TRENDS, PREVALENCE AND ASSOCIATED RISK FACTORS OF MALARIA INFECTION IN DALE DISTRICTS OF SIDAMA REGION, ETHIOPIA

MSc THESIS IN BIOMEDICAL SCIENCE

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COLLAGE OF NATURAL AND COMPUTATIONAL SCIENCES

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TRENDS, PREVALENCE AND ASSOCIATED RISK FACTORS OF MALARIA INFECTION IN DALE DISTRICTS OF SIDAMA REGION, ETHIOPIA

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HAWASSA, ETHIOPIA

DECLARATION

I hereby declare that this MSc thesis is entitled **'Trends, Prevalence and Associated Risk Factors of Malaria Infection in Dale Districts of Sidama Region, Ethiopia** is my original work and has not been presented for a degree in any other university, and all source of materials used for the thesis have been appropriately acknowledged.

Name: **Tigist Yonas**

Signature: ______________________

ADVISORS' APPROVAL SHEET

This is to certify that the thesis entitled '**Trends, Prevalence and Associated Risk Factors of Malaria Infection in Dale Districts of Sidama Region, Ethiopia** submitted in partial fulfillment of the requirements for the degree of Master of Science Degree in Biomedical Science, and carried out by **Tigist Yonas,** under our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department for defense.

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We, the undersigned, members of the Board of Examiners of the final open defense by **Tigist Yonas,** have read and evaluated her thesis entitled **'Trends, Prevalence and Associated Risk Factors of Malaria Infection in Dale Districts of Sidama Region, Ethiopia** and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science in Biomedical Science.

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Acronyms/Abbreviations

MoH - Ministry of Health

ITNs - Insecticide-Treated Nets

LLINs - Long-Lasting Insecticidal Nets

IRS - Indoor Residual Spraying

RDTs - Rapid Diagnostic Tests

Pf - Plasmodium falciparum

Pv - Plasmodium vivax

PCR - Polymerase Chain Reaction

SPSS - Statistical Package for the Social Sciences

OR - Odds Ratio

CI - Confidence Interval

B - Regression Coefficient

P - p-value

EDHS - Ethiopian Demographic and Health Survey

NMCP - National Malaria Control Program

Abstract

Malaria is one of the leading causes of morbidity and mortality in tropical and sub-tropical regions. The bulk of global malaria burden is in Sub Saharan African countries including Ethiopia. Despite global efforts to combat malaria, the disease's prevalence and transmission dynamics vary across regions, influenced by socio-economic, environmental, and climatic factors. This study aims to assess the prevalence, trends, and associated risk factors of malaria infection in the Dale Districts of the Sidama Region, Ethiopia. By examining both previous prevalence data from 2018 to 2022 and assessing active malaria cases in 2023, this research provides a comprehensive understanding of malaria dynamics in the region. Data on malaria trends over five years were obtained from the malaria laboratory registry books of local health facilities. For active malaria cases, a cross-sectional survey was conducted involving adults with febrile symptoms from selected villages. The study employed both microscopic blood analysis and structured questionnaires to assess malaria prevalence and respondents' knowledge of the disease.The finding of this study indicate that, from 2018 to 2022, a total of 129,613 suspected malaria cases were recorded, with 15,030 testing positive, yielding an overall positivity rate of 11.60%. Plasmodium falciparum was the dominant parasite, accounting for 76.80% of cases. Gender analysis revealed higher incidence rates among males (54.76%), while age-specific analysis showed the highest incidence in young adults aged 15-29 years which is (24.76%). Seasonal trends indicated a peak in malaria cases between September and November. Statistical analysis using Negative Binomial regression highlighted significant factors influencing malaria prevalence, including seasonality and age. For the cross sectional study the, prevalence of malaria among 381 respondents, females exhibited higher malaria prevalence (16.38%) compared to males (9.51%). The highest prevalence was observed in individuals over 50 years old (22.00%). Logistic regression identified significant associations with the use of mosquito nets, anti-malaria spraying, and the presence of stagnant water in the surrounding . In the study area both plasmodium falciparum and plasmodium vivax co-exist with the dominance of Plasmodium falciparu, in malaria cases underscores the need for targeted interventions against this species. The findings recommend targeted interventions focusing on high-risk groups, enhanced healthcare access, and community engagements are crucial for effective malaria control in the Dale Districts.

Key Words*:* malaria control, malaria prevalence, risk factor, Sidama Region, trend analysis

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Malaria is an infectious disease caused by parasites of the Plasmodium genus(Collins et al., 2007; Talapko et al., 2019). It mostly spread to humans through the bites of infected female Anopheles mosquitoes (Sato, 2021; Tuteja, 2007). The World Health Organization's [WHO] statistical report shows it as a severe health problem for the human population globally. The survey reveals that a child dies from malaria every two minutes, and more than 200 million new cases occur each year(WHO, 2020a, 2020b). In 2022 alone, an estimated 249 million cases of malaria were recorded globally, leading to almost 610,000 deaths(Mboussou et al., 2024). The WHO African Region continues to carry a disproportionately large part of the global malaria burden, accounting for around 94% of all malaria cases and 95% of malaria-related fatalities globally(Monroe et al., 2022).

In addition to the loss of life, malaria also causes huge economic consequences internationally. The expenditures connected with controlling this parasitic disease consume enormous resources that may otherwise be used for economic development. For instance, in 2016 alone, nearly USD 2.7 billion was committed to worldwide malaria eradication efforts. This not only impedes development successes but also reduces cultural resilience and generates economic crises, particularly in less developed nations (WHO, 2020b; Talapko et al., 2019).

Furthermore, recent studies show that malaria is endemic in 76 countries throughout the world. In response, several countries have launched control programs at various levels, achieving considerable results by lowering total incidence and fatality rates (Mboussou et al., 2024; Monroe et al., 2022; WHO, 2020b). Ethiopia, as one of these malaria-endemic country has advanced one of the biggest and most sophisticated malaria control initiatives in Africa. This effort is designed to aid the country’s Health Sector Development Plan (HSDP), the National Strategic Plan (NSP), and the national child survival plan, with the purpose of lowering death rates by two-thirds by 2015 (WHO, 2020b). The National Data Management Center for Health

(NDMC) reported in 2019 a surprising reduction in the malaria burden in Ethiopia (Sahile et al., 2022).

However, despite these improvements, various studies have stressed the persistent public health concern of malaria in Ethiopia at both national and subnational levels (WHO, 2023; Tessema et al., 2023). For instance, retrospective studies done in northeastern Ethiopia from 2015 to 2020 found that malaria remains a severe problem and fluctuates between the years (Sahile et al., 2022) . Similarly, studies done in southwestern Ethiopia between 2010 and 2015 demonstrated stable and variable malaria transmission patterns (Misganaw et al., 2017). Another study focused on the highland areas of Ethiopia from 2011 to 2016 indicated that malaria continues to be a severe health problem, with incidence rates varying depending on seasonal and climatic circumstances (Sahile et al., 2022). A systematic study and meta-analysis of malaria prevalence among adults in Ethiopia, done from 2000 to 2016, showed malaria as a leading cause of illness and mortality, causing substantial public health and economic challenges (Misganaw et al., 2017). The varied and seasonal pattern of malaria transmission, the poor protective immunity of the population, and the risk of infection and morbidity across all age groups are severe concerns in Ethiopia (Gebretsadik et al., 2018).

Studies further reveal that malaria is present in over 75% of the country's land, with 68% of the entire population at risk in Ethiopia. The condition accounts for around 12% of outpatient visits and 10% of hospitalizations at health institutions, making it the biggest cause of morbidity (Gebretsadik et al., 2018; Sahile et al., 2022; Tefera et al., 2020). The distribution of malaria varies according to temperature, rainfall patterns, and altitude, with epidemics being widespread in some highland or highland peripheral areas, especially at elevations of 1,000 to 2,000 meters above sea level. Climate variables contributing to malaria transmission dynamics include differences in temperature, precipitation, wind, and sunshine. These variables highlight the complicated and persistent character of malaria in Ethiopia, underscoring the need for ongoing efforts in prevention, control, and eradication methods (Adimasu et al., 2021; Mekonnen & Berhe, 2023).

Despite various initiatives and research addressing malaria in Ethiopia, considerable gaps continue, particularly in the Sidama area (Hawaria & Kibret, 2023a). Geographically positioned inside a tropical climate, the location generates an atmosphere suited to the spread of Anopheles mosquitoes, the principal vectors of malaria. Socioeconomic circumstances greatly increase risk, including obstacles such as restricted access to healthcare, inadequate infrastructure, and difficulty in implementing efficient vector control strategies (Fikrie et al., 2021a; Hawaria & Kibret, 2023a). Additionally, the region's agricultural ecology, typified by extensive irrigation and land use practices, provides breeding grounds for mosquitoes. Climate change impacts, notably changes in temperature and precipitation patterns, compound the issue by changing the distribution of both malaria parasites and their mosquito vectors. The continuous urbanization and population movements within and into the area also contribute to the changing epidemiology of malaria, perhaps introducing new genetic strains of the parasite and modifying the immunological profile of the population (Fikrie et al., 2021).

Hence, there is a need for detailed investigations into the trends of malaria infection over the years and the current prevalence of the disease in Sidama Region. Additionally, knowing the status of knowledge about malaria and preventative behaviors, as well as identifying risk factors for transmission, is vital. Therefore, this study intends to overcome these gaps by offering a picture of malaria dynamics in Dale District, Sidama Region, and enabling more effective intervention strategies.

1.2 Statement of the Problem

Despite numerous studies and intervention mechanisms aimed at eliminating malaria in Ethiopia, particularly in the Sidama region, significant challenges persist due to gaps in understanding the trends of malaria infection, prevalence rates, and factors influencing malaria transmission and prevention practices. Local studies generally aggregate data at national or regional levels, hiding unique tendencies in Sidama (Abate & Abate1, 2019; Fikrie et al., 2021a; Hawaria & Kibret, 2023a).

There is also inconsistent data on malaria prevalence, with some studies reporting high rates (Mekonnen & Berhe, 2023) in particular locations while others report lower estimates, leading to contradictions in background data(Gebretsadik et al., 2018). Furthermore, research on risk factors gives varied results about their relevance. For example, whereas Gebremedhin et al., (2016) stress the importance of socio-economic position and environmental circumstances, other research finds these aspects less influential (Abate & Abate1, 2019; Demelash et al., 2015; Fikrie et al., 2021a). Inconsistencies also exist in understanding community attitudes towards malaria prevention, with some research indicating great knowledge and others revealing major gaps.

The malaria issue in the Sidama region emerges across a spectrum of dimensions, influencing health, mortality, the economy, social structures, education, and vector management. Health-wise, the spike in malaria cases stresses local healthcare resources, raising the need for medical services, particularly for vulnerable groups like children and pregnant women(Hawaria & Kibret, 2023). Malaria-induced mortality not only results in the loss of lives but also weakens social structures and educational endeavors within communities. Economically, the disease exerts a toll through treatment costs, productivity loss, and economic stagnation. The social implications involve perpetuating cycles of poverty, limiting access to education and healthcare resources, thereby hindering educational progress. Families dealing with malaria often face interruptions in educational pursuits, contributing to a cycle of limited opportunities (Deressa et al., 2007; Tefera et al., 2020). Additionally, the challenges in vector control, essential for malaria prevention, present a significant economic burden, exacerbating the overall impact on public health and economic development in the Sidama region (Fikrie et al., 2021b; Hawaria & Kibret, 2023b; Ibrahim et al., 2023).

Recognizing these multi-faceted issues, the Ethiopian government and various concerned parties have acknowledged the seriousness of the malaria problem in Sidama. Common methods implemented were to incorporate vector control programs, such as insecticide-treated bed nets and indoor residual spraying, and directed at minimizing mosquito-borne transmission. There is also an emphasis on upgrading healthcare infrastructure to improve the diagnosis, treatment, and surveillance of malaria cases (Hawaria & Kibret, 2023b). However, studies indicate that low community awareness and education campaigns in local areas about malaria prevention strategies and the importance of seeking timely medical care (Dabaro et al., 2023; Ibrahim et al., 2023b).

Despite the implementation of several interventions to prevent malaria in the Sidama region, persistent challenges continue, and new steps may be necessary to address these concerns. The consequences of not taking further steps might include the return of malaria cases, leading to increasing morbidity and death rates. The danger of drug-resistant malaria strains and vector resistance to insecticides may grow, and hindering treatment and control efforts (Hawaria &

Kibret, 2023b). Failure to sustain access to antimalarial drugs and address core causes might perpetuate economic losses and social disturbances within communities (Tefera et al., 2020). To prevent these possible consequences, continual surveillance, study, and adaptive strategies are required.

However, to the best knowledge of the researcher, there is a remarkable shortage of local studies addressing the prevalence, trends, and related risk factors of malaria in the Dale districts in the Sidama region. This scarcity of localized research presents a considerable challenge to the creation of focused and context-specific malaria control measures. Recognizing the importance of knowing the particular variables driving malaria sensitivity in the Dale district, this study intends to fill the current gap by giving detailed insights into the local dynamics of the disease.

1.3 Research Questions

The study was guided by the following specific research questions:

i. What have been the trends of malaria infection in the Dale districts over the past five years (2018 - 2022)?
ii. What is the current prevalence of malaria in the Dale districts?
iii. What is the level of knowledge among the local population about malaria signs, symptoms, and prevention methods?
iv. What are the associated risk factors contributing to malaria transmission in the Dale districts?

1.4. Objectives

1.4.1. General Objective

The general objective of this study was to assess the prevalence, trends and associated risk factors of malaria infection in Dale districts in Sidama Region, Ethiopia.

1.4.2. Specific Objectives

The specific objectives of the current research were:

i. To analyze the trends of malaria infection in the Dale districts over the past five years (2018 - 2022).

ii. To determine the current prevalence of malaria in the Dale districts.

iii. To assess the level of knowledge among the local population about malaria signs, symptoms, and prevention methods.

iv. . To identify the associated risk factors contributing to malaria transmission in the Dale districts

1.5 Significance of the Study

The significance of this study rests in its holistic strategy to thoroughly understand and treat the complicated issue of malaria in the studied region. Firstly, by examining the trends of malaria infection over the previous 5 years, the research may give useful insights on the temporal patterns of the disease, enabling concerned bodies to identify periods of high risk. Secondly, describing the current level of malaria prevalence gives a baseline for future comparisons, facilitating the evaluation of continuing malaria control and preventive activities. Thirdly, the assessment of knowledge about malaria and habits connected to the disease is vital for developing focused educational efforts and producing a better-informed population that is empowered to prevent and treat malaria. Lastly, the analysis of related risk factors for malaria transmission not only enriches the communities understanding of the disease dynamics but also gives actionable information for devising targeted treatments to minimize the incidence of malaria in the studied region. This research, therefore, has the potential to inform evidence-based public health measures, eventually leading to a decrease in malaria burden and an enhancement of overall community well-being. Consequently, the conclusions of this study may be a springboard for additional research projects, generating a cumulative body of information to support national malaria control efforts.

1.6 Scope of the Study

The study focused on analyzing malaria trends, prevalence, knowledge levels, and associated risk factors in the Dale districts of the Sidama region. Specifically, it aimed to provide insights into the local dynamics of malaria infection to inform the development of targeted control strategies. Geographically, the study covered five selected localities within the Dale districts chosen for active case investigation, ensuring a representative sample of the region's diverse conditions. For trend data, five years (2018–2022) of records from local health centers in the district and Yirgalem hospital were analyzed. The study integrated data from active case investigations and health records to offer a comprehensive understanding of malaria in the area and contribute to more effective public health interventions.

1.7 Limitation of the Study

As with any scientific study, the current research is not without limitations. These limitations may affect the interpretation and generalizability of the findings. One limitation of the study is its reliance on retrospective data, which might be vulnerable to reporting mistakes and biases. Additionally, the study's focus on five selected localities within the Dale districts may limit the broader applicability of the results to the entire region. The use of data from local health clinics and Yirgalem hospital may create selection bias, as these institutions may not catch all cases of malaria in the community.

1.8 Organization of the Study

This study was organized into five chapters. The first chapter deals with background of the study, statement of the problem, objectives of the study, significance of the study, the delimitations and limitations of the study. The second chapter presents a review of relevant and related literatures. Chapter three focuses on research design and methodology including the sources of data, the study population, sample size and sampling technique, procedures of data collection, data gathering tools, and method of data analysis and ethical consideration. The fourth chapter is about data analysis and interpretation and finally, chapter five presents about summary, conclusions and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Malaria

Malaria is life-threatening illness caused by plasmodium species. Plasmodium species are protozoan parasites responsible for malaria and belong to the Kingdom Protista, Phylum Apicomplexa, Class Aconoidasida, Order Haemospororida, Family Plasmodiidae, and Genus Plasmodium (Duszynski et al., 2020; Ogedengbe, 2015).Notable species within this genus include Plasmodium falciparum, known for causing the most severe form of malaria; Plasmodium vivax, which can remain dormant in the liver and cause relapses; Plasmodium malariae, associated with chronic malaria and quartan fever cycles; Plasmodium ovale, similar to P. vivax in its ability to remain dormant; and Plasmodium knowlesi, a species that infects both macaques and humans, particularly in Southeast Asia. These species are recognized by their genetic and physical traits, as well as their unique life cycle phases in vertebrate and invertebrate hosts (WHO, 2023).

Female Anopheles mosquitoes serve as the major vectors for delivering the malaria parasites. It is responsible for transmitting the illness, as they require a blood meal to grow their eggs (Khan et al., n.d.). The genus Anopheles has multiple species, although not all of them are effective vectors for spreading malaria. In Ethiopia, frequent Anopheles species that play key roles in malaria transmission include Anopheles arabiensis, Anopheles funestus, and Anopheles pharoensis (WHO, 2000).Anopheles arabiensis, member of the Anopheles gambiae complex, is the major vector, recognized for its adaptability to varied conditions and resilience to pesticides (Mboussou et al., 2024).. Anopheles funestus is another prominent vector, commonly located in more permanent water bodies and is also a problem owing to its pesticide resistance. Anopheles pharoensis, albeit less frequent, contributes to malaria transmission in select places, notably in areas with extensive vegetation and water. These species' ranges and behaviors are impacted by ecological conditions and human activities, making them major targets for malaria control efforts in Ethiopia (Monroe et al., 2022).

2.2 Transmission of Malaria and its Life Cycle

Malaria is transmitted by the bites of infected female Anopheles mosquitoes. When mosquito bites an infected person, it ingests blood carrying the sexual stage of the Plasmodium parasite. Inside the mosquito, these parasites undergo growth, finally generating motile sporozoites (Khan et al., n.d.). These sporozoites move to the mosquito's salivary glands, ready for the next blood meal. During a subsequent bite, the mosquito injects the sporozoites into the human bloodstream along with its saliva. Once in the human body, the sporozoites move to the liver, infect liver cells, and mature into merozoites. These merozoites then infiltrate red blood cells, triggering symptoms of malaria and commencing a cycle of proliferation and cell rupture. Mosquitoes feeding on an infected person at this stage might pick up gametocytes, completing the transmission cycle when they bite another human (Zambare et al., 2019).

The Plasmodium parasite has a complicated life cycle that involves both the female Anopheles mosquito and human hosts. When an infected mosquito bites a human, it injects sporozoites into the circulation. Sporozoites move to the liver, where they infect liver cells and grow, and thereby producing liver-stage illness. After mature, the parasites are discharged into the circulation as merozoites, which infect red blood cells, leading to the symptoms of malaria (Bray et al., 1982; Matteelli et al., 1997).

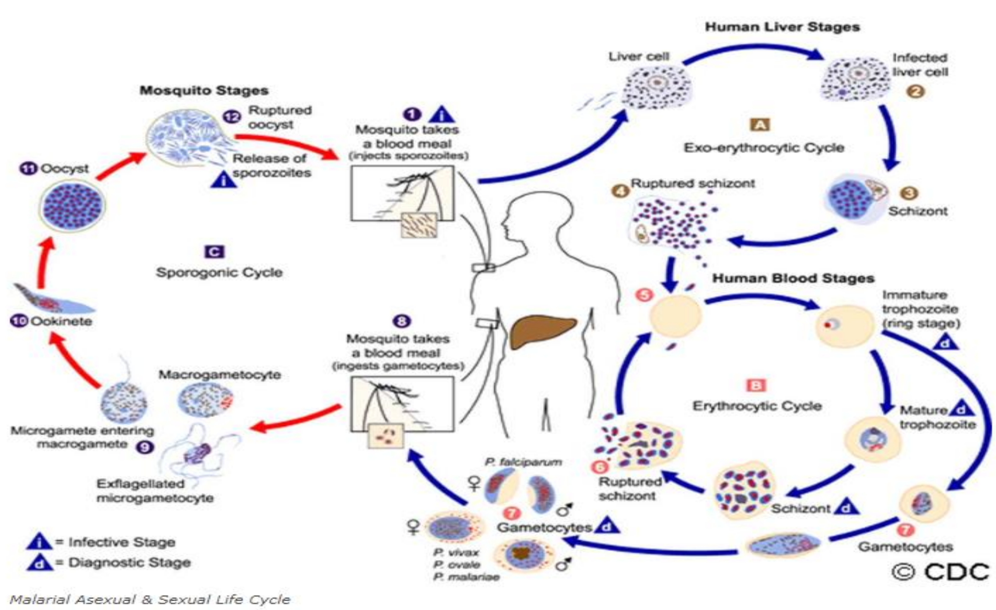

Figure 1: Malaria Asexual and Sexual Life Cycle

2.3 Pathophysiology of Malaria and Clinical Manifestation

Malaria's pathophysiology evolves through a succession of sophisticated phases involving the Plasmodium parasites and the host's physiological responses. The process occurs when an infected Anopheles mosquito delivers sporozoites into the human circulation following a bite. These sporozoites migrate to the liver, where they infect hepatocytes, undergoing the exoerythrocytic phase and converting into merozoites. Released into the circulation, merozoites enter red blood cells, starting cycles of replication and cell rupture, which emerge as the hallmark symptoms of malaria (Fujioka & Aikawa, 1999; Matteelli et al., 1997).

Malaria pathology typically emerges in the blood stage of the illness. During this phase, the parasites infect red blood cells, leading to their death and the release of merozoites into the bloodstream. This cyclical mechanism culminates in periodic fever episodes characteristic of malaria (Eckhoff, 2011). The severity of the disease varies, with Plasmodium falciparum being the most virulent species, often causing serious consequences such as cerebral malaria, organ failure, and death. Virulence factors include the capacity of P. falciparum to stick to endothelial cells in tiny blood vessels, resulting to microvascular sequestration and reduced blood flow. Additionally, the parasite might trigger the generation of inflammatory cytokines, adding to the systemic signs of the illness (Ogedengbe, 2015).

Malarial parasites display antigenic diversity, allowing them to escape the host immune response and establish persistent infections (Eckhoff, 2011). Notably, Plasmodium falciparum-infected red blood cells can stick to blood vessel walls, leading to sequestration and consequences such cerebral malaria. The host's immune system develops a reaction, creating antibodies and activating immune cells; yet, the malaria parasite deploys evasion techniques. As certain parasites change into gametocytes in response to immunological pressure, mosquitoes that bite an infected human complete the transmission cycle by swallowing gametocytes (Duszynski et al., 2020; Ogedengbe, 2015).

Malaria manifests with distinct clinical symptoms Characterized by persistent fever, chills, and sweats .malaria's cyclical rhythm adds to its distinctive symptoms. Severe instances, particularly with Plasmodium falciparum, may entail complications such as cerebral malaria, defined by disorientation, convulsions, and coma. Enlargement of the spleen and liver, as well as stomach pain, can also develop. (Malariology et al., 2017.; WHO, 2000).

2.4 Diagnosis and Treatment of Malaria

Diagnosing malaria entails a multidimensional approach, beginning with a thorough clinical assessment that evaluates the patient's medical history and symptoms, particularly recent travel to malaria-endemic areas and the pattern of fever onset (Malariology et al., 2017).

The gold standard for malaria diagnosis is the microscopic inspection of a blood smear, which permits the identification of Plasmodium parasites, determination of the species, and evaluation of parasitemia. Rapid diagnostic tests (RDTs) offer a rapid alternative by identifying malaria antigens in the blood. Molecular approaches, such as polymerase chain reaction (PCR), give a very sensitive and specific means of verifying and detecting Plasmodium DNA, even in situations where parasitemia is low (WHO, 2000). Serological assays identifying antibodies against malaria parasites are performed for epidemiological purposes but are not commonly used for acute case diagnosis. The choice of diagnostic procedure depends on aspects including resource availability, healthcare infrastructure, and the patient's characteristics. A swift and correct diagnosis is crucial for prompt treatment and the prevention of serious consequences (Marrelli & Brotto, 2016).

The treatment of malaria requires the use of antimalarial drugs, with the choice of therapy dependent on criteria such as the type of Plasmodium causing the infection, the severity of the sickness, and the geographic region of transmission. Artemisinin-based combination treatments (ACTs) are commonly recommended as the first-line therapy for uncomplicated malaria, as they are extremely effective and help battle drug resistance. For severe malaria cases, especially those caused by Plasmodium falciparum, intravenous artesunate is frequently the preferred treatment because of its quick effect (Zambare et al., 2019). Quinine and other antimalarials may also be utilized in particular conditions (Jones et al., 2015). Additionally, supportive care, including the management of problems such as anemia or respiratory distress, is a crucial aspect of therapy. Early identification and timely commencement of suitable antimalarial medication are critical to avoiding the development of severe illness and minimizing death. It's crucial to adjust treatment regimens based on regional medication resistance trends and specific patient characteristics to enhance therapeutic results (Hrycyna et al., 2014).

2.5 Prevention and Control Mechanism

Key strategies include vector control through the use of insecticide-treated bed nets, indoor residual spraying, and larval control measures to target mosquitoes that transmit the malaria parasite (Mathanga et al., 2012; Moonen et al., 2010). Additionally, prompt diagnosis and effective treatment of infected individuals are crucial to prevent the spread of the disease. Health education and community engagement play essential roles in promoting awareness about malaria prevention methods, encouraging early detection of symptoms, and fostering community participation in control efforts (Chanda et al., 2013; Mlozi et al., 2015) . Research and development of new tools, such as vaccines and antimalarial drugs, also contribute to enhancing the overall effectiveness of malaria prevention and control programs. Coordinated efforts at local, national, and international levels are essential to combat malaria comprehensively and reduce its global burden.

2.6 Prevalence of Malaria

Malaria is a prevalent and important public health hazard, particularly in tropical and subtropical portions of the world. The incidence of malaria varies across distinct nations and regions. According to the World Health Organization (WHO), in 2019, there were an estimated 229 million cases of malaria globally, with the majority occurring in sub-Saharan Africa (Achan et al., 2011; WHO, 2020b)Africa has the biggest burden of malaria, accounting for roughly 94% of all cases and fatalities. Within Africa, states such as Nigeria, the Democratic Republic of Congo, Mozambique, and Uganda have relatively high malaria prevalence rates (WHO, 2020b). These nations contribute greatly to the global malaria burden. Outside of Africa, malaria is also common in regions of Southeast Asia, the Eastern Mediterranean, and the Americas. Countries like India, Indonesia, Pakistan, and Bangladesh have a large number of malaria cases.

The prevalence of malaria is affected by various factors, including climate, geography, socio-economic situations, and the efficacy of malaria control strategies. Regions with warm temperatures, high humidity, and ideal breeding locations for mosquitoes are likely to have higher malaria transmission rates (Monroe et al., 2022).

Efforts to control and prevent malaria have been underway for many years (WHO, 2020b.). These include the provision of insecticide-treated bed nets, indoor residual spraying of insecticides, prompt diagnosis and treatment of cases, and the development of malaria vaccines. However, barriers such as drug resistance, pesticide resistance, and restricted access to healthcare facilities continue to hinder efforts in malaria management. In recent years, there have been substantial advances in decreasing the worldwide malaria burden. Between 2010 and 2019, malaria incidences declined by 29% globally, whereas malaria-related mortality decreased by 60% (WHO, 2020b). However, the COVID-19 pandemic has created additional barriers to malaria control efforts, probably leading to failures in some regions (Kant et al., 2021; Weiss et al., 2021; Zawawi et al., 2020). .

Studies suggest that malaria is a severe public health problem in Ethiopia, with the nation experiencing a high burden of the infection. According to the World Health Organization (WHO), Ethiopia accounted for roughly 4% of worldwide malaria infections in 2019. It is among the top 10 major causes of illness and death in children under the age of five and adults. Malaria is endemic in 75% of the population; with transmission happening throughout the year in most regions. The largest transmission rates are generally documented in lowland areas, particularly in the western and southern portions of the nation (WHO, 2020). These regions give favorable climatic conditions for mosquito development, such as heavy rainfall and warmth, which contribute to the high incidence of the sickness.

The incidence of malaria varies from place to location based on temperature, rainfall patterns, and altitude. The illness is largely seasonal, with varied transmission rates across different agro ecologies, and frequently corresponds with the peak agricultural activity that would substantially damage the socio-economic growth of the nation(T. G. Yhdego et al., 2022). The peak times of malaria incidence occur between September and December following the main rainy seasons (June–September) and from March to May during and after the little rainy seasons (February-March).(moh). Limited access to healthcare services and poor diagnostic facilities contribute to the burden of malaria in Ethiopia. Many afflicted groups, especially in rural locations, experience difficulty in receiving early and adequate diagnosis and treatment (Deressa et al., 2 017). This might result in delayed or poor treatment, resulting to increased morbidity and death.

The predominant malaria-causing organism in Ethiopia is Plasmodium falciparum, which is responsible for the majority of severe malaria cases and fatalities (WHO, 2020). However, Plasmodium vivax is also prevalent in some regions, especially at higher altitudes accounting for 60% and 40% of cases, respectively. In 2009, 98% of malaria cases in Africa were assigned to Plasmodium falciparum, while in other places, this figure was 65% . Furthermore, the global proportion of malaria infections ascribed to Plasmodium vivax has declined from 8% (20.5 million cases) in 2000 to 2% (4.9 million cases) in 2021 (Monroe et al., 2022). This study stresses the continuous difficulties of malaria control despite overall progress, stressing the requirement for continual efforts to address the persistently high frequency of malaria cases.

In research done in Maygaba town, northwest Ethiopia, Plasmodium falciparum was widely identified and became the leading species causing malaria (T. G. Yhdego et al., 2022). Another investigation done in the Jimma Zone identified Plasmodium falciparum and Plasmodium vivax, accounting for 66.4% and 33.6%, respectively (Daba et al., 2023). In accordance with this, the research done in the Sidama region suggested that the common species of malaria in the region are Plasmodium falciparum and Plasmodium vivax (Hawaria & Kibret, 2023b). similarly studies done in Wondo Genet, Sidama Regional State, indicated that Plasmodium falciparum was the prevalent species causing malaria (Abate & Abate1, 2019). Additionally, in irrigated communities in the Endorheic Rift Valley Basin of Sidama Region, Plasmodium falciparum was the primary source of malaria infection, followed by Plasmodium vivax. It is crucial to note that the incidence and distribution of Plasmodium species may fluctuate over time and across various places within Sidama region (Hawaria & Kibret, 2023a).

The Ethiopian government, in partnership with foreign partners and organizations, has been adopting several initiatives to control and prevent malaria. These include the distribution of insecticide-treated bed nets, indoor residual spraying, and the availability of effective antimalarial medications (WHO, 2020b). Additionally, community-based interventions, such as community health workers providing diagnosis and treatment at the community level, have been established to enhance access to malaria treatments (Deress et al., 2019).

The primary vector control efforts conducted in Ethiopia are indoor residual spraying (IRS), long-lasting insecticidal nets (LLINs) and larval source reduction (LSM). The country has succeeded in scaling up vector control operations in all malarious zones since 2005. For example, almost 90 million LLINs have been supplied to families between 2006 and 2017, and the spraying of more than 85% of the units planned for IRS has been achieved. Implementation of suitable vector control measures will continue for the fulfillment of the national goals.(moh). Ethiopia has made tremendous progress in lowering malaria-related morbidity and death. Between 2010 and 2019, the number of malaria cases declined by 39%, and malaria-related fatalities were reduced by 67% (WHO, 2020b). This achievement can be attributed to the scale-up of malaria control programs and better access to healthcare services. However, sustaining these advances and substantially decreasing the burden of malaria in Ethiopia needs continuous investment in prevention, diagnostic, and treatment techniques. It is also crucial to address the underlying socioeconomic and environmental drivers of malaria, such as poverty, poor housing, and restricted access to clean water and sanitation (T. G. Yhdego et al., 2022). Accurate identification and quick treatment of malaria patients are key measures in the battle against the illness. This needs better diagnosis of malaria cases using microscopy or multispecies RDTs and delivering fast and effective malaria case management at all health institutions throughout the nation (Mulugeta et al., 2022).

2.7 Risk Factors Associated with Malaria

2.7.1 Mosquito Habitat

The risk factors for mosquito habitat and malaria transmission are complicated and multifaceted. The abundance and closeness of malaria mosquitoes' aquatic habitats, the presence of big farmed animals, the type of homes, the usage of anti-mosquito measures in the house, and the number of occupants are all risk factors for malaria transmission (Mehari et al., 2021.; Zewude et al., 2022).

There are conflicting study findings on malaria transmission linked to mosquito habitat in Ethiopia. According to several studies, those who live near stagnant water are more likely to become infected with the malaria parasite (AOR = 16.191, 95% CI: 9.137, 28.692) than those who reside elsewhere (Molla et al., 2021a). According to certain research, malaria is a severe public health and economic concern in Ethiopia, affecting 75% of the terrain regions below 2000 meters above sea level (Daba et al., 2023; Yhdego et al., 2022). Other studies indicate that malaria transmission is unstable and seasonal, with periodic, focused, and even large-scale outbreaks. According to studies, new dam building in Africa exacerbates malaria transmission because Anopheles mosquitoes thrive in bodies of water (Kibret et al., 2021). Another study discovered that the yearly malaria case rate among those living within 1 kilometer of the Koka Reservoir in Ethiopia was 2.9 times higher than those living between 1 and 2 km from it, and 19.9 times higher than those living 5 to 9 km away. Another study done in the Ziquala district of northeast Ethiopia discovered that residing near a water feature, such as a river or stream, might be a significant risk factor for malaria infection (Kibret et al., 2017).

2.7.3 Lack of Vector Control

Vector control is the primary method for preventing and reducing malaria transmission. However, a lack of vector management poses a considerable danger for malaria transmission. Ecological changes in soil, sunshine cover, plant type, water pocket formation, and water temperature all have an impact on mosquito breeding conditions and can increase the risk of malaria transmission. Inadequate use of insecticide-treated bed nets (ITNs), indoor residual spraying (IRS), and larval control techniques are all risk factors for poor vector control and malaria transmission (Fuseini et al., 2019.; Musoke et al., 2023).. ITNs and IRS are extremely successful in preventing infection and limiting disease spread. However, growing pesticide resistance among Anopheles mosquitos jeopardizes worldwide malaria control efforts (Sun et al., 2023).

One of the most significant risk factors for malaria transmission in Ethiopia is a lack of vector control. However, other studies have reported conflicting findings on the relationship between a lack of vector management and malaria risk factors in Ethiopia. One research done in Lake Tana and neighboring areas in northwest Ethiopia discovered that environmental, human host, parasite, and vector variables all influence malaria transmission (Adugna et al., 2022), however there was no significant link between a lack of vector control and malaria incidence. Another study conducted in Jimma town in southwest Ethiopia discovered that malaria transmission is determined by major factors such as human behavior and the presence of the malaria parasite, as well as social and environmental factors, but there was no significant link between a lack of vector control and malaria risk factors (Manoharan et al., 2021).

Some researches, however, have revealed a substantial link between a lack of vector control and malaria risk factors in Ethiopia. For example, a research done in Ethiopia's highlands discovered that residences that were either poorly constructed or located near a breeding location had much greater malaria transmission rates and vector density than those that were not (Alemu et al., 2014; Haile et al., 2017). A study in Mizan Tepi University Teaching Hospital, Southwest Ethiopia found that individuals living in houses not sprayed with insecticides were more susceptible to malaria infection (AOR = 0.215, 95% CI: 0.128 0.360). Another study in Jimma town, South West Ethiopia, found that individuals who do not use insecticide-treated bed nets (ITN) were more likely to be infected with malaria (OR = 13.6; 95% CI 4.9-37.2, $p < 0.001$) compared with (Duguma et al., 2022).

2.7.4 Environmental Factors

Environmental factors have an important influence in the spread of malaria. Empirical research shows that geo-climatic elements such as temperature and moisture have a crucial role in malaria transmission. Temperature influences the growth of both the mosquito vector and the malaria parasite, whereas moisture affects mosquito reproduction and survival(Fisiha, 2002; Manoharan et al). Climate factors such as precipitation and air temperature have a crucial role in determining the geographical distribution and relative abundance of malaria vector species in Africa. For example, Anopheles gambiae is the most frequent species in high rainfall areas, but Anopheles arabieansis is more common in desert places. However, climatic conditions are also linked to elevation (Abate & Abate1, 2019).

Humidity, height, vegetation index, and living circumstances are all connected with malaria transmission. Shoreline puddles, irrigation canals, rain pools, and man-made ponds all have the potential to be mosquito breeding grounds. Environmental variables are also connected to population migration and malaria transmission. Climate change, for example, has the potential to expand malaria transmission zones and create new malaria foci (Fisiha, 2002; Manoharan et al., 2021).

In contrast, several empirical investigations discovered no substantial link between climate change and malaria transmission (A. Alemu et al., 2011; Kaseya et al., 2024; Mekonnen & Berhe, 2023). A study published in Scientific Reports discovered that near-term climate change implications on subnational malaria transmission varied by area and were not usually substantial. A study explored the two opposing opinions on the link between global warming and an increasing prevalence of malaria. While some feel there is a substantial link between the recent increase in malaria prevalence and global warming, the article points out that meteorological data from 1966 to 1995 revealed no significant changes. These findings underscore the need for more study to better understand the link between climate change and malaria transmission. While some research discovered a strong correlation, others found no evidence of a relationship.

The results reveal that environmental variables have a substantial impact on malaria transmission in Ethiopia. A study of three big dams in Ethiopia discovered that dam-related environmental variables and local climatic drivers impact malaria transmission. The study found that the presence of water bodies, plant cover, and distance from the reservoir coastline were all strong predictors of malaria transmission (Kibret et al., 2017). The study also discovered that the incidence of malaria was greater in lowland and midland areas than in highland locations. According to studies, meteorological factors such as rainfall and temperature have a crucial role in malaria transmission in Ethiopia (Haile et al., 2017; Vajda & Webb, 2017). A research done in Jimma town, South West Ethiopia discovered that monthly total rainfall was the most important factor influencing malaria transmission in the study region (Manoharan et al., 2021). Another study discovered that rainfall and temperature were the most important factors of malaria transmission in Ethiopia, with the distribution being extremely seasonal in several areas (Berhe et al., 2019; A. A. Taddese et al., 2019).

Land use changes, such as deforestation and urbanization, can disrupt the local ecosystem and provide new mosquito breeding grounds. However, the extent to which land use change influences malaria transmission is still unknown (Hawaria & Kibret, 2023b).

Empirical investigations on malaria prevalence and its connection with the rainy season vs the dry season in Ethiopia have shown conflicting results (Dabaro et al., 2021). Some research discovered a strong link between malaria transmission and the rainy season, whereas others found none. For example, a research done in Ethiopia's highlands discovered that climate impacts on malaria prior to the main rainy season might persist throughout the rainy season and influence malaria transmission (Haile et al., 2017). Another study discovered that malaria was more prevalent during the rainy season than during the dry season in western Ethiopia. However, a research done in Ethiopia's lowlands discovered that, while the incidence of asymptomatic malaria is significant and well-studied in the rainy season, there is little data on the burden of asymptomatic malaria infection and related variables during the dry season. Similarly, another study discovered that malaria prevalence was lower during the dry season than during the peak malaria transmission season in the nation (Vajda & Webb, 2017) .

2.7.5 Lack of Personal Protection

Personal protective measures are critical in avoiding malaria infections. The use of insecticide-treated nets (ITNs) is the cornerstone of worldwide malaria control, with studies demonstrating a 50-60% reduction in malaria morbidity. However, environmental, behavioral, and physical issues including as pesticide resistance, inappropriate application, and net deterioration can all jeopardize ITN efficacy. The application of mosquito nets and anti-malarial spray on the home walls altered the risk of malaria. Individuals who lived in sprayed dwellings and utilized malaria nets were less likely to contract malaria. Individuals who did not use mosquito nets were more likely to develop malaria (Montoya et al., 2022).

To limit the risk of mosquito bites, wear long-sleeved shirts and pants, use insect repellent, and avoid outside activities during peak mosquito hours. Most studies have found a link between malaria illness frequency and socioeconomic position, including poor living conditions, low income, and a low level of education. Improving socioeconomic standing can result in higher malaria protection (Musoke et al., 2023).

Access to healthcare services and quick treatment can help people protect themselves against malaria. Finally, personal protective measures against malaria include the use of ITNs, improved socioeconomic position, adequate home construction and maintenance, personal conduct, and access to healthcare. These strategies can greatly lower the risk of malaria infection while also improving the health outcomes of people living in malaria-endemic areas (Duguma et al., 2018; Yirsaw et al., 2021).

The research findings on risk factors for malaria related with a lack of personal protection in Ethiopia are conflicting. According to certain research, personal protective measures such as the usage of insecticidal treated bed nets (ITNs) and indoor residual spray (IRS) have a vital role in malaria prevention. A case-control study in Laelay Adyabo area, northern Ethiopia, discovered that poor ITN and IRS usage were recognized risk factors for malaria. Similarly, a 2012 study discovered that low socioeconomic position, lack of access to ITNs, and poor living circumstances were all related with an increased risk of malaria infection. Another study done in Ethiopia's highlands discovered that poorly constructed dwellings and those located near breeding areas had much greater malaria transmission rates than those with acceptable construction and placement (Solomon et al., 2019). Other research has revealed that personal protective measures may not be the most important risk factor for malaria transmission in Ethiopia (Fikrie et al., 2021.; Nesga et al., 2018).

2.7.6 Socioeconomic Factors

Several researches have looked into the relationship between socioeconomic characteristics and malaria risk. In a research done in Arsi Zone, socioeconomic indicators such as education, employment, and income were found to be connected with the malaria burden among children (Kedir et al., 2017). Another systematic review and meta-analysis done in sub-Saharan Africa found that socioeconomic variables such as education, employment, income, and household characteristics contribute to malaria's high burden (Boyce et al., 2019). The age, education, employment, social group, and family size of the home have been linked to the risk of malaria. Lower education levels and outside vocations, such as farming, have been related to an increased risk of malaria (Eze et al., 2022).

Individuals with low socioeconomic status are more likely to contract malaria. One way to reduce the risk of malaria is to improve the household's dwelling conditions. Houses that were poorly built or located near breeding areas had greater malaria transmission rates and vector density. Furthermore, home features such as house style, sources of drinking water and cooking fuel, agricultural land, and asset index have been found as factors that potentially increase malaria risk (Njagi et al., 2018).

Addressing these variables, such as improving housing conditions, boosting education, and implementing personal preventive measures, can lower the burden of malaria and improve the health outcomes of people living in malaria-endemic regions (Kebede et al., 2020).

2.7.7 Travel to Endemic Areas

Traveling to endemic areas increases the risk of malaria infection. The risk of contracting malaria varies greatly from tourist to traveler and area to region, even within the same nation. The risk varies depending on the intensity of transmission within each location, as well as the itinerary, duration, season, and kind of travel. Travelers visiting rural regions or staying in lodgings without screens or air conditioning are at a higher risk. The highest risk of malaria is connected with first-time visitors to endemic locations (Ahmed et al., 2020).

The risk of malaria infection is also linked to the sort of activities in which tourists participate. For example, tourists who indulge in outdoor activities like camping or trekking are more likely to contract malaria. Long-term visitors face more risks than short-term tourists. Adherence to mosquito prevention and prophylactic instructions is critical in avoiding malaria infection. Some traveler groups, such as those visiting friends and family, are more likely to contract malaria than others (Dabaro et al., 2021).

There is data that contradicts the risk factors for malaria related with travel to endemic regions in Ethiopia. A comprehensive study found no significant association between malaria prevalence among Ethiopian adults and travel to endemic locations (Tilaye et al., 2022). According to the same comprehensive study and meta-analysis, outdoor activities such as camping or hiking have no significant impact on malaria prevalence among Ethiopian adults.

2.7.8 Seasonal Variation

Malaria is a disease heavily impacted by weather conditions (Taddese et al., 2019.; Taddese et al., 2019). Climate can influence malaria transmission directly, via transmission dynamics, or indirectly, via socioeconomic variables that contribute to malaria risk. According to studies, rainfall patterns and temperature have a significant impact on malaria transmission. Malaria incidences often peak when rainfall seasonality is at its lowest point, and vice versa. However, the relationship between temperature and malaria transmission is not always clear and may vary based on geographical location (Dabaro et al., 2021).

Malaria seasonality can be influenced by a variety of environmental variables in addition to climate. Elevation or topography has been shown to have a crucial influence in defining the key climatic determinants of seasonal malaria transmission. For example, in locations with lower altitudes, temperature may be a major regulator of malaria seasonality, but in areas with higher elevations, other factors such as terrain may have a greater impact. Malaria seasonality can vary regionally, with various places experiencing distinct patterns and intensities of transmission throughout the year. Local climate, environmental circumstances, and population dynamics can all influence regional variance (Alemu et al., 2011).

Climate change may increase the likelihood of malaria transmission in traditionally malarious locations, as well as in places where the illness has been controlled or eliminated. However, it may be impossible to quantify the impact of climate change on malaria transmission, which is influenced by a variety of factors such as population and demographic dynamics, drug and insecticide resistance, human activities such as deforestation, irrigation, swamp drainage, and so on, as well as their impact on local ecology (Hawaria & Kibret, 2023a). More study is needed to acquire a better understanding of the risk factors related with seasonal fluctuation in malaria across the world.

Some studies have identified a strong correlation between malaria transmission and seasonal rainfall and temperature fluctuation, whereas others have found no link between meteorological parameters and malaria transmission risk(Dabaro et al., 2021). One research in Jimma town found that malaria was substantially linked with lowest temperature, total rainfall, and maximum temperature with a one-month lag (Ouedraogo et al., 2019). Another study, however, discovered that the malaria load fluctuated over time in different locations of Ethiopia, with the maximum malaria transmission occurring in the spring and then again in the summer. According to one study, the risk of malaria transmission was highest in locations with an altitude of less than 2000 meters and yearly rainfall of more than 1000 mm (Dabaro et al., 2021). Another study discovered that the risk of malaria transmission was highest in locations within 5 km of water sources (Kibret et al., 2017).

2.8 Knowledge of Local Population about Malaria Signs and Symptoms

Local communities' understanding of malaria signs and symptoms varies widely between Ethiopian areas, depending on factors such as education, access to health information, and local malaria incidence rates. Studies undertaken in various locations of Ethiopia give a thorough overview of these knowledge levels, which are classified as high, moderate, and poor. According to several research, certain populations have a high level of awareness about malaria signs and symptoms. For example, a research done in Ethiopia's Jimma Zone discovered that 81.3% of respondents correctly identified fever as a key symptom of malaria, whereas 69.5% listed headache and chills as symptoms (Abdissa et al., 2024). Furthermore, in the Kersa district, more than 75% of participants were aware that symptoms such as fever, headache, vomiting, and joint pain were important markers of malaria, indicating a high degree of knowledge (T. G. Yhdego et al., 2022).

Other studies have shown a moderate degree of awareness among local inhabitants. A survey conducted in the Shebedino District of the Sidama Zone found that around 60% of respondents accurately identified at least one malaria symptom, such as fever, chills, and headaches. A research in the Southern Nations, Nationalities, and Peoples' Region (SNNPR) found that 58% of participants recognized common malaria symptoms such as fever, headache, and vomiting. This level of awareness indicates a modest comprehension, with opportunity for development in community health education (Suleman et al., 2018).

In contrast, some localities have a poor degree of understanding about malaria signs and symptoms. According to a survey conducted in Ethiopia's Gambella Region, just 43% of respondents correctly identified fever as a malaria symptom, with 32% recognizing headache or chills. Similarly, in a remote section of the Benishangul-Gumuz Region, just 35% of participants recognized critical symptoms such as fever, chills, and headaches. These findings indicate considerable knowledge gaps, emphasizing the need for more effective health education activities in these communities (Duguma et al., 2018).

The disparities in understanding of malaria signs and symptoms throughout Ethiopia's regions can be linked to a number of interconnected variables, including educational attainment, access to health information, socioeconomic position, and the success of local health initiatives. s (Fikrie et al., 2021).

2.9 The Effect of Knowledge of Malaria Signs and Symptoms on Malaria Prevention Methods

Global research has found that improved understanding of malaria symptoms frequently leads to higher adoption of preventative measures. Globally, greater knowledge of malaria symptoms such as fever, chills, and headache is connected with a higher chance of people taking preventative steps. For example, Henok et al., (2015) and Vajda & Webb, (2017) found that persons who could recognize malaria symptoms were more likely to use insecticide-treated nets (ITNs) and seek quick treatment, indicating a direct relationship between knowledge and action. This conclusion is reinforced by Koenker et al. (2014), who discovered that awareness campaigns greatly improved ITN use in several African nations.

In Southeast Asia, Suwannapong et al. (2017) found that comprehensive education programs on malaria symptoms and prevention dramatically enhanced community compliance with preventative measures such as bed net use and early diagnosis. This shows that well-executed awareness initiatives can help to close the gap between knowledge and practice. Similarly, Singh et al. (2013) found that villages with greater levels of awareness used more ITNs and had reduced malaria incidence, demonstrating the efficiency of information dissemination.

However, the situation in Ethiopia, particularly in locations like as Sidama, is more complex. According to Deress and Girma, (2019) while a considerable majority of the Ethiopian population could recognize key malaria symptoms, this knowledge was not consistently translated into preventative actions such as ITN use and early treatment seeking. This disparity implies that simply expanding knowledge may not be enough. Ayele et al. (2016) performed a research in the Oromia area and discovered high levels of knowledge of malaria symptoms, but major gaps persisted in the continuous application of preventative measures. This suggests that knowledge alone is not a cure-all, and that additional factors such as access to preventative methods, economic restraints, and cultural attitudes must be considered.

Furthermore, Asnake et al., (2016) found that in the Sidama region, despite high knowledge of malaria symptoms, real ITN use was inadequate. This discrepancy was linked to a variety of variables, including the scarcity of ITNs, socioeconomic constraints, and the belief that malaria is an inescapable part of life. Similar findings were reported by Woyessa et al., (2013) who discovered that cultural beliefs and practices had a substantial impact on the adoption of preventative interventions in southern Ethiopia.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Description of the Study Area

This study area is located in the southern half of the nation, between latitudes 5°45'N and 6°45'N and longitudes 38° and 39°E. Geographically, the Sidama Region lies 270 kilometers south of Addis Ababa, the capital city of Ethiopia, and is surrounded by the Oromia Region to the north and west, the Southern Nations, Nationalities, and Peoples' Region (SNNPR) to the south, and the Gedeo Zone to the east(SRCTSB). The region contains various terrain, ranging from highland regions to lowland plains, and experiences a tropical climate, with an average annual temperature ranging between 17.6 and 22.5°C and average annual rainfall between 801 and 1000 mm (Ware et al., 2023).

The healthcare situation in the Sidama Region is characterized by a combination of governmental and private health services, including one hospital,14 health center , and 26 health posts. While there have been advancements in healthcare facilities and services, difficulties continue, particularly in rural regions where access to healthcare is restricted. The region confronts a high burden of illnesses, especially malaria, which exerts tremendous demand on the limited healthcare resources (CSA, 2023).

Within this larger context, the research primarily focused on the Dale District, a sample location within the Sidama Region. Dale District is situated at 310 kilometers south of Addis Ababa, the capital city of Ethiopia, and 35 kilometers southwest of Hawassa City, the seat of the Sidama Regional state, between latitudes 6°36'N and 6°53'N and longitudes 38°17'E and 38°30'E. The district symbolizes the region's geographic variety, containing both highland and lowland regions.

Demographically, Dale District has a diversified population that encompasses many ethnic groups and age cohorts. Its projecte total population in 2023 is 264,664 (CSA, 2023). The economic activities of Dale District are largely agricultural, with local farming methods constituting a key element of the community's existence. The healthcare infrastructure in Dale

District comprises multiple health institutions and clinics, but like the greater region, it confronts problems such as low resources and accessibility concerns (CSA, 2023).

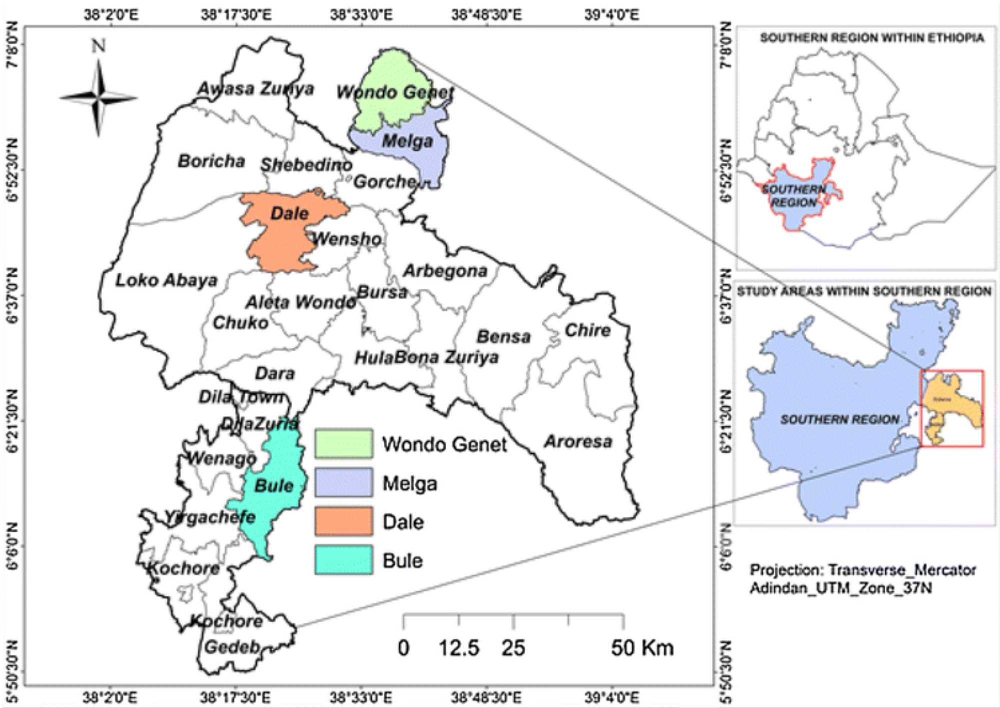

Figure 2: Map of Study Area

3.2 The Research Design

This study employed a health facility-based retrospective design alongside a community-based cross-sectional approach. The retrospective study was conducted by analyzing malaria data recorded in health facilities over five years (2018–2022) in Dale District, Sidama region. This analysis aims to identify trends in malaria prevalence and incidence in the study area, providing a trend analysis for understanding the evolution of the disease.

The community-based cross-sectional study was carried out from April to June 2023, coinciding with during short rainy season. This phase involved a parasitological survey to determine the current status of malaria through active case detection. Additionally, household-related questionnaires were administered to assess various factors contributing to malaria transmission. The combination of retrospective data analysis and cross-sectional surveys ensures a comprehensive understanding of both trends and current malaria dynamics in Dale District, Sidama region, providing strong evidence to inform effective malaria control strategies.

3.3 Study Population

For the retrospective part of the study, the population included all recorded malaria cases from health facilities in the study area over the five-year period from 2018 to 2022. The study participants for the active cases were adults aged $\geq$18 years with symptoms of a febrile case from the selected villages.

3.4 Sample Size Determination for Parasitological Survey

For the retrospective component, assessing trends over the five-year period, the data was obtained from secondary data. For parasitological survey, the determination of the sample size was based on statistical considerations and the specific objectives of the study. A prevalence of 50% was chosen there was no previous research on the prevalence of malaria in the study area. This conservative approach ensures that the sample size was adequate even if the true prevalence is at the lower or higher end of the spectrum (WHO, 2009). Similarly, a precision of 5% was selected to achieve a reasonable level of accuracy in estimating the true prevalence of malaria. This level of precision ensures that the study findings are reliable and can be generalized to the broader population. Additionally, a confidence level of 95% was chosen to provide a high level of confidence in the study results. The sample size was determined by using the formula for estimating single population. Based on this, the total sample was calculated as follows:

$$n = \frac{Z^2 * p\,(1-p)}{E^2}$$ Where:

n= sample size

zα/2= 1.96 (Z=score corresponds to 95% confidence interval),

p= 0.5 (Prevalence of the study area) and

E= 0.05 (margin error). Then,

$$n = \frac{(1.96)^2 * (0.5)\,(0.5)}{(0.05)^2} = 384.16$$

Hence, the sample size for the study was 385 individual.

3.4 Sampling Techniques for Parasitological Survey

The sampling technique employed in this study was a multistage approach designed to ensure representation across various strata, capturing both geographical and demographic diversity. In the initial stage, Dale District was purposefully selected as it represents the broader geographic and demographic spectrum of the Sidama Region. In the subsequent stage, *Kebeles* within the Dale District were cataloged with an emphasis on geographical diversity and previous malaria incidence(which was identified from health facilities). This led to the clustering of all *Kebeles* into three distinct groups, as high, moderate and low previous malaria prevalence.

From these clusters, two *Kebeles* from high malaria incidence, two from moderate and one *kebele* with large population size for low previous incidences were systematically selected to ensure unbiased representation and to capture diverse malaria transmission dynamics across different historical exposure levels. Within each selected *Kebele*, a comprehensive household listing was compiled, from which households were systematically sampled. The sample size was proportionally allocated to each *Kebele* to maintain demographic representativeness.

The sample size was allocated proportionally for the selected *Kebeles*.

Table 1: *The Selected Kebeles and Proportional Allocation of Samples*

S.No	Name of the *Kebele*	Total Households	Allocated Samples
1	Soyama	1958	95
2	Debub Mesenkela	1382	66
3	Megara	1452	70
4	Warra	1875	91
5	Kalit Simita	1298	63
	Total	**7965**	**385**

Table 1 provides an overview of the selected Kebeles within the Dale District and the proportional allocation of samples for the study. Five Kebeles were selected from the total of 26 kebeles: Soyama, Debub Mesenkela, Megara, Warra, and Kalit Simita. Soyama, with the highest number of households (1958), had 95 samples allocated. Warra followed with 1875 households and 91 samples. Megara, having 1452 households, resulted in 70 samples, while Debub Mesenkela, with 1382 households, had 66 samples. Kalit Simita, with 1298 households, had 63 samples allocated. The total number of households across these Kebeles is 7965, with a total of 385 samples allocated. This proportional allocation method ensures a representative sampling from each Kebele, reflecting their respective population sizes. The household selection process after allocation for each kebele was based on systematic random sampling; for example, in

Soyama, with 1958 households and 95 sample households, every 21st household was selected. Similarly, systematic sampling was applied to the other kebeles, ensuring an unbiased and representative selection of households for the study. Finally,study particpants aged greater than 18 years with febrile case from systematically selected households of the villages were chosen.

3.6 Methods of Data Collection

3.6.1 Retrospective Data Collections

To assess the trend of malaria prevalence in the study area, a five-year (2018-2022) data on the trend of malaria prevalence was carefully reviewed from the institutional malaria laboratory registry book of the health facilities. All public health facilities (hospital, health center and health posts) that provide malaria diagnosis and treatment service were included in the study. All facilities use the same kind of malaria laboratory register, so that the variables captured were similar. A carefully prepared checklist (data collection format) was applied to collect data for the malaria trend in the study area from the health facilities.

Then the malaria morbidity data were transferred from the registers on the prepared data collection format and then finally to the Excel spreadsheet. The parameters such as date of examination, total clinically treated and confirmed cases in months and years, types of malaria species, tools of diagnosis and socio-demographic data such as age and sex were collected. The records which missed one or more of these variables were excluded from the study.

3.6.2 Blood Sample Collection and Examination

The current malaria prevalence survey was carried out in the study population. Blood sample was collected from participants who were voluntary participated in study by giving informed consent. Finger prick blood collection was done by trained professionals, from the systematically selected participants (febrile patients) through house-to-house visit. The finger of patients was cleaned up with 70 % alcohol before pricking. Then prick site was exposed to dry and the first drop of blood was removed with the dry cotton to prevent the external contamination. The thick and thin blood smears were prepared on the same frosted slide side by side. The smears were air dried and the thin blood smear was fixed with methanol at the sites. The samples were packed in the slide box and carefully transported to the central laboratory (Mesenkela primary Hospital) where parasitological examination by microscopy was performed. All the parasitological examination of blood sample was conducted by following the protocols established.

3.6.3 Questionnaire Survey

The structured questionnaire was administered to the participants during the blood sample taking. It addressed the socio-economic and socio-demographic characteristics of the participants. The questionnaire involving the factors associated with malaria infection was developed first in English language and then translated to the local language (Sidamu Afo) and administered to study participants. After the purpose of the study was clearly explained to the study participants, questionnaire was filled out while the blood sample collection. The heads of house-holds assisted to give the relevant information. The questionnaire translated back to English in order to check its validity. The survey data was collected by using Kobo tool box.

3.7 Inclusion & Exclusion Criteria

The study included the participants that were permanent member in the community and able to give informed consent through their voluntary participation. For malaria parasitological survey, members of the selected households with febrile cases were included except those who were on anti-malaria therapy during the study period. children < age 18 and the community members who were unable to communicate and individuals with mentally impairment were not included the study. Individuals who were taking anti-malarial therapy or who had been treated with anti-malarial drugs within the past 2 weeks prior to the study were excluded from the study.

3.8 Data Analysis

The data analysis was commenced with a careful review of the study instruments, focusing on ensuring uniformity, accuracy, and completeness. Descriptive statistics was used to examine the prevalence and trends of malaria transmission in terms of seasons, years, gender, age and species of malaria parasite. The data for level of knowledge about the signs and symptom of malaria infection, and the prevention methods were collected by multiple response questions and analyzed by frequency counts and the percentages. Data results were presented in tables and figures.

Furthermore, the inferential statistics Negative Binomial Regression analysis was conducted to examine the factors impacting the incidence of malaria for trend data. Finally, to examine the risk factors associated with malaria infection for active data, the Logistic Regression was employed. The use of diverse statistical techniques ensured a thorough exploration of the research questions, contributing to a robust interpretation of the study findings.

3.9 Ethical Considerations

Ethical considerations were paramount throughout the study, guided by the ethical review process of the university's School of Graduate Studies. The research proposal underwent thorough review by the college's ethical review committee to ensure compliance with all relevant rules and regulations. Subsequently, an official letter of cooperation was issued by the Department of Biology to all relevant authorities, seeking permission for data collection in the study area.

Prior to data collection, explicit approval was obtained from the responsible authorities in the study area. Participation in the study was entirely voluntary, and participants were provided with detailed explanations of the study objectives and procedures. They were also given the opportunity to reconsider their participation and were free to withdraw from the study at any time based on their preference.

To protect participant confidentiality, all data and information were anonymized using codes instead of participants' names. Additionally, individuals who tested positive for malaria were provided with treatment at no cost.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Trends of Malaria in Sidama Region, Dale Districts

This section illustrates the trends in malaria cases in Dale Districts of the Sidama Regional state, Ethiopia, over a five-year period from 2018 to 2022. The data includes the total cases and their respective percentages, providing insights into the prevalence and burden of malaria in the study area. In current study, suspected cases represent the number of individuals who presented with symptoms suggestive of malaria, while positive cases indicate the number of confirmed malaria infections through diagnostic testing.

Table 2: *Malaria Cases in Dale Districts, Sidama Region, Ethiopia from 2018 to 2022*

Year	Suspected Cases	Negative cases	percent	Positive Cases	Percent
2018	15900	14924	93.86	976	6.14
2019	18751	17716	94.48	1035	5.52
2020	29636	25384	85.65	4252	14.35
2021	30698	25731	83.82	4967	16.18
2022	34628	30,828	89.03	3800	10.97
Total	129613	114,583	88.40	15030	11.60

The investigation of malaria cases in the Dale Districts, Sidama Region, Ethiopia, from 2018 to 2022, demonstrates considerable changes in both suspected and confirmed malaria cases. Table 2 demonstrates that throughout this five-year period, a total of 129,613 suspected malaria cases were registered, with 15,030 positive cases, resulting in an overall malaria positivity rate of 11.60%. The statistics suggest a considerable year-to-year variance in malaria prevalence, with 2021 posting the highest malaria positivity rate at 16.18% and 4,967 positive cases, while 2018 had the lowest with 6.14% positivity and 976 positive cases. Interestingly, while 2022 had the largest number of suspected cases (34,628), the positive rate declined to 10.97%, suggesting potential advances in malaria control efforts or changes in the disease dynamics.

The information shows a five-year variation in malaria cases, with different annual prevalence levels. The greatest positive rates were seen in 2021 followed by 2020, indicating a possible rise in malaria transmission during those years. Climate, patterns of mosquito breeding, and availability and use of healthcare may have all played a psart in these swings.

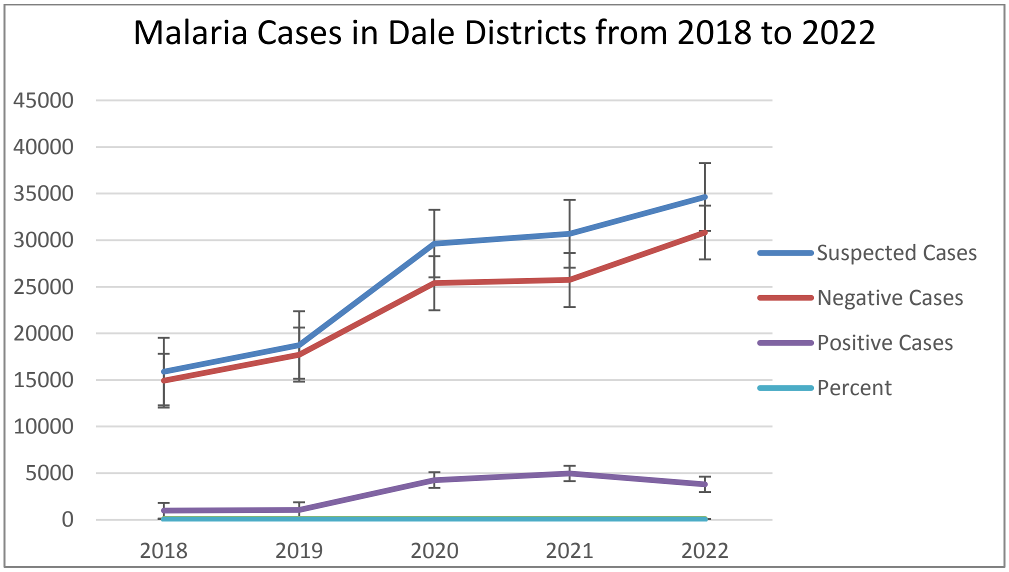

Figure 3: Malaria Cases in Dale Districts, Sidama Region, Ethiopia from 2018 to 2022

The surge in positive malaria cases during 2020 and 2021, as demonstrated by the 14.35% positivity rate in 2020 and 16.18% in 2021, may be ascribed to numerous variables. Empirical research shows that climate changes, notably in rainfall patterns and temperature variations, might contribute to an increase in malaria transmission by generating ideal circumstances for mosquito reproduction. Research by Deribew et al. (2019) illustrates how fluctuations in rainfall and temperature may dramatically alter the geographical and temporal distribution of malaria in Ethiopia. Additionally, COVID-19-related interruptions to healthcare services in 2020 and 2021 may have limited the population's access to malaria prevention and treatment, worsening the disease burden, as stated by Kifle et al. (2021). The lower positive rate in 2022 might suggest the recovery of health services and better malaria preventive treatments, such as insecticide-treated bed nets and indoor residual spraying (IRS), backed by data from studies done in similar locations (Taffese et al., 2018).

Furthermore, the dropping malaria positive rate from 2018 to 2019, while rising suspected cases, shows greater community awareness and improvements in diagnostic methods, as well as maybe wider access to malaria testing. Studies such as Alemu et al. (2020) confirm this tendency, indicating that enhanced diagnostic facilities can lead to more accurate identification of non-malaria febrile diseases, hence decreasing the positive rate in tested cases. However, the spike in positive cases in 2020 and 2021 shows a temporary setback, probably due to environmental and healthcare access problems.

4.2.1 The Yearly Trends of Plasmodium Species Distribution.

In an analysis of malaria case distributions spanning from 2018 to 2022, data reveals varying prevalence of the two primary malaria parasites along with mixed infections.

Table 3: *Malaria Cases by Species in Dale Districts, Sidama Region, Ethiopia*

Year	P. Falciparum	P. vivax	Mixed Cases	Total Positive Cases
2018	795 (81.45%)	106 (10.86%)	75 (7.68%)	976 (100%)
2019	737 (71.21%)	291 (28.12%)	7 (0.68%)	1035 (100%)
2020	3090 (72.69%)	1137 (26.73%)	25 (0.59%)	4252 (100%)
2021	3946 (79.43%)	1005 (20.23%)	16 (0.32%)	4967 (100%)
2022	2975 (78.29%)	823 (21.66%)	2 (0.05%)	3800 (100%)
Total	**11543 (76.80%)**	**3362 (22.37%)**	**125 (0.83%)**	**15030 (100%)**

The result from the table 3 indicates that, over the total period analyzed, the region reported 15,030 malaria cases. The distribution was predominantly P. falciparum with 11,543 cases (76.80%), followed by P. vivax with 3,362 cases (22.37%), and mixed cases were the least common with only 125 cases (0.83%). The data shows Plasmodium falciparum (P. falciparum) consistently dominated the malaria landscape across the five-year period. In 2018, of the 976 total malaria cases reported, P. falciparum accounted for 795 cases (81.45%), Plasmodium vivax (P. vivax) contributed 106 cases (10.86%), and mixed infections comprised 75 cases (7.68%). By 2019, the total cases slightly increased to 1,035, with P. falciparum cases decreasing to 737 (71.21%), whereas P. vivax cases increased significantly to 291 (28.12%), and mixed cases dramatically decreased to 7 (0.68%).

The year 2020 marked a substantial rise in total malaria reports, with 4,252 cases; P. falciparum cases were 3,090 (72.69%), P. vivax cases climbed to 1,137 (26.73%), and mixed cases were recorded at 25 (0.59%). In 2021, the total cases peaked at 4,967, where P. falciparum contributed 3,946 cases (79.43%), P. vivax had 1,005 cases (20.23%), and mixed cases decreased further to 16 (0.32%). The year 2022 saw a reduction in overall cases to 3,800, with P. falciparum cases reducing to 2,975 (78.29%), P. vivax cases accounting for 823 (21.66%), and mixed cases being the lowest reported at 2 (0.05%).

This dataset underlines the persistent prevalence of P. falciparum in the region, complemented by significant yet fluctuating contributions from P. vivax, reflecting complex transmission dynamics and challenges in malaria control.

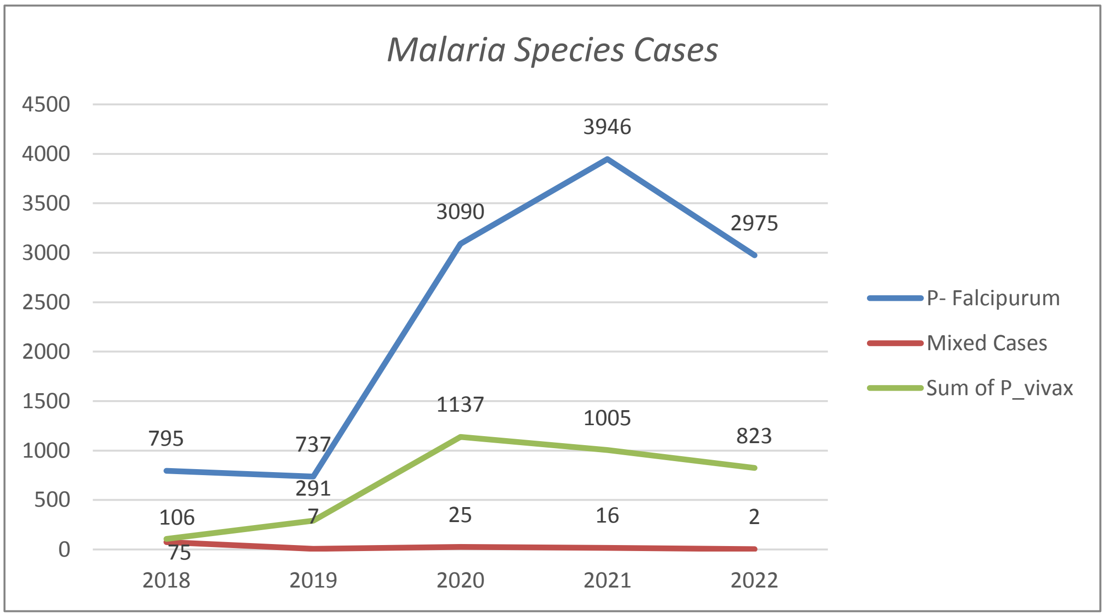

Figure 4: *Malaria Cases by Species in Dale Districts, Sidama Region, Ethiopia*

4.2.2 Trends of Malaria Cases among Sex

Regarding sex-wise distribution, the data shows that both males and females were affected by malaria, with no significant difference in the number of positive cases between the two sexes.

Table 4: *Malaria Cases in trend data by Sex in Dale Districts, Sidama Region, Ethiopia*

Year	Male Count (Percentage)	Female Count (Percentage)	Grand Total
2018	481 (49.28%)	495 (50.72%)	976 (100%)
2019	531 (51.30%)	504 (48.70%)	1035 (100%)

2020	2335 (54.91%)	1917 (45.09%)	4252 (100%)
2021	2836 (57.08%)	2131 (42.92%)	4967 (100%)
2022	2046 (53.84%)	1754 (46.16%)	3800 (100%)
Grand Total	**8229 (54.76%)**	**6801 (45.24%)**	**15030 (100%)**

In examining the malaria case distribution by sex within Dale Districts, Sidama Region, Ethiopia, from 2018 to 2022, the data reveal a gender-based fluctuation in malaria prevalence (see Table 4). In 2018, of the total 976 recorded cases, males accounted for 481 cases (49.28%), while females represented a slightly higher proportion with 495 cases (50.72%). The trend shifted slightly in 2019; where males comprised a majority of the cases at 531 (51.30%) out of 1035 total cases, with females constituting 504 cases (48.70%).

The discrepancy in malaria cases between sexes became more evident in 2020, as males accounted for 2335 cases (54.91%) of the 4252 total cases, and females reported 1917 cases (45.09%). This trend continued into 2021, with males having an even larger share of the cases; they were 2836 cases (57.08%) out of 4967, compared to 2131 cases (42.92%) for females. In 2022, the total cases decreased to 3800, with males again constituting a majority at 2046 cases (53.84%), and females at 1754 cases (46.16%).

Over the five-year period, a cumulative total of 15,030 malaria cases were reported, with males consistently showing a higher incidence rate, totaling 8229 cases (54.76%), compared to 6801 cases (45.24%) for females. This data indicates a persistent higher susceptibility or exposure to malaria among males compared to females in the region during the specified years.

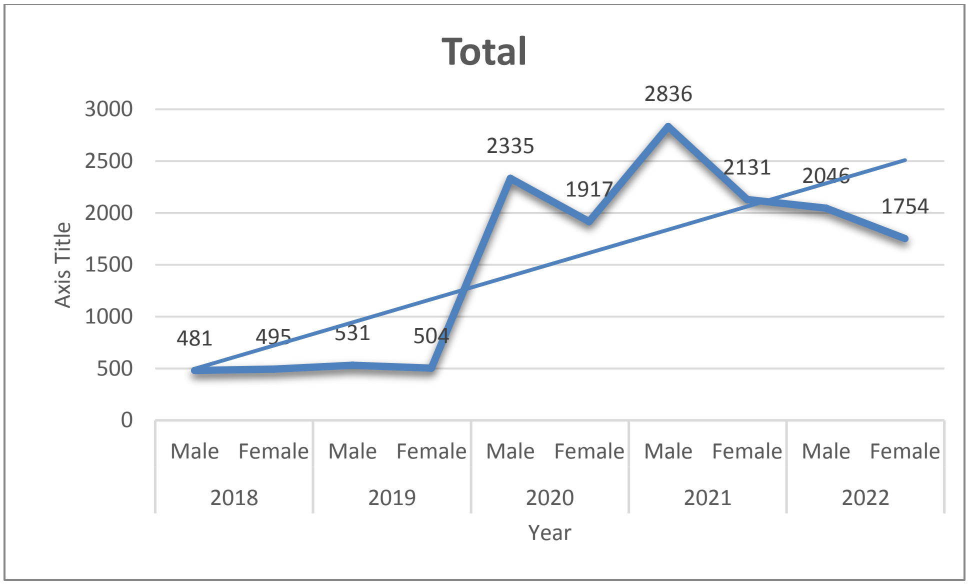

Figure 5: *Malaria Cases in trend data by Sex in Dale Districts, Sidama Region, Ethiopia*

The data suggests that malaria affects both males and females in Dale Districts, highlighting the importance of implementing targeted interventions to control and prevent malaria transmission in both sexes. Understanding the sex-wise distribution of malaria cases is crucial for developing effective malaria control strategies and ensuring equitable access to malaria prevention and treatment services for all populations in endemic areas like Dale Districts.

4.2.3 Trends of Malaria Cases among Age Groups from 2018 -2022

Table 5 below shows an evaluation of malaria case patterns across different age groups across the Dale Districts during a five-year period from 2018 to 2022. The population is divided into five age groups: under <5, 6 to 14, 15 to 29, 30 to 45, and >46. The distribution of malaria cases among various age categories gives insights on the age-related sensitivity and exposure to malaria within the community. Understanding these patterns is vital for devising tailored treatments and preventative measures that address the individual requirements of each demographic category.

Table 5: *Trends of Malaria Cases among Age Groups from 2018 -2022*

Row Labels	Sum of Total positive cases	Percentage
< 5 Years	3564	23.71
6 - 14 Years	3599	23.95
15 - 29 Years	3722	24.76
30 - 45 Years	2331	15.50
46 - 60Years	1234	8.21
>60 Years	580	3.85
Grand Total	15030	100

The result from Table 4 indicates malaria cases across different age groups from 2018 to 2022. Among children under 5 years old, there were 3,564 positive cases, accounting for 23.71% of the total malaria cases. Children aged 6 to 14 years had 3,599 cases, representing 23.95% of the total. Young adults aged 15 to 29 years experienced the highest number of cases, with 3,722 cases, making up 24.76% of the total. Adults aged 30 to 45 years had 2,331 cases, accounting for 15.51% of the total cases. Additionally, the adults population aged 46 - 60 years had 1234 (8.21%) of the total cases. Finally, old aged population, which are greater than 60 years accounted 580(3.85%) cases.

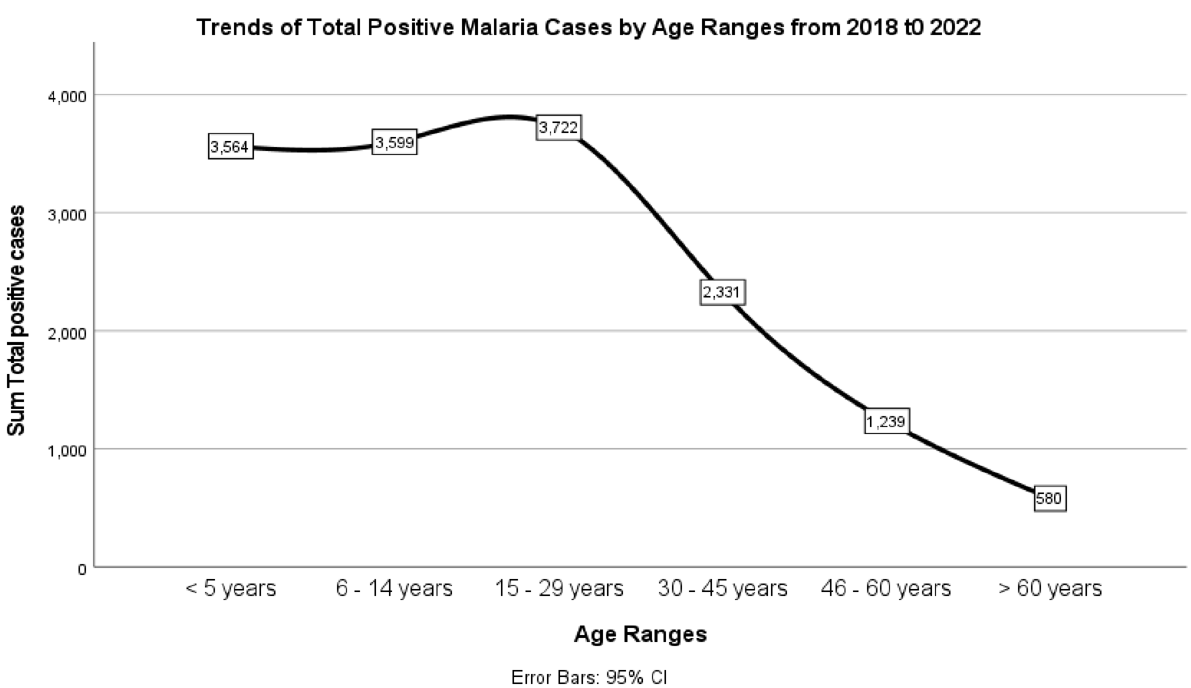

Figure 6: Trends of Malaria Cases among Age Groups from 2018 -2022

In this five-year period, there seems to be a progressive increase in malaria cases from the age group (< 5 years) to the young adult group (15 - 29 years), which had the largest number of cases. This tendency then decreases in the later adult categories, with fewer instances among those aged 30 - 45 years and even fewer among those in between 46 – 60 years old. The trend indicates the least malaria positive cases for age groups grater than 60 years.

This trend might be ascribed to numerous reasons, including changes in exposure due to behavioral patterns (e.g., outdoor activities, sleeping habits), immunity built over time, and access to healthcare. Young children and young people could be more exposed due to outdoor activities and less developed immune, resulting to greater illness rates. Older persons, on the other hand, may have gained some amount of immunity over time or may be more careful in their activities, resulting to reduced infection rates in these age groups.

In the context of the Sidama region and similar places, researches confirmed the observed patterns in malaria prevalence across different age groups. For instance, a research by Abate & Abate1, (2019) done in the Sidama region revealed greater malaria incidence rates among young people (15 - 29 years) and children compared to older persons, matching with the findings of this study. Additionally, a research by Molla et al., (2021) in a neighboring Gedeo zone with similar demographic and climatic characteristics revealed a comparable pattern of malaria incidence, further confirming the generalizability of the trends seen in this study.

Furthermore, a study by Tesfaye et al. (2018) in a region with similar malaria endemicity and population demographics demonstrated a similar age-specific pattern of malaria incidence, with higher rates among younger age groups.

4.2.4 The Seasonal Distribution of Malaria Positivity in Dale District

The total cases observed each year and their distribution across different seasons were described in terms of actual counts and corresponding percentages of the annual totals.

Table 6: *The Seasonal Distribution of Malaria Positivity in Dale District within Five Years (2018-2022)*

Year	Sep - Nov (Percentage)	Dec - Feb (Percentage)	Mar - May (Percentage)	Jun - Aug (Percentage)	Total
2018	352 (36.07%)	247 (25.31%)	205 (21.01%)	172 (17.62%)	976 (100%)
2019	317 (30.63%)	282 (27.25%)	193 (18.65%)	243 (23.48%)	1035 (100%)
2020	1551 (36.48%)	922 (21.67%)	870 (20.46%)	909 (21.39%)	4252 (100%)
2021	1663 (33.47%)	1288 (25.92%)	1175 (23.65%)	841 (16.93%)	4967 (100%)
2022	1023 (26.92%)	861 (22.66%)	990 (26.05%)	926 (24.37%)	3800 (100%)
Grand Total	**4906 (32.65%)**	**3600 (23.96%)**	**3433 (22.85%)**	**3091 (20.57%)**	**15030 (100%)**

The result from the Table 6 indicates, in 2018, a total of 976 malaria cases were recorded. The majority of these cases occurred between September and November, accounting for 36.07% of the annual total, followed by cases in December to February (25.31%), March to May (21.01%), and June to August (17.62%). This trend indicates a peak in malaria cases during the late rainy season transitioning into the dry season.

In the subsequent year, 2019, there were 1,035 cases, with the highest percentage again in the September to November season at 30.63%. The distribution was more evenly spread across the remaining seasons compared to 2018, with December to February and June to August having a higher incidence than March to May.

The year 2020 witnessed a significant increase in malaria cases, totaling 4,252. The distribution pattern shifted slightly with September to November still recording the highest percentage (36.48%), but June to August saw an increase to 21.39%, almost aligning with the cases in December to February (21.67%) and March to May (20.46%).

By 2021, the total count rose to 4,967, with September to November once again having the highest incidence of cases at 33.47%. However, the spread across other seasons showed a more balanced distribution compared to previous years, with December to February (25.92%) and March to May (23.65%) showing substantial numbers of cases.

The year 2022 showed a slight decrease in overall cases to 3,800. The seasonal distribution was more uniform across all seasons, with September to November accounting for 26.92% of the cases, followed closely by March to May (26.05%), June to August (24.37%), and December to February (22.66%).

Summarizing the five-year period, the grand total of malaria cases reached 15,030, with the highest overall percentage of cases occurring from September to November (32.65%). This season was followed by December to February (23.96%), March to May (22.85%), and June to August (20.57%), reflecting a consistent pattern of malaria peak after the rainy season across the years. This distribution is indicative of the seasonal and climatic factors affecting malaria transmission in the Dale District of the Sidama Region.

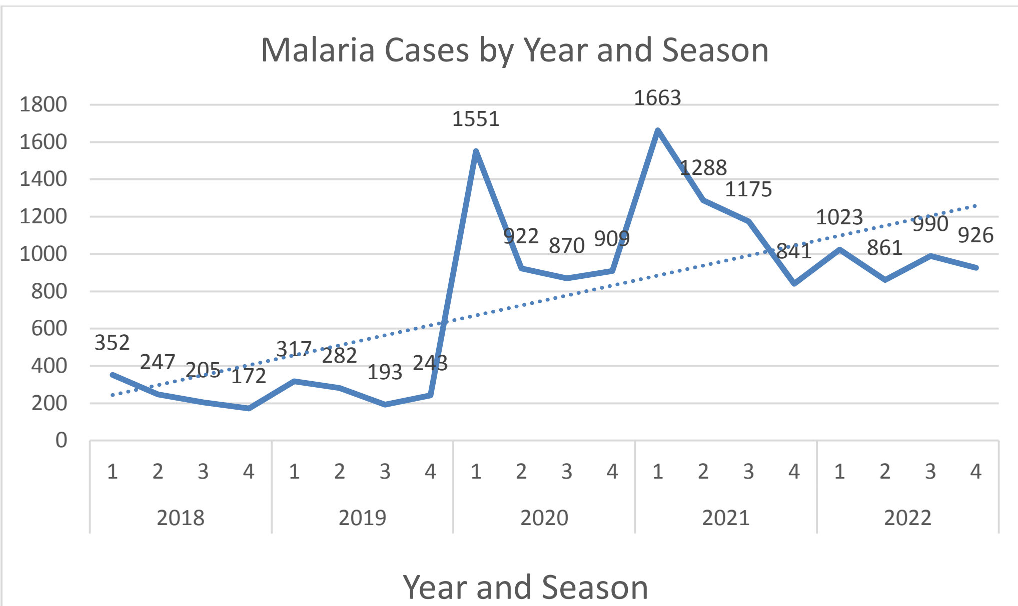

Figure 7: *The Seasonal Distribution of Malaria Positivity in Dale District within Five Years (2018-2022)*

4.2.5 The Factors Impacting the Incidence of Malaria Cases in Dale District

This section investigates the interaction effects of variables on malaria prevalence through statistical methods to assess how the combined influence of demographic factors (such as age and sex) and seasonal variation impacts the incidence of malaria cases. This analysis goes beyond examining the individual effects of these variables and seeks to understand how they interact and potentially amplify or mitigate each other's effects on malaria prevalence. The researcher assumed statistical method, Poisson regression analysis with interaction terms, for the quantification of these interactions, to provide insights into how different population groups may be more susceptible to malaria during specific seasons or age ranges.

To this end, the assumptions of the Poisson regression model were tested to ensure the validity of the analysis. Specifically, the assumption of equidispersion, where the mean and variance of the count data are equal, was assessed.

Table 7: *One-Sample Kolmogorov-Smirnov Test for Poisson distribution*

		Total Positive Cases
N		240
Poisson Parameter	Mean	1
Most Extreme Differences	Absolute	.986
	Positive	.000
	Negative	-.986
Kolmogorov-Smirnov Z		13.949
Asymp. Sig. (2-tailed)		.000

The one-sample Kolmogorov-Smirnov test was conducted to assess whether the distribution of total positive malaria cases follows a Poisson distribution. A total of 240 cases were analyzed, assuming a Poisson distribution with a mean of 1. The test revealed significant deviations from the expected Poisson distribution, with a Kolmogorov-Smirnov Z statistic of 13.949 and a p-value of <0.001. The most extreme difference between the observed and expected cumulative distribution functions was 0.986, indicating a substantial discrepancy. These results suggest that the assumption of a Poisson distribution for the total cases may not hold true. Consequently, the researcher used alternative statistical approach, Negative Binomial regression, to appropriately model the data and draw reliable conclusions regarding the factors influencing malaria prevalence in the Dale Districts of the Sidama Region, Ethiopia.

Table 8: *Negative Binomial Regression Parameter Estimate*

Parameter	B	Std. Error	Hypothesis Test			Exp(B)	95% Wald Confidence Interval for Exp(B)	
			Wald Chi-Square	df	Sig.		Lower	Upper
(Intercept)	2.32	.21	118.44	1	.000	10.16	6.69	15.43
[Season 1= Sep - Nov]	.53	.19	8.06	1	.005	1.69	1.18	2.43
[Season 2= Dec - Feb]	.18	.18	.99	1	.320	1.20	.84	1.73
[Season 3= Mar - May]	.05	.19	.07	1	.787	1.05	.73	1.51
[Season 4= June - Aug]	0[a]	.	.	.	.	1	.	.
[Age 1= < 5 years]	1.86	.23	65.93	1	.000	6.40	4.09	10.02
[Age 2= 6 - 14 years]	1.88	.23	67.17	1	.000	6.54	4.17	10.24
[Age 3= 15 - 29 years]	1.89	.23	68.42	1	.000	6.64	4.24	10.40
[Age 4= 30 - 45 years]	1.42	.23	38.22	1	.000	4.12	2.63	6.45
[Age 5= 46 – 60 years]	.79	.23	11.49	1	.001	2.18	1.38	3.42
[Age 6= > 60 years]	0[a]	.	.	.	.	1	.	.
[Sex 1= Male]	.22	.13	2.82	1	.093	1.25	.96	1.61
[Sex 2= Female]	0[a]	.	.	.	.	1	.	.

Table 8 indicates that the Negative Binomial Regression analysis conducted to assess the impact of demographic and seasonal factors on malaria prevalence in the Dale Districts of Sidama Region, Ethiopia, yielded significant results. The model's intercept was highly significant (B = 2.32, SE = 0.21, Wald χ^2 = 118.44, $p < .001$), indicating a substantial baseline incidence of malaria when other predictors were held constant. The odds of malaria occurrence were 10.16

times higher than the baseline, which suggests a strong likelihood of malaria prevalence independent of other factors.

Regarding seasonality, the period from September to November showed a significant increase in malaria cases (B = 0.53, SE = 0.19, Wald $\chi^2 = 8.06$, $p = .005$), with 1.69 times higher odds compared to the reference season (June to August). However, the periods of December to February (B = 0.18, SE = 0.18, Wald $\chi^2 = 0.99$, $p = .320$) and March to May (B = 0.05, SE = 0.19, Wald $\chi^2 = 0.07$, $p = .787$) did not show statistically significant differences from the reference season, suggesting minimal seasonal variation during these periods.

Age was a significant factor affecting malaria prevalence. Children under 5 years were much more likely to experience malaria, with the odds of occurrence being 6.40 times higher than those in the reference group of individuals over 60 years (B = 1.86, SE = 0.23, Wald $\chi^2 = 65.93$, $p < .001$). Similarly, children aged 6-14 years were at significantly higher risk, with an odds ratio of 6.54 (B = 1.88, SE = 0.23, Wald $\chi^2 = 67.17$, $p < .001$), and those aged 15-29 years exhibited the highest vulnerability, with odds of malaria being 6.64 times greater than the reference group (B = 1.89, SE = 0.23, Wald $\chi^2 = 68.42$, $p < .001$). Individuals aged 30-45 years also faced a considerably elevated risk of malaria (B = 1.42, SE = 0.23, Wald $\chi^2 = 38.22$, $p < .001$; OR = 4.12), while those in the 46-60 years group had lower odds, though still significantly higher than the reference group (B = 0.79, SE = 0.23, Wald $\chi^2 = 11.49$, $p = .001$; OR = 2.18).

Gender was marginally significant in this analysis, with males having 1.25 times higher odds of contracting malaria compared to females (B = 0.22, SE = 0.13, Wald $\chi^2 = 2.82$, $p = .093$), though this finding did not reach the conventional level of statistical significance.

The finding that seasonality significantly influences malaria incidence in the Dale Districts, with the highest number of cases recorded from September to November, aligns well with broader epidemiological patterns observed in Ethiopia and similar regions. This increase during the September to November period can likely be attributed to the rainy season, which typically spans from June to September, creating optimal breeding conditions for mosquitoes. Literature from Ethiopia verifies this seasonal pattern; for instance, Deress and Girma, (2019) and Tadesse et al., (2017) reported in their study in the Oromia region that malaria transmission peaks immediately after the rainy season, supporting the observed pattern in current analysis.

Contrastingly, the lack of significant differences in malaria cases during December to February and March to May compared to the baseline of June to August is insightful. This could be due to several factors, including the relatively dryer conditions prevalent during these months, which are less conducive to mosquito breeding. Moreover, these findings are consistent with studies like Hailu et al., (2017); Solomon et al., (2021) and Woyessa et al., (2013) who observed that malaria incidence in the Southern Nations, Nationalities, and Peoples' Region (SNNPR) of Ethiopia, which includes the Sidama region, decreases during the dry season.

Contrary to current findings, studies in other regions of Ethiopia, such as the study by Tefera et al., (2022) in the northwest, report minor seasonal fluctuations and a more evenly distributed incidence throughout the year, suggesting a potential regional variability in malaria transmission patterns. This discrepancy underscores the complexity of malaria epidemiology in Ethiopia, influenced by local ecological, climatic, and human factors.

The result that age strongly determines malaria incidence, notably in children under 5 years, those aged 6-14 years, and young people aged 15-29 years, is consistent with previous studies done in Ethiopia and other malaria-endemic locations. In Ethiopia, investigations such as that by Alemu et al. (2013) in the Jimma zone have found a greater burden of malaria among children younger than 5 years, underscoring the sensitivity of this age group to malaria infection. Similarly, study by Ouedraogo, (2018) in the Oromia area indicated that children aged 6-14 years were more likely to be infected with malaria, which corresponds with results. Moreover, research by Tefera et al., (2022) in the Amhara area and Berhe et al., (2019) in the Tigray region of Ethiopia have also revealed greater malaria incidence among adolescents and young adults aged 15-29 years, validating observation of increased malaria cases in this age range. These studies explain the greater prevalence among young people to variables such as outdoor activities and occupational exposure, which increase their risk of mosquito bites and malaria infection.

Additionally, the lack of significant difference in malaria incidence among individuals aged 30-45 years might reflect acquired immunity developed over years of exposure to malaria, as suggested by studies such as those by Agegnehu et al., (2018) who discuss how repeated malaria infections over the lifespan can lead to a degree of protective immunity in adults living in endemic regions. Conversely, this finding contradicts with studies from other locations. For example, a research by Alemu et al., (2014) in the Amhara area indicated that adults aged 30-45 years had a greater risk of malaria, presumably due to occupational activities that increase exposure to mosquito bites. However, it is important to note that some studies, such as that by Haile et al., (2017) in the Southern Nations, Nationalities, and Peoples' Region (SNNPR) of Ethiopia, have reported no significant age-specific differences in malaria incidence, highlighting the complex interplay of factors influencing malaria transmission dynamics.

The result of marginal relevance relating sex and malaria risk, with males possibly having a greater risk than females. This may due to males are engaged in out door activity until evening mosquito peak biting times and also most of the time ITNs is used by mothers and younger chidren.accords with some current studies but contradicts with others. Studies from Ethiopia, such as that by Alelign et al., (2018) in the Amhara area, have shown similar findings of slightly greater malaria prevalence in males compared to females, attributable to variations in outdoor activity and exposure to mosquito bites. Additionally, study by Berhe et al., (2019) in the Tigray region indicated a slightly greater frequency of malaria in men, which confirms the current result. However, some research have revealed inconsistent outcomes. For instance, a research by Yewhalaw et al., (2014) in the Gilgel-Gibe district of Ethiopia revealed no significant variation in malaria incidence between males and females. Similarly, a research by Solomon et al., (2019) in the SNNPR revealed identical malaria prevalence rates in both genders.

The marginal relevance reported in this study implies that sex may have a role in malaria risk but that other factors, such as age, seasonality, and environmental circumstances, may have a more noticeable influence. In general, the negative binomial regression analysis showed numerous major conclusions about malaria prevalence in the Dale Districts of the Sidama Region, Ethiopia. Seasonality revealed as a key determinant, with the biggest number of cases occurring during the September to November period, perhaps due to the rainy season. Children under 5 years, as well as those aged 6-14 years and 15-29 years, demonstrated a greater chance of malaria infection, underlining age-specific vulnerabilities.sex exhibited marginal relevance, suggesting that males may be at a little greater risk than females.

4.3 Prevalence of Active Malaria Cases

The first component of the study focuses on assessing the patterns of malaria distribution in the Dale Districts during a five-year period from 2018 to 2022. However, this part gives the prevalence of active malaria cases among 381 (with 4 participants drop from the study) .respondents involved in a cross-sectional survey conducted (from April to June 2023) in the Dale Districts of the Sidama Region, Ethiopia. The study comprised microscopic analysis of blood samples to detect the presence of malaria parasites and structured questionnaire to examine the knowledge of the respondents about the signs and symptom of malaria and risk factors associated with malaria disease infections.

4.3.1 Socio-Demographic Characteristics of Respondents Participated in Cross-Sectional Study

Table 9: *The socio demographic characteristics of the study participants*

Character	Categories	Frequency	Percent (%)
Sex	Male	221	58.0
	Female	160	42.0
	Total	381	100
Age	18-29	124	32.5
	30-40	154	40.4
	41-50	52	13.6
	50 and above	50	13.1
	Total	380	100
Marital status	Single	40	10.5
	Married	311	81.6
	Widowed	23	6.0
	Divorced	7	1.8
	Total	381	100
Main occupation	Farmer	113	29.7
	Housewife	173	45.4
	Casual laborer	78	20.5
	Merchant	9	2.4
	Government employed	5	1.3
	Unemployed	2	1.1

	Total	380	100
Educational status	Illiterate	152	39.9
	Read and write only	106	27.8
	Primary school	54	14.2
	Secondary school	60	15.7
	Diploma and above	9	2.4
	Total	381	100
Residence	Rural	324	85.0
	Urban	54	14.2
	Total	378	100
Household size	1-4	203	53.3
	5-8	177	46.5
	9 – 12	1	0.3
	Total	381	100

The result from Table 9 indicates that the sample comprised 221 males (58.0%) and 160 females (42.0%), indicating a slightly higher participation of males in the study. Regarding age distribution, the majority of respondents fell within the age groups of 18-29 years (124, 32.5%) and 30-40 years (154, 40.4%), with smaller proportions in the 41-50 years group (52, 13.6%) and those aged 50 and above (50, 13.1%). In terms of marital status, the majority of respondents were married (311, 81.6%), followed by single individuals (40, 10.5%), widowed (23, 6.0%), and divorced (7, 1.8%).

Occupationally, the sample was predominantly composed of housewives (173, 45.4%), farmers (113, 29.7%), and casual laborers (78, 20.5%), with smaller proportions engaged in merchant activities (9, 2.4%), government employment (5, 1.3%), and unemployment (2, 1.1%). Educational status varied among respondents, with a notable portion being illiterate (152, 39.9%) or having only basic reading and writing skills (106, 27.8%). A smaller percentage had completed primary school (54, 14.2%), secondary school (60, 15.7%), or attained a diploma and above (9, 2.4%).

Regarding residence, the majority of respondents resided in rural areas (324, 85.0%), with a smaller proportion residing in urban areas (54, 14.2%). Household size varied, with the majority of respondents living in households with 1-4 members (203, 53.3%), followed by households with 5-8 members (177, 46.5%), and a negligible proportion in households with 9-12 members (1, 0.3%). These demographic characteristics provide valuable insights into the composition of the study sample and can help contextualize the findings related to malaria prevalence and associated risk factors in the Dale Districts of the Sidama Region, Ethiopia.

4.3.2 Knowledge and Practice of Respondent

The data for this analysis were gathered through multiple-response questions, allowing for a comprehensive assessment of respondents' knowledge levels.

Table 10: *Knowledge of Respondents about Signs and Symptom of Malaria*

		Responses		Percent of Cases
		N	Percent	
Knowledge of Respondents about Signs and symptom of malaria	Fever	217	16.1%	57.1%
	Loss of appetite	248	18.4%	65.3%
	Feeling cold	253	18.8%	66.6%
	Headache	176	13.1%	46.3%
	Nausea and vomiting	186	13.8%	48.9%
	Body ache joint pain	137	10.2%	36.1%
	Others	128	9.5%	33.7%
Total		1345	100.0%	353.9%

Table 10 offers a summary of respondents' knowledge about the signs and symptoms of malaria in the Dale Districts of the Sidama Region, Ethiopia. The data suggests that lack of appetite and feeling cold were the most generally recognized symptom, with 248 (18.4%) and 253 (18.8%) respondents identifying them, respectively. Fever was also well-known symptom with 217 responses (16.1%). Headache, nausea and vomiting, and bodily ache/joint discomfort were indicated by 176 (13.1%), 186 (13.8%), and 137 (10.2%) individuals, respectively. Additionally, 128 respondents (9.5%) identified other symptoms not specified in the survey.

In agreement to the present conclusion, numerous research have indicated differing degrees of awareness of malaria symptoms among different groups. A research done in the Amhara region by Yhdego et al., (2022) indicated that while fever was well recognized as a sign of malaria, other symptoms such as headache, chills, and body pains were less well-known. Similarly, a research in the Tigray region by Haile et al., (2017) found gaps in awareness of malaria symptoms, with many respondents unable to accurately identify essential symptoms.

Table 11: *Knowledge of Respondents about Causes of Malaria*

		Responses		
		N	Percent	Percent of Cases
Knowledge of Respondents about Causes of Malaria	Mosquito bites	276	68.3%	72.4%
	Eating contaminated food	11	2.7%	2.9%
	Socked with rain	24	5.9%	6.3%
	Changing weather	35	8.7%	9.2%
	Other	58	14.4%	15.2%
Total		404	100.0%	106.0%

Table 11 presents the knowledge of respondents about the causes of malaria in the Dale Districts of the Sidama Region, Ethiopia. The table indicates that the majority of respondents identified mosquito bites as a cause of malaria, with 276 respondents (68.3%) correctly recognizing this mode of transmission. Other causes such as eating contaminated food, being soaked with rain, and changing weather were less commonly mentioned, with 11 (2.7%), 24 (5.9%), and 35 (8.7%) respondents identifying them, respectively. Additionally, 58 respondents (14.4%) mentioned other causes not listed in the survey.

The findings suggest a reasonable level of awareness among respondents regarding the causes of malaria, particularly in recognizing mosquito bites as the primary mode of transmission. This aligns with existing literature on malaria knowledge in Ethiopia. A study by Abebaw et al., (2022) in the Amhara region found that 72.6% of respondents identified mosquito bites as a cause of malaria, which is consistent with the current sstudy. Similarly, a study by Taffese et al., (2018) in the Southern Nations, Nationalities, and Peoples' Region (SNNPR) reported that 73.9% of respondents identified mosquito bites as a cause of malaria.

Table 12: *Knowledge of Respondents about Protective Measures of Malaria*

		Responses		Percent of Cases
		N	Percent	
Knowledge of Respondents about Protection	Sleeping under net	284	66.7%	84.3%
	Use mosquito repelient	2	0.5%	0.6%
	Preventive medication	25	5.9%	7.4%
	Spray insecticides	16	3.8%	4.7%
	Fill in puddles	77	18.1%	22.8%
	Mosquito screen on widows	16	3.8%	4.7%
	Other protection mechanisms	6	1.4%	1.8%
Total		426	100.0%	126.4%

Table 12 displays the knowledge of respondents on preventative measures against malaria in the Dale Districts of the Sidama Region, Ethiopia. The data demonstrates that the majority of respondents identified sleeping under a mosquito net as a preventive measure, with 284 respondents (66.7%) correctly recognizing this strategy. Other protective methods such as applying mosquito repellent, taking preventive medicine, and spraying pesticides were less regularly stated, with just 2 (0.5%), 25 (5.9%), and 16 (3.8%) respondents recognizing them, respectively. Additionally, 77 respondents (18.1%) suggested filling up puddles, and 16 (3.8%) indicated installing mosquito screens on windows as precautionary measures against malaria.

The findings suggest level of awareness among respondents regarding protective measures against malaria, particularly in recognizing the importance of lying under mosquito nets. This aligns with existing literature on malaria prevention in Ethiopia. A study by Taffese et al., (2016) found that 68.4% of respondents identified lying under a mosquito net as a preventive measure, which is consistent with the findings in current study. Similarly, a study by Asale et al. (2018) in the Southern Nations, Nationalities, and Peoples' Region (SNNPR) reported that 73.1% of respondents identified lying under a mosquito net as a protective measure against malaria.

While sleeping under a mosquito net is widely regarded as a vital protective strategy against malaria, it is important to highlight the value of other preventative techniques as well. The World Health Organization (WHO) emphasizes a comprehensive approach to malaria prevention, which includes not only the use of insecticide-treated nets (ITNs) but also the use of indoor residual spraying (IRS), mosquito repellents, and environmental management to reduce mosquito breeding sites (WHO, 2022). These extra precautions are necessary in places where mosquito resistance to pesticides is a problem or where availability to ITNs is limited.

Despite these limitations, it is vital to advocate a holistic strategy to malaria prevention that encompasses several preventative measures. This not only enhances the efficiency of malaria control operations but also solves the developing concerns of mosquito resistance and restricted availability to ITNs.

4.3.3 Prevalence of Malaria Based on Socio-Demographic Factors

In this section, the prevalence of malaria based on various socio-demographic factors in the Dale Districts of the Sidama Region, Ethiopia was examined. The analysis focuses on factors such as sex, age, occupation, household size, education status, and residence of the participants.

Table 13: *Socio-Demographic Factors and Malaria Prevalence*

Variables	Categories	Malaria Negative (f)	% of Negative Cases	Malaria Positive (f)	% of Positive Cases
Sex	Male	200	90.49	21	9.51
	Female	133	83.62	26	16.38
Age	18-29	105	84.68	19	15.32
	30-40	139	90.85	14	9.15
	41-50	49	94.23	3	5.77
	>50	39	78.00	11	22.00
Occupation	Government Employed	5	100.00	0	0.00
	Merchant	7	77.78	2	22.22
	Student	63	81.82	14	18.18
	Farmer	97	82.20	21	17.8
	Retired	1	100.00	0	0.00
	Housewife	158	94.64	10	5.36
	Unemployed	2	100.00	0	0.00
Household size	1-4	179	88.61	23	11.39
	5-8	153	86.44	24	13.56
	9 – 12	1	100.00	0	0.00
Education status	Illiterate	131	86.18	21	13.82
	Read and write only	96	91.43	9	8.57
	Primary School	51	94.44	3	5.56

	Secondary School	48	80.00	12	20.00
	Higher Education (College, University)	7	77.78	2	22.22
Residence of the participants	Urban	286	88.55	37	11.45
	Rural	45	83.33	9	16.67

The result from Table 13 gives a thorough breakdown of malaria infection status among participants based on many demographic characteristics. A total of 385 study participants were recruited for this investigation, of which only 381 engaged in survey questioner and submitted blood samples (a non-response rate of 1.1%). Of the total febrile patients who participated in this study, 47 (12.37%) were infected with malaria parasites. Among the infected subjects, 21 (44.7%) were male and 26 (55.3%) were females. From the total of 47 malaria-infected individuals, infections with Plasmodium falciparum,Plasmodium vivax and mixed infection were 29 (61.7%), 15 (31.9%) and 3(6.4) respectively.

In terms of sex, 90.49% of males tested negative for malaria, while 9.51% tested positive. Conversely, among females, 83.62% tested negative, while 16.38% tested positive. This shows a potential gender difference in malaria susceptibility, with females demonstrating a slightly higher positive rate compared to males.

Regarding age categories, the findings suggest that younger persons (18–29 years) had an 84.68% negative rate and a 15.32% positive rate, indicating a modest risk of malaria in this age bracket. For the age group 30–40, there was a 90.85% negative rate and a 9.15% positive rate. The 41–50 age groups demonstrated a particularly high negative rate of 94.23%, with people over 50 years old having a higher positive rate of 22.00%, indicating an increased sensitivity to malaria in this age category.

Occupationally, government-employed persons reported a 100% negative rate, suggesting a decreased risk within this group. Merchants had a 77.78% negative rate and a 22.22% positive rate, suggesting a significant risk. Students had 81.8% negative rate and an 18.18% positive rate, and farmers had an 82.2% negative rate and 17.8% positive rate.

In terms of household size, smaller households (1-4 members) displayed an 88.61% negative rate and an 11.39% positive rate, whereas larger households (5-8 members) had an 86.44% negative rate and a 13.56% positive rate. This shows a slightly increased risk of malaria in larger families.

Education status was also found to impact malaria infection rates, with illiterate people displaying an 86.18% negative rate and a 13.82% positive rate. Individuals with a primary school education had a 94.44% negative rate and a 5.56% positive rate, indicating a decreased risk among this group. However, individuals with higher education (college or university) demonstrated a 77.78% negative rate and a 22.22% positive rate, suggesting a larger risk compared to other education levels.

Residence location also had a factor, with urban inhabitants exhibiting an 88.55% negative rate and a 11.45% positive rate, while rural people had an 83.33% negative rate and a 16.67% positive rate. This implies a somewhat increased risk of malaria in rural locations compared to urban areas.

Even though the result from Table 13 gives a significant beginning insight into the relationship between several demographic characteristics and malaria infection, it is crucial to emphasize that this study alone is not adequate to demonstrate a conclusive association or predictive ability of any variable. Further, the researcher applied a more rigorous statistical test, logistic regression analysis, to completely analyze the prediction capacity of each variable and their independent contributions to malaria infection risk.

4.3.4 The Analysis of Risk Factors Associated with Malaria Infection in the Study Area

In this part, logistic regression was applied to explore the link between various demographic and environmental variables and malaria infection. The factors evaluated for the study were age, sex, education, employment, availability of mosquito nets, windows in residences, separate rooms, anti-malaria medication spraying during the previous 12 months, the presence of stagnant water, and the recent travel history of the individuals.

This statistical technique was used to analyze how numerous factors impact the chance of malaria infection among the population. This statistical approach is well suited for epidemiological studies where the result is binary, such as the presence or absence of malaria infection among participants. The choice of logistic regression is underlined by its capacity to generate odds ratios for each predictor, delivering a quantifiable estimate of how each factor effects the chance of malaria infection (Hosmer et al., 2013). This element is critical for understanding both the strength and direction of the relationships between each risk factor and malaria infection. Additionally, logistic regression may compensate for any confounding variables, therefore enhancing the accuracy of the results by isolating the influence of each independent variable on the likelihood of infection. Hence, before doing the analysis, the fundamental assumptions for logistic regression were checked.

Table 14: *Case Processing Summary for Logistic Regression*

Un-weighted Cases		N	Percent
Selected Cases	Included in Analysis	376	98.7
	Missing Cases	5	1.3
	Total	381	100.0
Unselected Cases		0	.0
Total		381	100.0

The case processing summary for the logistic regression analysis in the study indicates a comprehensive use of the collected data. Out of a total of 381 cases, 376 were included in the analysis, accounting for 98.7% of the sample, which underscores a robust basis for the findings due to the high inclusion rate. Only 5 cases, or 1.3%, were missing and not included, suggesting that the dataset was largely complete and reliable for analysis. No cases were unselected, indicating that all available data was considered, maximizing data utilization and maintaining the statistical power of the analysis. This completeness and effective management of data collection enhance the validity of the study's results.

Table 15: *Omnibus Tests of Model Coefficients for Logistic Regression Analysis*

		Chi-square	df	Sig.
Step 1	Step	53.310	15	.000
	Block	53.310	15	.000
	Model	53.310	15	.000

The Omnibus Tests of Model Coefficients table plays a crucial role in determining the overall significance of predictors in a logistic regression analysis. This table tests the null hypothesis that adding predictors to a model does not enhance its fit compared to a model that only includes an intercept. In the study at hand, the Chi-square value reported was 53.310 at Step 1, across the step, block, and model categories, with a degrees of freedom count of 15. This figure represents the chi-square statistic that evaluates the change in the -2 Log-likelihood of the model due to the incorporation of predictors.

The significant p-value of .000 firmly rejects the null hypothesis, indicating that the predictors significantly improve the model's fit beyond what would be expected with the intercept alone. This finding underscores a statistically significant association between the predictors included and the likelihood of malaria infection among participants. Such a result is vital as it justifies the inclusion of these predictors in the model, confirming their collective effect on the outcome variable.

Table 16: *Model Summary of Logistic Regression*

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	226.105[a]	.132	.252

a. Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

The model summary table from the logistic regression analysis provides key indicators of the model's explanatory power. The '-2 Log likelihood' figure presented here is 226.105, which indicates the extent to which the model deviates from the perfect model (a lower number indicates a better fit). This estimation terminated at iteration number 7, suggesting that the model reached stability as the parameter estimates changed by less than .001, which signifies that a convergence was achieved in the model fitting process.

Furthermore, the table reports Cox & Snell R Square and Nagelkerke R Square values, which are .132 and .252 respectively. These values represent the amount of variance in the dependent variable (malaria infection) explained by the model. The Cox & Snell R Square and Nagelkerke R Square are measures of the goodness of fit for logistic regression models. The Nagelkerke R Square, an adjusted version of the Cox & Snell R Square, provides a more accurate interpretation by scaling the statistic to allow a maximum value of 1. In this case, a Nagelkerke R Square of .252 suggests that approximately 25.2% of the variability in malaria infection risk is explained by the model, which is a reasonably substantial proportion for epidemiological studies involving human behavior and environmental factors.

Table 17: *Hosmer and Lemeshow Test*

Step	Chi-square	df	Sig.
1	8.789	8	.360

The Hosmer and Lemeshow Test, as illustrated in Table 14, is a statistical test used to assess the goodness of fit of a logistic regression model. It analyzes how closely the model's projected probability matches the actual observed outcomes.

In this test, the chi-square value is 8.789 with 8 degrees of freedom, resulting in a p-value of.360, which is larger than .05 and shows that there is no significant difference between the predicted probability and the actual outcomes, showing a satisfactory fit of the model. Since the p-value in this test is .360, which is more than.05, we fail to reject the null hypothesis. This shows that the logistic regression model fits the data well, showing that there is no substantial discrepancy between the anticipated probability and the actual results.

The model's capacity to generate odds ratios for each predictor offers a quantitative estimate of the determinants' effect on malaria infection, improving our comprehension of the correlations. Furthermore, the model's goodness of fit, as evidenced by the Hosmer and Lemeshow Test with a non-significant p-value of .360, indicates that the predicted probabilities align well with the observed outcomes, confirming the model's reliability and effectiveness in identifying significant predictors of malaria. Overall, the logistic regression model seems to be a viable tool for guiding targeted measures to lower the malaria burden in the study region, highlighting its relevance in epidemiological research and malaria control methods.

Table 18: *Crude and Adjusted Odds Ratios of Risk Factors Associated with Malaria Infection*

Predictor	Category	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Sex	Female	1	1	1	
	Male	.537(.290, .994)	.048	.417(.198, .876)	.021
Age of respondents	18 – 29 years	1	1	1	
	30 – 40 years	.557(.267, 1.161)	.118	.661(.221, 1.977)	.459
	41 – 50 years	.338(.096, 1.198)	.093	.390(.077, 1.983)	.257
	>50 years	1.559(.681, 3.569)	.294	.967(.254, 3.680)	.961
Education level respondents	Illiterate	1	1	1	
	Read and write	.585(.257, 1.333)	.202	.570(.200, 1.625)	.293
	Primary school	.367(.105, 1.284)	.117	.270(.056, 1.295)	.102
	Secondary school	1.560(.713, 3.411)	.266	1.507(.368, 6.171)	.569
	Higher education	1.782(.347, 9.166)	.489	2.268(.290, 17.764)	.436
Residence of participation	Urban	1	1	1	
	Rural	1.546(.699, 3.418)	.282	1.094(.401, 2.985)	.860
Using mosquito nets	No	1	1	1	
	Yes	.283(.141, .569)	.000	.350(.158, .776)	.010
Availability of windows	No	1	1	1	
	Yes	.766(.396, 1.482)	.429	.748(.341, 1.642)	.469
Availability of separate rooms	No	1	1	1	
	Yes	1.824 (.495, 6.718)	.366	.604(.143, 2.557)	.494
Anti-malaria drug sprayed	No	1	1	1	
	Yes	.067(.009, .490)	.008	.061(.008, .474)	.008
Travel history recent	No	1	1	1	
	Yes	2.797(1.220, 6.411)	.015	1.853(.664. 5.173)	.239
Presence of stagnant water	No	1	1	1	
	Yes	1.915(1.036, 3.541)	.038	2.267(1.118, 4.599)	.023

Table 12 illustrates the Crude and Adjusted Odds Ratios of risk variables related with malaria infection in the research area. The demographic and environmental variables included in the model were age, gender, education, occupation, availability of mosquito nets, windows in homes, separate rooms, anti-malaria drug spraying within the last 12 months, the presence of stagnant water, and recent travel history of the participants.

The results indicated a substantial association between sex and malaria infection. Males showed reduced chances of malaria infection compared to females in both the crude (OR = 0.537, 95% CI [0.290, 0.994], p = 0.048) and adjusted models (OR = 0.417, 95% CI [0.198, 0.876], p = 0.021), showing that females are at a higher risk of malaria in study region. This conclusion is validated by several studies done in different locations of Ethiopia. For example, research in the Jimma Zone indicated that females were more likely to be infected with malaria than males (Ouedraogo, 2018). Similarly, research in the Oromia Region revealed a greater frequency of malaria among females compared to males (Mekuria et al., 2022). Additional study in the Gedeo Zone in Southern Ethiopia Molla et al., (2021), Addisu et al., 2019, the Hadiya Zone (Taye et al., 2017), the Harari Region (Yimer et al., 2015), and the Benishangul-Gumuz Regional State (Lemma et al., 2014) also found similar result.

There are additional studies that imply greater malaria prevalence among males in specific situations. Conversely, there is research from other nations that indicates different outcomes. For example, research in Nigeria indicated that males had a greater frequency of malaria than females (Ajegena et al., 2020). Another study in Ghana revealed a similar tendency, with men having a greater frequency of malaria (Matrevi et al., 2024).

In addition to this, conflicting results have also been observed, with some studies revealing no significant difference in malaria prevalence between males and females (Addisu et al., 2019; Taye et al., 2017; Yimer et al., 2015; Lemma et al., 2014). These different findings show that the association between sex and malaria infection may be altered by factors particular to each research region, such as local transmission dynamics, socio-economic characteristics, and access to healthcare facilities. While the specific reasons for this gap are not completely known, various variables may contribute to this tendency. For example, changes in exposure to mosquito bites due to variances in outdoor activities and sleeping arrangements between males and females might have an impact. Additionally, biological variables, such as hormonal variations, may potentially impact susceptibility to malaria infection.

Contrary to predictions, the research indicated that age did not exhibit a significant connection with malaria infection in the Dale Districts. Although individuals aged >50 years had higher odds of malaria infection in the crude model (OR = 1.559, 95% CI [0.681, 3.569], p = 0.294), this association was not significant in the adjusted model (OR = 0.967, 95% CI [0.254, 3.680], p = 0.961), indicating that age may not be a significant risk factor for malaria in this population.

This conclusion is consistent with other investigations done in Ethiopia. For example, research by Aschale et al. (2015) in the Jimma Zone revealed no significant connection between age and malaria infection. Similarly, research by Yimer et al. (2015) in the Harari Region likewise revealed no significant association between age and malaria prevalence. Another study by Alemu et al. (2011) in the Amhara Region indicated that age was not a significant predictor of malaria infection.

The absence of a relationship between age and malaria prevalence might be attributable to many variables. One possible reason may be that malaria transmission in Ethiopia is not highly impacted by age but rather by other variables such as environmental circumstances and vector behavior.

The result from the table likewise demonstrates a non-significant connection between the degree of education and malaria infection in either the crude or adjusted models. Although individuals with higher education levels showed increased odds of malaria infection in the crude model (Crude OR = 1.782, 95% CI [0.347, 9.166], p = 0.489), these associations were not significant in the adjusted model (Adjusted OR = 2.268, 95% CI [0.290, 17.764], p = 0.436), suggesting that education may not be a significant predictor of malaria in this context. This conclusion fits with many studies done in Ethiopia that have similarly revealed a lack of substantial connection between education level and malaria prevalence. For instance, research by Haile et al. (2014) in the Tigray Region revealed no significant link between education status and malaria infection. Similarly, research by Taffese et al. (2011) in the Oromia Region likewise revealed no significant connection between education level and malaria prevalence. These data show that education may not be a key driver of malaria risk in Ethiopian communities.

The absence of a correlation between education level and malaria infection might have numerous explanations. One probable reason is that malaria transmission in Ethiopia is predominantly driven by environmental variables and the availability of vector control methods rather than individual-level factors.

There was also no significant correlation between residence (urban or rural) and malaria infection reported in both the crude and adjusted models. This suggests that the risk of malaria infection was equal between urban and rural locations in the Dale Districts of the Sidama Region, Ethiopia. The crude OR was 1.546 with a 95% CI [0.699, 3.418] and a p-value of 0.282, while the adjusted OR was 1.094 with a 95% CI [0.401, 2.985] and a p-value of 0.860.

The absence of a substantial connection between domicile (urban or rural) and malaria infection is consistent with research demonstrating equal malaria prevalence rates between urban and rural locations. In support of this, research by Yimer et al. (2015) in the Harari Region revealed no significant connection between residency and malaria infection. Similarly, research by Alemu et al., (2014) in the Amhara Region likewise revealed no significant variation in malaria prevalence between urban and rural populations.

One possible reason for this may be a lack of relationship: malaria transmission in Ethiopia is impacted by a multitude of factors beyond just urban or rural domicile. Environmental elementss such as temperature, rainfall, and altitude have a crucial impact on malaria transmission and may vary within both urban and rural settings.Furthermore, the absence of a correlation between residence and malaria infection may possibly be attributable to the significant mobility of inhabitants in Ethiopia, with many individuals often commuting between urban and rural locations. This mobility might lead to the mixing of people and the dissemination of malaria parasites across different locations, making residency a less relevant determinant in predicting malaria risk. In conclusion, this study demonstrates the necessity of focusing malaria therapies in both urban and rural settings to successfully reduce malaria transmission.

The use of mosquito nets was substantially related to malaria infection. Individuals who used mosquito nets had lower odds of malaria infection compared to those who did not use mosquito nets in both the crude (OR = 0.283, 95% CI [0.141, 0.569], p = 0.000) and adjusted models (OR = 0.350, 95% CI [0.158, 0.776], p = 0.010), highlighting the effectiveness of mosquito nets in malaria prevention. The results indicated a substantial relationship between the use of mosquito nets and lower malaria infection rates. Individuals who reported using mosquito nets had a considerably decreased probability of acquiring malaria compared to those who did not use them.

This conclusion fits with research done in Ethiopia and other malaria-endemic locations, indicating the effectiveness of insecticide-treated bed nets (ITNs) in minimizing the risk of malaria transmission. For instance, research by Haile et al. (2020) done in the Sidama Zone of Ethiopia indicated that ITN use was related to a considerable drop in malaria prevalence. Similarly, research by Taffese et al. (2018) in the Gamo Gofa Zone of Ethiopia revealed a substantial reduction in malaria cases among those using ITNs. These findings underline the relevance of ITNs in malaria control efforts. Additionally, research by Tula et al., (2023) in the Adami Tullu area of central Ethiopia indicated that the use of long-lasting insecticidal nets (LLINs) was related to a substantial drop in malaria prevalence among children under five years old. Moreover, recent research by Asfaw et al. (2019) in the Kersa district of eastern Ethiopia indicated that the use of LLINs was related to a 60% reduction in malaria infection among children under five years old. These studies jointly underscore the important significance of promoting and securing broad use of mosquito nets, particularly LLINs, as a major method for successful malaria control in Ethiopia.

The result further indicated that the availability of windows in houses and availability of separate rooms were not significantly associated with malaria infection in either the crude (OR = 0.766, 95% CI [0.396, 1.482], $p = 0.429$) or adjusted models (OR = 0.748, 95% CI [0.341, 1.642], $p = 0.469$) and (OR = 1.824, 95% CI [0.495, 6.718], $p = 0.366$) or adjusted models (OR = 0.604, 95% CI [0.143, 2.557], $p = 0.494$) respectively, indicating that having availability of windows in houses and availability of separate rooms may not influence the risk of malaria infection in the study area. However, the usage of anti-malaria medication spraying was strongly related with malaria infection. Individuals whose houses were sprayed with anti-malaria drugs had lower odds of malaria infection compared to those whose houses were not sprayed in both the crude (OR = 0.067, 95% CI [0.009, 0.490], $p = 0.008$) and adjusted models (OR = 0.061, 95% CI [0.008, 0.474], $p = 0.008$), indicating the effectiveness of this intervention. This investigation found a substantial correlation between anti-malaria medication spraying and lower malaria infection rates. Individuals residing in houses where anti-malaria spraying was administered over the previous 12 months were considerably less likely to be infected with malaria compared to those in households where no spraying was done.

This conclusion is validated by several studies done in Ethiopia, stressing the usefulness of indoor residual spraying (IRS) in malaria reduction. For instance, research by Abeku et al. (2003) in the Ziway district of central Ethiopia indicated that IRS greatly decreased malaria transmission. Similarly, research by Woyessa et al. (2014) in the Adami Tullu area of central Ethiopia revealed a substantial drop in malaria prevalence following IRS adoption. These studies highlight the usefulness of IRS as a supplemental tool to mosquito nets in malaria control efforts in Ethiopia. Furthermore, research by Deressa et al. (2014) in the Jimma Zone of Ethiopia emphasized the efficiency of IRS in lowering malaria incidence, particularly in regions with high malaria transmission rates. Additionally, a research by Yewhalaw et al. (2017) in the Butajira area of Ethiopia indicated that IRS was related to a substantial decrease in malaria cases among children under five years old. Overall, our data underline the relevance of anti-malaria medication spraying as a crucial intervention technique for malaria control in Ethiopia, particularly in regions with high malaria transmission rates.

Concerning recent travel history, the data from the table reveals a highly significant connection with malaria infection. Individuals with recent travel experience exhibited greater risks of malaria infection compared to those without recent travel history in the crude (OR = 2.797, 95% CI [1.220, 6.411], $p = 0.015$) model. However, this link was not significant in the adjusted model (OR = 1.853, 95% CI [0.664, 5.173], $p = 0.239$), suggesting that additional variables may obscure this relationship.

The research found a substantial relationship between recent travel history and malaria infection in the unadjusted odds ratio. This conclusion was supported by research by Jima et al. (2010) in Ethiopia, which emphasized the influence of seasonal migration on malaria transmission, revealing that people who traveled to lowland regions during the rainy season were at increased risk of malaria infection. Similarly, research by Tulu et al. (2016) in the Amhara Region of Ethiopia indicated that travel to malaria-endemic regions was a strong predictor of malaria infection. The study by Alemu et al. (2011) in the Jimma Zone of Ethiopia indicated that recent travel was a major risk factor for malaria infection. Similarly, research by Legesse et al. (2014) in the Gamo Gofa Zone of Ethiopia revealed that travel to malaria-endemic areas was associated with an increased risk of malaria. These studies demonstrate that traveling directly to locations with higher malaria transmission rates increases the probability of developing malaria.

The presence of stagnant water was substantially linked with malaria infection. Individuals living in households with stagnant water had higher odds of malaria infection compared to those living in households without stagnant water in both the crude (OR = 1.915, 95% CI [1.036, 3.541], p = 0.038) and adjusted models (OR = 2.267, 95% CI [1.118, 4.599], p = 0.023), indicating that stagnant water may be a significant risk factor for malaria in the study area.

The research suggested that a strong connection between the presence of stagnant water and malaria infection was discovered in study region. Individuals living in locations with stagnant water were more likely to be infected with malaria compared to those living in areas without stagnant water. This discovery is consistent with several previous studies done in Ethiopia and other malaria-endemic locations, demonstrating the function of stagnant water as a breeding ground for mosquitoes, the vectors of malaria. For example, a research by Alemu et al. (2018) in Ethiopia indicated that families with stagnant water surrounding their living environment had a greater incidence of malaria compared to those without stagnant water. Similarly, a research by Molla et al., (2021b) in the Amhara Region of Ethiopia revealed that the presence of stagnant water bodies near houses was substantially related with an elevated risk of malaria infection. Additionally, a research by Woyessa et al., (2013) in southern Ethiopia found that the presence of stagnant water bodies, such as ponds and ditches, boosted the population of malaria vector mosquitoes.

Furthermore, a research by Dabaro et al., (2023b) in Ethiopia indicated that the deployment of larval source management measures, such as larviciding and habitat modification, resulted in a considerable decrease in malaria transmission. These results underline the necessity of addressing environmental variables, such as stagnant water, in malaria control efforts.

4.4 **Comparison of Results from Trend Data from 2018 to 2022 and Active Malaria**

In general, comparing trend data from 2018 to 2022 with active malaria case data from 2023 yields some contradictory results in terms of malaria prevalence and related risk factors. While the trend data showed a greater frequency among men, the active case data revealed a higher incidence among females. This disparity might be ascribed to a number of causes, including changes in malaria transmission dynamics, variances in data collecting procedures, and disparities in sample characteristics.

One probable reason for the difference is the time of data gathering. The trend data ranged from 2018 to 2022, and there might have been variations in malaria transmission patterns, resulting in changes in the demographic categories most impacted. In contrast, active case data were obtained in 2023, providing a picture of the present malaria condition that may vary from past years' patterns.

Another issue to examine is the sampling process used in each dataset. The trend data came from institutional malaria laboratory registries, which may have been more typical of the general population. In contrast, active case data were collected via home parasitological exams, which may have targeted certain groups or kebeles, resulting in disparities in sample demographics. Furthermore, variations in healthcare-seeking behavior between men and women may have impacted the results.

Overall, the divergent results between trend data and active case data illustrate the dynamic nature of malaria transmission and the significance of taking numerous variables into account when evaluating epidemiologic data. More study is required to investigate these disparities and their implications for malaria control efforts in the Dale Districts of Ethiopia's Sidama Region.

CHAPTER FIVE

CONCLUSION AND RECOMMENDTIONS

5.1 Conclusion

The study on malaria infection in the Dale Districts of the Sidama Region, Ethiopia, provides a comprehensive analysis of the prevalence, trends, and associated risk factors of malaria. The findings suggest that malaria transmission in the area is influenced by various factors, including age of particapnts, staginant water, indoor residual spraying and mosquito net usage.The dominance of Plasmodium falciparum in malaria cases underscores the need for targeted interventions against this species.

The finding from trend data from 2018 to 2022 and active malaria case data from 2023 yields some contradictory results in terms of malaria prevalence and related risk factors. One probable reason for the difference is the time of data gathering. Another issue may be the sampling process used in each dataset. Furthermore, variations in healthcare-seeking behavior between men and women may have impacted the results. Overall, the study provides valuable insights that can guide malaria control and prevention strategies in the Dale Districts of the Sidama Region, Ethiopia.

5.2 Recommendations and Future Implications

This study's key results indicate numerous suggestions and future implications for concerned bodies in Dale District, Sidama Region to improve malaria management and prevention.

1. Females and males are at increased risk of malaria infection according to the research finding. Hence, the health department, NGOs and schools at Dale district should give health education and intervention efforts to all populations at all age levels to lower infection rates.

2. Mosquito nets and anti-malaria spraying can reduce malaria infection rates. Hence, in areas where mosquitoes are more prevalent, insecticide-treated mosquito nets should be distributed and used properly. Regular and successful anti-malaria spraying programs, especially before peak transmission seasons, are also needed by local government.

3. Stagnant water and recent travel were malaria risk factors. Local governments and community could drain stagnant water sources, manage garbage, and organize community clean-ups to eliminate mosquito breeding areas. Additionally, health education and preventative measures should be provided to travelers, especially those traveling malaria-endemic areas.

4. The research indicated September to November as the peak season for malaria cases. Health institutions should prepare for increasing caseloads during this time by maintaining enough supplies of diagnostic instruments, antimalarial medications, and healthcare professionals. Seasonal malaria awareness efforts should be strengthened before and throughout the peak transmission seasons to educate populations about preventative measures and promote early treatment-seeking behavior.

5. To continue malaria control programs, it is vital to involve local populations effectively. Community-based health education initiatives should concentrate on improving knowledge of malaria symptoms, causes, and preventive techniques. Programs should try to improve attitudes and practices that contribute to malaria transmission, such as correct use of mosquito nets, prompt seeking of treatment, and eradication of mosquito breeding areas.

6. The disparities between trend data and current case data underline the necessity for consistent and trustworthy data gathering techniques. Health officials should build effective monitoring mechanisms to track malaria trends properly. Regular training for healthcare professionals on data collection and reporting processes would assist assure data quality and dependability, supporting improved planning and response to malaria outbreaks.

7. Future logtudinal research should be conducted to understand the disparities observed between trend data and active case data. Investigations should explore changes in transmission dynamics, data collection procedures, and sample characteristics that may have influenced the results.

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APPENDEX A

Survey Questionnaire

The prevalence of malaria infections and associated factors in selected districts of Sidama Region

General instruction

Dear Enumerator, please note that each question must be answered/filled.

Dear respondent,

The overriding objective of this questionnaire survey is to collect data for determining the prevalence of malaria infections and associated factors in selected districts of Sidama Region. Therefore, your responses to the questions are valuable and will be held in utmost confidentiality to be used only for the analysis of this research. If you accept to participate in this research, you will be doing so voluntarily, and there will not be any monetary returns. You are also free to refuse to respond to any questions you do not feel comfortable answering or to withdraw from the research altogether. This interview will take about an hour of your time to respond to the questions.

Date of Questionnaire (DD/MM/YYYY) _____________ Questionnaire Code _________________

Enumerator's name_________________

Respondent name __________________ Respondent phone number_____________________

Woreda _____________ Kebele_______________ Start time--------------- End time____________

Question Number	Variable		Code
A	**Sociodemographic Characterstics**		
01	Sex of the respondent	☐ Female	
		☐ Male	
02	What is your age (in years)?	_________	
03	What is your Marital status?	☐ Single	
		☐ Married	
		☐ Widowed	
		☐ Divorced	
04	What is your religion?	☐ Orthodox	
		☐ Catholic	
		☐ Protestant	

		☐ Muslim	
		☐ Other (specify)____________	
05	What is your main occupation?	☐ Government employed	
		☐ NGO employed	
		☐ Merchant	
		☐ Student	
		☐ Casual labor	
		☐ Retired	
		☐ Housewife	
		☐ Unemployed	
06	What is your highest education level?	☐ Illitrate	
		☐ Read and write only	
		☐ Primary School	
		☐ Secondary School	
		☐ Higher Education (College, University)	
07	Residence	☐ Urban	
		☐ Rural	
08	Availability of window in the house(record observation)	☐ Yes	
		☐ No	
09	If yes (Q08), how many?	___________	
10	If yes (Q09), what type of window?	☐ Window without cover	
		☐ Windows with glass	
		☐ Windows with screens	
		☐ Windows with curtains or shutter	
		☐ other, specify ______________	
11	How many separate rooms are in this household? Include all rooms, including kitchen, toilet, sleeping rooms, salon, etc.	_________________	
12	How many separate sleeping spaces are there in your household? Include	________________	

	all sleeping spaces, including if there is more than one sleeping space in each room used for sleeping.		
13	What is your household size (*members who often stay and eat together, most of the time ,at home)*	_____________	
14	Household individuals ≤ 5years olds	_____________	
15	Household individuals 6-15years olds	____________	
16	Household individuals ≥16years olds	____________	
17	Presence of stagnant water near the residential place	☐ Yes	
		☐ No	
18	History of antimalarial treatment	☐ Yes	
		☐ No	
19	GPS Data?		
B	**Knowledge and practice of the respondent**		
20	Can you tell me the main signs or symptoms of malaria? Multiple responses possible circle more than once (anything else?)	☐ Fever	
		☐ Loss of appetite	
		☐ Feeling cold	
		☐ Headache	
		☐ Nausea and vomiting	
		☐ Body ache or joint pain	
		☐ Other, specify_____________	
21	What causes malaria? Multiple responses Circle more than once (Anything else?)	☐ Mosquito bites	
		☐ Eating and drinking contaminated food and water	
		☐ Getting soaked with rain	
		☐ Cold or changing weather	
		☐ Other, specify_____________	
22	How can someone protect themselves against malaria? Multiple responses circle more than once (Anything else?)	☐ Sleep under a mosquito net(or ITN)	
		☐ Use mosquito repellant	
		☐ Take preventive medication	
		☐ Spray house with insecticide	
		☐ Fill in puddles (stagnant water)	

		☐ Put mosquito screens on the windows	
		☐ Other (specify)__________	
23	What type of actions you take when malaria illness in you or your family?	☐ Visit health services without home treatment	
		☐ Home treatment alone	
		☐ Other (specify)__________	
24	Usual sources of bought for anti-malarial drugs	☐ Private clinic	
		☐ Health post	
		☐ Health centre	
		☐ Pharmacy	
		☐ Others specify	
25	Anti-malarial drugs frequently used by you or your family	☐ Chloroquine	
		☐ Sulfadoxine–pyrimethamine **(**Coartem®)	
		☐ Primaquine	
		☐ I don't know	
		☐ Others specify	
26	Did you recently receive education/information on malaria at your home	☐ Yes	
		☐ No	
27	If yes, from whom did you receive this information/education? Probe, but do not provide answers	☐ Health extension worker	
		☐ Friends/family	
		☐ Health post/ Health center /hospitals/family	
		☐ Other (specify)	
28	At any time in the past 12 months, has anyone sprayed the interior walls of your dwelling against mosquitoes?	☐ Yes	
		☐ No	
29	How many months ago was the house sprayed against mosquitoes?	☐ Less than one month	
30	Who sprayed the house against	☐ Government worker/program	

	mosquitoes?	☐ Household member	
		☐ Other (specify)	
31	At any time in the past 12 months, have the walls in your dwelling been plastered or painted?	☐ Yes	
		☐ No	
32	How many months ago were the walls plastered or painted?	☐ Less than one month	
		☐ Month ago(Specify)	
33	Does your household have any mosquito nets	☐ Yes	
		☐ No	
34	Ask respondent to show you the net(s) in the household.	Net observed --------------------------	
35	How long ago did your household obtain the mosquito net?	Net observed ----------------------	
36	Where did you obtain the net?	☐ Government	
		☐ Clinic/hospital	
		☐ Health committee	
		☐ Health extension worker	
		☐ Retail shop /pharmacy	
		☐ Workplace	
		☐ Other (specify)___________	
37	Did anyone sleep under this mosquito net last night?	☐ Yes	
		☐ No	
38	Why did no-one sleep under this mosquito net last night?	☐ No malaria	
		☐ No nuisance/insects	
		☐ No space for net	
		☐ Irritation	
		☐ Suffocation /too hot	
		☐ Difficult hanging net shape	
		☐ Other(specify)	
39	How do you the use the net at night	☐ Hanging over the bed to the floor	
		☐ Hanging over the bed tucked in	

		☐ Hanging over sleeping mat/matters	
		☐ Other(specify)	
40	Travels history	☐ Recent travel malariaous rural area	
		☐ Recent travel malariaous urban area	
		☐ Regular travel to malarias rural area	
		☐ Regular travel to malarias urban area	

APPENDEX B

5 year Trends of Malaria prevalence in Sidama Region

Year	Total malaria suspected patients	Sex		Lab. Result				Species of malaria			prevalence
		M	F	Positive		negative		p.f	p.v	mixed	
				M	F	M	F				
2018											
2019											
2020											
2021											
2022											

APPENDEX C

Laboratory results reporting format of respondents in five selected kebeles

Respondent No	Card №	Sex	Age	Malaria test result		Plasmodium species			Remark
				positive	negative	*p.f*	*p.v*	mixed	

APPENDIX D

Statistical Test Results

A. Test for Poisson distribution

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Total_positive_cases	200	75.15	56.902	3	334

One-Sample Kolmogorov-Smirnov Test

		Total positive cases
N		200
Poisson Parameter[a,b]	Mean	1
Most Extreme Differences	Absolute	.986
	Positive	.000
	Negative	-.986
Kolmogorov-Smirnov Z		13.949
Asymp. Sig. (2-tailed)		.000

a. Test distribution is Poisson.

b. User-Specified

Generalized Linear Models

Model Information

Dependent Variable	Total_positive_cases
Probability Distribution	Negative binomial (1)
Link Function	Log

Categorical Variable Information

			N	Percent
Factor	season	Sep - Nov	60	25.0%
		Dec - Feb	60	25.0%
		Mar - May	60	25.0%
		June - Aug	60	25.0%
		Total	240	100.0%
	Age_	< 5 years	40	16.7%
		6 - 14 years	40	16.7%
		15 - 29 years	40	16.7%
		30 - 45 years	40	16.7%
		46 - 60 years	40	16.7%
		> 60 years	40	16.7%
		Total	240	100.0%
	Sex_	Male	120	50.0%
		Female	120	50.0%
		Total	240	100.0%

Continuous Variable Information

		N	Minimum	Maximum	Mean	Std. Deviation
Dependent Variable	Total_positive_cases	240	1	334	62.65	56.775

Goodness of Fit[a]

	Value	df	Value/df
Deviance	149.962	230	.652
Scaled Deviance	149.962	230	
Pearson Chi-Square	113.101	230	.492
Scaled Pearson Chi-Square	113.101	230	
Log Likelihood[b]	-1184.443		
Akaike's Information Criterion (AIC)	2388.887		
Finite Sample Corrected AIC (AICC)	2389.848		
Bayesian Information Criterion (BIC)	2423.693		
Consistent AIC (CAIC)	2433.693		

Dependent Variable: Total_positive_cases

Model: (Intercept), season, Age_, Sex_

a. Information criteria are in smaller-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
100.922	9	.000

Dependent Variable: Total_positive_cases

Model: (Intercept), season, Age_, Sex_

a. Compares the fitted model against the intercept-only model.

Tests of Model Effects

Source	Type III Wald Chi-Square	df	Sig.
(Intercept)	3596.344	1	.000
season	9.813	3	.020
Age_	112.442	5	.000
Sex_	2.816	1	.093

Dependent Variable: Total_positive_cases

Model: (Intercept), season, Age_, Sex_

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval Lower	95% Wald Confidence Interval Upper	Hypothesis Test Wald Chi-Square	Hypothesis Test df	Hypothesis Test Sig.	Exp(B)	95% Wald Confidence Interval for Exp(B) Lower	95% Wald Confidence Interval for Exp(B) Upper
(Intercept)	2.319	.2131	1.901	2.736	118.444	1	.000	10.162	6.693	15.429
[season=1]	.526	.1852	.163	.889	8.060	1	.005	1.692	1.177	2.432
[season=2]	.184	.1853	-.179	.548	.990	1	.320	1.202	.836	1.729
[season=3]	.050	.1855	-.313	.414	.073	1	.787	1.051	.731	1.512
[season=4]	0[a]	.	.	.	.	.	.	1	.	.
[Age_=1]	1.857	.2286	1.408	2.305	65.930	1	.000	6.402	4.089	10.021
[Age_=2]	1.877	.2291	1.428	2.326	67.170	1	.000	6.537	4.172	10.241
[Age_=3]	1.893	.2289	1.445	2.342	68.424	1	.000	6.641	4.241	10.401
[Age_=4]	1.415	.2289	.966	1.863	38.224	1	.000	4.116	2.628	6.446
[Age_=5]	.778	.2296	.328	1.228	11.493	1	.001	2.178	1.389	3.415
[Age_=6]	0[a]	.	.	.	.	.	.	1	.	.
[Sex_=1]	.220	.1310	-.037	.477	2.816	1	.093	1.246	.964	1.611
[Sex_=2]	0[a]	.	.	.	.	.	.	1	.	.
(Scale)	1[b]									
(Negative binomial)	1[b]									

Dependent Variable: Total positive cases

Model: (Intercept), season, Age, Sex

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Statistics

		Gender of the respondents	Age of respondent	Educational level of the participants	Marital status of respondents	Respondents main occupation	Residence of the participants
N	Valid	381	380	381	381	381	378
	Missing	0	1	0	0	0	3

Gender of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	160	42.0	42.0	42.0
	Male	221	58.0	58.0	100.0
	Total	381	100.0	100.0	

Age of respondent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	124	32.5	32.6	32.6
	2	154	40.4	40.5	73.2
	3	52	13.6	13.7	86.8
	4	50	13.1	13.2	100.0
	Total	380	99.7	100.0	
Missing	System	1	.3		
Total		381	100.0		

Educational level of the participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Illitrate	152	39.9	39.9	39.9
	Read and write only	106	27.8	27.8	67.7
	Primary School	54	14.2	14.2	81.9
	Secondary School	60	15.7	15.7	97.6
	Higher Education (College, University)	9	2.4	2.4	100.0
	Total	381	100.0	100.0	

Marital status of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Single	40	10.5	10.5	10.5
	Married	311	81.6	81.6	92.1
	Widowed	23	6.0	6.0	98.2
	Divorced	7	1.8	1.8	100.0
	Total	381	100.0	100.0	

Respondents main occupation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Government employed	5	1.3	1.3	1.3
	Merchant	9	2.4	2.4	3.7
	Casual laborer	78	20.5	20.5	24.1
	Farmer	113	29.7	29.7	53.8
	Retired	1	.3	.3	54.1
	Housewife	173	45.4	45.4	99.5
	Unemployed	2	.5	.5	100.0
	Total	381	100.0	100.0	

Respondents main occupation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Government employed	5	1.3	1.3	1.3
	Merchant	9	2.4	2.4	3.7
	Student	78	20.5	20.5	24.1
	Casual labor	113	29.7	29.7	53.8
	Retired	1	.3	.3	54.1
	Housewife	173	45.4	45.4	99.5
	Unemployed	2	.5	.5	100.0
	Total	381	100.0	100.0	

Residence of the participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Urban	54	14.2	14.3	14.3
	Rural	324	85.0	85.7	100.0

	Total	378	99.2	100.0	
Missing	System	3	.8		
Total		381	100.0		

Household size Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 - 4	203	53.3	53.3	53.3
	5-8	177	46.5	46.5	99.7
	9 - 12	1	.3	.3	100.0
	Total	381	100.0	100.0	

Gender of the respondents * Malaria test result Cross-tabulation

		Malaria test result					
		Negative		Positive		Total	
		N	%	N	%	N	%
Gender of the respondents	Female	133	39.9%	26	55.3%	159	41.8%
	Male	200	60.1%	21	44.7%	221	58.2%
Total		333	100.0%	47	100.0%	380	100.0%