Malaria Outbreak Investigation And Associated Risk Factors In Siraro District, Oromia Region, Ethiopia, 2021

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Research Article

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Malaria Outbreak Investigation And Associated Risk Factors In Siraro District, Oromia Region, Ethiopia, 2021

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Abstract

**Background:** In Ethiopia, malaria is highly seasonal in many communities, with epidemic-prone transmission patterns and serious public health emergencies that have a major impact on health and the economy. This investigation aimed to assess the malaria outbreaks, determine risk factors for infection and preventive measures in the Siraro district.

**Methods:** A unmatched case-control study with a 1:1 case-to-control ratio was conducted in the Siraro District from 16 June 2021 to 03 August 2021. The calculated sample size for this study was 148 and a simple random sampling technique was used to select cases and controls. We reviewed the previous five year’s malaria data to establish a threshold level. Both descriptive and analytical statistical procedures were performed. The data were entered using Epi-Info version 7.2.4.0 software and analyzed by using SPSS version 25. Multivariable logistic regression analysis was conducted to identify independent factors associated with malaria infection.

**Results:** Of the total malaria cases (n=183), *Plasmodium falciparum* species are about 149(81.4%) and almost 100% of the cases were confirmed by RDT/Microscopy. Age group ≥ 5 years were the most affected with an attack rate (AR) of 2.04/1000. Multivariate analysis revealed the place of stay during night adjusted Odds Ratio (AOR) 5.62, 95% CI= 1.016–31.069, a person with malaria in the house with AOR 15.74,95% CI= 3.029-81.865, presence of stagnant water near to house AOR of 25.60, 95% CI= 4.696-139.649, availability of plants with temporary water pools in the compound an AOR of 90.94,95% CI= 9.019-917.012 and a person who does not hear about malaria prevention on insecticide-treated bed nets utilization adjusted Odds Ratios (AOR) of 0.14,95% CI: 0.076, 1.061 were the main associated risk factors for the occurrence of the outbreak.

**Conclusions:** The malaria outbreak in Siraro District mostly affected children above 5 years of age. Of the variables studied, a people with malaria in the house, stagnant water, and plants with temporary water pools and lack of awareness about malaria transmission were all significantly associated with the occurrence of malaria outbreaks. The community should be aware of malaria prevention and control measures.

**Keywords:** Malaria, Outbreak, Investigation, Risk factors, Siraro district, Ethiopia
Introduction

Background of the study

Malaria is a life-threatening disease caused by the infection of red blood cells by protozoan parasites of the genus *Plasmodium*, which are transmitted to humans through the bites of infected female *Anopheles* mosquitoes (1). Globally, according to a 2019 World Health Organization (WHO) report, there were 229 million malaria cases and 409,000 deaths. Children under the age of five are the most vulnerable group, accounting for approximately 67 percent (274,000) of all malaria deaths worldwide (2). The WHO African Region had the highest number of cases (215 million or 94 percent), followed by the WHO South-East Asia Region with 3 percent (6.3 million) and the WHO Eastern Mediterranean Region with 5 million. Malaria cases in the WHO African Region (213 million or 93 percent) accounted for 94 percent of all malaria deaths in 2018, and almost half of the world's population was at risk for malaria infection (3). A Malaria-Free World and the World Health Organization (WHO) have updated the Global Technical Strategy 2016-2030. According to the 2018 Global Malaria Report, Ethiopia has shown a 57 percent reduction in malaria incidence and a 54 percent reduction in malaria mortality between 2015 and 2018 (4,5). Malaria is found in about 75% of Ethiopia's land area and 60% of the country's population (63,495,055) is at risk of infection (6). *P. falciparum* and *P. vivax* are the two most dominant malaria parasites in Ethiopia, accounting for 60-70% and 30-40% of malaria cases, respectively. *Anopheles Arabiensis*, a member of the *Anopheles Gambiae* complex, is the main malaria vector in Ethiopia (7). Ethiopia became one of the focus countries for the President's Malaria Initiative (PMI) in Africa. The overall goals of the Ethiopian Presidential Malaria Initiative (PMI) program include scaling up support, especially for vector control in high-burden areas, continuing procurement and distribution of insecticide-treated bed nets (ITN) to support insecticide-treated bed nets (ITN) universal coverage, continued procurement of antimalarial drugs to address national shortages, and strengthen national-level surveillance and district-level support in low-burden areas to promote regional elimination (4,8). Children with severe malaria often develop one or more of the following severe symptoms: severe anemia, respiratory distress due to metabolic acidosis, or cerebral malaria. Multi-
organ involvement is also common in adults. In malaria-endemic areas, people can develop partial immunity, allowing asymptomatic infection to occur. Malaria is a preventable and curable disease (9). The amount of money spent on malaria interventions across Africa, particularly in Ethiopia, has increased significantly. Ethiopia recently announced a plan to eliminate malaria nationwide by 2030, beginning with sub-national elimination in districts with low malaria transmission (5,10). Malaria is usually an endemic disease, although it can sometimes be epidemic. Recent studies have found indicators that may be contributing to malaria outbreaks in Ameya Woreda, in southwestern Oromia. The epidemic resulted in 4,768 malaria cases (infection rate: 50 per 1,000) and 17 malaria deaths (case fatality rate: 0.2 percent) (11).

In June 2021, the Siraro District Health office informed the West Arsi Zonal Health Department suspected cases of malaria had been detected in 16 Kebeles (villages). The purpose of this study was to confirm the existence of an outbreak, describe the extent of the disease, identify risk factors and implement control measures.

**Methods**

**Study Area**

The study was conducted in Siraro District, West Arsi Zone, Oromia Region. This area is under the catchment of Biftu and Shasha Health centers. Siraro District is located in the Great Rift Valley of Southern, Oromia Region, Ethiopia. The administrative center of Siraro District is Loke, which is located about 304 kilometers to the South of Addis Ababa and 54 kilometers away from Shashamanne (Zonal town). The district borders Sidama Region to the southeast, Walayita zone to the southwest, Hadiya zone to the west, Halaba special zone to the north, and Shala District to the east (Figure 1). Demographically speaking, a total of 207,541 people in which 107,921 were females and 30,410 were under-five children inhabit the District. The district is administratively organized into 28 rural kebeles, and 4 urban kebeles. The District had one primary hospital, 6 health centers (HCs), and 28 health posts (HPs) with primary health care coverage of 85.7% reported by Siraro district. The climate is 90% desertic. The district generally lays at an altitude between 1500 and 2075 meters above sea level. These above districts' weather conditions, altitude, and temperature favor
breeding of disease-causing vector-like anopheles mosquitoes. The district covers an area of 1312.855 square kilometers. The annual average rainfall is about 1650 milliliters, but inadequate and seasonal between 900 to 1500 milliliters per year.

**Study Period**

The study was conducted in the Siraro district of West Arsi zone, Oromia, Ethiopia, from 16 June to 03 August 2021.

**Study Design**

We used a community-based unmatched case-control study design with a 1:1 ratio of case and control to identify risk factors and cross-sectional study design to describe in terms of person, place and time for the occurrences of the malaria outbreak in the district.

**Population**

**Source Population**

The Source Population was all residents of the Siraro District

**Study Population**

The study population was all residents of the Siraro district who met the case and control criteria.

**Eligibility criteria**

**Inclusion Criteria**

**For cases:** Any resident of the Siraro district where malaria outbreak occurred and who had symptoms of malaria and confirmed positive by microscopy or Rapid Diagnostic Test (RDT) for *Plasmodium* parasites and agree to participate were included from the study.

**For controls:** Any resident of Siraro district where malaria outbreak occurred, neighbor to a case and who did not develop signs and symptoms or free from malaria disease in the house and confirmed negative by microscopy or Rapid Diagnostic Test (RDT) for *Plasmodium* parasites and agree to participate.
Exclusion Criteria

For cases: Any resident of Siraro district where malaria outbreak occurred, who had symptoms of malaria and confirmed positive by microscopy or Rapid Diagnostic Test (RDT) for *Plasmodium* parasites but who refused to participate were excluded from the study.

For controls: Those who refused to participate, were unavailable during the study period, and did not fulfill inclusion criteria were excluded from the study.

Variables in the study

Dependent variables

Presence of malaria infection (case & control).

The independent variables

Socio-demographic factors: Age, sex, occupation, religion, ethnicity, and educational status.

Environmental factors: Plant water pools, open deep well, broken materials, and stagnant water.

Housing condition factors: House screen, sprayed and bed net in household.

Knowledge related factors: Way of transmission, know symptoms of malaria, and way of prevention.

Early diagnosis and treatment factors: cured and Recovery

Operational, case definitions and measurements

Malaria: A disease in an individual in which the presence of *Plasmodium* parasites in blood has been confirmed.

Resident: Individuals (workers) who had been living for more than 3 months and are normal residents of the study area.

Cases: Any person with fever or fever with headache, rigor, back pain, chills, sweats, myalgia, nausea, vomiting and confirmed positive by microscopy or RDT for *plasmodium* parasites.

Controls: Any person who is a neighbor to a case and who did not develop symptoms of malaria.
Suspected: Patient with fever or history of fever in the last 48 hours and who lives in malaria-endemic areas or has a history of travel within the past 30 days to malaria-endemic areas.

Probable: Any person with fever and one or more major signs such as headache, rigor, back pain, chills, sweats, myalgia, nausea, and vomiting are diagnosed clinically as malaria.

Confirmed: Any suspected case that is confirmed by microscopy or RDT for *plasmodium* parasites.

Line-List: Registrations of cases by place, person, and time.

Knowledgeable: If respondents answer >60% correctly knowledge-related questions, then they are known to that question.

Not Knowledgeable: If respondents answer ≤60% correctly knowledge-related questions, then they are not known to that question.

Sample size determination and sampling procedures

Sample size determination

For descriptive epidemiology: Malaria was defined and identified as an acute febrile illness with blood smear positive for malaria in the Siraro District outbreak in 2021. During this outbreak investigation, the number of malaria cases and deaths were collected from health facilities on a daily and weekly basis. The magnitude of this outbreak was described by age, sex, and kebele, weekly, monthly, slide positivity rate was calculated as those positive for malaria among the total 183 confirmed cases examined from line list reported of Siraro district.

For analytical epidemiology: The cases and controls were chosen using a simple random sampling technique based on the population proportions of the two clusters. The assumption taken from a previous study indicates that the proportion of controls exposed was 55% for a power of 80% with an odds ratio (OR) of 2.90. (12). The sample size was calculated with a 1:1 ratio taken from each group was determined by Epi-Info version 7.2.4.0 and the final sample size generated was 74 malaria cases and 74 community controls total of 148 study participants. The significance of risk factors for the outbreak was determined through multivariate analysis by calculating Odds Ratio (OR) and 95% Confidence Interval (CI).
**Sampling technique and procedures**

The simple random sampling method was used at the places where the outbreak occurred and was selected randomly confirmed cases with the highest caseloads and community control interviewed from two affected kebeles.

**Data collection method, tools, and procedures**

Data was collected by using a structured questionnaire and by reviewing secondary data at the district after discussing with relevant bodies (task force), review of weekly Public Health Emergency Management (PHEM) reports at different levels (zone health department, District health office, and Health facilities), health extension workers (HEWs), review on available data from line list, visiting of the affected village and interview of community members (patients) to collect risk factors for the malaria outbreak. Case patients and controls were interviewed by using a structured questionnaire to grow data on potential exposures such as the presence of mosquito breeding sites on their premises and near the house within 500 meters or less, environmental control, and ITN uses, availability of uncovered plastic water containers, old tires, and broken glasses in the home or outside the home for analytical analysis. Quantitative data that was addressed socio-demographic characteristics and potential exposures were collected. Laboratory technicians had conducted thick and thin smears with a 100 × oil immersion microscopy at Biftu Health Center of Siraro District. Additionally, Diagnostic Test (RDT) was also used in this health center whenever they faced a shortage of some reagents and during interruption electric power. Health extension workers also used Rapid Diagnostic Test (RDT) to identify confirmed malaria cases at the health post and community level during the outbreak investigation. A five-year (2017 to 2021), fiscal budget years recorded malaria data at the Siraro health office were reviewed. Daily data to weekly total cases in the affected localities in the previous weeks and months were compiled. By taking the second-largest malaria trend from the five-year reviewed malaria data as a threshold and comparing it with the number of cases of the weeks and months of 2021, the malaria out-break was determined.
Data Quality Assurance

Before the start of data collection, orientation was given to data collectors. Each completed questionnaire was daily reviewed by the principal investigators to monitor and improve the data quality. Before analysis, data were also cleaned for any missing and logically inconsistent values. A pre-test was conducted on 7(5%) of the sample size. Internal quality control was conducted for laboratory investigation using known prepared slides. The quality of the RDT result was cross-checked against microscopy. All procedures from sample collection to staining and examination were undertaken properly. Blood to diluting buffer proportion was maintained as per guidelines in RDT. Finally, the data was cleaned, coded, and cross-checked using the Epi-info software before data analysis.

Data processing and analyzing

Data enter and summarizing were done using Epi- Info version 7.2.4.0 software. Then data were imported to Microsoft Excel and analyzed by SPSS version 25. We identified independent determinants by bivariate & multivariate logistic regression. Used a P-Value (<.05) and AOR with 95% CI to report significance and strength of association, respectively.

Ethical considerations

Ethical clearance was obtained from the institutional review board (IRB) (Ref.No.PHD 23/806/2021) of St. Paul’s Hospital Millennium Medical College and Oromia Regional Health Bureau. An official letter was sent to West Arsi Zonal health department and Siraro district health office. After obtaining permission from the the district to participate in the study, an informed, voluntary, written, and signed consent was obtained for the participation of both the the district health office and the patients. The patient’s privacy and confidentiality were ensured through an interview in a non-public place, and they will be aware that their participation in the study would not be an incentive or harm. Finally, the identity of the participants remained anonymous throughout the process of data collection and analysis.
Results

Descriptive epidemiology

Description of a case by a person

A total of 221 blood smear tests was done by Microscopy and Rapid Diagnostic Test (RDT) for suspected malaria cases at all health facilities of these 183 were confirmed cases from March to June 2021 in Siraro District. A total of 183 confirmed cases were treated and an 82.8% positivity rate. Total confirmed cases 104 (56.8%) were male. The proportion of suspected malaria cases was higher among males than females. Of the total positive cases, *Plasmodium falciparum* accounts for about 149(81.4%) followed by *P. Vivax* 34(18.6%) (Table 1).

Descriptive epidemiology by place

Among the total confirmed malaria cases, 97(53%) were from Dongoro Bonkoya kebele. The populations in Dongoro Bonkoya kebele were the most affected by the malaria outbreak followed by Shasha Goyke kebele with an attack rate of 16.7/1000 and 1.9 /1000 population, respectively (Table 2).

Distribution of malaria cases by kebele in Siraro District

The malaria epidemic was detected & reported to Regional Health Bureau on June 10 of 2021. Malaria cases identified in 16 Kebeles among these most cases, 97(53%) Dongoro Bonkoya and 33(18%) cases Shasha Goyke while 53(29%) cases other (14) kebeles (Figure 2).

Descriptive epidemiology by time

In the kebele, the malaria outbreak was verified by comparing the current year data with the second largest number during the previous 5 years (2017-2021). It was shown that the current case trend line crossed the threshold levels in the district and peaked in the 19th WHO week and started to decline after the 25th WHO week of May 2021 (WHO week 15 to 25/2021). Epi- curve showed that the district health office departed to the outbreak area early, as soon as the outbreak started (Figure 3).

The Epi-curve showed the outbreak was a propagated one with multiple peaks with a possibility of person-to-person transmission. The weeks when the epidemic started were on the first week of May 2021 and notified by the district health office (Figure 4).
Analytical epidemiology

Socio-demographic characteristics of the study participants

During this case-control study, 74 malaria case patients and 74 community controls were recruited. The mean age of study participants was 27.14 years with ±14.042 standard deviations. They recruited study subjects (both cases and controls) all have participated in the study which gives a response rate of 100%. Among total study subjects, 47(63.5%) cases were male of which 39(52.7%) were controlled. Almost all (90.5%) of the respondents were Oromo by ethnicity and (94.6%) Muslim followers (Table 3).

Risk factors analysis study results

Person with malaria in the house was 15 times higher among persons who reside with malaria-infected persons in the household than those who reside in households where there is no malaria-infected person an AOR of 15.74 [95% CI= 3.02-81.86, P= 0.001]. Staying outside the home during the night was 5 times higher of contracting malaria than staying inside the home AOR 5.62,95% CI= 1.01–31.06, P-value 048. Stagnant water near living areas was 25 times the risk of malaria contracting malaria when comparing the counterpart an AOR of 25.60,95% CI= 4.69-139.64, and at a p-value of 0.000. Availability of plants with temporary water pools in the compound was also found to be contributing risk factors for the occurrence of the outbreak with an AOR of 90.94 [95% CI= 9.01-917.01, P= 0.000]. A person who did not hear about malaria was AOR 0.14 [CI: 0.07, 1.06, P=0.008] times less likely to have malaria than individuals who heard about malaria prevention on ITN utilization.Individuals who were not awareness about the transmission of malaria were 0.02 times (CI: 0.002-0.18) less likely to have malaria than individuals who know transmission of malaria (Table 4)

Epidemic preparedness, response, and public health intervention

There was a functional rapid response team to respond to the outbreak in the district. They had traveled almost about 46 km away from the district to investigate and respond to the outbreak. Case management/treatment of infected individuals was made in parallel with outbreak investigation. Awareness was created while collecting data and visiting the environment where the outbreak occurred (Figure 5)
About 650 Insecticide-treated nets was distributed for 146 households including pregnant mothers in the affected Shasha Goyke kebele. About 2249 populations at risk were protected by the distribution of ITN. A total of 1220 households with 2862-unit structures were chemical sprayed at Dongoro Bonkoya kebele of the district. Communities were mobilized and taught on prevention and control measures of malaria disease. Health professionals were mobilized and assigned to affected kebeles for active case search and early case management at the communities and health facility level. Awareness was also given to the affected communities on the prevention of the diseases concerning the way to avoid the breeding sites for malaria vectors, especially on environmental management. While distributing insecticide-treated nets, the affected communities were aware of using ITN properly by giving priority to pregnant women and children less than five years of age (Figure 6)

Discussion

Outbreaks of malaria are often complex, multi-factorial, and may have natural and human-made determinants. During this outbreak investigation time in the study area, it was found that health facilities were using Rapid Diagnostic Test (RDT) and microscopy to identified cases, from 221 suspects tested 183(83%) confirmed cases without death were reported. Of total cases, male (AR=2.2/1000) and age >5 years (AR=2.04/10,00) were more attacked in the District. The malaria outbreak was verified by comparing the current year data with the second largest number during the previous 5 years (2017-2021) in the district. It was shown that the current case trend line crossed the threshold levels in the district and peaked in the 19th WHO week and started to decline after the 25th week (WHO week 15 to 25/2021) with threshold line for monitoring malaria epidemic on the chart and confirmed. The overall attack rate of malaria infection in this study area was 10.31%, with a higher attack rate in the Dongoro Bonkoya kebele (16.7%) communities. This result was greater than reports from a study done in an institutional-based conducted at Dilla Town and the Surrounding Rural Areas, Gedeo Zone, Southern Ethiopia which is 16% (13). The results of this study revealed that from malaria parasite species, P. falciparum accounts for 81.4% followed by P.vivax 18.6%. This finding was higher than that of a study on the analysis of malaria prevalence in Arsi Negelle health center, southern Ethiopia, that found Plasmodium species, P. Vivax accounting for (74%), P. falciparum was (19.8%). This finding was similar with that of Amaya Woreda, southwest Shoa, Oromia, where 84% were
P. falciparum and 16% were P. Vivax (11,14). The transmission of malaria is determined by main factors such as human behavior and the existence of malaria parasite, as well as social and health facility factors such as housing condition, environmental management, KAPs of the community towards malaria causation, transmission, treatment-seeking behavior, and presence of mosquito control activities can affect malaria prevalence. The findings of this study revealed that living in the nearby stagnant water was identified as a risk factor. A significantly higher parasite rate was found among the individuals near stagnant water around their houses. The study conducted in Dilla Town and the surrounding rural areas, Gedeo Zone and Tape town the study showed that persons who live in an area where there is stagnant water were 34.26 times more likely to be exposed to malaria parasites than those who do not live in an area with stagnant water (13,15)

Availability of Plants with temporary water pools in the compound was also found to be contributing risk factor for the occurrence of the outbreak were more affected. It can be explained by the fact that they are more exposed to mosquito bites because these areas are suitable for the breeding of mosquitoes around their homes. This study agrees with a different study done at Afar Region on Malaria outbreak investigation, and also a study conducted in Gololcha District, Arsi Zone, Oromia Ethiopia (12,16)

Persons who stay outside at night were 5.62 times more likely to develop malaria parasites than those who do not stay outside at night. Individuals with malaria patients in the house were 15.74 times more likely to develop malaria parasites than those who do not have malaria patients in their house. This result agrees with the study conducted in West Armachiho District, Northwest Ethiopia, that revealed that staying outside during the night is more likely to develop malaria than those who stay inside during the night (7)

Community knowledge on malaria prevention and control options is important and the effort is related to either environmental management, personal protection, or vector control. The results of this analytical epidemiological study showed that persons who have never heard about the transmission of malaria were significantly associated with the occurrence of this outbreak. The result of this study is similar to Malaria prevalence, knowledge, attitude, and practice among febrile patients attending Chagni health center, Northwest Ethiopia and a study also revealed that 97% of the respondents had ever heard about malaria and recognized it as a serious health problem (17).
Limitation of the study

The main limitation was a shortage of medical entomologists to confirm the existence of anopheles mosquito larvae and measure their quantity in stagnant water. Late notification of the outbreak might show that there was weak monitoring of malaria trends at all levels.

Conclusions

A malaria outbreak has been confirmed in the Siraro district of West Arsi Zone. Of the 16 kebeles of the district malaria area Dongoro Bonkoya, Shasha Goyke, and Torba Hansawe kebeles were more affected by the malaria outbreak. Children aged five years and older were more affected by the malaria outbreak. The presence of stagnant water, plants with temporary water pools in the compound, stay outside of their home during the night, the presence of malaria patients in the household, and persons who have never heard about malaria prevention on insecticide-treated bed nets (ITN) utilization were risk factors associated with malaria outbreaks in the study area. This may be due to poor environmental management that resulted in an unusual increase in the vector population, the presence of dense bushes, and stagnant water of affected kebeles in the district. Malaria outbreaks were recorded in areas where conditions were favorable for the spread of malaria and the population lacked protective immunity. An epidemic early warning, prevention and control group operated in the region. The West Arsi health department and Siraro District Health office should increase community awareness of malaria control and preventive measures.

Abbreviations and Acronyms

Declarations

Ethical Approval

The study protocol was approved by the Institutional Review Board (IRB) of St. Paul’s Hospital Millennium Medical College and a letter of permission was obtained from the West Arsi zone health office. Then the letter was delivered to the Siraro District Health office and the respective villages. The rationale of the study was explained to the participants. In addition, oral consent was obtained from each study participant. Blood smears were taken by experienced laboratory technicians under an aseptic technique using sterile gloves and disposable sterile lancets. Codes were used to ensure the confidentiality of Laboratory results. Participants with positive for malaria parasites were linked to the nearest health facilities for treatment according to the national malaria guideline.

Consent for publication

Not applicable.

Availability of data and materials

The data upon which the result is based could be accessed as a reasonable request.

Competing interests

Both authors declared that they have no conflicts of interest for this work.

Funding

Not applicable.

Authors’ Contributions

Girma Mideksa designed the study, developed the proposal, participated in the data collection, performed analysis and interpretation of data, and drafted the paper.

Takele Gezahegn contributed significantly from its beginning up to the manuscript preparation and its critical editing.
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Figures

Figure 1: Map of Siraro District, West Arsi Zone, Oromia Ethiopia, 2021

Figure 2: Distribution of malaria cases by kebele in Siraro District, West Arsi Zone, 2021
Figure 3: Trends of malaria cases crossing thresholds in Siraro district, West Arsi zone, Oromia, 2021

Figure 4: Epi-Curve confirmed Malaria cases by date of onset in Siraro district, 2021
Figure 5: Photo taken while data collection, awareness creation, and case management at Dongoro Bonkoya kebele, Siraro district, West Arsi Zone, 2021

Figure 6: A photo taken while awareness creation when ITN distribution at Shasha kebele, Siraro district, West Arsi Zone, 2021
Tables

Table 1: Malaria Positivity rate by age, sex, and species in Siraro district, Oromia, 2021

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Total tested by RDT or Microscopy</th>
<th>Total positive</th>
<th>Positivity rate (%)</th>
<th>Plasmodium species</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P. Falciparum N (%)</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;5</td>
<td>25</td>
<td>20</td>
<td>80%</td>
<td>16(10.7%)</td>
</tr>
<tr>
<td>≥ 5</td>
<td>196</td>
<td>163</td>
<td>83.1%</td>
<td>133(89.3%)</td>
</tr>
<tr>
<td>Sex</td>
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</tr>
<tr>
<td>Male</td>
<td>125</td>
<td>104</td>
<td>83.2%</td>
<td>92(61.5%)</td>
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<tr>
<td>Female</td>
<td>96</td>
<td>79</td>
<td>82.3%</td>
<td>57(38.5%)</td>
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<tr>
<td>Total</td>
<td>221</td>
<td>183</td>
<td>82.8%</td>
<td>149(81.4%)</td>
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</table>

Table 2: Malaria attack rate by place in Siraro District, Oromia, 2021

<table>
<thead>
<tr>
<th>S/N</th>
<th>Name of Kebele</th>
<th>Total Population</th>
<th>Sex</th>
<th>Total tested (RDT or Microscope)</th>
<th>Total cases</th>
<th>AR/1000</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Dongoro</td>
<td>5856</td>
<td></td>
<td>2869</td>
<td>2987</td>
<td>123</td>
</tr>
<tr>
<td></td>
<td>Bonkoya</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Shasha Goyke</td>
<td>6747</td>
<td></td>
<td>3340</td>
<td>3407</td>
<td>51</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>12603</td>
<td></td>
<td>6209</td>
<td>6394</td>
<td>174</td>
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Table 3: Socio-demographic characteristics of study participant’s malaria outbreak of Siraro District, West Arsi Zone, Oromia, 2021

<table>
<thead>
<tr>
<th>Variables</th>
<th>Response</th>
<th>Frequency (%)</th>
<th>Cases(N=74)</th>
<th>Controls(N=74)</th>
</tr>
</thead>
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<tr>
<td>Age</td>
<td>&lt;5</td>
<td>4(5.4%)</td>
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<tr>
<td></td>
<td>5-14</td>
<td>23(31.1%)</td>
<td>1(1.4%)</td>
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</tr>
<tr>
<td></td>
<td>15-24</td>
<td>15(20.3%)</td>
<td>20(27.0%)</td>
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</tr>
<tr>
<td></td>
<td>25-34</td>
<td>13(17.6%)</td>
<td>25(33.8%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35-44</td>
<td>11(14.9%)</td>
<td>14(18.9%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>45-54</td>
<td>5(6.8%)</td>
<td>11(14.9%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;55</td>
<td>3(4.1%)</td>
<td>3(4.1%)</td>
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</tr>
<tr>
<td>Sex of respondent</td>
<td>Male</td>
<td>47(63.5%)</td>
<td>39(52.7%)</td>
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</tr>
<tr>
<td></td>
<td>Female</td>
<td>27(36.5%)</td>
<td>35(47.3%)</td>
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</tr>
<tr>
<td>Marital status</td>
<td>Single</td>
<td>19(25.7%)</td>
<td>42(56.8%)</td>
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</tr>
<tr>
<td></td>
<td>Married</td>
<td>46(62.2%)</td>
<td>27(36.5%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Divorced</td>
<td>3(4.1%)</td>
<td>1(1.4%)</td>
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</tr>
<tr>
<td></td>
<td>Widowed</td>
<td>6(8.1%)</td>
<td>4(5.4%)</td>
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</tr>
<tr>
<td>Occupational status</td>
<td>Employed</td>
<td>2(2.7%)</td>
<td>3(4.1%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unemployed</td>
<td>18(24.3%)</td>
<td>24(32.4%)</td>
<td></td>
</tr>
<tr>
<td>Risk factors</td>
<td>Response</td>
<td>Case status</td>
<td>Crude OR(95%CI)</td>
<td>Adjusted OR(95%CI)</td>
</tr>
<tr>
<td>--------------</td>
<td>----------</td>
<td>-------------</td>
<td>----------------</td>
<td>-------------------</td>
</tr>
<tr>
<td></td>
<td>Case (N=74)</td>
<td>Control (N=74)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Place of stay</td>
<td>Inside house</td>
<td>53</td>
<td>64</td>
<td>2.53(1.09-5.85)</td>
</tr>
</tbody>
</table>

Table 4: Bi-variate Vs multivariate analysis of risk factors for malaria outbreak in Siraro, West Arsi Zone Oromia, Ethiopia, 2021
<table>
<thead>
<tr>
<th></th>
<th>During night</th>
<th>Outside house</th>
<th>21</th>
<th>10</th>
<th>1</th>
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<tbody>
<tr>
<td>Person With malaria in the house</td>
<td></td>
<td></td>
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<tr>
<td>With malaria in house</td>
<td>47</td>
<td>30</td>
<td>2.55 (1.31-4.95)</td>
<td>15.74 (3.02-81.86)</td>
<td>0.001</td>
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<tr>
<td>Without malaria in house</td>
<td>27</td>
<td>44</td>
<td>1</td>
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<td></td>
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<tr>
<td>Plant with temporary water pools</td>
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<tr>
<td>Yes</td>
<td>63</td>
<td>30</td>
<td>8.4 (3.80-18.52)</td>
<td>90.94 (9.01-91.01)</td>
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<tr>
<td>No</td>
<td>11</td>
<td>44</td>
<td>1</td>
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<tr>
<td>Stagnant water</td>
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<tr>
<td>Near to house</td>
<td>46</td>
<td>21</td>
<td>4.15 (2.08-8.26)</td>
<td>25.6 (4.69-139.64)</td>
<td>0.000</td>
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<tr>
<td>Not near to the house</td>
<td>28</td>
<td>53</td>
<td>1</td>
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<tr>
<td>Hear about Malaria</td>
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<tr>
<td>Heard</td>
<td>29</td>
<td>48</td>
<td>0.35 (0.17-0.68)</td>
<td>0.14 (0.07-1.06)</td>
<td>0.008</td>
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<tr>
<td>Not heard</td>
<td>45</td>
<td>26</td>
<td>1</td>
<td></td>
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<tr>
<td>Having awareness transmission of malaria</td>
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<td></td>
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<tr>
<td>Yes</td>
<td>34</td>
<td>57</td>
<td>0.25 (0.12-0.51)</td>
<td>0.02 (0.02-0.18)</td>
<td>0.000</td>
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</tr>
<tr>
<td>No</td>
<td>40</td>
<td>17</td>
<td>1</td>
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<td></td>
</tr>
</tbody>
</table>