



**WALLAGA UNIVERSITY  
INSTITUTE OF HEALTH SCIENCE  
SCHOOL OF PUBLIC HEALTH**

**DETERMINANTS OF MALARIA OUTBREAK IN BURE DISTRICT,  
ILU ABABORA ZONE, OROMIA, ETHIOPIA: COMMUNITY BASED  
UNMATCHED CASE CONTROL STUDY**

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**WALLAGA UNIVERSITY**

**INSTITUTE OF HEALTH SCIENCES**

**DEPARTMENT OF PUBLIC HEALTH**

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## **ACRONYMS AND ABBREVIATIONS**

|       |                                             |
|-------|---------------------------------------------|
| AOR   | Adjusted Odds Ratio                         |
| COR   | Crude Odds Ratio                            |
| CI    | Confidence Interval                         |
| FMOH  | Federal Ministry of Health                  |
| GDP   | Gross Domestic Product                      |
| GTS   | Global Technical Strategy                   |
| HRP2  | Histidine-Rich Protein 2                    |
| ICF   | International Classification of Functioning |
| IRS   | Indoor Residual Spraying                    |
| ITN   | Insecticide Treated bed Net                 |
| LLINs | Long-Lasting Insecticidal Nets              |
| MIS   | Malaria Indicator Survey                    |
| OHB   | Oromia Health Bureau                        |
| PMI   | President's Malaria Initiative              |
| RDT   | Rapid Diagnostic Tests                      |
| SPSS  | Statistical Package for the Social Sciences |
| WHO   | World Health Organization                   |

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## ABSTRACT

**Background:** Malaria, caused by *Plasmodium* protozoan parasites transmitted through mosquito bites, has resulted in over 7.3 million cases in Ethiopia, leading to 1,157 deaths and a case fatality rate of 0.02%. This high prevalence results in lost workdays, increased school absenteeism, and complications such as anaemia and preterm births in pregnant women. So that, this study was identifying significant gaps contributing to malaria outbreak in the Bure District of Ilu Ababora Zone.

**Objective:** This study aims to identify the factors contributing to malaria outbreaks in Bure District, Ilu Ababora Zone, Oromia, Ethiopia, from February 20 to March 18, 2025.

**Method:** A community-based case-control study design was employed. Data were collected from residents in Bure District using a systematic random sampling technique to select participants, resulting in a sample size of 256 individuals, with 128 cases and 128 controls. The data were entered into Epi Data and exported to SPSS for analysis. Bivariate logistic regression analysis was conducted to identify variables for multivariable logistic regression at  $p\text{-value} < 0.25$ . All candidate explanatory variables were assessed using a multivariable logistic regression model, reporting adjusted odds ratios and 95% confidence intervals (CIs) to evaluate the strength of associations, with significance set at  $p < 0.05$ .

**Results:** The response rate of study participants were 96.1%, with mean ages of 34.1 years ( $\pm 12.1$ ) for cases and 37.8 years ( $\pm 12.4$ ) for controls. Male sex (AOR = 2.16; 95% CI 1.375-3.43), non-formal educated (AOR = 2.41; 95% CI 1.12-6.39), presence of stagnant water near living areas (AOR = 2.74; 95% CI 1.18-5.85) and staying outdoors at night (AOR = 1.6; 95% CI 1.28-3.48) were to be found a significant predictor for malaria outbreak.

**Conclusion:** This study was identified male sex, non-formal education, stagnant water, and staying outdoor night time as key predictors of malaria outbreaks in Bure district and majority of those factors were modifiable. Therefore, community education specifically targeting non-formal educated population units, eliminating stagnant water sources, use of long sleeves during outdoor activities at night will prevent happening of malaria outbreak.

**Keywords:** Determinants, malaria outbreak, Bure District, Ethiopia.

# 1. INTRODUCTION

## 1.1 Background

Malaria is a disease caused by protozoan parasites belonging to the genus *Plasmodium*, which are transmitted by mosquitoes through blood feeding on human hosts (1). There are five known species of plasmodium that cause malaria in humans: *Plasmodium vivax*, *Plasmodium falciparum*, *Plasmodium ovale*, *Plasmodium malariae* and *Plasmodium knowlesi* (2) . The risk of infection is determined by the number and species of mosquitoes present in a given area, along with local climate and geography (3). In many parts of the world, transmission of malaria coincides with the rainy season, when mosquitoes flourish and breed, and agricultural activity increases (3). Additionally, population movements resulting from political instability, climate events, and environmental changes due to urbanization, deforestation, and irrigation have all played a role in the rising incidence of malaria (4).

The geographical distribution and transmission of malaria are affected by rainfall, temperature, and humidity. It observed that seasonal malaria transmission was within a temperature window of 15°C–40°C and was sustained if average temperature was well above 15°C or below 40°C. Monthly maximum rainfall for seasonal malaria transmission did not exceed 600 in west Central Africa, and 400 mm in the Sahel, Guinea Savannah, and East Africa. Rainfall provides the environment for vector breeding and relative humidity of at least 60% appears necessary for vector survival (5).

In Ethiopia, malaria transmission is unstable and seasonal, typically occurring in months from September to December and again from April to May. These periods align with the major planting and harvesting seasons for farmers whereby occurrence of malarial would result in increased economic losses. The distribution and transmission of malaria vary significantly from place to place and largely influenced by altitude. Altitude primarily affects malaria distribution patterns through its impact on temperature. The highest risk of malaria is found in the western lowlands of Oromia, Amhara, and Tigray, as well as in nearly entire regions of Gambela and Benishangul-Gumuz (6).

Sociodemographic determinants such as, occupation, age, gender, and education attainment and family size of house hold can influence the risk of contracting malaria. Individuals

working in farming which were residing in rural areas face greater exposure to malaria due to environmental conditions that favour mosquito breeding, such as stagnant water and nearby bushes (7) . On other hand, age plays a critical role with children under 15 being particularly vulnerable to malaria infection. Research indicates that children aged 5 to 14 and those younger than five have significantly higher prevalence rates compared to older populations(7). Furthermore, men, due to their greater participation in outdoor activities like farming, fishing, and construction, are generally at increased risk of mosquito bites, especially in malaria-endemic regions where these activities often align with peak mosquito activity, heightening their chances of contracting the disease(8). Additionally, educated mothers tend to possess better problem-solving skills and greater confidence when caring for a sick child compared to those without formal education. For example, a mother who has received vocational training may be more adept at properly installing a mosquito net than one who has never attended school (7). Overall, lower levels of education and income correlate with higher rates of malaria, as individuals lacking formal education and those with low incomes are more likely to contract the disease(9).

Malaria is easily preventable and curable disease if all prevention strategies applied well (10). The World Health Organization proposes a package of prevention techniques to reduce outbreak associated with the disease in malaria-endemic areas (11). Malaria control has mostly focused on reducing the malaria burden through the use of insecticide-treated mosquito nets and indoor residual spraying (12). Malaria prevention strategies in Ethiopia are vector control by the method epidemiological surveillance, using of ITN and conducting of IRS (13). Despite the long history of IRS in Ethiopia, there is a shortage of knowledge, attitudes, and IRS-related behaviours in the country. The community's reaction to IRS differs; in certain areas, plastering house walls following pesticide application is rather typical(14).

Research indicates a significant relationship between malaria infection rates and the type of construction materials used in housing. Individuals living in poorly constructed homes made from mud or thatch face a much higher risk of malaria compared to those in well-built houses with brick or concrete walls and metal roofs(15). Essentially, higher-quality housing is associated with a reduced risk of malaria infection. Improving housing conditions can aid in malaria control and elimination by minimizing the entry of malaria vectors into homes, thus

decreasing exposure to bites(15). Analysis reveals that modern housing is associated with a 9% reduction in the odds of malaria infection as measured by microscopy, and a 14% reduction as assessed by rapid diagnostic tests, in comparison to traditional housing in sub-Saharan Africa(15)

Therefore, determinants linked to malaria outbreak included the presence of stagnant water, level of educational attainment, lack of sticky to prevention, and control mechanisms like not using insecticide-treated bed nets, lack of environmental control, spending the night outside, poor housing construction and low coverage of malaria prevention services(16–18).

## 1.2 Statements of the Problem

According to WHO international news room fact sheets published on 11 December 2024, malaria has been the major public health problems. Globally, there were an estimated 263 million malaria cases and 597,000 malaria deaths in 83 countries. The World Health Organization African Region carries the heaviest burden which were 94% cases (246 million) and 95% (569,000) of malaria deaths. Children under 5 accounted for about 76% of all malaria deaths in the Region (19).

Between January 1 and October 20, 2024, Ethiopia reported more than 7.3 million cases of malaria and 1,157 deaths, resulting in a case fatality rate of 0.02%. This figure represents the highest number of malaria cases recorded in a single year over the past seven years (20). In comparison, 2023 saw 4.1 million malaria cases and five hundred twenty-seven (527) deaths. Four regions were particularly affected in 2024, contributing to 81% of the total cases and 89% of malaria-related deaths in health facilities: Oromia (44% of cases; 667 deaths), Amhara (18% of cases; 56 deaths), Southwest (12% of cases; 250 deaths), and the South Ethiopia Regional State (7% of cases; 45 deaths). The Western part of the country, due to its favourable geo-ecological conditions, is facing a significant malaria burden and is severely impacted by the current unprecedented (20).

According to African Union statement on the occasion of the world malaria day on April 25, 2018, malaria affects the economies of African countries. It costs the continent's economy approximately US\$ 12 billion per year in direct losses, equating to 1.3% of lost annual gross in terms of domestic product (21). A study conducted in four provinces of Kenya found that the mean number of days affected due to malaria infection was 7.2 days for income loss for ill adults, 5.4 days for caregivers, and 4.0 days for school days affected. A systematic literature review conducted in Africa, encompassing nineteen studies from twelve countries and concluding with a final search on January 4, 2024, revealed that the cost of treating severe malaria in children surpasses 10% of the monthly gross national income per capita in these nations (22).

Study published in 2020, on economic burden of malaria and associated factors among rural households in Chewaka district, western Ethiopia shows, the mean annual cost of malaria illness to households was US\$16. The mean direct cost of malaria illness was US\$14.5 and most of the cost of malaria illness was comprised of medical costs. In every household, on

average, patients and companions or caregivers lost 3.4 productive workdays due to malaria illness (23).

Therefore, a higher prevalence of malaria leads to a higher rate of child absenteeism from school, child labour when a parent is ill, low productivity because of illness, and permanent neurological and other damage to infants. Furthermore, it affects pregnant women's anaemia, cognitive decline, intrauterine growth retardation, and preterm due to both severe and mild cases of malaria infection (24).

Since 2004, Ethiopia has implemented several initiatives to prevent and control malaria. These efforts include indoor residual spraying and distributing long-lasting insecticidal nets, introducing rapid diagnostic tests, expanding health facilities and health extension worker programs to enhance access to malaria diagnosis and treatment, prioritizing research and surveillance to monitor malaria vectors, and updating vector control policies in response to emerging threats (4,25)

Despite these efforts, there was not enough data especially pertaining to educational attainment sociodemographic related determinants and housing conditions related determinants on malaria outbreak in Ethiopia. Additionally, data from the Ilu Ababora zonal health office and the Bure district health office indicate that malaria prevalence has increased over the past two years, resulting in an outbreak. However, no research has been conducted to explore the factors contributing to this outbreak in the study area (26,27). The aim of this study is to identify the determinants of the malaria outbreak in the Bure District of Ilu Ababora Zone, Ethiopia.

### **1.3 Significance of the Study**

Assessment of determinants of malaria outbreak have top importance in providing strategic information for service improvement in hospitals, health centres and health posts. The target of national strategic plan is to reduce malaria incidence by identifying malaria determinants in areas with high malaria transmission. The research finding will help the communities by vindicating the impact of malaria and crucial for providing strategic information that can enhance service delivery will be given in health facilities.

The findings also furnish the Bure District health office with important information on malaria outbreak, which can be utilized to strengthen control efforts and speed up progress toward malaria elimination. Additionally, these results provide valuable insights for enhancing malaria prevention activities and implementing targeted actions within the district. It will also benefit the community, the zonal health office, and various stakeholders to develop solutions based on the identified determinants. Finally, this research paper was reference material for those who will be engaged on research in this study content.

## **2. LITERATURE REVIEWS**

### **2.1 Determinant of Malaria Outbreak**

#### **2.1.1 Sociodemographic related determinants**

The most common sociodemographic characteristics of patients that can predict malaria outbreak are age, sex, and educational attainment. According to book of child and adolescent health and development disease control priority, volume 8, third edition, the age distribution of malaria outbreak is influenced by the intensity of transmission. In areas where the population is occasionally exposed to mosquito bites, malaria occurs across all age groups (28).

As a retrospective study done in 2024 on blood smears examination and prevalence of malaria in Addis Zemen town, Northwest Ethiopia, found that malaria infections were present across all age groups, with the highest prevalence among individuals aged 15 to 45 years (57%). In contrast, children under five years accounted for 15.2% of cases, while those aged 5 to 14 years represented 18.3%, and individuals over 45 years made up 9.5% of cases. The lowest malaria prevalence was seen people older than 45 years (1)

Based on various contributing factors, malaria outbreak has been observed in specific age categories. A cross-sectional study conducted in 2024 on the prevalence of malaria in four zones of former southern Ethiopia found that 86% of children under five years old were affected by the disease (29)

A study conducted in 2024 at Metehara health center in East Shoa, Oromia, Ethiopia, analysed malaria trends over six years and found that males represented a higher proportion of cases, accounting for 66%, compared to 34% for females (30).

An analysis of eleven Sub-Saharan African countries in 2023 revealed a negative association between malaria infection and mothers' education. The study found that malaria outbreak was significantly higher among children whose mothers had no formal education 61.5% compared to those whose mothers had secondary or higher education 11.3% (31).

A 2021 study conducted in Nigeria emphasized the significant impact of maternal education on malaria prevalence in children. The research revealed that children whose mothers had

secondary education faced a considerably reduced risk of malaria infection compared to those whose mothers had no formal education. Specifically, the odds of malaria infection were 56% lower for children with educated mothers (32). According to a 2020 study on the causes, symptoms, and prevention strategies of malaria among Malawian women of reproductive age, women without formal education were 3.73 times more likely to have inadequate knowledge of malaria preventive measures than women with secondary or higher education(33).

A study conducted in 2022 in East Hararge Zone, Oromia, Ethiopia, revealed that education level influences malaria outbreak. Odds of having malaria were 4.91 times more likely higher among children whose family had no formal education compared to those whose family had a higher educational level (34).

## **2.1.2 Preventive method related determinants**

### **2.1.2.1 Insecticide treated bed net**

Widely used interventions, such as ITN, have significantly decreased malaria-related outbreak, particularly among vulnerable groups like pregnant women and children under the age of five. In 2023, research from Ghana revealed that the risk of malaria infection in pregnant women who sleep under ITN was reduced by 95% (35). A study conducted in 2023 in pregnant women of Nigeria also found a significant connection between ITN usage and malaria prevalence. The prevalence of participants who did not sleep under insecticide-treated nets was 71.4%, compared to just 18.7% among those who used ITNs daily(36). Additionally, the rate of malaria positivity was higher in those who did not sleep with ITNs reaching 75.5% (36). Another research conducted in 2018 in Gambia showed, the estimated percentage of the at-risk population sleeping under an ITN rose from 30% to 53%. During this time, disease incidence and malaria-related deaths have fallen by 21% and 29%, respectively (37).

Study conducted in 2021 in East Belessa District , Northwest Ethiopia found that these nets protect individuals from mosquito bites and also benefit the broader community by killing mosquitoes, which helps decrease the transmission of malaria parasites (38). Furthermore, a study published in 2022 in the East Hararghe zone of Ethiopia on determinants of malaria morbidity among school-aged children found that children whose households used ITNs the

previous night experienced a reduction in malaria morbidity by 81% compared to their counterparts (34).

#### **2.1.2.2 Indoor residual spray**

Indoor residual spraying (IRS) has been the main tool used to control malaria. Reducing the life span and the density of the vector mosquitoes are direct effects of IRS towards restricting malaria transmission. IRS remains one of the long-standing malaria control tools in the country, and the Federal Ministry of Health (FMOH) implements IRS annually in all regions of the country (39).

A 2022 study in Indonesia identified the use of indoor residual spraying (IRS) as a key factor in malaria prevention(40). Another, a community-based case-control study conducted in 2022 in East Hararghe zone of Ethiopia found that school-aged children living in homes where the walls had been sprayed with IRS chemicals within the last six months were less likely to suffer from malaria outbreak compared to those whose homes had not been treated (34). A cross-sectional study published in 2024 on malaria prevalence and its associated risk factors in South Ethiopia indicated that participants whose houses had been sprayed with insecticide in the past six months were three times less likely to contract malaria (29). A study published in 2024 examining the prevalence of asymptomatic malaria infection in Mizan-Aman town, Southwest Ethiopia, found that individuals residing in homes that were not treated with insecticides had a significantly higher malaria prevalence of 16.3%, compared to just 4.9% in homes that were sprayed (41).

#### **2.1.3 Environmental related determinants**

According to a study in 2021, the incidence of malaria and related variables among children who visit medical facilities in the South Gondar Zone of Northwest Ethiopia, the prevalence of malaria is 2.2 times higher in areas with stagnant water than in areas without it. The risk of contracting malaria was 6.17 times higher for those who lived close to the breeding site than for those who did not (29). Study conducted in 2022 on prevalence of malaria and its risk factors in lake Tana and surrounding areas, Northwest Ethiopia shows, participants who live within less than 1 km distance of mosquito breeding site had a twenty three-fold higher probability of *plasmodium* infection than those who lived greater than 2 km of AOR 222.9 (42). In 2024, a case-control study investigating a malaria outbreak in Nono Benja Woreda,

Jimma Zone, Ethiopia, found that the presence of stagnant water in living areas increases the likelihood of contracting malaria fourfold compared to the control group (43).

In the East Hararge zone Ethiopia, study in 2022 findings reveal that having shrubland cover around homes increases the likelihood of malaria morbidity compared to bare land (34). In contrast, cultivated land cover around homes was linked to lower odds of malaria morbidity when compared to shrubland cover. This shrub cover was typically found in lowland areas and high-transmission regions, exacerbated by heavy rainfall and poor housing conditions, that significantly lack basic structural integrity and sanitary facilities(34). Studies indicate that the distribution of malaria is influenced by elevation. Malaria outbreak is associated with warmer temperatures, rainfall, and humidity (5)

#### **2.1.4 Housing condition related determinants**

A community-based cross-sectional study conducted in 2021 across twelve villages in Gambela and the former Southern Nations, Nationalities, and Peoples Region and Afar in Ethiopia found that the prevalence of asymptomatic malaria infection among individuals living in houses made with traditional materials, such as mud block walls, dung floors, and stick-and-mud roofs ranges from 8.1% to 8.4%. In contrast, those residing in modern houses, characterized by tile or cement floors, concrete walls, and metal or concrete roofs, have a prevalence ranging from 2.0% to 4.6% (44).

#### **2.1.5 Outdoor activities related determinants**

##### **2.1.5.1 Overnight travel**

A case control study in 2020 from Kampala, Uganda, malaria was diagnosed in an Urban setting strongly associated odds of 22 times with recent overnight travel (45). A study conducted in Gambia on residual malaria transmission dynamics indicates a higher risk of infection associated with traveling outside at night in the village (37).

##### **2.1.5.2 Sleeping outdoors**

A 2024 study on asymptomatic malaria and its predictors among migrant farmworkers in the East Shewa Zone of Oromia, Ethiopia, found that individuals engaged in outdoor activities at night were ten times more likely to have asymptomatic malaria infections compared to those

who did not, with an odds of 10.14 (46). Another conducted in 2021 on malaria prevalence and associated risk factors in Dembia district, North-Western Ethiopia, individuals with frequent outdoor activity were 16.4 times more vulnerable than individuals with limited outdoor activities (47).

A study conducted in 2021, on the prevalence of malaria and associated factors among children under five in Sherkole refugee camp, Benishangul-Gumuz region, Ethiopia, indicates that malaria infections are 3.9 times more likely in children who spend time outdoors at night compared to those who do not (48).

## 2.2 Conceptual Framework

The framework suggests that specific determinants influence malaria outbreak. Only the variables and constructs pertinent to this study were chosen. Figure 1 illustrates the framework, highlighting the connections between the selected determinants and malaria outbreak. This study focuses on several independent variables: sociodemographic determinants, preventive method-related determinants (such as the use of insecticide-treated nets and indoor residual spraying), environmental and housing condition-related determinants, and personal activity-related determinants (specifically outdoor activities). The dependent variable is malaria outbreak.

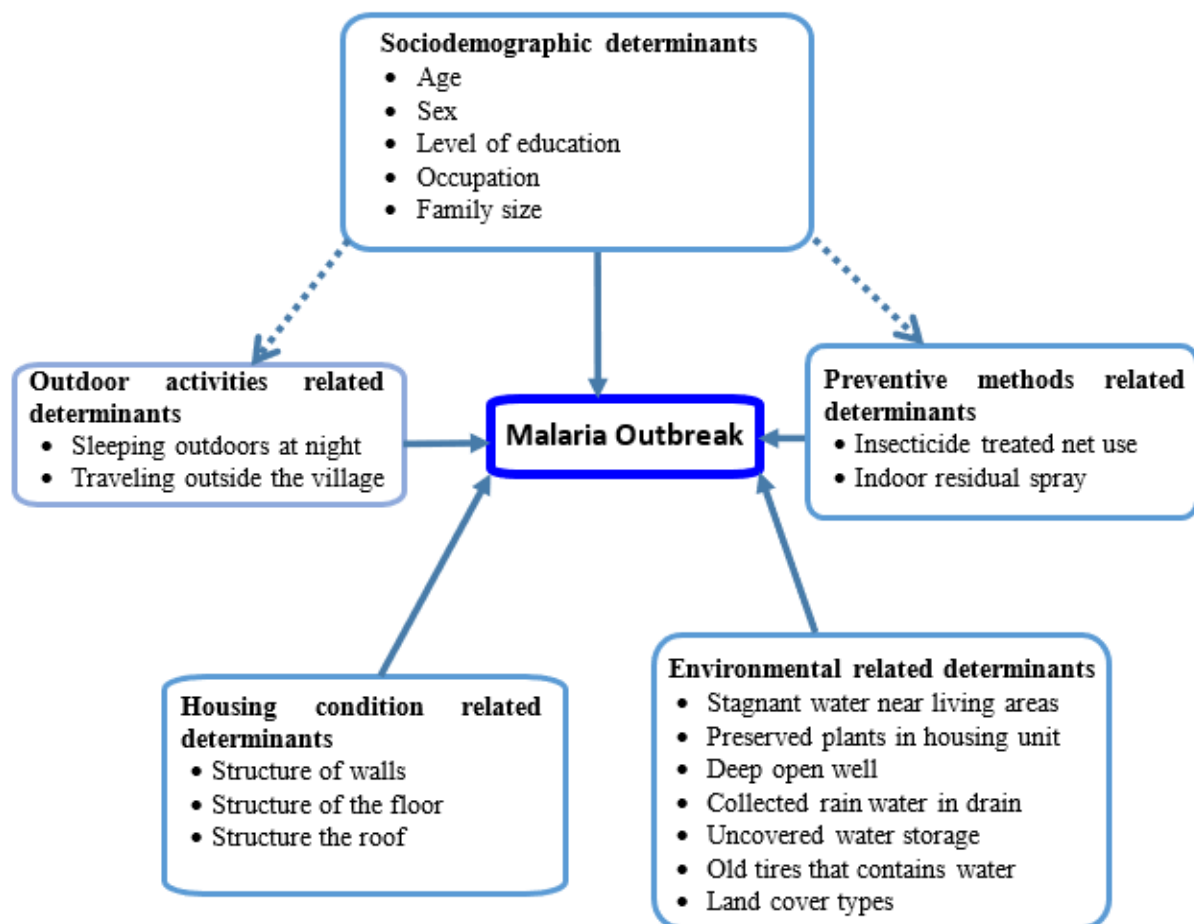


Figure 1: Conceptual framework developed from literature review that show determinants of malaria outbreak in Bure district, Ilu Ababora zone, Oromia, Ethiopia, 2025 (23,26,28,43,44)

### **3. OBJECTIVE**

To identify the determinants of malaria outbreak in Bure district, Ilu Ababora zone, Oromia, Ethiopia from February 20, 2025 to March 18, 2025.



## **4.2 Study Design**

Community based unmatched case control study design was applied.

## **4.3 Population**

### **4.3.1 Source population**

All individuals residing in Bure district were considered part of the source population

### **4.3.2 Study population**

Population residing in the selected kebeles of Bure district

**Cases:** Residents of selected kebeles who visited health posts and diagnosed with malaria by RDT as having malaria infection during last six months.

**Control:** Residents of selected kebeles who had no history of malaria treatment during last six months.

### **4.3.3 Study units**

Study units were cases and controls those enrolled in the study, from which data was taken.

## **4.4 Eligibility Criteria**

### **4.4.1 Inclusion criteria**

**Cases:** Any resident of Bure district who had been tested positive for malaria using an RDT was included.

**Control:** Any individual living in selected kebeles for last six months, with no history of malaria treatment was included.

### **4.4.2 Exclusion criteria**

**Cases:** Individuals who had been clinically treated for malaria and participants unable to provide the required information due to extreme illness, or lack of parental or guardian consent for their children's participation were excluded.

**Controls:** Any individual living in selected kebeles for last six months, with history of malaria treatment was excluded.

## 4.5 Sample Size Determination and Sampling Procedures

### 4.5.1 Sample size determination

The study's sample size was determined using Epi Info version 7.0, assuming a power of 80% and confidence interval 95%. A margin of error is set at 5%, with a case to control ratio of 1:1. Final sample size was derived from a previous study conducted in East Hararge zone Ethiopia which considered proximity to stagnant water as a determinant. In that study, 26.8% of the control group was exposed, with an odds ratio of 2.26, as reported by Mohammedawel and colleagues (34). Considering the previously determined sample size and incorporating a 10% non-response rate, the study's final sample size established at 256 participants, comprising 128 cases and 128 controls. This adjustment ensures a more accurate representation and accounts for potential dropouts, thereby maintaining the study's validity.

$$\text{Sample Size} = \frac{(r+1) (P^*) (1-P^*) (Z_{\alpha/2} + Z_{\beta})^2}{r(P_1 - P_2)^2}$$

$r$  = Ratio of controls to cases

$p^*$ (Average proportion exposed) = (Proportion of exposed cases + Proportion of control exposed)/ 2

$Z_{\beta}$  = Standard normal deviate for two tailed tests based on beta level (relates to the power level)

$Z_{\alpha/2}$  = Standard normal deviate for two tailed tests based on alpha level (relates to the confidence interval level)

$P_1$  = Proportion of Cases with exposure

$P_2$  = Proportion of Controls with exposure

*Table 1: Sample size determination for determinants of malaria outbreak in Bure District, Ilu Ababora Zone, Ethiopia, 2025 (34).*

| S/N | Determinant factors selected | % controls exposed | Case control ratio | AOR  | Power | CI  | Sample size |         |       |
|-----|------------------------------|--------------------|--------------------|------|-------|-----|-------------|---------|-------|
|     |                              |                    |                    |      |       |     | Case        | Control | Total |
| 1   | ITN use in last night        | 81.5               | 1:1                | 0.33 | 80    | 95% | 74          | 74      | 148   |
| 2   | Proximity to Stagnant water  | 26.8               | 1:1                | 2.26 | 80    | 95% | 116         | 116     | 232   |
| 3   | IRS used in the home         | 56.3               | 1:1                | 0.29 | 80    | 95% | 51          | 51      | 102   |
| 4   | Educational status           | 42                 | 1:1                | 8.01 | 80    | 95% | 23          | 23      | 46    |

#### 4.5.2 Sampling Procedures

The district consists of 22 kebeles, all situated in areas with high malaria prevalence (27). Then, 30% of the total kebeles in the district were selected randomly as the threshold for an intervention to have public health relevance and be cost-effective according to the WHO (49). The number of cases and controls were proportionally allocated to all selected kebeles based on their number of populations and the proportional allocation, leading to the inclusion of seven kebeles with a combined population of 34,994. The selected kebeles are Sibbo 5242, Dorani Dobi 4405, Bure 01 5962, Geba Witeta 4187, Kufi 3498, Agelo Moka 6442, and Toli 5258, each with their respective populations (26).

A case was defined as an individual coming to seek care at one of the participating health posts for uncomplicated malaria episode defined as fever (temperature > 37.5°) with positive test result of malaria with the rapid diagnostic test (RDT) according to the MOH guidelines. Control was a person who was living in the neighborhood of the case with no history of malaria treatment in last six months.

The community health information system (CHIS) registration at health posts were used to create the sampling frame for each kebele from which cases and controls were traced at their home. Then the malaria case treated individuals were taken from the home selected by using systematic random sampling techniques.

A total of 256 individuals were proportionally allocated based on the populations of the selected kebeles, comprising 128 cases and 128 controls. The distribution of sampled units in each kebele was as follows: Sibbo (18 cases and 18 controls), Dorani Dobi (16 cases and 16 controls), Bure 01 (22 cases and 22 controls), Geba Witeta (15 cases and 15 controls), Kufi (13 cases and 13 controls), Agelo Moka (24 cases and 24 controls) and Toli (20 cases and 20 controls). This study would employ an unmatched case-control design with a 1:1 ratio. The proportional allocation of cases and controls were determined using the following formula:

$$N = \frac{M \times S}{T}$$

$N$  = Sample size of each kebeles

$S$  = Population size of each kebeles

$M$  = Sample size of all kebeles

$T$  = Populations size of all kebeles

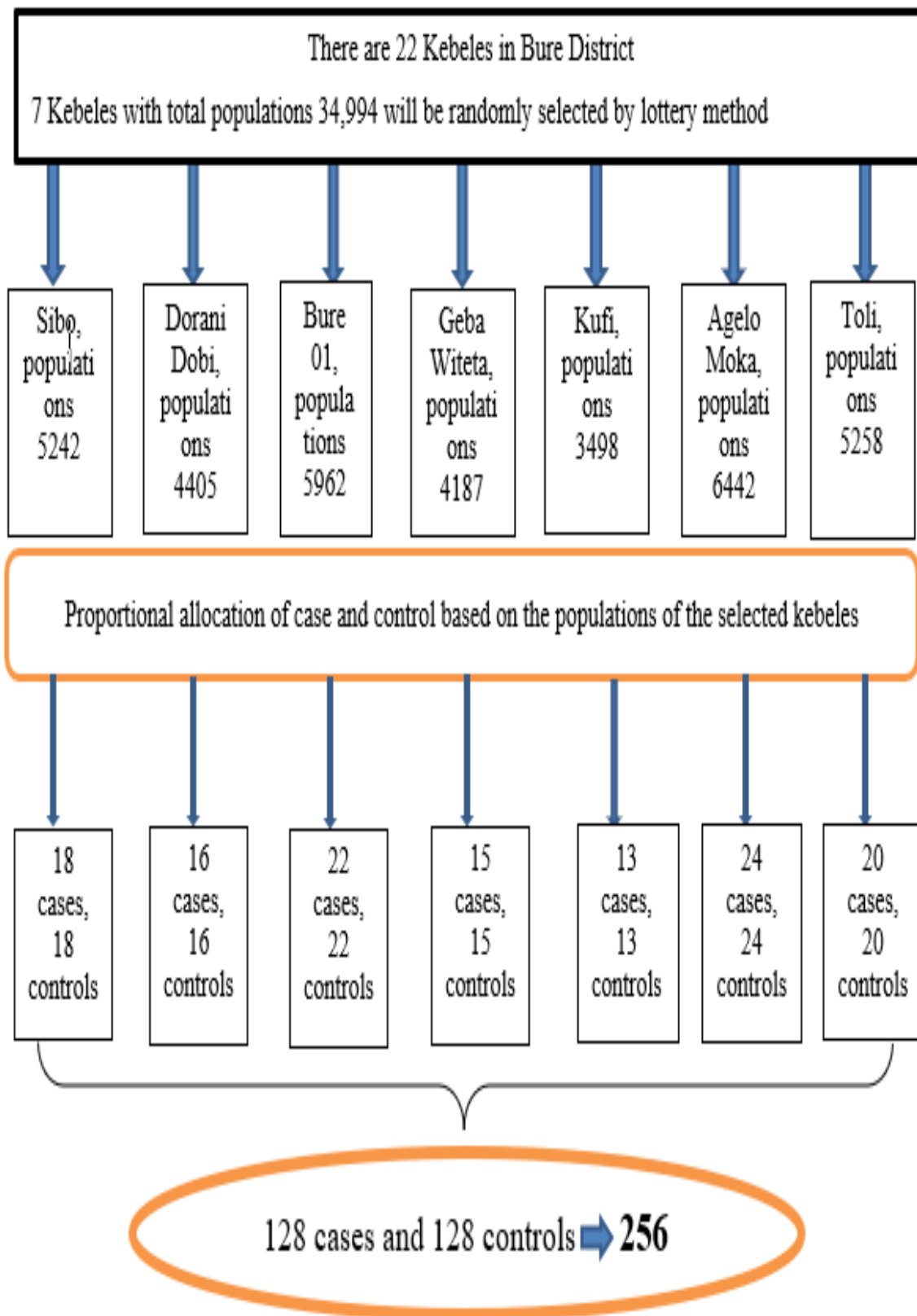


Figure 3: Schematic diagram shows sampling procedure of the study participants in Bure District, Ilu Ababora Zone, Ethiopia, 2025

## 4.6 Study Variables

### 4.6.1 Dependent variable

Malaria outbreak

### 4.6.2 Independent variables

**Socio-demographic related variables:** Age, sex, educational status, and occupation.

**Preventive method related variables:** ITN use and indoor residual spray.

**Environmental related variables:** Stagnant water near living areas, preserved plants in the housing unit, deep open wells, collected rainwater in drains, uncovered water storage, old tires that contained water, and land cover types.

**Housing condition related variables:** Materials used to make walls, materials used to make floors, and materials used to make roofs.

**Staying outdoor at night variables:** Sleeping outdoors at night and traveling outside the villages.

## 4.7 Operational Definitions

**Residents:** Individuals who was lived in the Bure district for a minimum duration of six months before the study period.

**Malaria Outbreak:** A rise in instances of the disease in a given week that is more than the second-largest report from the 5-year malaria report or doubles the number of cases observed during the same WHO weeks previous year (43).

**Insecticide Treated bed Net:** Either a long-lasting net that does not require re-treatment or a pre-treated net obtained within the last 12 months, or a net that had been soaked with insecticide within the last 12 months (34).

**Indoor Residual Spray:** was the application of long-acting chemical insecticides on the walls and roofs of all houses and domestic animal shelters in a given area, in order to kill adult vector mosquitoes that land and rest on these surfaces (14).

**Standard wall materials:** Material used to build the walls of the houses that include bricks, cement blocks, cement, stone with lime or cement, wood planks or shingles, and covered adobe (44).

**Standard floor materials:** Material used to build the floor of the houses that include vinyl or asphalt strips, ceramic tiles, cement, and carpet, parquet, or polished wood (44).

**Standard roof materials:** Material used to build the roofs of the houses that include calamine or cement fibbers, metal, wood, and roofing shingles, ceramic tiles and cement (44).

**Staying outdoor:** the respondent was considered as staying outdoor if he /she stays outside home beyond 3:00 o'clock local time at night

**Stagnant water around:** When stagnated water was found in their environment within a diameter of 2 km around their living home (up to 25 min away on foot) (43).

**Type of plasmodium:** RDTs diagnostic methods employed for confirmation of malaria etiologic or identifying the malaria parasite species. The main malaria parasites were *P. falciparum* and *P. Vivax*

#### **4.8 Data Collection Tools and Procedures**

Data were collected using a structured questionnaire adapted from various literatures and modified version of the Malaria Indicator Survey (MIS) questionnaire used by the Ethiopia FMOH in 2015 and International Classification of Functioning, Disability and Health (ICF) (50,51), then translated into the Afaan Oromo language before conducting interviews that helps ensure that participants fully understand the questions and improving the accuracy of responses (35,36). The questionnaire consists of socio demographic characteristics of the respondents as well as malaria prevention, housing condition and environment and personal activity related variables. The data was collected by using an interviewer administered questionnaire.

Data were collected by eight health extension workers who had received training prior to the study's commencement. They were supervised by three experienced malaria focal persons from nearby health centers. A case was defined as an individual seeking care at one of the participating health posts for an uncomplicated malaria episode, characterized by a fever (temperature > 37.5°C) or a history of fever within the past 48 hours, along with a positive malaria rapid diagnostic test (RDT) according to the Ministry of Health's 2018 guidelines. A control was defined as a person living in the same neighbourhood as the case, with no history of malaria treatment (34).

#### **4.9 Data Quality Assurance**

To ensure the collection of information appropriately, data quality assurance techniques were applied before the study, during the study and after the data collection period that means during data processing. The pre-test of the questionnaire was done on 5% of the sample size in outside of the study area in Miriga kebele. One day of training was given for data collectors and supervisors by principal investigator on the study tools and data collection procedure prior to data collection. The training was focused on understanding the meaning of each question, keeping confidentiality of the information to be gathered and quality of data. The consensus was made with the trainees during the training on the way the questions to be asked, their meaning and how to explain for the study participants. During data collection period, the supervisors supervised the data collectors and help them closely by dealing with the challenges that the data collectors might face. The principal investigator supervised the overall data collection process. The careful check-up of the collected data was ensured completeness and consistency of the questionnaire. After data collection period, the collected data were entered into Epi Data software version 3.1. The data was entered twice by independent individuals and the inconsistency was checked from the original questionnaire.

#### **4.10 Data Processing and Analysis**

The collected data were entered into Epi Data version 3.1, checked for completeness and missing values before being coded. The data was exported to SPSS version 24 for further analysis. Variable recoding and transformation were occurred prior to the final data analysis. After cleaning and organizing the data, descriptive statistics such as mean, standard deviation, percentages, and frequencies were calculated. The results were presented in tables, graphs/figures, and written summaries.

Bivariable logistic regression analysis was conducted to identify variables that might be candidates for multivariable logistic regression, using a p-value threshold of  $<0.05$ . Multicollinearity among independent variables were assessed using a correlation matrix. All candidate explanatory variables were included in the model, and non-significant variables were excluded.

The determinants of malaria outbreaks were analyzed using a multivariable logistic regression model. The results were reported as adjusted odd ratios with corresponding 95%

confidence intervals to evaluate the strength of associations, considering a significance level of  $p < 0.05$  for adjusted results. Ultimately, the findings were presented in both tables and text.

#### **4.11 Ethical Considerations**

The proposal was approved by Wallaga University Ethical Review Committee and ethical clearance letter was obtained. Permission letter was given from district health office before start data collection. Consent form was signed by each participant prior to data collection. Codes rather than names of the participant was used to ensure secrecy of data. The confidentiality of participant's information was kept. The participant would reserve full right of not to participate for those who weren't willing to respond. All activities were carried out in accordance with international, national guidelines and regulations of human right.

#### **4.12 Plan for Dissemination**

The study's findings will be presented and defended appropriately at Wallaga University's Institute of Health Science, School of Public Health. To help with intervention, the findings will be shared with the Bure district health office, the Ilu Aba Bora Zonal Health Office, and the relevant kebeles. Lastly, the research's findings will be discussed in various workshops, meetings, and seminars.

## 5. RESULTS

### 5.1 Sociodemographic Characteristics of the Study Participants

A total of 246 participants took part in this study, yielding of response rate 96.1%. The mean age of all participants 35.9 ( $\pm$  12.4 SD) years. From this study findings, the overall mean of cases and controls were 34.12 ( $\pm$  12.1 SD) and 37.85 ( $\pm$  12.43 SD) years, respectively. Regarding educational status, from the total cases, 54 (43.9%) attended primary education, and 46 (37.4%) did not attend any formal education. Regarding marital status, the majority of both cases (79.7%) and controls (75.6%) were married. More than two-third of the participants, 164 (66.7%), were farmers; that was, agriculture the main source of income for 61.0% of the cases and 72.4% of the controls, (see table.2).

*Table 2: Socio-demographic characteristics of study participants of Bure District, Ilu Ababora Zone, Ethiopia, 2025 (N=246)*

| Variables      | Category   | Malaria status |              |
|----------------|------------|----------------|--------------|
|                |            | Cases (%)      | Controls (%) |
| Sex            | Male       | 83(67.5)       | 96(78.0)     |
|                | Female     | 40(32.5)       | 27(22.0)     |
| Age            | 8-17       | 10(8.1)        | 1(0.8)       |
|                | 18-27      | 26(21.1)       | 28(22.8)     |
|                | 28-37      | 44(35.8)       | 40(32.5)     |
|                | >37        | 43(35.0)       | 54(43.9)     |
| Religion       | Muslim     | 19(15.4)       | 30(24.4)     |
|                | Orthodox   | 44(35.8)       | 25(20.3)     |
|                | Protestant | 60(48.8)       | 68(55.3)     |
| Ethnicity      | Oromo      | 107(87.0)      | 97(78.9)     |
|                | Amhara     | 11(8.9)        | 19(15.4)     |
|                | Tigre      | 5(4.1)         | 7(5.7)       |
| Marital Status | Married    | 98(79.7)       | 93(75.6)     |
|                | Single     | 17(13.8)       | 21(17.1)     |
|                | Divorced   | 6(4.9)         | 5(4.1)       |
|                | Widowed    | 2(1.6)         | 4(3.3)       |

|             |                                |          |          |
|-------------|--------------------------------|----------|----------|
| Education   | Not attending formal education | 46(37.4) | 24(19.5) |
|             | Primary education (1-8)        | 54(43.9) | 71(57.7) |
|             | Secondary education (9-12)     | 13(10.6) | 25(20.3) |
|             | Higher Education 12+           | 10(8.1)  | 3(2.4)   |
| Occupation  | House wife                     | 17(13.8) | 12(9.8)  |
|             | Farmer                         | 75(61.0) | 89(72.4) |
|             | Government/NGO employee        | 12(9.8)  | 6(4.9)   |
|             | Merchant                       | 3(2.4)   | 6(4.9)   |
|             | Student                        | 16(13.0) | 10(8.1)  |
| Family size | 1 to 5                         | 73(59.3) | 98(79.7) |
|             | 6 to 10                        | 50(40.7) | 25(20.3) |

## 5.2 House Condition Related Characteristics

Respondents in the groups, that is, 61% of the cases and 76.4% of the controls, had their houses constructed from mud and stick walls. In addition to this, 70 (56.9%) of the cases and 78 (63.4%) of the controls' house roofs were constructed from stick dung. Thirty-two (26.0%) of the cases and 55 (44.7%) of the controls' houses had preserved plants in their house unit (see table 3)

*Table 3: Housing condition of respondents in Bure District, Ilu Ababora Zone, Ethiopia, 2025*

| Variables                          | Category        | Malaria status |              |
|------------------------------------|-----------------|----------------|--------------|
|                                    |                 | Cases (%)      | Controls (%) |
| Material use to make the wall      | Mud and Sticks  | 75(61.0)       | 94(79.7)     |
|                                    | Iron Sheets     | 20(16.3)       | 8(6.5)       |
|                                    | Stone           | 15(12.2)       | 15(12.2)     |
|                                    | Wood            | 13(10.6)       | 2(1.6)       |
| Material used to make the roof     | Sticky dung     | 70(56.9)       | 78(63.4)     |
|                                    | Concrete cement | 22(17.9)       | 21(17.1)     |
|                                    | Wood            | 31(25.2)       | 24(19.5)     |
| Material used to make floor        | Wood            | 8(6.5)         | 2(1.6)       |
|                                    | Stick dung      | 90(74.0)       | 95(77.2)     |
|                                    | Concrete cement | 24(19.5)       | 26(21.1)     |
| Preserved plants in the house unit | Yes             | 32(26.0)       | 55(44.7)     |
|                                    | No              | 91(74.0)       | 68(55.3)     |

## 5.3 Environmental Related Characteristics of study participants

Ninety-three (75.6%) of the controls and 98 (79.7%) of the cases stated that their lands had been farmed within 200 meters of their residence. However, eight (6.5%) of the controls and twelve (9.8%) of the cases stated that there was bare land within 200 meters of their residence. Most study participants, both in cases and controls, lacked a drain to collect water from their premises (see table 4).

*Table 4: Environmental related characteristics of study participants in Bure District, Ilu Ababora Zone, Ethiopia, 2025.*

| Variables                                        | Category | Malaria status |              |
|--------------------------------------------------|----------|----------------|--------------|
|                                                  |          | Cases (%)      | Controls (%) |
| Cultivated land cover within 200m of the home    | Yes      | 98(79.7)       | 93(75.6)     |
|                                                  | No       | 25(20.3)       | 30(24.4)     |
| Bare land within 200m of the home                | Yes      | 12(9.8)        | 8(6.5)       |
|                                                  | No       | 111(90.2)      | 115(93.5)    |
| Forest /shrub land cover within 200m of the home | Yes      | 8(6.5)         | 14(11.4)     |
|                                                  | No       | 115(93.5)      | 109(88.6)    |
| Open deep well in your compound                  | Yes      | 6(4.9)         | 5(4.1)       |
|                                                  | No       | 117(95.1)      | 118(95.9)    |
| Drain to collect rain water in your compound     | Yes      | 3(2.4)         | 0(0.0)       |
|                                                  | No       | 120(97.6)      | 123(100.0)   |
| Uncovered water storage in your compound         | Yes      | 10(8.1)        | 3(2.4)       |
|                                                  | No       | 113(91.9)      | 120(97.6)    |
| Old tires that contains water                    | Yes      | 4(3.3)         | 4(3.3)       |
|                                                  | No       | 119(96.7)      | 119(96.7)    |
| Stagnant water near to your home                 | Yes      | 36(29.3)       | 18(14.6)     |
|                                                  | No       | 87(70.7)       | 105(85.4)    |

#### 5.4 Malaria Prevention Method Related Variables

Among the study participants, 96 (78.0%) of the cases and 102 (82.9%) of the controls had insecticide-treated nets (ITNs) in their homes. Furthermore, 59 (61.4%) of the cases and 76 (74.5%) of the controls who had ITNs reported sleeping under them in the past three weeks. Regarding indoor residual spraying (IRS) in the last six months, 41 (33.5%) of the cases and 56 (73.6%) of the controls indicated that their homes had been sprayed (see table 5).

*Table 5: Malaria prevention method related variables in Bure district, Ilu Ababora Zone, Ethiopia, 2025.*

| Malaria prevention related variables |           | Cases (%) | Controls (%) |
|--------------------------------------|-----------|-----------|--------------|
| Presence of ITN                      | Yes       | 96(78.0)  | 102(82.9)    |
|                                      | No        | 27(22.0)  | 21(17.1)     |
| Sleep under ITN                      | Yes       | 59(61.4)  | 76(74.5)     |
|                                      | No        | 37(38.6)  | 26(25.5)     |
| How often sleep under ITN            | Always    | 41(69.5)  | 56(73.6)     |
|                                      | Sometimes | 18(30.5)  | 20(26.4)     |
| IRS sprayed in the last six months   | Yes       | 41(33.3)  | 47(38.2)     |
|                                      | No        | 82(66.7)  | 76(61.8)     |

## 5.5 Determinants of Malaria Outbreak

Covariates with P-value  $<0.25$  in the bi-variable logistic regression analysis were selected for multivariable logistic regression analysis. Accordingly, age, sex, education status, occupation, ITNs, stagnant water, cultivated land, shrub land, and sleeping of outdoor were selected for multivariable logistic regression. In the multivariable model, factors associated with malaria outbreak were identified at the statistical level of p-value  $<0.05$ . Finally, four independent variables namely, sex, educational status, presence of stagnant water near home and staying outdoor at night were found to have statistically significant association with malaria outbreak during multivariable logistic analysis.

Among the study participants, males were 2.16 times more likely to have malaria than females (AOR = 2.16; 95% CI: 1.375, 3.43). Additionally, participants who were unable to read and write had 2.41 times the odds of having malaria compared to those who attended junior secondary school or college (AOR = 2.41; 95% CI: 1.12, 6.39). Furthermore, those living in areas with stagnant water were 2.74 times more likely to have malaria than those without stagnant water in their surroundings (AOR = 2.74; 95% CI: 1.18, 5.85). Lastly, staying outside at night increased the odds of malaria by 1.6 times compared to the control group (AOR = 1.6; 95% CI: 1.28, 3.48) (see table 6).

Table 6: Multivariate analysis for determinants of malaria outbreak in Bure district, Ilu Ababora Zone, Oromia, Ethiopia, 2025

| Variables                                        | Category                 | Malaria status |              | COR (95% CI)        | AOR (95% CI)          | P-Value |
|--------------------------------------------------|--------------------------|----------------|--------------|---------------------|-----------------------|---------|
|                                                  |                          | Cases (%)      | Controls (%) |                     |                       |         |
| Sex                                              | Male                     | 83 (67.5)      | 96 (78.0)    | 0.58 (0.33, 1.30)   | 2.16 (1.38, 3.43) *   | 0.001   |
|                                                  | Female                   | 40 (32.5)      | 27 (22.0)    | 1.0                 | 1.0                   |         |
| Age                                              | 8-17                     | 10 (8.1)       | 1 (0.8)      | 0.08 (0.01, 0.65)   | 0.35 (0.003, 0.401) * | 0.048   |
|                                                  | 18-27                    | 26 (21.1)      | 28 (22.8)    | 0.86 (0.44, 1.67)   | 0.58 (0.25, 1.33)     |         |
|                                                  | 28-37                    | 44 (35.8)      | 40 (32.5)    | 0.72 (0.44, 1.67)   | 0.68 (0.36, 1.31)     |         |
|                                                  | >37                      | 43 (35.0)      | 54 (43.9)    | 1.0                 | 1.0                   |         |
| Education                                        | Non-formal educated      | 46 (37.4)      | 24 (19.5)    | 2.46 (1.39, 4.39)   | 2.41 (1.12, 6.39) *   | 0.001   |
|                                                  | Educated                 | 77 (62.6)      | 99 (80.5)    | 1.0                 | 1.0                   |         |
| Occupation                                       | House wife               | 17 (13.8)      | 12 (9.8)     | 1.13 (0.38, 3.33)   | 0.64 (0.15, 2.74)     | 0.130   |
|                                                  | Farmer                   | 75 (61.0)      | 89 (72.4)    | 1.90 (0.81, 4.43)   | 0.96 (0.28, 3.28)     |         |
|                                                  | Government /NGO employer | 12 (9.8)       | 6 (4.9)      | 0.80 (0.23, 2.82)   | 0.40 (0.08, 1.99)     |         |
|                                                  | Merchant                 | 3 (2.4)        | 6 (4.9)      | 3.20 (0.65, 15.78)  | 5.03 (0.81, 31.08)    |         |
|                                                  | Student                  | 16 (13.0)      | 10 (8.1)     | 1.0                 | 1.0                   |         |
| Cultivated land cover within 200m of the home    | Yes                      | 98 (79.7)      | 93 (75.6)    | 1.0                 | 1.0                   | 0.311   |
|                                                  | No                       | 25 (20.3)      | 30 (24.4)    | 1.27 (0.69, 2.31)   | 1.38 (0.74, 2.57)     |         |
| Forest /shrub land cover within 200m of the home | Yes                      | 8 (6.5)        | 14 (11.4)    | 0.54 (0.22, 1.34)   | 2.16 (0.76, 6.09)     | 0.147   |
|                                                  | NO                       | 115 (93.5)     | 109 (88.6)   | 1.0                 | 1.0                   |         |
| Stagnant water near to your home                 | Yes                      | 36 (29.3)      | 18 (14.6)    | 2.41 (1.282, 4.546) | 2.74 (1.184, 5.85.) * | 0.001   |
|                                                  | No                       | 87 (70.7)      | 105 (85.4)   | 1.0                 | 1.0                   |         |
| Use of ITN                                       | Yes                      | 96 (78.0)      | 102 (82.9)   | 1.0                 | 1.0                   | 0.242   |
|                                                  | No                       | 27 (22.0)      | 21 (17.1)    | 0.73 (0.39, 1.38)   | 0.68 (0.35, 1.30)     |         |
| Staying outdoor at night                         | Yes                      | 54 (43.9)      | 42 (34.1)    | 1.51 (0.90, 2.51)   | 1.6 (1.28, 3.48) *    | 0.001   |
|                                                  | No                       | 69 (56.1)      | 81 (65.9)    | 1.0                 | 1.0                   |         |

\* = show associated variables with malaria outbreak in Bure district

## 6. DISCUSSIONS.

Malaria is a major public health problem in the world, mainly in Sub Saharan Countries including Ethiopia due to different factors including environmental, household characteristics, prevention approaches and sociodemographic characteristics for malaria outbreak. Regarding to factor associated with malaria outbreak, four independent factors (sex of the study participants, educational level, presence of stagnant water and staying outdoor were identified as significant factors for malarial outbreak. But age, occupation, cultivated land within 200m, presence of shrub land cover with 200m of the home and presence of ITN were not identified as significant factors for malaria outbreak.

Males participants were found to be 2.16 times more likely to be attacked with malaria compared to females. Research conducted in various settings has consistently shown that male sex is a significant predictor of malaria infection. A study in Laelay Adyabo district northern Ethiopia found that males accounted for a higher percentage of malaria cases during outbreaks compared to female participants (17). Similarly, another study in Thailand reported that the infection rate in males was significantly higher than in females, reinforcing the notion that gender plays a crucial role in malaria susceptibility (52). This increased vulnerability can be due to males were often more engaged in outdoor activities, which increases their exposure to mosquito bites, particularly during peak transmission times. Furthermore, many males work in occupations such as agriculture that require significant time spent outdoors.

Participants who have no formal education are 2.41 times more likely to experience malaria outbreaks compared to those with formal education. This finding is encouraged by a case control study conducted in East Harage Zone, Ethiopia, odds of having malaria were 4.91 times more likely higher among children whose family had no formal education compared to those whose family had a higher educational level. This result agreed with the results from Ethiopia, Mali, and India. This possible justification may be due to the fact that non-formal educated people cannot read and understand the messages written as teaching aids such as leaflets, brochures, and banners that focus on the prevention and control methods of malaria (34).

Proximity to stagnant water sources within 2 km of the home has been identified as a breeding ground for malaria vectors. This study also found that living near stagnant water is a significant risk factor. Individuals residing close to stagnant water are 2.74 times more likely

to experience malaria infections during outbreaks compared to those who do not have such water sources nearby. This finding is consistent with research conducted in the Dembia district of Northwest Ethiopia, which indicated that proximity to stagnant water increases malaria risk by 2.7 times compared to those living farther away. Consequently, individuals near stagnant water bodies face a higher risk of malaria than their counterparts. One reason for this heightened risk is that open stagnant water can serve as ideal breeding habitats for mosquitoes. As a result, mosquitoes can easily travel within a 2 km radius from their breeding sites, increasing the likelihood of biting people in these areas (47).

In addition, outdoor activity was associated with malarial illness in this study, participants spend time outdoors at night were 1.6 times more likely to experience malaria outbreaks compared to those who remain indoors. This finding was supported with the study done at in Melka Denbi Kebele of Nensebo Woreda, Oromia, Southeast Ethiopia, staying outdoor overnight were 3.11 times contracting malaria. The possible justification can be due to bed nets were not used during outdoors that decreasing their effectiveness in preventing malaria illness (53).

## **6.1 Strength and Limitation of the Study**

### **6.1.1 Strength of the study**

Supervision was carried out by experienced malaria focal persons from nearby health centers to the health posts and conducting assessment on malaria outbreak is the current national government issues.

### **6.1.2 Limitation of the study**

The study encountered several limitations. First, it was not conducted during the light rainy season, a time commonly associated with higher malaria cases and essential for identifying factors related to outbreaks. Second, the study was prone to selection and recall biases, particularly concerning self-reported data on stagnant water near homes. Information about sleeping under ITNs was provided by participants instead of being directly observed by interviewers, and staying outdoor at night were also self-reported. Furthermore, relying on RDTs to identify malaria cases, rather than more reliable diagnostic methods, may undermine the findings and limit their generalizability.

## **7. CONCLUSION AND RECOMMENDATION**

### **7.1 Conclusion**

Generally, the finding of this study shows sex, education status, the presence of stagnant water, and staying outdoor were found to be independent predictors for malaria outbreak in Bure District. An integrated approach combining prevention, timely diagnosis, effective treatment, and a strong surveillance system is necessary for effective malaria case control in the study area

### **7.2 Recommendation**

Evidence from this study suggests that interventions such as community education initiatives will be implemented, focusing on malaria prevention and specifically targeting illiterate populations. This will include the use of visual aids to help individuals recognize malaria symptoms, understand the importance of prompt treatment, and learn preventive measures. Additionally, local communities will be encouraged to participate in clean-up drives aimed at eliminating stagnant water sources, which are breeding grounds for malaria-carrying mosquitoes. Furthermore, advocacy for the use of long sleeves garments during outdoor activities at night will be promoted, as they cover more skin and reduce the likelihood of mosquito bites.

To address the identified limitations, future research should include multiple seasons, particularly light rainy periods, to capture a more comprehensive understanding of malaria factors. Additionally, incorporating direct observational methods for data collection on environmental factors will reduce reliance on self-reported information. Researchers should also consider using more reliable diagnostic tests alongside RDTs to enhance the accuracy of malaria case identification.

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## 9. ANNEXES QUESTIONNAIRES

### **Annex: Questionnaire**

#### **Informed Consent**

##### ***Read this for the respondent!***

Hello, my name is \_\_\_\_\_ I am collecting data for research purpose on malaria outbreak determinants in Bure District, which is conducted by Mr. Tujuba Adinew for a partial fulfilment of master degree in General Public Health. The information you provide will contribute to improve malaria prevention and control in the district. If you are volunteer to involve in this study, I would like to ask you some questions and it will take about 20 to 30 minutes. The information you give us will be kept confidential, and neither your name nor other personal identification of yours will be disclosed or published. If there is any problem you can stop at any time and withdraw from the study.

Do you have any questions? May I begin the interview now?

Respondent agrees to be interviewed . . . 1

Respondent does not agree to be interviewed . . . 2 ends

I hope we will finish this interview successfully.

## Annex 1: English version Questionnaire

### Identification

Keble\_\_\_\_\_ Id. of respondent\_\_\_\_\_

Zone\_\_\_\_\_

### Section 1: Socio-demographic related determinants

| No  | Questions                                        | Responses                                                                                                                            | Skip to |
|-----|--------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|---------|
| 101 | Case status                                      | 1. Case<br>2. Control                                                                                                                |         |
| 102 | Sex of the respondent:                           | 1. Male<br>2. Female                                                                                                                 |         |
| 103 | What is your age in full years?                  | Year_____                                                                                                                            |         |
| 104 | What is your religion?                           | 1. Muslim<br>2. Orthodox<br>3. Protestant<br>4. Other (specify)_____                                                                 |         |
| 105 | What is your ethnic group?                       | 1. Oromo<br>2. Amhara<br>3. Tigre<br>4. Other (specify)_____                                                                         |         |
| 106 | What is your current marital status?             | 1. Married<br>2. Single<br>3. Divorced<br>4. Widowed                                                                                 |         |
| 107 | What is your educational status?                 | 1. Illiterate (can't read and write)<br>2. Primary education (1-8)<br>3. Secondary education (9-12)<br>4. Higher education (12+)     |         |
| 108 | What is your current main work/occupation?       | 1. Housewife<br>2. Farmer<br>3. Daily labourer<br>4. Government/NGO employee<br>5. Merchant<br>6. Student<br>7. Other (specify)_____ |         |
| 109 | How many people currently live in the household? | Total number of household members _____                                                                                              |         |

## Section 2: Housing condition related determinants

| No. |  | Questions                                        | Responses                                                                  | Skip to |
|-----|--|--------------------------------------------------|----------------------------------------------------------------------------|---------|
| 110 |  | What type of material is used to make the wall?  | 1. Mud and sticks<br>2. Iron sheets<br>3. Bricks<br>4. Stone<br>5. Wood    |         |
| 111 |  | What type of material is used to make the roof?  | 1. Sticky dung<br>2. Concrete cement<br>3. Wood                            |         |
| 112 |  | What type of material is used to make the floor? | 1. Wood<br>2. Sticky dung<br>3. Concrete cement<br>4. Other (specify)_____ |         |
| 113 |  | Are there preserved plants in the housing unit?  | 1. Yes<br>2. No                                                            |         |

## Section 3: Environment related determinants

| No. | Questions                                                    | Responses       | Skip to                     |
|-----|--------------------------------------------------------------|-----------------|-----------------------------|
| 114 | Is there cultivated land cover within 200m of the home?      | 1. Yes<br>2. No |                             |
| 115 | Is there bare land within 200m of the home?                  | 1. Yes<br>2. No |                             |
| 116 | Is there forest/shrub land cover within 200m of the home?    | 1. Yes<br>2. No |                             |
| 117 | Is there open deep well in your compound?                    | 1. Yes<br>2. No |                             |
| 118 | Is there drain to collect rain water in your compound?       | 1. Yes<br>2. No |                             |
| 119 | Is there any uncovered water storage in your compound?       | 1. Yes<br>2. No |                             |
| 120 | Are there old tires that contains water?                     | 1. Yes<br>2. No |                             |
| 121 | Is there stagnant water near to your home?                   | 1. Yes<br>2. No | If No to Q#121, go to Q#123 |
| 122 | If yes to Q121, what is the distance from home in kilometre? | _____(KM)       |                             |

**Section 4: Malaria prevention related determinants**

|     |                                                         |                           |                               |
|-----|---------------------------------------------------------|---------------------------|-------------------------------|
| 123 | Is there ITN in your home?                              | 1. Yes<br>2. No           | If No to Q#123<br>go to Q#126 |
| 124 | If yes did you sleep under ITN in<br>last three weeks?  | 1. Yes<br>2. No           | If No to Q#124<br>go to Q#126 |
| 125 | If yes how often do you sleep<br>under ITN              | 1. Always<br>2. Sometimes |                               |
| 126 | Is your house sprayed with IRS in<br>the last 6 months? | 1. Yes<br>2. No           |                               |

**Section 5: Personal activity related determinants**

|     |                                                             |                 |  |
|-----|-------------------------------------------------------------|-----------------|--|
| 127 | Do you stay outside of home at<br>night beyond 3:00 o'clock | 1. Yes<br>2. No |  |
|-----|-------------------------------------------------------------|-----------------|--|

***Thank you!***

Date of data collection\_\_\_\_\_

Name and signature of data collector\_\_\_\_\_

Name and signature of supervisor\_\_\_\_\_

**Annex 2:** Af- gaaffii Afaan Oromoon gaaffilee qorannoo

Adda baasaa

Ganda \_\_\_\_\_ Lakk.Eenummaa \_\_\_\_\_ Zoonii \_\_\_\_\_

**Kutaa1:** Odeeffannoo haala jireenya hirmaattotaa

| T.L | Gaaffilee                              | Deebii                                                                                                                                                    | darbi |
|-----|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 101 | Haala yaalamaa                         | 1. busaa qaba<br>2. busaa hin qabu                                                                                                                        |       |
| 102 | Saala hirmaataa/ttuu                   | 1. Dhiira<br>2. Dhalaa                                                                                                                                    |       |
| 103 | Umuriin kee waggaadhan meeqa?          | waggaa _____                                                                                                                                              |       |
| 104 | Amantaan kee maali?                    | 1. Musliima<br>2. Ortoodoksii<br>3. Protestaantii<br>4. Kan biro(caqasi)-----                                                                             |       |
| 105 | Sabni kee maali (sabi irraa dhalatte)? | 1. Oromoo<br>2. Amaara<br>3. Tigiree<br>4. Kan biro (caqasi)_____                                                                                         |       |
| 106 | Haalli gaa“ela kee maali?              | 1. Kan heerumte /fuudhe<br>2. Kan hin heerumne/ hin fuune<br>3. Kan hiike/ hiikte<br>4. Kan haati manaa ykn abbaan manaa jalaa du“e                       |       |
| 107 | Sadarkaan barnootaa kee maal fakkaata? | 1. Barreessuu fi dubbisuu kan hin dandeenye<br>2. Sadarkaa 1ffaa (1-8)<br>3. Sadarkaa 2ffaa (9-12)<br>4. Sadarkaa olaanaa (12+)                           |       |
| 108 | Hojiin kee kan ammaa maali?            | 1. Haadha warraa<br>2. Qotee bulaa<br>3. Dafqaan bulaa<br>4.Hojjetaa mootummaaa/Miti mootummaaa<br>5. Daldalaa<br>6. Barataa/ttuu<br>7. Kan biroo(caqasi) |       |
| 109 | Lakkofsi maatii kee meeqa?             | Lakkofsa miseenota maatii _____                                                                                                                           |       |

**Kutaa 2: Haala mana jireenyaa waliin walqabate**

|     |                                                   |                                                                                                                  |  |
|-----|---------------------------------------------------|------------------------------------------------------------------------------------------------------------------|--|
| 110 | Dhaabni manaa maal irraa ijaaarama?               | 1. Dhoqqee fi mukarraa<br>2. Sibiila ayiranii irraa<br>3. Bilookeetii irraa<br>4. Dhaagaa irraa<br>5. Muka irraa |  |
| 111 | Baaxiin manaa maalin haguugame?                   | 1. Dhoqqee maxxanu<br>2. Konkiriitii simmintoo<br>3. Muka irraa                                                  |  |
| 112 | Lafti manaa keessaa maaliin hojjettame?           | 1. Xaawulaa qaqallaa<br>2. Dhoqqee maxxanu<br>3. Konkiriitii simmintoo/gipsamii<br>4. Kan biroo _____            |  |
| 113 | Biqilaa miidhaginaaf mana keessatti ni guddistaa? | 1. Eeyyee<br>2. Miti                                                                                             |  |

**Kutaa 3: Haala naannoo wajjin walqabatee jiru**

|     |                                                                                 |                       |  |
|-----|---------------------------------------------------------------------------------|-----------------------|--|
| 114 | Qonnaan biqilootaan uffifame meetira 200 asitti naannoo manaa jiraa?            | 1. Eeyyee<br>2. Lakki |  |
| 115 | Lafti hin qotamin qullaa ta'e meetira 200 asitti naannoo manaa jiraa?           | 1. Eeyyee<br>2. Lakki |  |
| 116 | Lafti mukeen xixiqqaa ykn bosonaan uwwifame naannoo manaa meetira 200 as jiraa? | 1. Eeyyee<br>2. Lakki |  |
| 117 | Biiriin bishaanii qadaada hin qabne dallaa keessa jiraa?                        | 1. Eeyyee<br>2. Miti  |  |
| 118 | Dhangala'aan mooraa keessa kuufamee jiru jiraa?                                 | 1. Eeyyee<br>2. Miti  |  |
| 119 | Bishaan qadaada hin qabne mooraa keessa kuufame jiraa?                          | 1. Eeyyee<br>2. Miti  |  |
| 120 | Gommaa moofaan bishaan qabatee jiru mooraa keessa jiraa?                        | 1. Eeyyee<br>2. Miti  |  |
| 121 | Haroon bishaanii naannoo manaa jiraa?                                           | 1. Eeyyee<br>2. Miti  |  |
| 122 | Yoo deebiin G121 eeyyee ta'e KM meeqa fagaata?                                  | _____ (KM)            |  |

**Kutaa 4:** Haala ittisa busaa wajjin wal qabatu

|     |                                                                                    |                                    |                                    |
|-----|------------------------------------------------------------------------------------|------------------------------------|------------------------------------|
| 123 | Agoobara mana keessaa qabduu?                                                      | 1. Eeyyee<br>2. Lakki              | G123 lakkii yoo jette G126tti cehi |
| 124 | Agoobara jala torbee sadan darban jala rafaaf turteettaa?                          | 1. Eyyee<br>2. Lakki               | G124 lakkii yoo jette G126tti cehi |
| 125 | Yoo deebiin G124 eeyyee ta'e, yeroo kam jala ciifta?                               | 1. Yeroo hunda<br>2. Darbee darbee |                                    |
| 126 | Manni keessan ji'a 6'n darbe keessa keemikaala farra bookee busaa biifamee beekaa? | 1. Eeyyee<br>2. Lakki              |                                    |

**Kutaa 5:** Haala sochii nama dhuunfaa

|     |                                 |                       |  |
|-----|---------------------------------|-----------------------|--|
| 127 | Halkan sa'a 3 booda ala turtaa? | 1. Eeyyee<br>2. Lakki |  |
|-----|---------------------------------|-----------------------|--|

***Galatoomaa!***

Guyyaa odeeffannoon itti walitti qabame\_\_\_\_\_

Maqaa fi mallattoo nama odeeffannoo walitti qabuu\_\_\_\_\_

Maqaa fi mallattoo supparvaayizeraa\_\_\_\_\_