*) and the distribution of long-lasting insecticidal-treated mosquito nets (*Total effectiveness 100%*) was the most effective community-based and climate-resilient malaria interventions approach for Busia County, followed by malaria vaccines (*Total effectiveness 82%*) and Indoor residue spraying(IRS) (*Total effectiveness 82%*). Larval source control and public education campaigns were identified as the least effective climate-resilient interventions compared to the others, with 81.9% and 66.5% of respondents, respectively, indicating their effectiveness in withstanding climate change.

Conclusion: The study concluded that the distribution of treated mosquito nets, RDTs and antimalarial treatments were the most effective community-based and climate-resilient malaria intervention approaches for Busia County. It emphasized the need for increased funding to effectively implement these approaches, as malaria control efforts in this rural county heavily rely on government and international funding

Keywords: *Community-Based, Climate-Resilient, Malaria, long-lasting insecticidal-treated mosquito nets, RDTs and antimalarial, Vaccination*

Chapter One: Introduction

1. Introduction

Malaria is a life-threatening disease caused by a parasite and spread to people through mosquito bites, primarily in tropical regions. Despite treatment and prevention efforts, it remains a major global health problem. The disease is transmitted through the bite of an infected female Anopheles mosquito. In rare situations, it can be spread by blood transfusions or contaminated needles. Early symptoms, such as fever, chills, and headaches, may be confused for other ailments. If left untreated, especially infections caused by the P. falciparum parasite, the condition can quickly progress to severe symptoms such as fatigue, confusion, seizures, difficulty breathing and death within 24 hours *(Savi, 2022)*.

Despite efforts by the World Health Organization (WHO), various global and regional organizations, public health activists, and other local governmental and non-governmental public health organizations and ministries to control the spread and persistent effects of Malaria, the number of people being infected by this disease has continued to increase. Malaria stands out as a significant disease that threatens the lives of many populations across the globe. According to the *WHO Malaria Report (2022),* many people tend to live in fear of the disease since it has been a significant cause of death across the world. In 2022, the WHO recorded 249 million cases of malaria and 608,000 related deaths worldwide. Africa is ranked among the countries that register the highest number of fatalities resulting from Malaria infections, with infants, children under 5 years, pregnant women, travellers and people with HIV or AIDS being at the highest risk. The high risk of Malaria infections in children has been attributed to many factors including the lack of climate-resilient and Community-Based Interventional (CBIs) strategies. Arguably, constant climatic changes in regions marked as highly prevalent areas have slowed efforts to control the continuous spread of Malaria.

Among African countries with high Malaria prevalence, Kenya ranks as one of the countries with the highest cases of malaria infections and deaths. Findings from the study by *Elnour et al.* (2023) state that Kenya registers an annual average of 3.5 million new clinical cases of Malaria, with 10,700 estimated deaths annually. This study highlights that most of these cases are reported in the Lake region counties of Busia, Bungoma, Homa Bay, Kakamega, Kisii, Kisumu, Migori, Nyamira, Siaya, Trans Nzoia, Kericho, Bomet, Nandi and Vihiga.

The incidence of Malaria prevalence is expected to increase due to climate changes and constantly changing farming practices like deforestation. The Malaria risk in the identified lake region counties is closely linked to climatic changes in altitude, temperature, and rainfall patterns which vary across regions and seasons (Elnour et al., 2023a). Malaria prevalence in the county of Busia has been constantly high, with average reports of a prevalence rate of 37%, with most cases being children between 6 years and 15 years *(Chiuya et al., 2022).* Despite adopting various community-based interventions, constant climatic changes have slowed the attainment of the Malaria eradication strategy, showing the need for this study. As a result, this research aims to analyze the existing community-based Malaria control interventions across Busia County to determine their effectiveness in controlling Malaria with the changing climatic changes.

1.1. Background of the Study

Malaria is a major health concern worldwide, with half of the global population at risk. In Africa, *Ototo et al.* (*2022*) report that the disease is responsible for one in five childhood deaths (20%) of the total population. Although East Africa has a high probability of malaria-related deaths, all the East African Community (EAC) Partner States are still in the control phase, with most of them experiencing challenges related to the lack of community-based and climate-resilient control strategies. Eliminating this disease might be difficult due to unpredictable climate changes. The number of people infected by this disease has continued to increase despite continued efforts to control its spread. The WHO's *World Malaria Report of 2022* estimates that an average of 249 million people were infected and 608,000 of them died across 85 global countries (*WHO, 2022*). Africa has over the years been known to register high prevalent rates of Malaria with the year 2022 seeing an average infection rate of 94% of the global statistics and 95% of overall deaths as reported by the *WHO* (*2022*). Kenya, one of the EAC countries, has continued to report high cases of malaria infections and deaths. On average, Kenya reports an estimated 6.7 million clinical cases of malaria infections, with 70% of the total population being at risk of malaria infection and 4000 people dying annually as a result of this disease (*Elnour et al., 2023*).

Despite advancements in Malaria prevention and treatment, the disease has remained a significant public health issue globally. Alongside hepatitis, tuberculosis, and HIV/AIDS, it has claimed numerous lives worldwide and is often fatal. While the illness affects individuals across the globe, those in low and middle-income countries (LMICs) bear the greatest burden. Six Plasmodium species, including Plasmodium malariae, Plasmodium vivax, Plasmodium ovale, Plasmodium falciparum, Plasmodium cynomolgi, and Plasmodium knowlesi, have the potential to infect humans. Plasmodium falciparum is responsible for the majority of the disease burden and fatalities *(Wambani & Okoth, 2022)*.

Busia is one of the counties in the larger Western region that reports high annual malaria infections (*Chiuya et al., 2022*). As reported by *Population Services Kenya* (*2023*), out of the almost 900,000 people living in Busia county, 39% of them, representing an average of 351,000 people, are infected with Malaria annually. The impact of Malaria infections in Busia County has been so strong, making it difficult for the adopted community-based interventions to register success. A report from the study by *Kinyatta et al. (2023)* concluded that this disease had been

accelerated by constant climatic changes and other factors that have made it difficult for the adopted remedies to achieve the set objectives. Specifically, constant climatic changes and the high prevalence of socioeconomic factors such as age, level of education, poverty index, access to healthcare and occupation as outlined by *Kinyatta et al. (2023),* have been leading challenges to Malaria control across this county. Besides, *Mumtaz et al. (2023)* add that the challenge of the existence of many older adults within this county with high illiteracy levels at around 56.7% has equally hindered the successful implementation of the adopted community-based Malaria control interventions.

In highland epidemic zones, malaria transmission follows a seasonal pattern and shows considerable year-to-year variation. The intensity of transmission rises when the malaria vector benefits from favourable environmental conditions, such as prolonged periods of low temperatures hovering around 18°C, which create ideal conditions for vector reproduction. During an outbreak in areas prone to malaria, the mortality rates can skyrocket to levels that are as much as ten times higher than those observed in regions with endemic malaria near lakes and coastal areas (Elnour et al., 2023a).

Despite these challenges, *Kinyatta et al. (2023)* insist that constant climatic changes have been a significant setback towards the successful implementation of the adopted Malaria control measures. According to the study by *Kinyatta et al. (2023),* the implementation of the existing community-based interventions has been a significant challenge due to constant climatic changes characterized by floods, rise in temperatures and fluctuating humidity among other climatic changes. As a result, efforts by international, regional, national and local organizations dealing with malaria control have been futile, leading to high malaria prevalence. This study aims to fill this gap and solve the problem of the effects of climatic changes by assessing the effectiveness of community-based interventions. The main purpose is to determine if the current Malaria control strategies used in Busia County are climate-resilient or whether they can be used in all seasons. The primary focus of this study was to check whether the existing community-based approaches, other than the traditional ones are climate-resilient based on how they are implemented at the community level. This approach has ensured the research objectives are met and answered the research questions thus recommending appropriate community-based and climate-resilient interventions that must be adopted within this county to counter the increased spread of Malaria.

1.2. Statement of the Problem

Kenya is situated in eastern Africa, sharing borders with Ethiopia to the north, Somalia to the northeast, Tanzania to the south, Uganda to the west, South Sudan to the northwest, and the Indian Ocean to the southeast. The country is divided into 47 counties and 302 sub-counties. Approximately 80% of the land is dry or semi-arid, leaving only 20% suitable for farming. The nation is geographically divided into two primary regions: lowlands and highlands. The lowlands encompass the coastal and lake areas, while the highlands extend on both sides of the Rift Valley. Precipitation and temperature vary based on altitude and proximity to the Indian Ocean. The coastal region has a tropical climate with higher rainfall and temperatures compared to the rest of the country. These factors have influenced the prevalence of malaria in Kenya. Altitude, rainfall patterns, and temperature significantly impact the transmission and risk of malaria infection in different regions of the country, with the lake and coastal areas bearing the highest malaria burden.

The Kenya Malaria Strategy (2019-2023), which is currently being implemented, is one of the many related malaria control and elimination strategies. Despite several combined control efforts, malaria continues to be a public health problem in Kenya. empirical research shows that the disease imposes significant economic costs, affecting the realization of sustainable development goals (*Elnour et al., 2023*).

Busia County, located in western Kenya, is among the most affected areas as far as control of Malaria is concerned. The county has recorded high and increased cases of Malaria among children between the ages of 6 and 15 years and other ages, as reported in a study by *Chiuya et al. (2022*). While several interventions have been adopted to control the spread of Malaria in Busia County, challenges of constant climatic changes have been threatening the implementation of community-based approaches highlighting the need to adopt climate-resilient Malaria control strategies. What makes this issue stand out is the unique climatic features of Busia County, which are characterized by constant floods during the rainy seasons, fluctuating humidity, high temperatures, droughts that turn rivers into strings of pools and the existence of high adaptive areas that act as vectors (*Ofulla et al., 2016)*. These climatic changes have constantly challenged all efforts to control this disease leading to its high prevalence. Based on these challenges, recommendations from the study by (Chiuya et al., 2022) stress the need to adopt climate-resilient and community-based interventional strategies that enhance malaria control in this county. Given that some of the interventions used to address the spread of Malaria are vulnerable to the impact

of constant climate changes, this study aims to solve this challenge by analyzing the effectiveness of long-term community-based interventions to determine if they are climate-resilient. While community-based interventions offer a promising approach to controlling Malaria, there is limited research that documents their effectiveness in constantly changing climatic regions. This study will provide solutions to this problem by assessing the effectiveness of specific community-based interventions, identifying the best and climate-resilient approaches, reviewing challenges hindering effective implementation and recommending best practices that should be adopted to enhance malaria control in this county and other counties in the Lake Region Block.

1.3 The Study Purpose

This study aims to evaluate the effectiveness of community-based interventions for climate-resilient malaria control in Busia County, Kenya. Various interventions, such as distributing long-lasting insecticidal-treated mosquito nets, indoor residual spraying, community health education, vaccinations and integrated agricultural practices have been implemented to prevent the spread of Malaria in Busia County. The constant extreme changes in climate including frequent flooding, high temperatures, changes in humidity and the county's proximity to Lake Victoria, have hindered the success of these interventions. As a result, the county has failed to achieve success through the use of various control measures, emphasizing the urgent need to explore alternative approaches to develop the most effective resolution plan for this issue. (*Akwala, 2020*). This study identified and analyzed the effectiveness of community-based interventions for climate-resilient malaria control in Busia County, Kenya.

1.4. Significance of the Study

This study is important because it offers an evidence-based solution to sustained malaria control in Busia County through the use of community-based interventions which can withstand climate change. Despite there being other alternative control measures for Malaria effects in Busia County, they have been considered not fully adequate due to the climatic change constraint that negatively affects the implementation of these interventions (*Ototo et al., 2022*). These barriers have led to high malaria prevalence in Busia County, raising alarm about the need to adopt effective approaches to control the spread of this disease. Preliminary evidence from existing literature showed that the adoption of community-based and climate-resilient malaria control strategies is an under-researched area that lacks clear guidelines (*Ototo et al., 2022)*. Executing this study is

not only beneficial for Busia County's malaria control strategy but is equally important in providing literature that is essential in guiding the control of Malaria in other regions.

Secondly, this study is of significant importance as it investigates the reasons why current community-based interventions have not been successful in fully eradicating the persistent malaria problem in Busia County. As a county that registers high Malaria prevalence, Busia has been used to test and implement various community-based malaria control strategies. Findings from the study by *Olela et al. (2024)* revealed that Busia poses great potential in addressing Malaria control because different community-based interventional approaches have been implemented in this county. One of these strategies has been the mass testing and treatment of various community members. With a primary objective of preventing transmission of the disease, these community-based interventions have not registered the expected results, highlighting the need to assess their effectiveness. *Olela et al. (2024)* report that constant climatic changes have hindered the implementation of these strategies, highlighting the need to assess their abilities to withstand various climatic conditions. As a result, this study is justified because it assesses the existing community-based malaria control strategies and recommends appropriate guidelines that must be adopted to ensure the implementation of effective interventions.

Thirdly, the execution of this study is important because it identifies the specific challenges that hinder the successful implementation of community-based interventions for climate-resilient malaria control in Busia County. As explained by *Nabwire (2019),* Busia County has been a center for increased malaria research and control. Several malaria control strategies have been implemented in this county to counter the spread of this disease. Despite these efforts, cases of high malaria prevalence have continued to be reported due to various challenges. The execution of this study is very important because it assesses some of the underlying challenges that have hindered the implementation of effective community-based and climate-resilient malaria control strategies.

Lastly, this study is very important because it analyzes the impact of ongoing climatic changes on malaria control efforts in Busia County and recommends approaches that must be adopted to ensure that effective community-based and climate-resilient approaches are adopted. As explained by *Nabwire (2019)*, various stakeholders' efforts to control Malaria in Busia County have been delayed by constant climatic changes. *Nissan et al. (2021)* describe the flooding that occurs during the rainy season and explain how it obstructs the effectiveness of community-based

intervention measures. According to *Nissan et al. (2021),* floods lead to increased malaria cases in this county because they provide breeding zones for mosquitos, hinder the movement of community health workers, make it difficult to access the affected patients and destroy some of the community malaria control centers that have been established. Reviewing the ongoing impact of climatic changes on malaria control is significant in ensuring the adoption of community-based and climate-resilient strategies that can withstand all seasons.

1.5. Research Objectives

The study aims to achieve the following objectives:

1.5.1. Broad Objective

i. To analyze the effectiveness of community-based interventions for climate-resilient malaria control in Busia County, Kenya

1.5.2. Specific Objectives

i. To identify the challenges that hinder the successful implementation of community-based interventions for climate-resilient malaria control in Busia County.
ii. To assess the effectiveness of existing community-based interventions for climate-resilient malaria control in Busia County.
iii. To analyze the impact of ongoing climatic changes on malaria control efforts in Busia County

1.6. Research Questions

The executed research aimed to answer the following research questions:

i. What are the community-based interventions used in Busia County to prevent the spread of Malaria?
ii. How does constant climate change in Busia County affect the implementation of community-based interventions for climate-resilient malaria control?
iii. What are the most effective community-based and climate-resilient malaria control measures that can be implemented in Busia County?
iv. What are the challenges preventing the implementation of community-based interventions for climate-resilient malaria control within Busia County?

1.7. The Scope of the Study

The study focuses exclusively on Busia County, a region that has experienced high malaria infection rates for decades. The target area of this study includes all residents within the county, more so, those at risk of getting Malaria. The study examines various community-based interventions implemented to control the spread of Malaria in Busia County and assess whether they are climactic-resilience. Primary data collected outside of this county is not included in the analysis. The findings, conclusions and recommendations are specifically tailored to address the malaria situation in Busia County and are selectively applicable to neighbouring counties facing similar challenges. Regardless, this study's scope remains confined to Busia County, ensuring that the recommendations are directly relevant and effective for malaria control within this region.

Chapter Two: Literature Review

2. Introduction

Chapter two of this research provides a thorough review of the current literature significant to the primary concepts, theories and frameworks fundamental to this study. It methodically explores previous studies and scholarly discussions related to the key topics being explored. This section aims to summarize and assess current research in the field by reviewing a wide range of scholarly articles, books and empirical studies as well as provide a clear analysis of the major concepts crucial to this study.

The review is structured to critically evaluate and compare various theoretical perspectives, highlighting their development and relevance to the research question. This section outlines the conceptual and theoretical frameworks that will guide this study, integrating insights from the existing literature to provide a clear foundation for the analysis.

This section also identifies important gaps and limitations in the current body of knowledge. These gaps highlight the need for further research and provide a clear justification for the focus of this study. By addressing these shortcomings, this research seeks to contribute to the field offering valuable insights and advancing understanding of the topic.

2.1 The Effectiveness of Community-Based and Climate-Resilient Malaria Control Interventions

Community-based interventions (CBIs) typically involve the distribution of insecticide-treated nets (ITNs), indoor residual spraying (IRS) and education programs led by community health workers (CHWs). Studies show that these efforts result in higher rates of ownership and usage leading to a reduction in parasitemia (the presence of parasites in the blood) and malaria prevalence. For instance, community-driven programs in Malawi successfully increased the use of ITNs and improved local malaria prevention through educational workshops led by trained volunteers (*van den Berg et al., 2018)*

High global, regional and local malaria prevalence has led to enhanced assessment of the existing approaches to determine their effectiveness in countering the spread of this disease. Evidence from the current empirical literature indicates that adopting community-based and climate-resilience malaria control strategies is essential in countering the spread of Malaria. Community-based and climate-resilient malaria control interventions have demonstrated

significant efficiency in reducing the spread of malaria and improving public health outcomes. These interventions involve local communities in the implementation of sustainable malaria prevention strategies, making them adaptable to changing environmental and social settings (*Nissan et al., 2021*). For instance, a study carried out by *Nalinya et al. (2022)* concluded that adopting community-based interventions for climate-resilient malaria control leads to enhanced community engagement and participation in malaria control practices. According to *Nalinya et al. (2022),* adopting these approaches is crucial for the success of malaria control because these interventions actively engage and empower local communities in decision-making processes, planning, and implementation, ensuring that the whole community is actively involved in the malaria control initiatives. Conclusions from the study by *Loha et al. (2019)* highlighted that community-based and climatic-resilient malaria control strategies were effective in countering Malaria because they integrate and consider constant climatic changes, ensuring that they adopt measures that survive all seasons, thus countering the spread of this disease.

Climate-resilient interventions are critical in settings where environmental factors such as rainfall and temperature have a significant impact on malaria transmission. Integrating climatic factors such as temperature and rainfall patterns into malaria control programs has resulted in more accurate prediction and early interventions leading to a reduction in Malaria outbreaks. In Burkina Faso, for example, climatic research combined with malaria control initiatives like ITNs and IRS led to considerable decreases in Malaria transmission risk over time *(Traoré et al., 2024)*.

The effectiveness of the community-based and climatic-resilient malaria control approaches is equally embedded in their effectiveness in promoting public health awareness and fostering behavioural change among community members. *Loha et al. (2019)* state that these approaches are effective because they adopt holistic interventional strategies such as public awareness campaigns, rapid diagnostic tests (RDTs), provision of antimalarial medications, and vaccinations that lead to large-scale malaria control. *Nissan et al. (2021)* add that countries that have adopted these approaches benefit from increased access to the required healthcare services register, enhanced surveillance and monitoring of malaria infection statistics, and real-sustainable interventions that have enabled them to reduce high malaria prevalence rates. Therefore, literature from existing studies stresses the need to adopt community-based interventions to foster climatic-resilient malaria control in counties like Busia, which experience constant climatic changes that affect the implementation and sustainability of the adopted interventional approaches.

In western Kenya, particularly Busia, studies have shown that CHVs use malaria rapid diagnostic tests (RDT) to diagnose malaria more accurately than professional lab technicians which improves early diagnosis and treatment in hard-to-reach communities. This strategy lowers the duration of treatment and helps minimize severe malaria cases. RDT identifies the presence of circulating malaria parasite antigens whereas microscopy detects the presence of malaria parasites in blood by direct inspection. The most frequent RDT detects Plasmodium falciparum-specific histidine-rich protein 2 (PfHRP2), while others detect lactate dehydrogenase (LDH) and aldolase. RDT findings may stay positive for a varied period (5-61 days) after successful antimalarial therapy depending on the kind of RDT employed, age and medication affecting their specificity. Sensitivity is connected with the test's intrinsic performance, as well as quality concerns related to test kit handling and testing process execution (*Marita et al., 2022)*

2.2. Challenges Hindering Implementation of Community-Based and Climate-Resilient Malaria Control Strategies

While literature from current studies justifies the need to adopt community-based and climate-resilient malaria control strategies to eradicate this disease, findings from the study by *Olela et al. (2024)* hold that various challenges hinder the implementation of these approaches. A significant challenge is the rapid emergence of resistance to insecticides in mosquito populations. As regularly applied insecticides in techniques such as insecticide-treated nets (ITNs) and indoor residual spraying (IRS) become less efficient, the capacity to control mosquito populations declines. Studies demonstrate that in western Kenya, particularly Busia, Anopheles mosquitoes have evolved resistance to pyrethroids, the most regularly used type of pesticides. This resistance undermines the long-term effectiveness of essential treatment methods *(Ochomo et al., 2022)*.

Community-based interventions need sustained funding as well as human resources to be effective. In Busia, there tend to be shortages of supplies such as ITNs as well as gaps in training and support for community health volunteers (CHVs) who play an important role in detecting and treating malaria patients. According to studies, CHVs in the region frequently lack adequate diagnostic equipment and have delays in the administration of anti-malarial drugs *(Marita et al., 2022).*According to *Olela et al. (2024),* the challenge of limited resources hinders many communities, especially in rural areas, from adopting community-based and climatic-resilient malaria control approaches. *Olela et al. (2024)* add that most of these communities always lack adequate resources such as funding, healthcare facilities, trained personnel, and medical supplies

to implement malaria control strategies effectively. Besides, *Ototo et al. (2022)* hold that the existence of weak healthcare systems, characterized by insufficient infrastructure, personnel, and health information systems, always affects the delivery of malaria prevention, diagnosis and treatment services. As a result, *Ototo et al. (2022)* suggest that strengthening healthcare systems is essential for the effective implementation of community-based and climatic-resilient malaria interventions.

Another major concern is the lack of health infrastructure in rural Busia, which adversely impacts access to malaria preventive and treatment services. Malaria control initiatives are less successful due to poor roads, a lack of health facilities and insufficient cold chain infrastructure for storing and delivering vaccinations and medications. This is particularly challenging in remote areas where CHVs are the primary healthcare providers *(Marita et al., 2022)*. A study by *Park et al. (2023)* concluded that challenges of limited access to healthcare services and shortage of community-based healthcare workers were other critical challenges that hindered the adoption and successful implementation of the community-based and climatic reliance malaria control strategies. According to *Park et al. (2023)*, geographic barriers such as transportation challenges and financial constraints always limit access to and implementation of these interventions. In effect, communities in remote areas of counties like Busia always experience difficulties in accessing healthcare facilities, leading to delays in diagnosis and treatment. Also, the research by *Oladipo et al. (2022)* highlighted that shortages of trained healthcare workers, including community health workers (CHWs), always limit the capacity to deliver malaria control interventions at the community level. Climate change makes malaria management more difficult because it disrupts mosquito breeding patterns.

Warmer temperatures and more rainfall provide an ideal environment for mosquito breeding, resulting in increased malaria transmission during the rainy season. In Busia, this inconsistency interferes with the timing and effectiveness of malaria therapies like IRS and ITN distribution, because the malaria outbreak season gets less predictable *(Ochomo et al., 2022)*. Cultural beliefs and practices can influence the acceptability and implementation of malaria control programs. Some community members in Busia may be hesitant to rely on or utilize ITNs, either owing to safety concerns or because they believe malaria is a regular, inevitable sickness. Non-compliance decreases the overall impact of control approaches, especially when community participation is critical for success (*Marita et al., 2022)*.

Constant climatic changes, lack of support from the local authorities and organization, resistance from the community, lack of community ownership, low education levels, and social-cultural factors were identified by *Oladipo et al. (2022)*; *Park et al. (2023)* as the leading barriers that hinder the adoption of community-based and climate resilient malaria control. *Oladipo et al. (2022)* hold that these challenges make it difficult to formulate and implement these approaches, while *Park et al. (2023)* add that lack of strong support from the community always leads to the failure of these interventions. As a result, successful implementation of these strategies in Busia County would require the elimination of these barriers.

2.3. The Impact of Climatic Changes on Malaria Control

Despite the adoption of various interventional approaches, constant climatic changes in different regions have always hindered successful malaria prevention. As explained by *Ofulla et al. (2016),* the situation is not different in Busia County because this county experiences constant climatic changes ranging from floods, high temperatures, and droughts, which delay malaria control interventions leading to an increase in malaria prevalence. *Ofulla et al. (2016)* state that constant climatic changes negatively affect malaria control strategies by shifting the malaria transmission zones. According to *Ofulla et al. (2016),* climatic changes, including variations in temperature and rainfall patterns, always alter the geographic distribution and intensity of malaria transmission, hindering the successful implementation of the adopted interventional measures.

Literature from the study by *Leal Filho et al. (2023)* state that constant climatic changes always derail the implementation of malaria control strategies due to increased cases of malaria infection. As explained by *Leal Filho et al. (2023),* rising temperatures and changes in precipitation create favourable conditions for mosquito breeding and the development of malaria parasites within mosquitoes. Higher temperatures shorten the incubation period of the malaria parasite within mosquitoes, leading to increased vector competence and higher transmission rates. Other constant climatic changes characterized by altered seasons of floods or droughts equally affect the implementation of the adopted malaria control measures by negatively impacting the vector behavior and distribution, leading to a high survival rate of the Malaria causing mosquitoes (*Nyawanda et al., 2023*). Seasonal changes like floods increase the interaction between vectors and parasites, leading to increased infection rates. The most vulnerable populations such as children under five years or the population living in malaria-prone areas, are equally impacted by the altered climactic changes because the sustainability of the adopted approaches is always

affected by ongoing climatic changes. In this regard, *Nyawanda et al. (2023)* conclude their study by stressing the importance of adopting community-based and climatic-resilient malaria control strategies to counter the challenge of ongoing climatic changes during malaria control measures.

2.4. The Effectiveness of the Selected Community-Based and Climate-Resilient Interventions

Various interventional approaches have been adopted to counter the spread of Malaria in various regions across the world. Literature from the current studies indicates that approaches such as the use of community health workers (CHWs) and integrated vector megamenu have commonly been adopted in different countries to counter the spread of Malaria (*Oladipo et al., 2022)*). Literature from the study by *Park et al. (2023),* who examined regional community-based interventional strategies that foster malaria control across Sub-Saharan Africa, identifies approaches such as community-based vector control, climate-smart agricultural practices and enhanced community engagement as crucial interventional strategies that should be prioritized in malaria control and prevention. Similar findings were established by *Barker et al. (2023),* who established that controlling high malaria prevalence in Kenya required the adoption of community-based interventional approaches such as public health education, behaviour change communication, cross-sectorial collaboration and enhanced surveillance and management. The selection of specific community-based and climate resilience malaria interventional strategies is affected by their effectiveness.

2.4.1. The Effectiveness of Insecticide-Treated Nets

The insecticide-treated nets (ITNs) are commonly used community-based and climatic resilience malaria control strategies in different regions across the world. According to *Barker et al. (2023),* ITNs stand out as the most sustainable community-based malaria control strategies that can withstand different climatic conditions. *Barker et al. (2023)* emphasize that this malaria control strategy has been effective because it has shown to be highly effective in preventing malaria transmission by providing a physical barrier against mosquito bites and killing mosquitoes that come into contact with the net. Numerous studies have demonstrated the effectiveness of ITNs in reducing malaria morbidity and mortality, particularly among vulnerable populations such as children under five and pregnant women (*Barker et al., 2023)*). Also, given that ITNs stand out as

cost-effective community-based malaria control strategies, they have been embraced by various people across the world based on their effectiveness in countering the spread of this disease.

2.4.2. The Effectiveness of Indoor Residual Spraying

Indoor residual spraying (IRS) has equally been identified by scholars like *Aongola et al. (2022)* as the most vital community-based malaria control approach that withstands different climatic conditions. The effectiveness of this malaria control strategy has been influenced by its ability to be applied to the interior walls of houses to kill mosquitoes. As explained by *Aongola et al. (2022),* IRS has been highly effective in reducing malaria transmission in areas where it is implemented consistently and at high coverage because it lasts for a long time and cannot be easily washed away by running water after spraying. As a result, IRS is particularly effective against malaria vectors that predominantly feed indoors and rest on walls, such as *Anopheles gambiae* and *Anopheles funestus*. Challenges of insecticide resistance, opposition from members of the public, and logistical challenges have limited the scope of application of this malaria control strategy in different areas across the world.

2.4.3. The Effectiveness of Rapid Diagnostic Tests (RDTs) and Antimalarial Medications

Rapid diagnostic tests (RDTs) and subsequent malaria treatment using antimalarial medication have equally been identified as community-based and climate-resilient malaria control strategies. Literature from the study by *Kinyatta et al. (2023)* states that RDTs are simple, rapid diagnostic tools that detect malaria parasites in blood samples, particularly in settings where microscopy is not available or feasible. *Zeleke et al. (2023)* add that RDTs are highly effective in diagnosing Malaria, with high sensitivity and specificity for detecting malaria infections. The use of RDTs enables prompt and accurate diagnosis of Malaria, leading to appropriate treatment and reducing the risk of severe illness and death. RDTs have facilitated the implementation of malaria case management strategies, including the timely administration of antimalarial medications. As explained by *Zeleke et al. (2023),* the use of antimalarial medications, such as artemisinin-based combination therapies (ACTs), has proved to be highly effective in treating malaria infections and reducing morbidity and mortality. These approaches have been vital in implementing intermittent preventive treatments (IPTs) by ensuring the administration of antimalarial drugs at regular intervals to vulnerable populations, such as pregnant women and infants, to prevent malaria

infection and related complications. These approaches have proved to be effective community-based and climate-resilient malaria control strategies that should be prioritized.

2.4.4. The Effectiveness of Malaria Vaccinations

Enhanced medical research led to the discovery of the malaria vaccine, which is being implemented in countries like Kenya. The discovery of these vaccinations attracted the attention of more scholars who conducted studies to examine their effectiveness in countering Malaria. For instance, an analysis by *Chutiyami et al. (2024)* revealed that the widespread use of the RTS/AS01 vaccine, also known as Mosquirix, has shown partial efficacy in clinical trials. This vaccine is effective in protecting young children against Malaria. In this regard, vaccines targeting different stages of the malaria parasite's life cycle are under development and hold promise for future malaria control efforts. The trial cases of these vaccines in Busia County have proved to be effective in countering the spread of this disease.

2.4.5. The Effectiveness of Social Mobilization

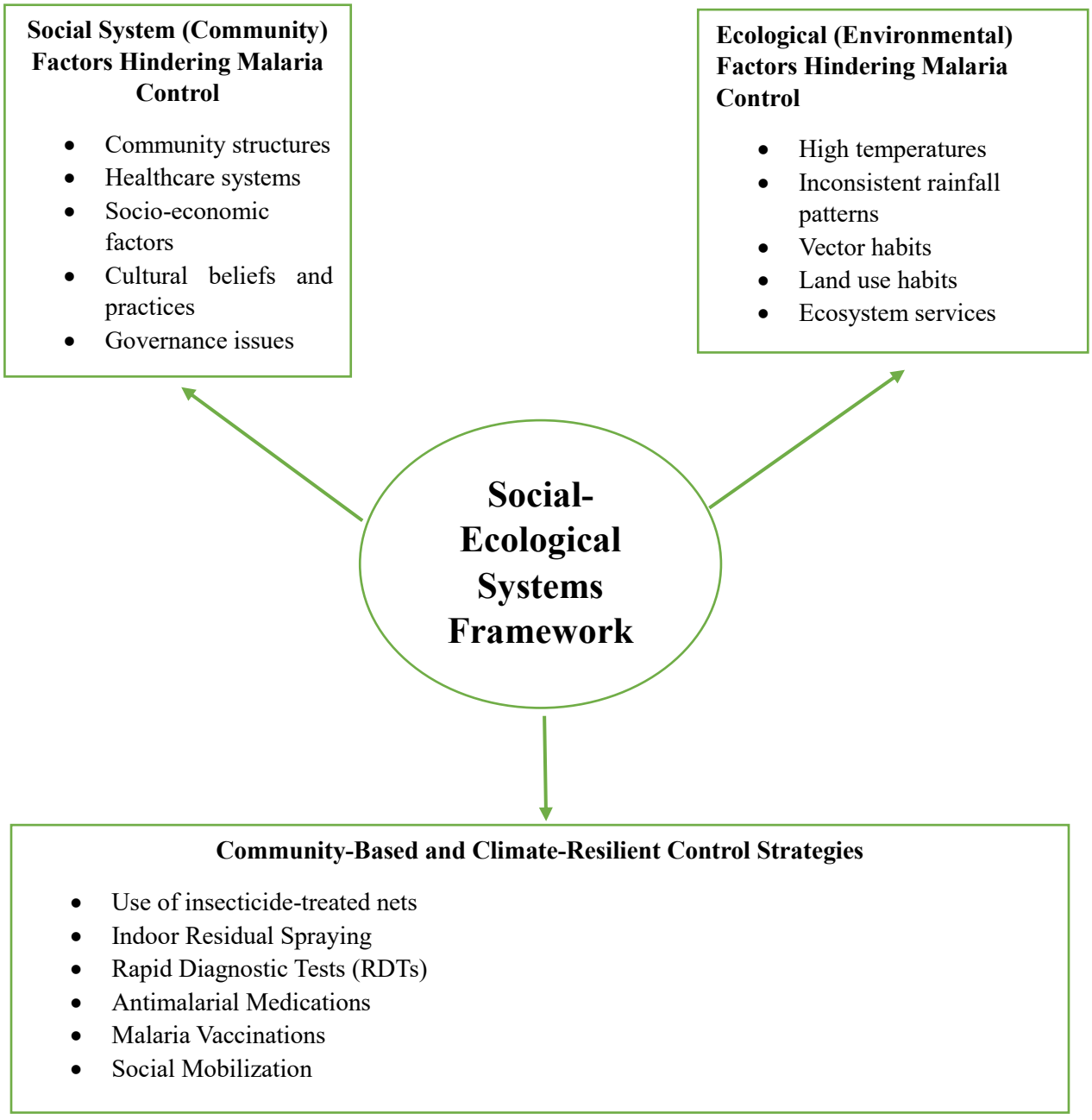
Public awareness on the effect of Malaria educating the general public on how it is spread, how it can be prevented and how it is treated is another community-based and climatic resilient malaria control approach that has been continuously used in different countries around the world. According to *Awasthi et al. (2024),* these social mobilization approaches, which involve engaging communities in malaria control efforts through education, awareness-raising, and behaviour change communication, have been significant in countering the spread of this disease. Community health workers (CHWs) play an important role in malaria prevention through social mobilisation. CHWs are trusted members of their communities, and they frequently lead educational campaigns on malaria prevention, treatment, and diagnosis. They visit families, offer resources for learning, and encourage regular ITN use and treatment-seeking behaviour. In Kenya, CHW-led social mobilization has been found to increase early detection and treatment of malaria, lowering severe cases and malaria death by 18% in rural regions *(Marita et al., 2022).* Notably, effective social mobilization enhances community participation, promotes the adoption of preventive measures, and improves health-seeking behaviour (*Population Services Kenya, 2023*). Active community involvement and ownership in malaria control are essential for the success and sustainability of these programs. Social mobilization stands out as a critical component of comprehensive malaria control strategies.

2.5. The Conceptual Framework

Guided by the evidence from the reviewed literature, identification of research gaps, and consideration of the primary objectives and questions of this research, the decision to adopt a *Social-Ecological Systems Framework* as the primary conceptual framework proved to be highly effective in guiding the execution of this research. According to *Partelow (2018),* a *Social-Ecological Systems Framework* is a comprehensive concept that facilitates the diagnosis of interactions and outcomes of specific variables within a given ecological system. Its application in this research was important in providing a comprehensive approach that significantly enhanced the understanding of the interactions between social, ecological and institutional factors influencing malaria transmission and control in Busia County.

The *Social-Ecological Systems Framework* was particularly fitting for this research due to its recognition of the fact that malaria transmission is influenced by a combination of ecological factors resulting from climatic changes, vectors, socioeconomic determinants such as poverty, access to healthcare, as well as institutional factors such as governance and policy frameworks. This conceptual framework examines how community-based interventions might successfully reduce malaria in Busia County under changing climatic events. It takes a comprehensive approach, considering the interactions of community aspects, environmental circumstances and governance structures. These components are crucial in knowing how to adjust local strategies to the region's particular socio-environmental characteristics to achieve long-term malaria control. (*Partelow, 2018).* By emphasizing the interconnectedness of these factors, the *Social-Ecological Systems Framework* highlighted the importance of addressing the multilevel drivers of malaria transmission through integrated, context-specific interventions. This conceptual framework played a crucial role in informing the assessment of the community-based malarial control strategies, allowing for an in-depth examination of their climate resilience and their ability to counter the identified multi-causal factors. This in turn provided valuable insights into the effectiveness of these strategies in addressing the complex challenges posed by malaria transmission and control in Busia County.

Chart 1: The Conceptual Framework



The theoretical framework that guided the execution of this study was drawn from the developed conceptual framework. Specifically, this study was executed guided by *the Social-Ecological Systems Framework.* This study's theoretical framework uses a variety of theories; The Social-Ecological Systems (SES) Theory, The Health Belief Model (HBM) and The Social

Mobilization Theory, to explain the varied relationships between community-based interventions, climate resilience and malaria control. These theories serve as a foundation for understanding how social, ecological and governance factors affect the effective implementation of malaria control efforts in Busia County. *As shown in* ***Chart 1****,* the implementation of the Social-Ecological Framework began by identifying key components of social systems such as human dimensions, community structures, healthcare systems, socioeconomic factors, cultural beliefs, and governance mechanisms related to malaria control in Busia County. Ecological systems encompassing the natural environment, including factors such as climatic changes, vector habitats, land use practices and ecosystem services relevant to malaria transmission, were identified and analyzed. The interaction of these factors was assessed to determine how they result in increased malaria prevalence in Busia County and how they hinder the effectiveness of the adopted interventional measures. An analysis of the existing community-based interventional strategies to determine if they are climate-resilient was executed to determine their effectiveness.

The Social-Ecological Systems (SES) Theory, provides an extensive perspective for analyzing the relationship between populations and their surrounding environment. According to SES theory, social systems (community and governance structures) and ecological structures (climate, ecosystems, and mosquito habitats) are connected. In terms of malaria control, this hypothesis helps to explain how changes in environmental factors, such as climatic variability, impact mosquito distribution and behaviour, and therefore malaria transmission *(Ostrom, 2009)*.

The Health Belief Model (HBM) is used to understand better the behavioural aspects that impact individual and community decisions to participate in malaria prevention activities. According to HBM, people are more likely to engage in health-promoting behaviours (such as using insecticide-treated nets or seeking timely treatment for malaria) if they perceive themselves to be susceptible to the disease, believe the consequences of the disease are severe and are confident that taking action (such as using preventive measures) will reduce their risk. In addition, cues to action, such as health information campaigns or local social mobilization activities, might encourage the adoption of protective behavioural patterns *(Jones et al., 2015)*.

The Social Mobilization Theory examines how communities organize and work together to address public health issues. This theory highlights the importance of community involvement, participation, and empowerment in achieving social change. In this setting of malaria control in Busia County, social mobilization plays an important role for strengthening malaria prevention

awareness, promoting the use of ITNs, IRS, and RDTs and encouraging community members to engage in environmental management activities to reduce mosquito habitats.

According to social mobilization theory, it is also critical to establish trust between community people and public health officials and foster a sense of ownership over malaria control efforts. Social mobilization, which involves community leaders, local organisations, and health professionals in malaria control initiatives, increases the likelihood that measures will ensure that interventions are more likely to be accepted and sustained by the community *(Haldane et al., 2019).*

Combining these three theories HBM, SES and Social Mobilization gives a comprehensive explanation of malaria prevention in Busia County. HBM discusses individual behaviours and preventative challenges, SES theory addresses various social and ecological systems that drive malaria transmission. The Social Mobilization Theory highlight the need to work together in the community and involve local leadership in ensuring intervention success. These theories work together to guide the analysis of community-based interventions and their ability to withstand climatic changes, emphasizing the relevance of individual behavioural changes as well as community-wide participation. This theoretical framework was used to analyze Busia County's capacity to execute adaptive, community-driven and climate-resilient malaria control measures.

2.7. The Research Gaps

Malaria stands out as a chronic global pandemic that has existed for years, attracting the attention of various scholars. As a result, different scholars have conducted various studies to examine the causes, course, impacts, and interventional approaches for the malaria pandemic. There is enough literature detailing various factors that influence the persistent prevalence of Malaria and interventional approaches that must be adopted to counter the spread of this disease (*Chiuya et al., 2022*; *Elnour et al., 2023*). However, there is a scarcity of literature detailing community-based and climatic-resilient approaches that can be adopted in counties like Busia, which register a high malaria prevalence in different seasons, to counter the effects of this disease.

For instance, a study by *Chiuya et al. (2022)* sought to examine the prevalence of Malaria in the western region. While *Chiuya et al. (2022)* identified climatic factors such as temperature changes, rainfall, floods, and non-climatic factors such as vector mosquitoes, weak human immunities, socioeconomic factors, and other environmental factors as the main causes of high Malaria prevalence, this study failed to provide enough information on the community-based and

climate resilient malaria control strategies that should be adopted to counter the spread of this disease thus justifying the execution of this research.

Elnour et al. (2023) sought to analyze effective malaria interventional strategies that can be adopted to counter malaria prevalence in the Lake Region counties. Despite identifying vital interventional approaches such as the use of insecticide-treated nets (ITNs), indoor residual spraying (IRS), rapid diagnostic tests (RDTs), provision of antimalarial medications, intermittent preventive treatments (IPTs), vaccinations, larval source management, and social mobilization to enhance behavioural change, *Elnour et al. (2023)* failed to identify specific community-based climate resilient strategies that could be adopted by different communities counter the spread of Malaria, thus justifying the need for this research.

There are major gaps in collecting and analyzing data on malaria incidence and intervention achievements. Inadequate monitoring methods may hinder prompt responses to malaria outbreaks and restrict the capacity to track the efficacy of community-based interventions. This challenge is accelerated by the absence of comprehensive climate data, which can help predict malaria trends in reaction to changing weather patterns *(Ochomo et al., 2022).*

Chapter 3: Research Methodology

3. Introduction

This study sought to critically analyze the effectiveness of community-based interventions for climate-resilient malaria control in Busia County. This chapter outlines the methodological approach that guides the execution of this study. The chapter detailed the research design, the suggested study area, the study population, the sample and sampling procedures, the inclusion and exclusion criteria, the data collection/research instruments, the planned data analysis strategy, and ethical considerations that governed the execution of the planned research.

3.1. The Research Design

This study adopted a cross-sectional research design to meet the primary research objectives and answer the formulated questions. *Spector (2019)* explains that cross-sectional research design is the best methodological approach for studying the prevalence of specific characteristics, such as the outcome of specific treatment procedures. Adopting a cross-sectional research design was vital for this research because it aided in analyzing the effectiveness of community-based interventions for climate-resilient malaria control in Busia County. The adopted cross-sectional research design involved collecting and analyzing quantitative data from primary sources.

The primary data collecting tool for the study is questionnaire surveys, a quantitative approach that allows information to be gathered from a large sample size. This ensures that the research has enough statistical ability to identify patterns and correlations in the data. The questionnaire was designed to gather information about important elements such as ITN use, frequency of IRS, malaria diagnostic tests and community perceptions of climatic influences on malaria transmission. The quantitative character of the research methodology guarantees that the findings can be applied to the larger population of Busia County and serve as a foundation for evidence-based malaria control initiatives.

3.2. The Study Area/Location

Busia County is one of Kenya's 47 counties and is situated in the western region of Kenya. Busia County's main economic activities include agriculture, fishing, and trading. It shares borders with Uganda to the west, Bungoma County to the north, Kakamega County to the east, and Siaya County to the west. It is also surrounded by Lake Victoria to the southwest. Busia County's strategic location makes it the entrance to Kenya's East African Community neighbours - Uganda, Burundi, Rwanda, the Democratic Republic of the Congo, and Southern Sudan - with Busia and Malaba towns acting as official crossing points *(History of Busia County, 2024)*.

This study was executed in selected villages of the eight constituencies of Busia County. Primary data was collected from the Budalangi Constituency, Funyula Constituency, Matayos Constituency, Butula Constituency, Nambale Constituency, and Teso North, Central and South Constituencies. The identified study areas were a true representation of Busia County and data was collected from the public, community health volunteers, public health officers and other individuals participating in the malaria control initiatives. The selected study areas provided enough data that was used to critically analyze the effectiveness of the community-based interventions used in Busia County to determine if they are climate-resilient.

3.3. The Study Population

This study's population consisted of chosen members of the community in Busia County, Kenya. Participants came from a variety of key groups participating in malaria prevention programs, including community health volunteers (CHVs) from each of the county's eight constituencies. These CHVs serve an important role in community health education, Malaria prevention and early detection, making them an important part of data collection. By working with CHVs, the study was able to get useful insights into community-level malaria prevention activities, the implementation of strategies like insecticide-treated nets (ITNs) and the challenges caused by climatic conditions affecting the implementation of these interventions.

The study also included public health officers, nurses, medical practitioners and other healthcare personnel who participated in malaria control initiatives. These experts provided a more technical outlook on the effectiveness of malaria control measures, diagnostic processes, results from treatment and the implementation of climate-resilient practices into public health initiatives. Their inclusion ensures that the study covers both community and institutional views on malaria prevention, diagnosis, and treatment.

3.4. The Sample and Sampling Procedure

This study sought to collect primary quantitative data from a sample of 300 participants. A multistage, an extension of the cluster sampling strategy, was adopted as the primary sampling strategy. As explained by *Elston et al. (2007),* multistage sampling categorizes the selected samples into clusters in that the first cluster comprises randomly selected participants while the second cluster comprises the purposefully selected sample units. *Elston et al. (2007)* add that this design ensures that random and purposeful selection is applied at each cluster level and seeks to ensure that the researcher collects data from an appropriate population. The multistage sampling technique was applied by randomly selecting the identified participants in the selected villages across the eight constituencies of Busia County.

This population formed the first cluster. A large population of over 400 participants was randomly selected from residents who voluntarily wanted to be part of the study and were included in this cluster. Secondly, the second cluster was purposefully selected from the first cluster, guided by the formulated inclusion and exclusion criteria, ensuring the desired number of participants was achieved. A sample representation from each study area was prioritized and achieved in the second cluster sampling to ensure that the research findings portrayed a true representation of the community-based interventions that can be used to achieve climate-resilient malaria control in Busia County.

3.5. Inclusion and Exclusion Criteria

The study adopted specific inclusion and exclusion criteria that determined who was to participate in the study. The guidelines presented in ***Table 1*** were used in the second cluster sampling process to determine who to include in the research. The participants sampled in cluster 1 were assessed using the inclusion/exclusion criteria shown in ***Table 1*** to determine their eligibility to participate in the research. As shown in ***Table 1***, the inclusion criteria comprised all residents of Busia County residing in various villages across the eight selected constituencies and it was distributed to the selected participants before actual data collection.

Table 1: The Inclusion and Exclusion Criteria

Inclusion Criteria	**Responses**	**Exclusion Criteria**	**Responses**
Willingness to participate in the research	300 Participants	Unwillingness to participate in the research	100 Participants
A member of any of the 8 constituencies of Busia County (*Funyula, Matayos, Budalangi, Butula, Nambale, Teso North, central and South* Constituencies)	300 Participants	Not a member of any of the 7 constituencies of Busia County (*Funyula, Matayos, Butula, Budalangi, Nambale, Teso North,central and South* Constituencies)	100 Participants
Have stayed in Busia County for the past 2 years	300 Participants	Have stayed in Busia County for less than 2 years	100 Participants
18 years and above and consents to the research	300 Participants	Below 18 years old and cannot consent to the research	100 Participants
Basic proficiency in reading and writing English	300 Participants	Lack of basic proficiency in reading and writing English	100 Participants
Have participated in community-based malaria control initiatives such as the use of insecticide-treated mosquito nets	300 Participants	Have participated in community-based malaria control initiatives such as the use of insecticide-treated mosquito nets	100 Participants
A villager, a community health volunteer, a public health officer, a local authority dealing with Malaria control, an employee of any organization, a worker currently involved in malaria control programs in Busia County, etc.	300 Participants	Not a villager, a community health volunteer, a public health officer, a local authority dealing with Malaria control, an employee of any organization, nor a worker currently involved in malaria control programs in Busia County	100 Participants
Total Included Participants	**300**	**Total Excluded Participants**	**100**

As shown in ***Table 1***, all of those willing to participate in the research were individuals aged above 18 years, villagers, community health workers and volunteers, public health officers, local authorities involved in the control of Malaria, and those who possess basic reading and writing skills. Besides, the inclusion criteria comprised residents who have stayed in Busia County for at least two consecutive years, both men and women, people from all social clusters, and those who have participated in Malaria control initiatives in the past. On the contrary, ***Table 1*** shows that

those who were excluded from this study were non-residents of Busia County or those who had stayed in this region for less than two years, those not willing to participate in the research, those aged below 18 years, and those who not sign the consent form. Additionally, people who were unable to read and write English and those who have not participated in any malaria control initiative, such as the use of insecticide-treated mosquito nets, were not included in this study, as shown in ***Table 1.***

3.6. Data Collection and Data Collection Instruments

The data collection process was facilitated by the author, who is from Kenya and possesses established relationships with relevant respondents within the community. The familiarity of the author with the local context was instrumental in developing a culturally appropriate questionnaire that specifically addressed the needs and concerns of the population. Fieldwork was carried out across Busia County in June and July 2024, as shown in the work plan presented in ***Appendix A,*** allowing for direct engagement with participants and the detailed collection of data on community perceptions regarding malaria control interventions. This approach strengthens the validity of the findings by building trust and promoting open dialogue with respondents, thereby enriching the collected data.

This study's main data collection tool was a structured questionnaire, which is presented in ***Appendix C***. The questionnaire was created to be easy to read and straightforward, allowing it to successfully gather the necessary data while being uncomplicated for participants to figure out and complete. The questionnaire was developed following the study's research objectives and questions. The questionnaire had several sections that collected data on demographics, accessibility to medical care, awareness and use of malaria control strategies and perceived effects of climate change on malaria transmission. Closed-ended questions, which included multiple-choice and Likert scale items, were used to ensure consistency in responses and facilitate quantitative analysis.This data collection instrument was chosen for its ability to systematically gather information from a large sample size while maintaining the reliability and validity of the data collected.

3.7. The Adopted Data Analysis Strategy

The cross-sectional methodological approach adopted for this research led to quantitive data collection that fostered a comprehensive assessment. The collected quantitative data was statistically analyzed using R-Studio Desktop Pro 2024.04.2+764 software to determine correlations between the variables and conduct linear and logistic regression analysis. The second step involved calculating descriptive statistics, such as the mean, median, and standard deviation, for demographic variables, intervention coverage, and malaria outcomes from the qualitative data. A thematic analysis where word clouds and tree maps were used to identify themes like the most effective community-based and climate-resilient malaria intervention. This software was used to identify challenges hindering the implementation of these interventions in Busia County. Visualization, interpretation, and reporting were the last steps of analyzing the quantitative data collected

3.8. Ethical Considerations

To ensure the validity, reliability and quality of the research findings, the study adhered to the set ethical standards governing the execution of research. When conducting the study, professionalism was maintained throughout and strict adherence to ethical considerations that govern research was followed. The social-cultural diversity among the respondents was recognized and a focus on collecting valid, reliable and quality data was ensured. The set ethical standards were observed and permission was sought from the relevant bodies governing the execution of the research. The study was administered in strict compliance with the ethical standards set by the Haw Hamburg University ethical code of conducting research. Participating in this research was on a volunteer basis. The consent form shown in ***Appendix B*** was vital in ensuring that no one was forced or influenced to participate in the research, and no rewards or incentives were given to the participants to participate. Abiding by all of these ethical guidelines was vital in addressing the collection of valid, high-quality, and verifiable data that informed the conclusion and recommendations of the research.

Chapter 4: Results

4. Introduction

Chapter four of this research conducted an in-depth analysis of the collected quantitative data using R-Studio software. The collected quantitive data was analyzed using the R-Studio software. The results and findings from the collected data are discussed in this chapter, paying much attention to the quantitative analysis. The first part of the analysis is identifying the distribution of the data of the study through the adoption of descriptive analysis. Word clouds and tree maps were created to identify some of the key themes and the most frequent interventions and challenges that prevent the implementation of community-based interventions for climate-resilient malaria control within Busia County.

4.1 The Distribution of the Data

4.1.1 Age Distribution

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	Standard Deviation
21.50	21.50	30.50	31.11	40.50	50.50	9.32

The demographic analysis found that the ages of the participants in the study were between 18 - 25 years and 36 - 45 years, with an average age of 31.11 years. The age distribution curve is nearly symmetrical, except that the 18-25 and 36-45 age categories each had 130 responses, making them the peak or modal age groups. Most of the participants were within the age bracket of 18 – 45 years which is shown above. This means that most of the sample population were young or middle-aged adults. The period of 18 - 45 years signifies that no minors were included in the study, while the older adult age group has been identified as 50.50 years. Regarding the age, as shown in the demography of the study was also quite diverse in that the participants were drawn from different ages of adulthood to adequately represent different perspectives about community-based interventions for climate-resilient malaria control in Busia County, as shown in ***Figure 1***.

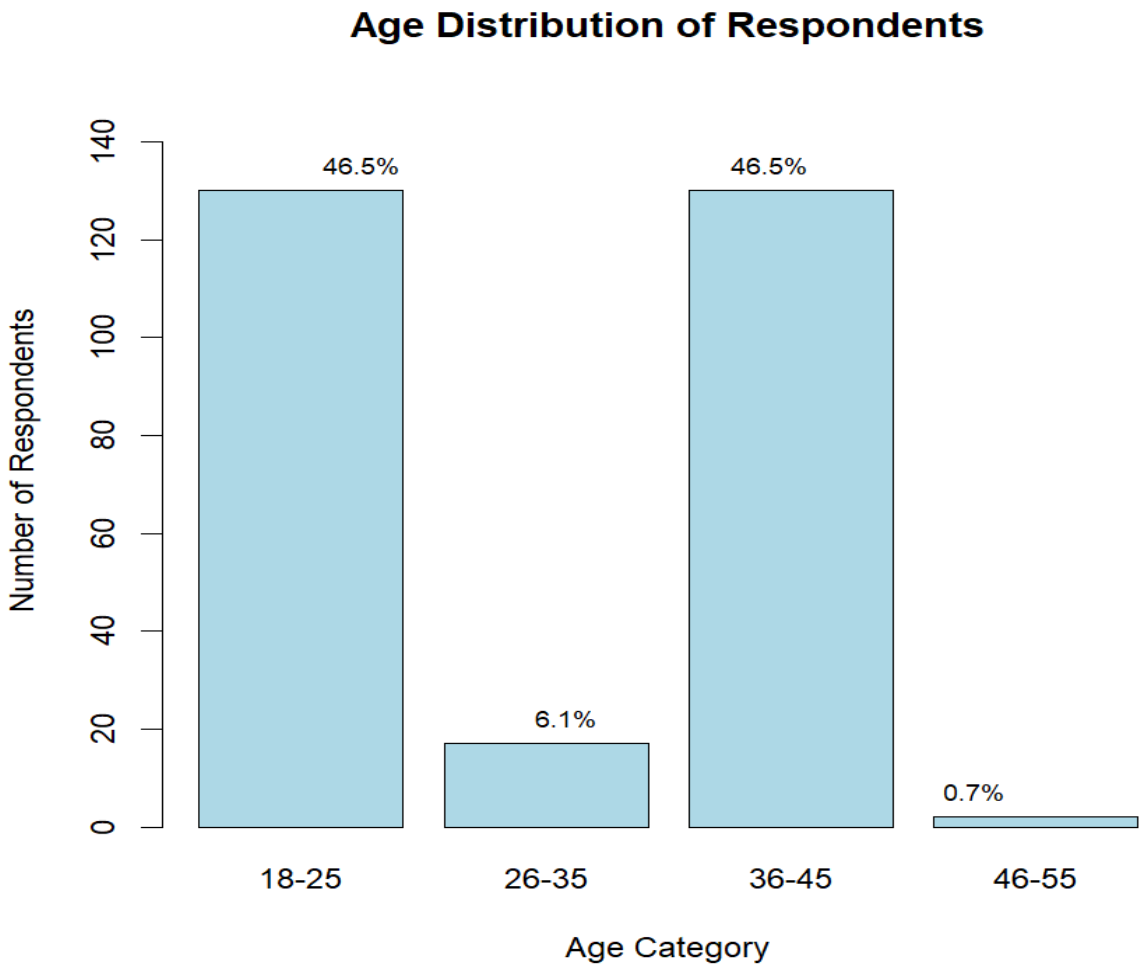


Figure 1: The Percentage Age of the Participants

4.1.2 Gender Distribution

The study participants' demographics indicate that the gender demographics were fairly represented, with just a slight difference between the genders of the participants, and this captured the research findings in their true form. Out of the 300 targeted respondents, 279 respondents returned filled questionnaires and were used in data analysis. As shown in ***Figure 2***, the following groups were used for the analysis: Females 51.3% (n = 143) and Males 48.7% (n = 136). This measure ensured that equal attention was given to both genders because both genders are equally affected by the strategies created to address the malaria pandemic in Busia County to be able to analyze the effectiveness of community interventions for climate-resilient malaria control. The percentage shows that 51.3% of females participated in the research, while 48.7% of participants were males. The cumulative percentages show that there was a 93% rate of participants. This suggests a positive trend, indicating equal participation of men and women in the study. This equal ratio reinforces the importance of involving the community and the impact of community-based malaria intervention as a whole, which is crucial in Busia County.

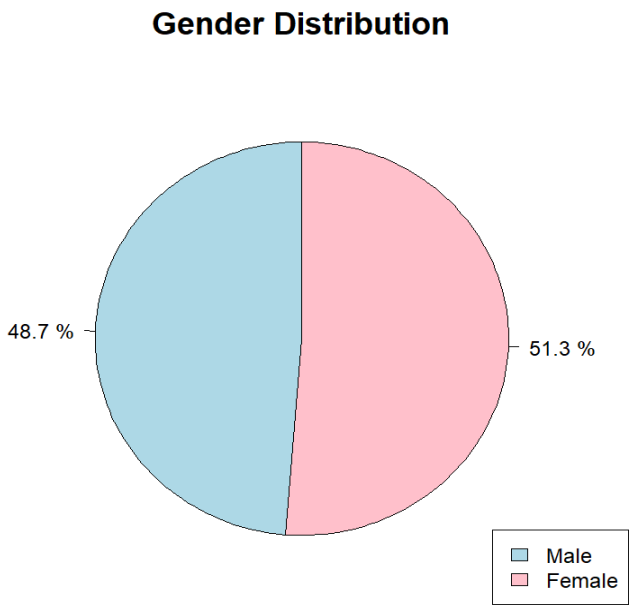


Figure 2: Gender Representation

4.2 The Community-Based Malaria Intervention Used in Busia County

Results show that several community-based interventions against malaria were used in Busia County. These interventions were revealed through the word cloud, emphasizing the need for comprehensive efforts to enhance their applicability. The frequency of terms such as vaccinations highlights how important immunization programs are in the fight against malaria. Vaccines like RTS and S/AS01 form a key part of the county strategy to prevent malaria infection in at-risk populations, especially young children and pregnant women. Similar findings were established by *Kinyatta et al. (2023)*, who showed that these vaccination programs are part of a series of broader public health initiatives aimed at reducing malaria cases in communities through community-wide vaccination, boosting a preventative aspect of disease control.

Another important term, “Mosquito,” which referred to the significance of vector control in malaria risk mitigation was evidenced in the analyzed data. In the community of Busia County, various strategies were used to minimize the mosquito population and minimize human vector contact. Some of these methods include the use of insecticide-treated nets and indoor residual spraying. ITNs are targeted to households to act as a barrier against mosquito bites when individuals take rest while IRS targets insecticides on internal wall surfaces of homes to kill mosquitoes that have brushed past the surfaces.

As explained by *Chiuya et al. (2022)*, The implementation of these interventions plays a crucial role in breaking the transmission cycle of the malaria parasite. The significance of all these

vector control interventions is highlighted in the word cloud, indicating the community's strong interest in malaria vector control. Other most frequent words included the preferred terms like ‘campaigns and ‘education’, reflecting the crucial role of public awareness and community participation in malaria control. Behaviour-change communication programs were found to be important for educating community members about the prevention of malaria, its symptoms, and the need to seek treatment in time. Similar to the emphasis by *Nabwire (2019)*, such campaigns rely on local leaders and organizations for the efficient delivery of information through education and lifestyle changes. As a result, the focus on education implies that the community-based interventions for malaria in Busia County entail significant awareness and information provision for the people to enable them to guard against malaria disease.

Lastly, the word cloud included terms like “public”, “residual”, “rapid” and “antimalarial”, which reflect a broad view of malaria prediction that ranges from prevention to the identification and treatment of malaria. Similar to the findings by *Zeleke et al. (2023)*, the analyzed data indicated that RDTs are instrumental in identifying and treating malaria cases, reducing the chances of developing severe diseases or spreading malaria. The provision and usage of antimalarial drugs are crucial for treating infected persons. In this regard, the community-based interventions in Busia County indicate an approach that combines all aspects of prevention, like vaccination, vector control, public education, and the provision of diagnostic and treatment services. This approach ensures that all aspects of malaria prevention and control are considered, thus empowering the community to deal with all dimensions of the disease.

Table 2: The Impact of the Climate-Change on the Implementation of Community-Based Interventions

	Participants	Percentage
Damages mosquito nets/ Limits community participation in interventions	108	39.7%
Reduces the effectiveness of insecticides used in the IRS	87	31.9%
Make it more difficult to control mosquito breeding	77	28.3%
Not sure	7	0.1%
Total	279	100%

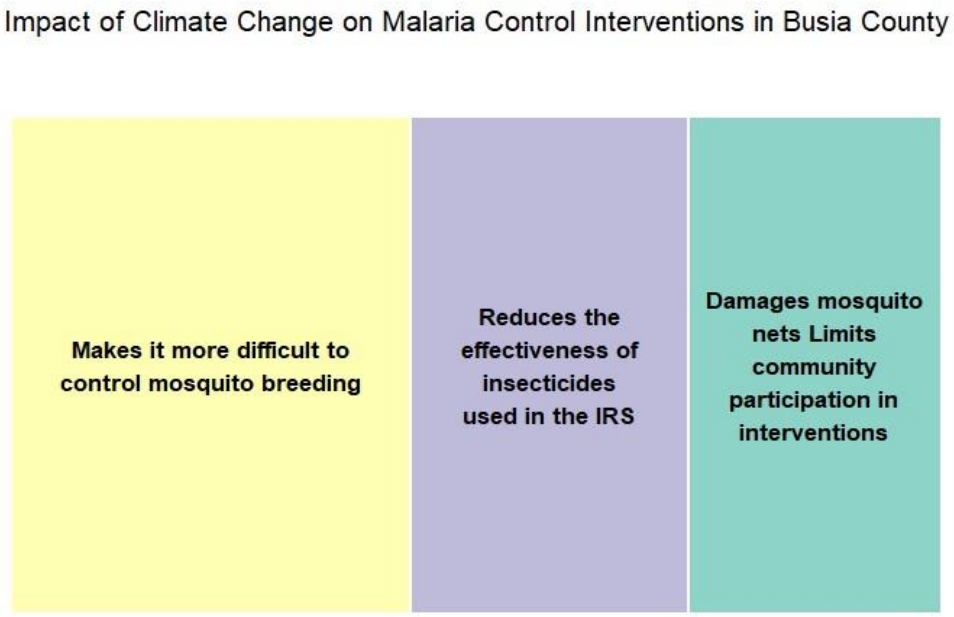


Figure 3: The Impact of Climate Change on Malaria Control Interventions in Busia County

The statistics shown in ***Table 2*** and ***Figure 3*** and the tree map shown in ***Figure 4*** highlight that climate change greatly impacts the development and implementation of malaria control interventions at the community level in Busia County. According to the study's findings, one of the most noticeable impacts is damage to mosquito nets and limitations on community participation, which was reported by 39.7% of respondents. Climatic change has a major influence on the implementation of community-based malaria control programs in Busia County, Kenya. Climate variability, as seen by increasing rainfall, rising temperatures, and extreme weather events, have created obstacles to both physical interventions and community engagement in malaria control initiatives such as indoor residual spraying (IRS) or health education campaigns, as these conditions can limit access to remote areas or interrupt community mobilization efforts.

As explained by Barker et al. (2023), the long-lasting insecticidal-treated mosquito nets experience the challenge of becoming physically damaged if they are left in heavy rains, floods, or storms. Similar findings were established from the collected data because rain was ranked as a leading cause of reduced effectiveness of insecticide-treated mosquito nets, making them unusable. In addition, these weather conditions were also found to affect the level of activities in communities and engagement in malaria control programs across Busia County. For instance, most parts of Busia County, like Budalangi, are prone to floods, which displace and relocate communities, making it inconvenient to form them to carry treated mosquito nets, abide by the malaria prevention measures, or facilitate distribution of malaria prevention and control equipment such as nets and medication (*Population Services Kenya, 2023).* This change needs strong community involvement approaches and plans to survive the unpredictability of environmental changes.

31.9% of respondents noted that climate change reduces the effectiveness of insecticides used in IRS. Weather variations can also reduce the persistence of the insecticide on the treated surfaces. For example, some chemical components in insecticides may break down faster in hot and humid conditions and may not live as long as they should. This requires more frequent spraying or the development of new or more durable formulations of insecticides, thus increasing the expenses of malaria control programs in terms of logistics and finances, as stressed in the findings by Barker et al. (2023). Warmer temperatures and unpredictable rainfall patterns can influence mosquito breeding patterns and survival rates, making them more resistant to insecticides over time. This is especially concerning because IRS is a basis of malaria control, and any reduction in its effectiveness can lead to an increase of mosquito populations and malaria cases.

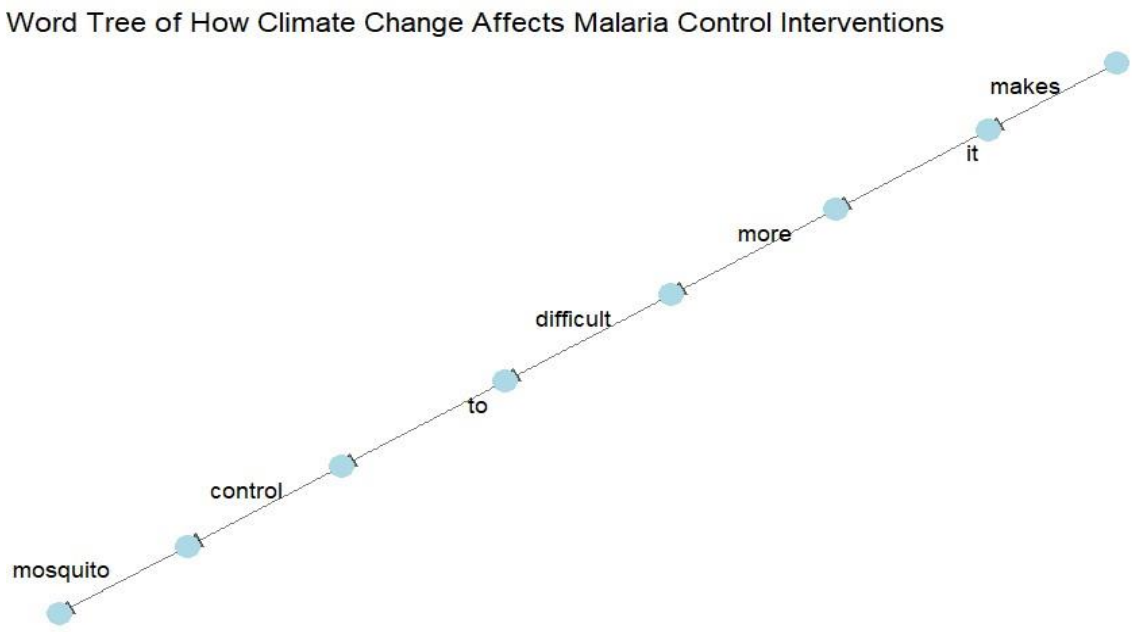


Figure 4: The Word Tree Map

The visualization in ***Figure 4***, known as a word tree map, provides a clear representation of the link between climate change and malaria control interventions. The structure conveys a linear progression of thought, illustrating how climate change complicates the effectiveness of malaria control interventions, particularly in managing mosquito populations. The phrase "makes it more difficult to control mosquito" highlights the significant challenges posed by changing environmental conditions, which can lead to increased mosquito breeding and resilience, ultimately undermining public health initiatives aimed at reducing malaria transmission. This representation emphasizes the necessity for adaptive strategies in malaria prevention, as climate variability significantly influences disease dynamics and public health outcomes. Such visualizations are crucial for effectively communicating complex interconnections in research and fostering a deeper understanding of the implications of climate change on global health *(Long et al., 2017).*

Another significant finding is that 28.3% of respondents believe climate change makes mosquito breeding more difficult to manage. Increased rainfall leads to more stagnant water, which mosquitoes use as hatching grounds. When combined with unpredictable weather patterns, this leads to an increase in mosquito populations and hinders the execution of initiatives targeted at reducing breeding grounds. Similar to the findings by *Ototo et al. (2022)*, the collected data indicated that more stagnant water is formed, leading to an increase in mosquito breeding grounds, hence reproducing high numbers. These aspects worsen the spread of malaria, leading to increased cases of malaria infections. As a result, the findings stressed the need to adopt community-based and climate resilient-control measures that must be adopted to adjust and intensify efforts in vector control by countering the expanding mosquito habitats.

Only 0.1% of respondents were unsure about the impact of climate change on malaria control, demonstrating that the community is informed of the impact of climatic variability on interventions. These findings highlight the critical need to adapt malaria control strategies to be climate-resilient, with a focus on improving the durability of interventions like mosquito nets, increasing the efficacy of IRS in changing environmental conditions, and encouraging community participation despite climatic challenges.

The study findings sought to analyze the collective impact of climate change on general community-based and climate-resilient malaria control measures in Busia County. Due to their complexity and multi-dimensional nature, solutions adopted to control malaria need to be multi-level and multi-faceted, as stressed by *Olela et al. (2024)*. Among the passive responses given by the respondents, 0.1% specifically stated that climate change hinders their community involvement, providing further evidence of the wider implications of climate change. It is, imperative that community-based interventions incorporate climate-resilient approaches, including discovering new insecticide formulations, enhancing the durability of mosquito nets by increasing the distribution of the nets in the community and education in the community regarding the preventative aspects of the nets and other interventions (*Kinyatta et al., 2023*; *Chiuya et al., 2022*; *Olela et al.,2024)*. Focusing on identifying and addressing how climate change influences malaria control was stressed by the collected data because these approaches are essential in helping programs adjust to changing climates to continue demonstrating similar success.

4.3 The Most Effective Community-Based and Climate-Resilient Malaria Control Measures

Community-based initiatives are crucial for malaria control, particularly in areas prone to climate change, such as Busia County, Kenya. The success of these initiatives is dependent on their capacity to involve local communities while adjusting to the obstacles provided by changing environmental circumstances. As climate change affects rainfall patterns, temperature, and mosquito breeding sites, malaria control measures must be both community-driven and climate-resilient. The most effective interventions combine preventative, curative, and adaptive strategies, with a focus on community engagement. These include extensive use of insecticide-treated nets (ITNs), indoor residual spraying (IRS), rapid diagnostic tests (RDTs), and antimalarial medicines. In addition to medical therapies, climate-resilient methods including environmental management, community education, and social mobilization assist communities in anticipating and mitigating the effects of climate change on malaria transmission. These strategies attempt to decrease malaria incidence by collaborating and integrating adaptable techniques, even when climatic circumstances change.

This section explores the most effective of these interventions, highlighting their efficacy in both reducing malaria prevalence and building resilience to the increasing threats posed by climate change.

4.3.1 The Efficacy of the Indoor Residual Spraying

The efficacy of Indoor Residual Spraying in malaria prevention in Busia County across climatic conditions has varying results. As shown in ***Figure 5***, the study's findings reflect different opinions on the effectiveness of Indoor Residual Spraying (IRS) for malaria control in Busia County. The majority of respondents, 63.1%, reported IRS is "somewhat effective," implying that while the intervention may help reduce mosquito populations, it may not always prevent malaria transmission due to factors such as insecticide resistance, improper spraying, or environmental conditions.

A smaller percentage, 18.9%, rated IRS as "very effective," indicating confidence in the method's capacity to considerably reduce malaria transmission when properly applied. This population is likely to benefit from proper usage and appropriate environmental circumstances that promote IRS effectiveness. Similar findings were equally established in a study by *Aongola et al. (2022),* thus justifying the findings of this research.

17.9% of respondents said the IRS was "not effective," which might be due to insufficient coverage, environmental constraints (such as heavy rains washing away pesticides), or mosquito resistance to the chemicals used. This reaction emphasizes the importance of improving IRS implementation, as well as other treatments like insecticide-treated nets (ITNs) and public health education. Although 82% of respondents believe IRS has some level of effectiveness, the findings show that just 18.9% believe it is completely effective, with the majority expressing concerns about consistency. This implies that improvements in IRS implementation, monitoring, and supplementing with other control strategies (such as insecticide-treated nets and community education) are required to maximise its impact in Busia County.

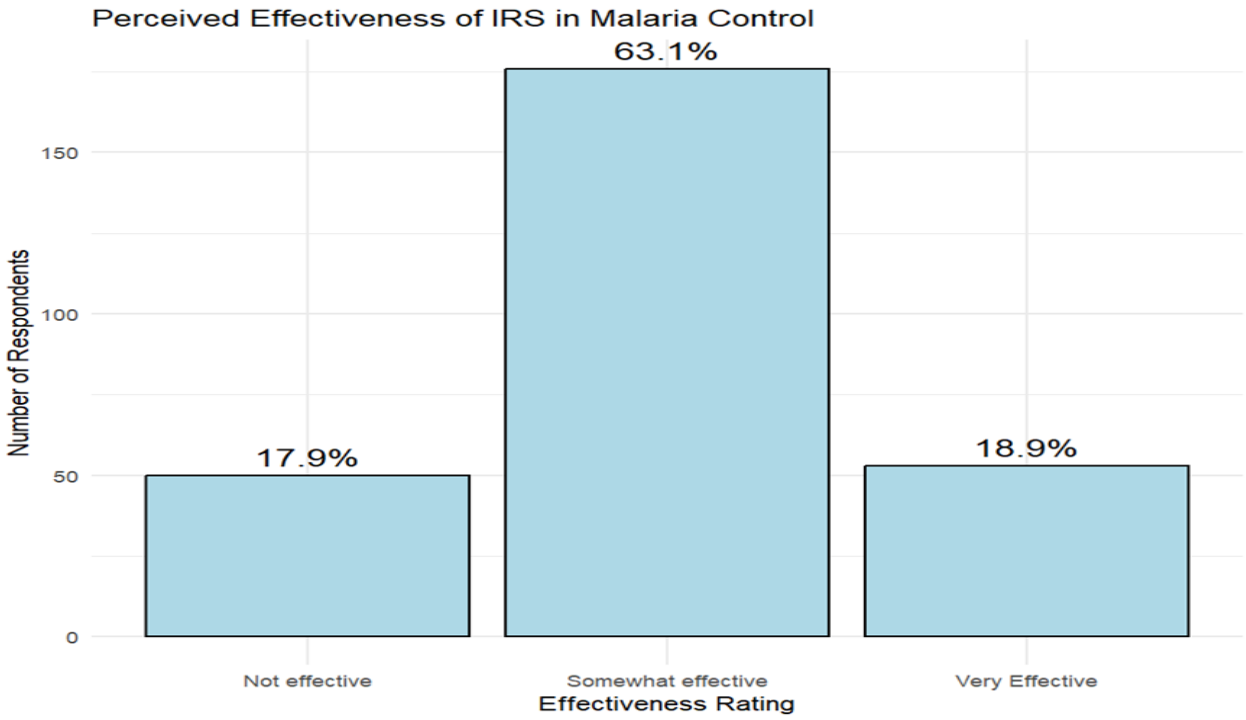


Figure 5: The Effectiveness of Indoor Residual Spraying

4.3.2 The Efficacy of Public Education and Campaign Programs

The study shows different opinions on the effectiveness of public education initiatives in reducing malaria in Busia County. ***Figure 6*** shows that 44.0% of respondents rated these initiatives as "somewhat effective," indicating that while the campaigns have helped to raise awareness and educate the public, there are undoubtedly areas where they might improve in terms of engagement and messaging to have greater impact. 22.5% of participants described the programs as "very effective," indicating that a small but substantial proportion feel the campaigns are making a major contribution to malaria prevention efforts by teaching communities about preventative measures and treatment methods. A smaller percentage, 5.0%, said the initiatives were "not effective," presumably indicating gaps in outreach, knowledge retention, or communication strategies that did not resonate with all community members. 28.3% of respondents were "not sure" about the success of these initiatives, which might indicate a lack of exposure or clarity on their effects. These findings highlight the need for ongoing improvements in public education strategies to ensure that they effectively reach all parts of the population, especially in terms of reaffirming the importance of malaria prevention and control measures in the context of climate change and evolving community health challenges.

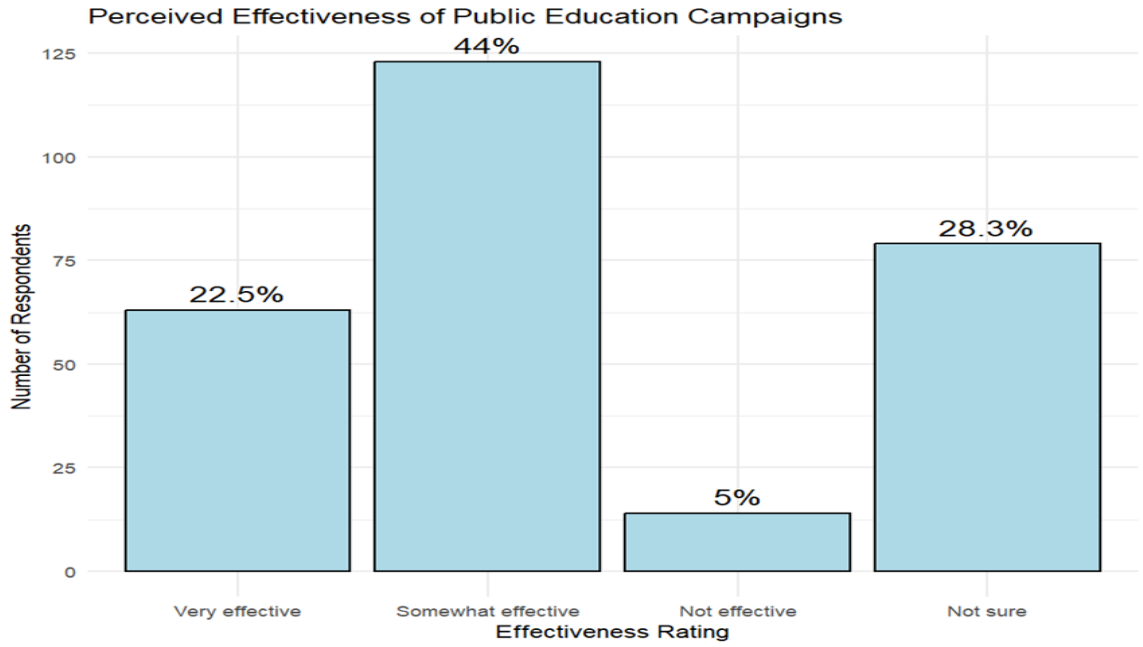


Figure 6: The Effectiveness of Public Education and Campaign Programs

4.3.3 The Efficacy of RDTs

The study showed a highly positive response to the effectiveness of Rapid Diagnostic Tests (RDTs) in diagnosing malaria in Busia County. Results shown in ***Figure 7*** show the vast majority of respondents (70.3%) considered RDTs as "very effective" thereby portraying the important role of RDTs and antimalarial in the intervention strategy. Similar findings were established by *Zeleke et al. (2023),* who concluded that RDTs stand out as the best intervention for malaria control. This implies that there is extensive confidence in the efficacy of these tests for accurate, rapid diagnosis, which is crucial for early malaria treatment and prevention. The ability of RDTs to provide early diagnoses is critical in lowering malaria transmission and preventing severe illness development, making them an important tool in community-based malaria interventions.

Although 29.7% of respondents found RDTs to be "somewhat effective," there may be concerns related to operational challenges, such as occasional inaccuracies, limited resources, or training gaps that could affect their consistent application. When combined, 100% of respondents consider RDTs to be effective to some degree, either "very effective" or "somewhat effective," highlighting their overall acceptability.

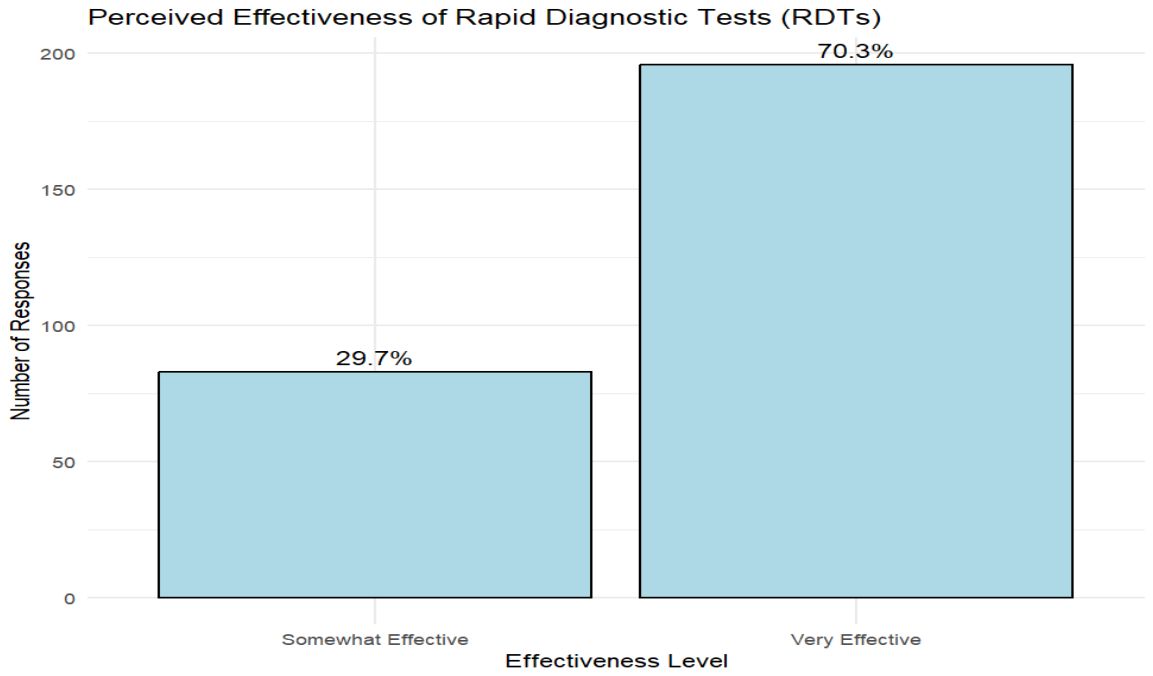


Figure 7: The Effectiveness of RDTs

4.3.4 The Efficacy of the Distribution of Long-Lasting Insecticidal-Treated Mosquito Nets

The provision of long-lasting insecticidal-treated mosquito nets in Busia County is perceived as a great mitigation mechanism for Malaria prevention during different climatic conditions. The survey results shown in ***Figure 8*** show that mosquito net distribution is widely recognized as an important malaria preventive tool in Busia County. A notable 72.0% of respondents rated the intervention as "somewhat effective," indicating that while most participants recognize mosquito nets' preventive outcomes, there are likely constraints that restrict their full effectiveness. These obstacles may include inconsistent utilization, poor maintenance, and environmental issues like as heat and humidity, which may discourage frequent use.

28.0% of respondents claimed mosquito net distribution is "very effective," indicating confidence in the intervention's capacity to considerably reduce malaria transmission when used appropriately. This population would benefit from regular access to and proper use of insecticide-treated nets (ITNs), which have been found to minimize mosquito bites and malaria incidence in high-risk locations. This portrays a high percentage of confidence in the effectiveness of the mosquito nets that provide a shield against malaria mosquito infections irrespective of climate changes, as evidenced in the studies by *Nalinya et al. (2022)*; *Barker et al. (2023)*.

Combining these two categories, 100% of respondents said that mosquito net distribution is effective to some extent. This significant response highlights the critical role mosquito nets play in community-based malaria control initiatives. The gap between "somewhat effective" and "very effective" ratings emphasizes the importance of continuing efforts to enhance community education on the proper and regular use of mosquito nets, as well as addressing challenges to their efficient deployment. This may include attempts to ensure that worn-out nets are replaced regularly, greater community sensitization and net distribution in conjunction with other malaria control techniques such as indoor residual spraying (IRS) and public education programs. These findings highlight the importance of mosquito nets as part of a comprehensive malaria control strategy, but they also indicate that more efforts are needed to maximize their effectiveness in preventing malaria transmission.

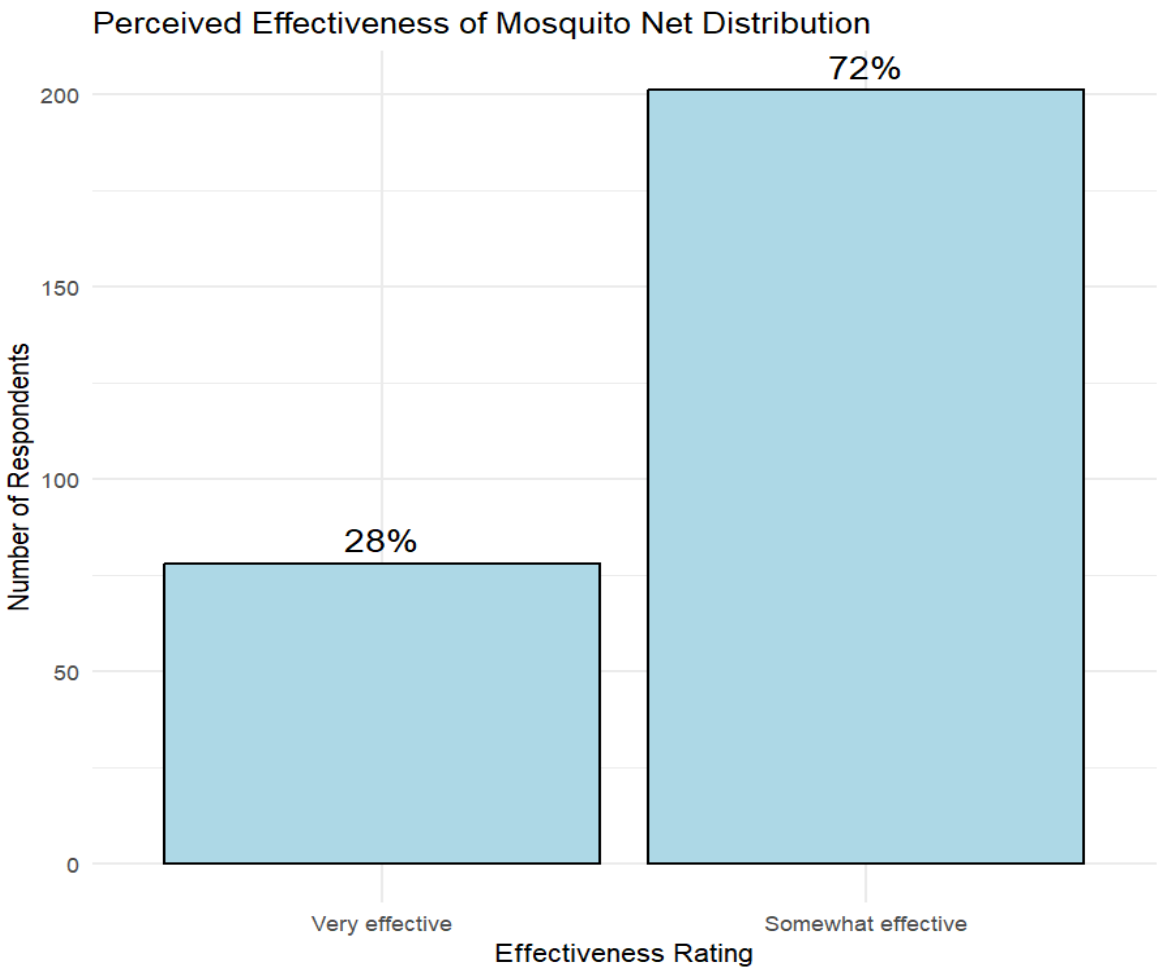


Figure 8: The Effectiveness of Distribution of Treated Mosquito Nets

4.3.5 The Efficacy of Vaccines

Although climatic conditions change from one season to another, most of the respondents had a positive perception of the effectiveness of vaccination in reducing the spread of malaria in Busia County. In more detail shown in ***Figure 9***, the majority of participants, 53.0%, considered vaccinations as "very effective." This study indicates a high level of confidence in vaccines' ability to prevent and reduce malaria transmission, particularly as part of a long-term, community-based climate resilient malaria control approach. The RTS, S/AS01 malaria vaccine that is currently administered in the area has demonstrated clinical effectiveness in clinical trials and deployment studies, especially in young children and pregnant women, who are some of the most affected groups by malaria. Similar findings were equally established by *Chutiyami et al. (2024)*; *Mumtaz et al. (2023)*, who executed studies to assess the preliminary efficacy of malaria vaccines used in Busia County. The development of this immune response, which can adapt to changes in climate and mosquito behaviour, makes the vaccine a strong tool in the fight against malaria.

29.0% of respondents believed vaccinations were "somewhat effective," indicating that while this group recognizes the advantages of vaccination programs, there may be perceived barriers in terms of accessibility, vaccine coverage, or efficacy in different subpopulations. These indicators could represent the early phases of vaccination acceptance or difficulties in reaching all vulnerable populations. A lower percentage, 17.9%, reported they were "not sure" about the effectiveness of malaria vaccines. This uncertainty indicates a lack of information or exposure to vaccination programs, as well as the region's relatively new malaria vaccine initiatives.

Overall, 82.0% of respondents (combining "very effective" and "somewhat effective") reported some level of confidence in vaccination efficacy, indicating widespread support for incorporating vaccines into community-based malaria therapies. This emphasizes the significance of ongoing investment in vaccination programs, as well as measures to address gaps in public knowledge and vaccine access, to guarantee maximum reach and efficacy in the fight against malaria in climate-affected areas such as Busia County.

This variation in perception is an indication that though vaccinations are effective climate-resilient and community-based malaria control interventions, there might be issues with the coverage or delivery of these vaccines. These issues include the storage conditions of the vaccine, the delivery process in harder-to-reach communities, and how to achieve the highest possible

coverage among the population. The communities' split opinion highlights the need for constant evaluation and adjusting the vaccination program to address the diverse population groups' needs as climatic conditions change.

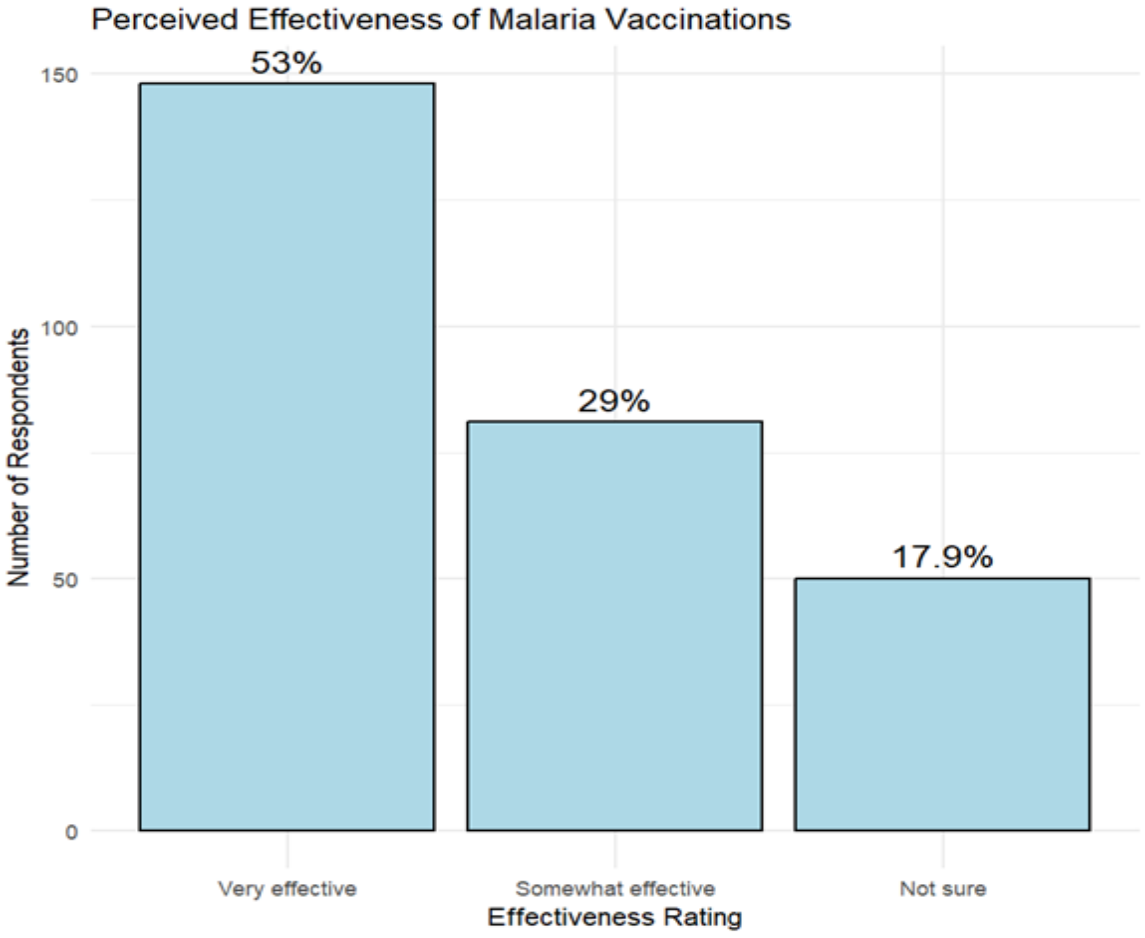


Figure 9: The Effectiveness of Vaccines

4.3.6 The Efficacy of Larva Source Control

Another significant community-based and climate-resilient approach that is used in the fight against malaria is larval source management (LSM), which seeks to eliminate breeding grounds for mosquitoes. The findings from the study provide significant insight into the community's perception of Larval Source Management (LSM) as a malaria control strategy in Busia County, with a notable 63.0% of respondents indicating that LSM is "somewhat effective." This outcome highlights the general understanding that LSM interventions, which focus on eliminating mosquito breeding sites, have a positive impact on reducing malaria transmission, though some factors, such as challenges in consistently identifying and treating all larval habitats may limit their full potential. The task of controlling these sources involves environmental manipulation, biological control agents, and chemical larvicides, with the result being influenced by constant monitoring and early interventions.

18.9% of participants rated LSM as "very effective," indicating that a portion of the population considers this strategy as highly effective in controlling malaria by targeting the root cause of mosquito larvae. These participants recognize the value of well-coordinated and frequent larval management efforts, including environmental modification and chemical treatments. 17.9% of participants considered LSM to be "not effective," showing that certain challenges may hinder the success of this intervention. These challenges could include the difficulty of sustaining community engagement, inadequate resources to consistently implement LSM measures, or environmental factors such as rainfall patterns and land use that promote persistent mosquito breeding. The impact of LSM varies depending on the level of participation and awareness of the communities as well as resource and technical constraints. To make LSM sustainable and effective, *Chiuya et al. (2022); Nabwire (2019)* argue that there must be a strong foundation, active participation of the communities, and contingency measures that can fit well in environmental changes caused by climate change. The mixed responses have highlighted the need to regularly review and improve LSM practices to make them robust and effective in different climatic conditions.

Overall, 81.9% of respondents (those who rated LSM as "somewhat effective" or "very effective") recognized the effectiveness of this method, demonstrating substantial community acceptance of its implementation in malaria prevention. These findings emphasize the need of enhancing LSM practices and overcoming implementation difficulties for malaria control efforts in climate-vulnerable areas such as Busia County.

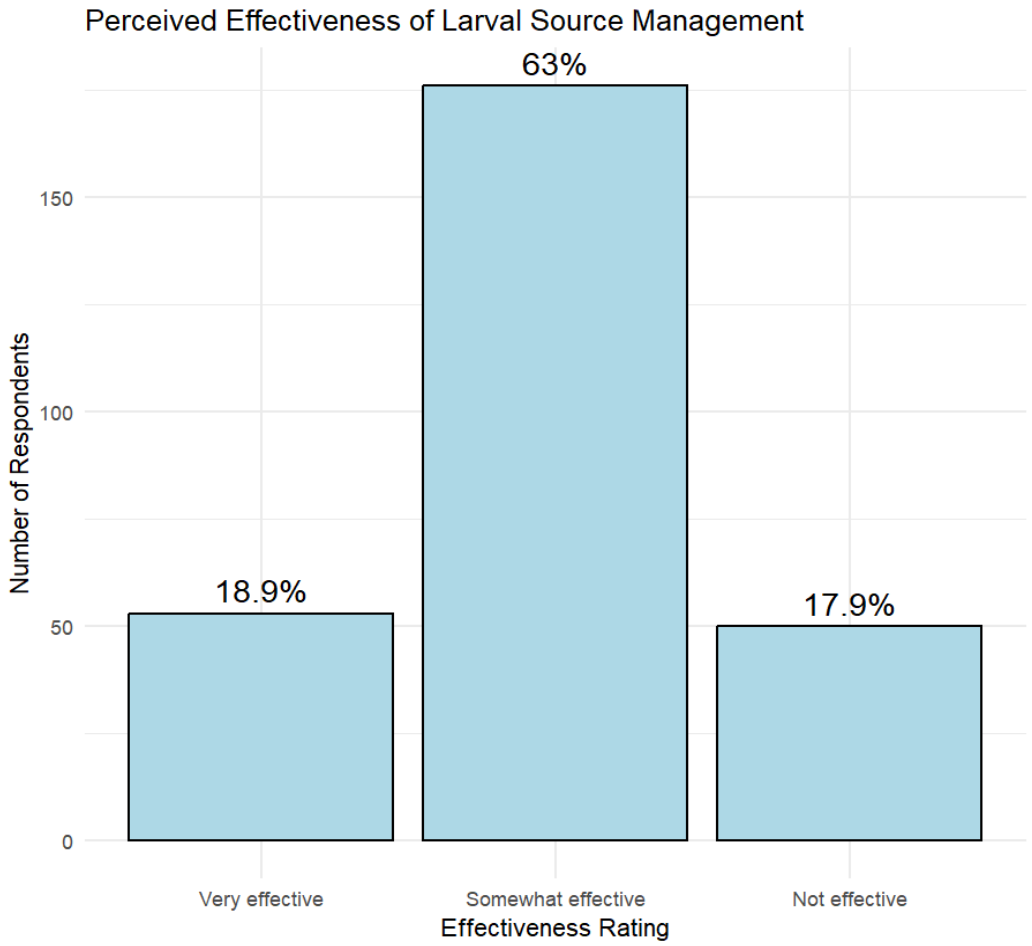


Figure 10: Effectiveness of Larva Source Management

4.3.7 A Comparative Analysis

A comparison of the six community-based and climate-resilient malaria interventions; the IRS, public education campaigns, RDTs and antimalarial, vaccinations, the distribution of long-lasting insecticidal-treated mosquito nets and larval source control, showed that RDTs and antimalarial, distribution of mosquito nets and vaccinations were the most effective community-based, and climate resilient malaria control strategies used in Busia County. Similar findings were stressed in the studies by *Kinyatta et al. (2023)*; *Chiuya et al. (2022); Nabwire (2019); Nalinya et al. (2022)*; *Barker et al. (2023)*, which concluded that the distribution of long-lasting insecticidal-treated mosquito nets, RDTs and antimalarial, and vaccinations were the most effective community-based and climate resilient malaria control strategies.

Based on the study results, 100% of respondents perceived mosquito nets and RDTs as either "very effective" or "somewhat effective" climate-resilient and community-based malaria control interventions. This commonly observed acceptance highlights the important role these strategies play in malaria prevention, with mosquito nets offering personal protection from mosquito bites and RDTs enabling timely and accurate diagnosis, which is essential for the treatment and control of malaria transmission. Despite being a relatively new intervention in malaria control, 82% of respondents rated malaria vaccinations as effective, indicating growing support for this emerging intervention. Vaccination programs have the potential to supplement existing strategies by providing long-term immunity and reducing reliance on traditional methods, and the combined effectiveness results highlight the role of vaccinations as a key preventive measure.

For Indoor Residual Spraying (IRS), 63% of respondents rated it as "somewhat effective," while 18.9% considered it "very effective." This indicates that IRS, although useful in malaria control, may be affected by changing climatic conditions, such as inconsistent rainfall and increasing temperatures, which can reduce the efficacy of insecticides over time. IRS remains important but may require more targeted implementation in response to environmental challenges. The results also show that Rapid Diagnostic Tests (RDTs) and antimalarial treatments are considered "very effective" by 70.3% of respondents. These findings reflect the community's confidence in these measures for timely diagnosis and prompt treatment, which are important for reducing the impact of malaria

Similarly, 53% of respondents claimed vaccines were "very effective" in managing malaria. This high percentage indicates confidence in the vaccines' ability to play an important role in malaria control, particularly in places vulnerable to climate change. Public education campaigns and other mass communication activities were given a 22.5% “very effective”, indicating relatively low efficacy in increasing awareness and advocating malaria management methods. While significant, the efficacy of these treatments falls short of physical preventative measures such as mosquito nets, which were considered "very effective" by 28% and "somewhat effective" by 72% of respondents. Overall, the data show the community's dependence on mosquito nets, RDTs, antimalarial medications, and vaccinations as the most effective malaria interventions in Busia County. This study also shows that climatic conditions can impact the success of specific interventions, such as IRS, emphasizing the need of climate-resilient techniques in malaria control.

4.4 The Obstacles Preventing the Implementation of Community-Based Interventions

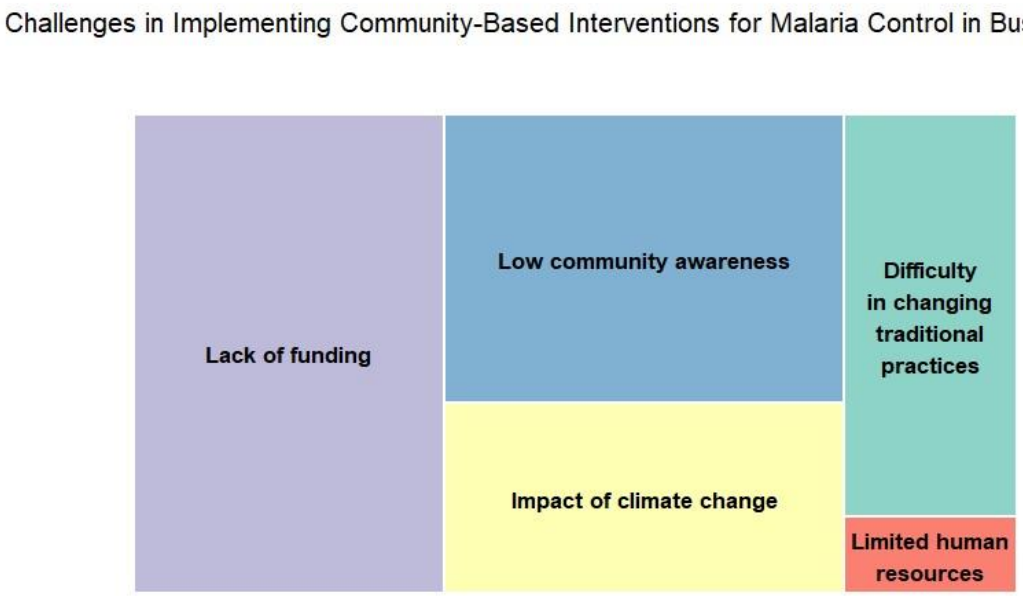


Figure 11: Challenges in Implementing Community-Based and Climate-Resilient Malaria Control Interventions

Formulating, adopting, and implementing community-based interventions for climate-resilient malaria control in Busia County was found to be faced with many challenges. As shown in ***Figure 11***, the lack of funds stood out as one of the major challenges as a lot of respondents highlighted it as a major barrier to implementing and sustaining malaria control interventions. These results further highlighted its significance as a barrier to malaria control. The key issue to address is the lack of funds needed to purchase required resources like mosquito nets and insecticides, as well as for training and paying healthcare workers. As explained by *Mumtaz et al. (2023)*, the lack of financial resources makes it difficult to ensure that the interventions are long-term and sustainable which is an important factor in fighting malaria due to constant climatic change.

The collected data revealed another major challenge, a lack of community awareness, which many respondents expressed as a major concern. Community awareness is critical to malaria control efforts because it provides individuals with information about preventative measures, symptoms, and treatment options (*Nalinya et al., 2022).* Without sufficient understanding, communities may fail to utilise important malaria control methods, such as insecticide-treated mosquito nets, or refuse to engage in initiatives such as Indoor Residual Spraying (IRS). This highlights the need for extensive and effective public education initiatives that raise awareness and encourage widespread community participation in malaria control programs. A more thorough and well-structured communication approach is critical for increasing community knowledge and commitment to malaria prevention activities.

The other significant challenge was the problem of exchanging the old ways of doing things. It is sometimes difficult for the community to let go of traditional customs and beliefs to effectively combine these with modern knowledge; this can lead to non-compliance regarding malaria control, as explained by *Nissan et al. (2021).* This aspect implies that overcoming this challenge requires culturally acceptable strategies that accommodate local practices within evidence-based health practices. A valuable resource is the inclusion of community leaders and the use of communication channels that are culturally accepted to bridge the gap between traditional practices and modern interventions.

The last reason for the climate-resilient and community-based malaria control challenge was influenced by climate change in Busia County. Respondents identified issues such as temperature changes that arise from global warming affect the habitat and behaviour of mosquitoes and hence reduce the predictability and control of malaria. Climate change and natural disasters such as floods were found to have significant implications on the process of intervention implementation due to poor infrastructure. As explained by *Kinyatta et al. (2023)* this means that only adaptive strategies that can withstand climatic changes need to be employed in such environmentally fluctuating zones. As a result, increased funding mechanisms, diversifying control mechanisms as well as constant monitoring and evaluation need to be prioritized to effectively respond to the current emerging challenges of malaria control in Busia County.

4.5 Interventions to be Prioritized in the Implementation of Community-Based and Climate-Resilient Malaria Control Strategies in Busia County

The findings of the survey reveal several CBIs that are targeted to support the implementation of optimal and climate-resilient malaria control measures in Busia County. ***Figure 12*** shows that LLINs are significant because they operate as a barrier, preventing mosquitoes from biting people and thereby minimizing malaria transmission. They are popular because of their effectiveness, particularly in locations where climatic changes induce increased mosquito reproduction, making them an effective tool in the battle against malaria (Nalinya et al., 2022). This response was frequently given, showing that the community appreciates the use of LLINs in reducing the risks of malaria.

Another important intervention identified by respondents is the enhancement of early warning for climatically-sensitive malaria epidemics. These systems are useful in predicting and preventing malaria incidences that are associated with climate variations, such as changes in precipitation and temperatures. These systems help to prevent malaria outbreaks from worsening due to the integration of climate data into malaria control planning. Finally, the respondents noted the importance of the proactive approach in integrating climate information into malaria control planning and resource allocation. This can be done by using climate predictions to determine where to allocate resources and which control measures to apply to safeguard the community against increased malaria risks due to climate change (Nissan et al., 2021). Collectively, these measures show the need to integrate climate preparedness into malaria prevention measures to guarantee that interventions are climate-resilient.

Figure 12: Interventions to be Prioritized

Chapter 5: Discussions

5.1 Introduction

This is the last chapter of this research and provides overall insights gained from the collected and critically analyzed quantitative data. Specifically, this chapter presents the overall discussions gained by the primary objectives, provides main conclusions, and issues recommendations that should be adopted by Busia County to enhance community-based and climate-resilient malaria control.

5.2 Discussions

The primary objective of this research was to provide an overview of the effectiveness of community-based interventions for malaria control in Busia County and identify contextual factors, such as climate change, that influence the control strategies. Analysis of the collected quantitive data using R-Studio, respectively, showed that the age span of the participants in the study was 18-55 years, with the average age being 31 years. The sample was nearly equal to reflect male and female inputs that are an important feature of public health interventions. The results further highlight that malaria prevention efforts are not limited to vaccinations but are also carried out through ITN, IRS, public education, rapid diagnostic tests, and antimalarial treatment.

The age composition of participants entailed young to middle-aged adults, who are one of the groups of people that can be targeted for prevention and control of malaria. Youth populations may have been higher due to mobility and exposure issues compared to the older population. This category of participants was also vital in the communication of information and practices in society. This approach contributed to solutions that were more inclusive and receptive to the diverse needs of men and women. By targeting gender-specific health behaviours, the interventions considered how gender roles and duties affect both malaria risk and access to control measures and treatment. Previous studies showed that gender norms and obligations, such as women's caregiving tasks or men's working outdoors for long hours might influence mosquito exposure and the adoption of preventative measures such as bed nets or involvement in health programs. Addressing these variables is critical to building more inclusive and successful malaria control programs. (*Olela et al., 2024; Aongola et al., 2022)*. The inclusion of an equal number of both genders in this study also forms a strong foundation for gender-oriented malaria control interventions.

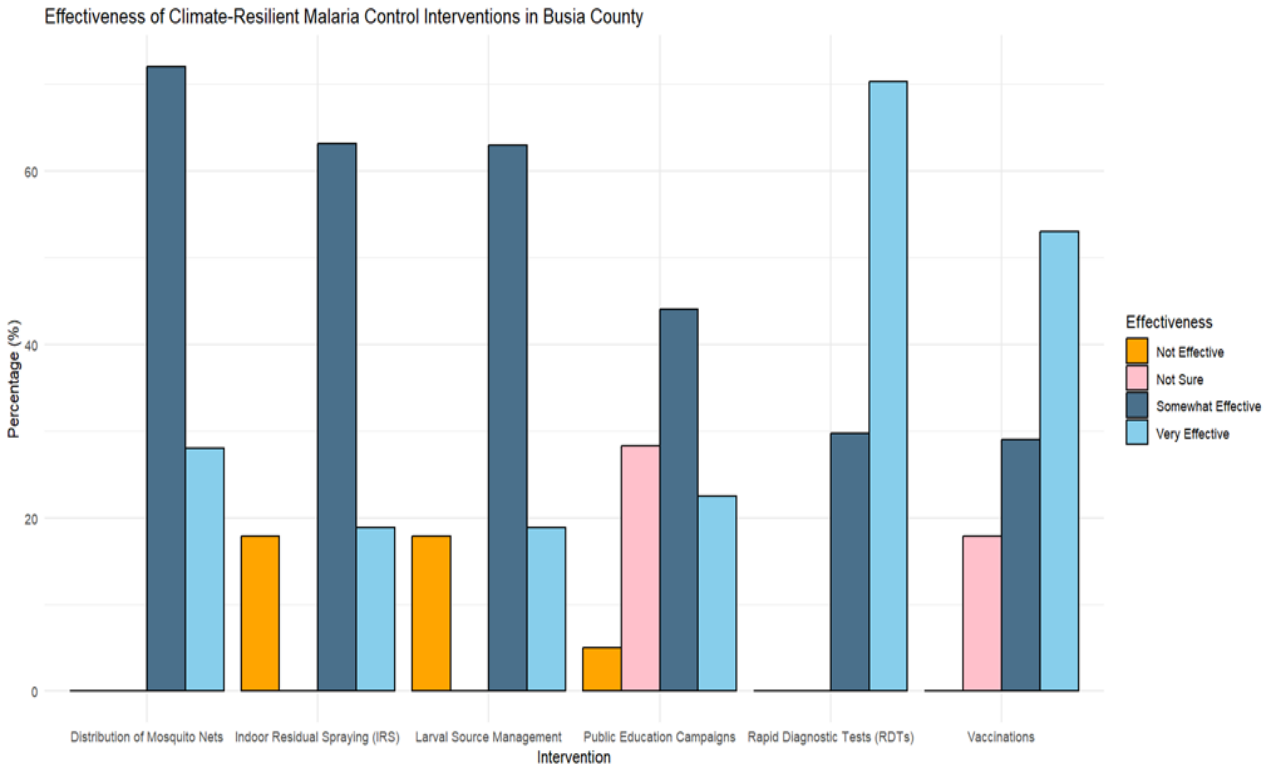


Figure 13: Scope of the Effectiveness of Climate Resilient Malaria Control Interventions

As seen in ***Figure 13,*** it is important to note that community-based interventions in Busia County focus on comprehensive malaria control-based control with much emphasis placed on vaccination, mosquito management, RDTs and antimalarial, education of the masses, and other public health interventions. At the core of these efforts are vaccinations, including the RTS and S/AS01 malaria vaccines. Efficacy against malaria has been demonstrated in the most vulnerable populations, including young children and pregnant women who are at substantial risk for severe disease and death (*Nalinya et al., 2022; Chutiyami et al., 2024*; *Mumtaz et al., 2023)*. By integrating vaccination schedules into general health programs, Busia County hopes to facilitate overall population immunity and decrease malaria prevalence. Such vaccination initiatives are vital in offering long-term protection, especially alongside other short-term preventive interventions.

The application of ITNs and IRS has a significant role in the integrated strategy of malaria control. ITNs offer a physical vector barrier during sleep that essentially eliminates bites and, consequently, malaria transmission. It is proven that using ITNs is an effective way to reduce

malaria morbidity and mortality (*Nalinya et al., 2022; Chutiyami et al., 2024*; *Mumtaz et al., 2023)*. Also, the IRS entails spraying insecticides on the inside walls to eliminate the mosquitoes that may land on the treated areas. It is also ideal in minimizing the indoor mosquito population so this method is effective in controlling the spread of malaria within households. ITNs and IRS act as the pillars of vector control, supporting the WHO Framework on integrated malaria management (IMM) (*WHO, 2022*). These interventions, combined with effective public awareness and community involvement, are helpful in the fight against malaria and in building community-wide health and life competency.

Climate change has a considerable effect on malaria control in Busia County, and 43.7% of the respondents cited this challenge as the main obstacle in malaria control. Indeed, climatic changes have a significant impact on malaria control in Busia County, with 81.4% of the respondents stating that climate change affected the prevalence of Malaria in Busia County. Similar to the studys by *Nissan et al. (2021); Nyawanda et al. (2023)*; *Ofulla et al. (2020)*; *Ototo et al. (2022)*, altered climatic conditions like increased rainfall levels and high temperatures provide ideal breeding grounds for mosquitoes, thus increasing the spread of malaria. Mosquitoes can develop and breed faster in wet and hot weather due to the presence of stagnant water bodies.

Such climatic changes make it difficult to forecast the occurrence of mosquitoes and thus to control the mosquito population (*Nissan et al., 2021*; *Nyawanda et al., 202)*; *Ofulla et al., 2020*; *Ototo et al., 2022)*. In effect, communities must also intensify their surveillance and mosquito control interventions by adopting more dynamic and adaptive activities to address these changes in the environment.

Also, 17.9% of respondents indicated reduced effectiveness of IRS insecticides used in the control of malaria vectors. *Leal Filho et al. (2023); Ototo et al. (2022)* state that climate change influences the residual effectiveness of insecticides through increased temperatures and humidity as the chemical compound of insecticides can be broken down at a faster rate. *Nissan et al. (2021)* add that this degradation reduces the longevity and effectiveness of IRS treatments and requires more frequency of applications and the development of new, more durable IRS formulations. Making these adjustments is very costly and logistically demanding and further strains malaria control programs. These issues must be addressed through further research and the development of more sustainable control methods that can withstand climatic changes to continue to protect

against malaria (*Leal Filho et al., 2023)*. These changes are necessary for coping with the impact of climate change on the IRS and other vector control interventions.

The high score for mosquito net effectiveness from all the respondents indicated that the nets are important in the implementation of community-based and climate-resilient malaria control interventions in Busia County. There is ample evidence that the use of mosquito nets, especially insecticide-treated nets (ITNs), is an effective intervention against mosquitoes that can bite during sleep when malaria transmission is most likely to occur (*Olela et al., 2024; Chutiyami et al., 2024)*. The universal consultation towards this intervention also indicates that this intervention is popular and acceptable in society. This effectiveness is supported by several studies demonstrating the reduction of malaria cases in areas where ITN coverage is high (*Olela et al., 2024; Chutiyami et al., 2024)*. Universal distribution and use of mosquito nets are crucial elements of any malaria intervention and provide direct, tangible benefits to people and households and contribute to the overall malaria control impact.

Public education campaigns are generally regarded as favourable; however, only 22.5% of respondents vouched for the adoption of this community-based and climate-resilient intervention approach. This uncertainty implies that although educational initiatives are important for educating and involving the community in the process, there are inconsistencies in the delivery and reach (*Aongola et al., 2022*; *Oladipo et al., 2022*). Mass education is crucial for spreading awareness about malaria-preventing behaviours, symptoms, and the necessity for early treatment. Such a variety of mixed perceptions reflects that these campaigns should be further enhanced and strengthened, possibly by using culturally appropriate media and effective communication methods to target all parts of the population (*Aongola et al., 2022*; *Oladipo et al., 2022)*. It was established from the research that involving the community, and the use of local leaders in these campaigns would enhance their impact so that the entire community receives the right information that would lead to increased adoption of preventive measures and behavior change.

The major challenges identified that hinder the formulation, adoption, and implementation of community-based and climate-resilient malaria control interventions include lack of funding, inadequate community awareness, and the challenge of changing old habits. Respondents mentioned a lack of funds, pointing to the current financial limitations in supporting malaria control programs. Malaria control is largely dependent on supplies, personnel, and community

engagement, which needs to be sustained *(Olela et al., 2024)*. Lack of funds hinders the implementation of the required interventions. Other challenges, such as lack of awareness, hinder the uptake of preventive strategies, thus the need to scale up educational and communication efforts *(Olela et al., 2024)*. These challenges need to be considered to enhance the successful implementation of community-based and climate-resilient malaria control approaches in Busia County.

5.3 Limitations of the Study

The limitations of this study on the effectiveness of community-based interventions for climate-resilient malaria control in Busia County, Kenya, include several aspects that may impact the overall reliability and validity of the findings. First, the use of purposive sampling, which targets community health volunteers, public health officers and other health workers, may create selection bias, limiting the ability to generalize the findings. The use of structured questionnaires for data collecting may result in response bias caused by self-reporting, reducing the accuracy of the data collected. The study's cross-sectional design limits its capacity to evaluate changes in malaria control efficacy over time, something a longitudinal approach may address more effectively.

Climate variability additionally creates an obstacle since the unpredictability of climate change hinders the assessment of its direct influence on malaria control initiatives. Time and budget restrictions limited the extent of data collection, decreasing the potential of expanding the study to include new constituencies or conducting qualitative interviews for deeper insight. The limited availability of localized climatic data made it difficult to analyze the precise impacts of climate change on malaria transmission. Addressing these limitations in future research may strengthen the findings and help to better understand the climate-resilient malaria control interventions.

Chapter 6: Conclusion and Recommendations

6.1 Conclusion

In summary, the study concluded that adopting approaches such as the distribution of treated mosquito nets, IRS, public education campaigns, RDTs and antimalarial, and vaccinations is crucial in fostering climate-resilience and community-based malaria control in Busia County. The considerations and incorporation of these strategies in this county have been affected by various challenges. Specifically, the identified community-based and climate-resilient malaria control strategies, such as the production or procurement and distribution of treated mosquito nets, IRS, RDTs, and vaccinations, were found to be only effective in areas where there are enough funds. Notably, enhanced funding fosters the elimination or countering of other obstacles such as climatic changes, difficulty in changing traditional practices, limited human resources, and low community awareness. From the study results, it is evident that managing malaria is challenging, especially in the face of climate change and similar challenges many people in Busia County encounter. The eradication of malaria requires multiple interventions, including vaccinations, control of mosquitoes, information campaigns, and enhancing adaptive capacity to climate change. Addressing the outlined challenges and engaging the communities' policy-makers and health practitioners can help improve the adaptability and efficiency of malaria prevention strategies. Long-term financial support, long-term education, and management by taking adaptive approaches play an important role in achieving effective malaria prevention in changing environments. It was established that communities living across the eight sub-counties of Busia County need to be educated on the health risks associated with malaria, the importance of adopting efficient interventional approaches that can accommodate changes in climatic conditions, and the need to enhance community participation. The dynamic nature of malaria transmission calls for adaptive management strategies combined with continuous surveillance in the face of climate change. Regardless of these factors, effective malaria control in Busia County requires the adoption of the distribution of mosquito nets, IRS, RDTs and antimalarial, and vaccinations, which were found to be the most effective community-based and climate-resilient interventional approaches.

6.2 Recommendations

The findings, analysis, and conclusion of this research provide several recommendations that should be adopted to register improved community-based and climate-resilient malaria control in Busia County. First, increased funding proves to be significant in sustaining community-based and climate-resilient interventions. This may include actively seeking increased financing from international donors and foreign aid organizations, as well as incorporating malaria control measures into larger health and development programs. Implementing such a plan will considerably enhance malaria control in Busia County by allowing for the successful implementation of key interventions such as the distribution of insecticide-treated mosquito nets, IRS, RDTs and antimalarial medicines, and vaccines. Busia County would be well-positioned to achieve significant reductions in malaria infection rates by allocating enough resources and combining malaria prevention programs with other health initiatives.

Secondly, public awareness and educational campaigns should be improved and encouraged to ensure the active participation of all community members, thus creating a united front that is much more focused on implementing community-based and climate-resilient interventional approaches. These campaigns should be culturally appropriate and use local leaders, local media and local languages to reach a wider range of people. These public awareness and educational campaigns will ensure that the community is actively engaged in malaria control initiatives. Engaging the traditional authority and using the ‘‘heard’ forms of health interventions will help promote participation in education and awareness campaigns. This approach will ensure that the formulated climate-resilient and community-based approaches are tailored to specific community needs across Busia County.

Further studies should focus on analyzing the existing data to provide profound effectiveness of community-based and climate-resilient approaches that can be adopted to control malaria across Kenya, East Africa, Africa, and globally. Further research focuses on assessing the effectiveness of the distribution of long-lasting insecticidal-treated mosquito nets, IRS, public education campaigns, RDTs and antimalarial, and vaccinations in community-based and climate-resilient malaria control in other parts of the globe. This analysis will be vital in providing literature that will assess the impacts of climate change on malaria transmission and control efforts.

Particular attention should be given to assessing the effectiveness of incorporating innovative technologies into the identified malaria control interventions to enhance control. Additionally, future research should assess the effectiveness of new trials of malaria control, such as the use of CRISPR/Cas sperm editing to control the breeding of malaria-causing mosquitos as a vital climate-resilient and community-based malaria control strategy. Executing these studies will be vital in ensuring the availability of enough literature that will guide the control of malaria using community-based and climate-resilient interventions.

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Appendix

Appendix A: The Work Plan

Activity	Timeframe			
	June	July	August	September
Research topic formulation and approval				
Formulation of research objectives and questions (Writing the concept paper)				
Literature Review				
Writing the research proposal				
Execution of the Research (Data collection, Presentation, Analysis)				
Report writing				
Presenting the reports for review and editing				
Final submission				

Appendix B: The Consent Form

Respondent's Declaration.

Greetings to everyone. I am Mercy Monden, a Master of Public Health (MPH) student at Hamburg University of Applied Sciences in Germany. As part of my course curriculum, I am conducting a research project. The survey analyses the effectiveness of community-based interventions for climate-resilient malaria control in Busia County, Kenya.

No personal data will be collected from you as part of this survey. All data collected is anonymized so that no conclusions can be drawn about your personal information. The anonymous data will be used for the preparation of a scientific publication. Until the end of the survey, you have the option of terminating it at any time without any disadvantage and requesting the deletion of the data already collected by the leading researcher. Once the survey has been completed, it is no longer possible to the person. It is therefore no longer possible to delete the data after the survey has been completed.

Your data will be processed in compliance with the currently applicable data protection regulations of the University of Applied Sciences (https://www.haw-hamburg.de/datenschutz/), treated confidentially and evaluated exclusively by the responsible Research and Transfer Center for Sustainability and Climate Impact Management at HAW Hamburg. The data collected will not be passed on to third parties and will be used exclusively for the above-mentioned purpose.

I have been fully informed about the nature of the study, I know the benefits, and I understand that there are no risks involved. I hereby give my consent to participate in this study.

Signature of participant……. Date…….

Researcher's Declaration.

I have fully disclosed all the relevant information concerning this study to the study respondent.

Signature of researcher ……. Date……

Appendix C: The Questionnaire

Preamble

Thank you for participating in this study, which seeks to analyze the effectiveness of community-based interventions for climate-resilient malaria control in Busia County, Kenya. This questionnaire aims to gather information from various stakeholders, including residents of Busia and those directly or indirectly involved in malaria control efforts. Your responses will be anonymous and will be used solely for research purposes.

Instructions

Please read each question carefully and select *(✓)* the answer that best reflects your experience or knowledge. If you have any questions, please do not hesitate to ask.

Section 1: Demographic Information

1. **Are you a resident of Busia County?**
   - Yes []
   - No []
2. **How old are you? (*Tick (✓) where appropriate*))**

Age	Response
18-25	
26-35	
36-45	
46-55	
56 and above	
Prefer not to say	

3. **What is your gender**
- Male []
- Female []
- Other []
4. **What is your occupation?**
- Not any []
- Farmer []
- Healthcare worker []
- Community health worker []
- Worker involved in malaria control programs in Busia County (Specify program)
- Student []
- Other (please specify)

5. How long have you stayed in Busia County? **(*Tick (✓) where appropriate*)**

Less than 1 year	More than 2 Years	1-5 years	5-10 years	More than 10 years

Section 2: Community-Based Interventions for Malaria Control

6. In your experience, what are the most common community-based interventions used to prevent Malaria in Busia County? (Select all that apply)

Method	**Level of Usage (*Tick (✓) where appropriate)***
Distribution of mosquito nets	
Indoor residual spraying (IRS)	
Larval source management	
Public education campaigns	
Medications Social Mobilization Activities such as clean-up drives)	
Vaccinations	
Rapid Diagnostic Tests (RDTs) and Antimalarial treatments	

7. How effective do you believe these interventions are in preventing Malaria?

Community-Based Malaria Control Intervention	**Effectiveness (*Tick (✓) where appropriate)***		
	Very Effective	Somewhat Effective	Not Very Effective
Distribution of mosquito nets			
Indoor residual spraying (IRS)			
Larval source management			
Public education campaigns			
Medications Social Mobilization Activities such as clean-up drives)			
Vaccinations			
Rapid Diagnostic Tests (RDTs) and Antimalarial treatments			

8. **How frequently are these interventions implemented in your homes, villages, or communities?**

Community-Based Malaria Control Intervention	**The frequency of utilization (*Tick (✓) where appropriate)***				
	Daily	**Weekly**	**Monthly**	**Occasionally**	**Not sure**
Distribution of mosquito nets					
Indoor residual spraying (IRS)					
Public education campaigns					
Vaccinations					
Rapid Diagnostic Tests (RDTs) and Antimalarial Treatments					
Traditional medicine practices					

9. **Have you noticed any changes in the effectiveness of these interventions over time? If yes, please explain.**

Yes [] (Please explain)

- ……
- ……

No []

Section 3: The Impact of Climate Change on Community-Based Malaria Control Interventions

10. **In your opinion, how has climate change affected the prevalence of Malaria in Busia County?**

The impact of climate change on malaria prevalence	***Tick (✓) where appropriate***
Increased significantly	
Increased slightly	
No change	
Decreased slightly	
Decreased significantly	

11. How does climate change affect the implementation of community-based interventions for malaria control? (Select all that apply)

Tick (✓) where appropriate	
Makes it more difficult to control mosquito breeding	
Reduces the effectiveness of insecticides used in the IRS	
Damages mosquito nets Limits community participation in interventions	
Other (Please specify)	

12. Do you think climate change needs to be considered when designing malaria control interventions in Busia County?

- Yes [] Justify ……
- No [] Justify…….
- Unsure []

Section 4: Effectiveness of Community-Based Interventions for Climate-Resilient Malaria Control in Busia County

13. How effective do you think the current community-based interventions can be in withstanding all climatic conditions to counter the spread of Malaria in Busia County?

Community-Based Malaria Control Intervention	**The level of effectiveness (*Tick (✓) where appropriate)***			
	Very effective	Somewhat effective	Not effective	Not sure
Distribution of treated mosquito nets				
Indoor residual spraying (IRS)				
Larval source management				
Public education campaigns				
Medications Social Mobilization Activities such as clean-up drives)				
Vaccinations				
Rapid Diagnostic Tests (RDTs) and Antimalarial Treatment				

14. What factors do you think contribute to the effectiveness or ineffectiveness of these interventions?

- …….

- ……..
- ……..

15. What are the biggest challenges do you think hinder the implementation of community-based interventions for climate-resilient malaria control in Busia County? (Select all that apply)

- Lack of funding []
- Limited human resources []
- Low community awareness []
- Difficulty in changing traditional practices []
- Impact of climate change []
- Other (Please specify) …….

16. What interventions do you think should be prioritized to ensure the implementation of community-based and climate-resilient malaria control strategies in Busia County? (Select all that apply)

Intervention	**Response (*Tick (✓) where appropriate)***
Strengthening early warning systems for climate-sensitive malaria outbreaks	
Promoting the use of long-lasting insecticidal nets (LLINs) treated with insecticides	
Enhancing larval source management through community participation in cleaning up breeding sites and promoting environmentally friendly mosquito control methods	
Integrating climate information into malaria control planning and resource allocation	
Investing in research and development of new climate-resilient malaria control tools	
Promoting behavior change communication campaigns that address climate-related risk factors for Malaria.	
Building the capacity of local health workers to implement climate-resilient malaria control strategies	
Enhancing collaboration between health and other sectors (e.g., water, sanitation, agriculture) to address the underlying determinants of malaria risk	
Other (Please specify) …….	

17. What other recommendations would you make to improve the effectiveness of community-based interventions for climate-resilient malaria control in Busia County?

- ……
- ……
- ……

-The End-

Thank you for your participation!