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ORIGINAL RESEARCH

Investigating the Determinants of Malaria Outbreak in Nono Benja Woreda, Jimma Zone, Ethiopia: A Case-Control Study

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Background: Malaria is one of the most widespread infections worldwide, particularly in developing countries. Accordingly, Jimma Zone is one of the widely affected areas by malaria in Ethiopia. In 2020 woreda health offices have reported the possible malaria epidemic that needs further investigation. Accordingly, this study aims to characterize the scope, pinpoint determinants connected to the Nono Benja woreda malaria outbreak, and implement suitable public health management measures.
Methods: A descriptive cross-sectional study was followed by an unmatched case-control study with a 1:1 ratio of cases to controls. The sample size of 136 individuals (68 cases and 68 controls) was used. The collected data was imported into Epi-data version 3.1 and analyzed using SPSS version 25.0. By doing multivariate logistic regression association was determined at 95% confidence intervals P value of 5%.
Results: A total of 687 instances were identified, giving an overall attack incidence of 1%. The assault rate ranged from 51.6 per 1000 people in Benja rural to 1.1 per 1000 people in Dhokonu Kebele. But there were no recorded deaths. *Plasmodium falciparum* and *Plasmodium vivax* were the major types of Plasmodium species reported. From independent variables absence of ITNS [AOR 3.98 (CI = 1.11–24.8)], residing in an unsprayed home [AOR = 3.83 (CI = 1.04–14.08], presence of stagnant water in residential area [AOR = 4.25, CI (1.37–12.24113.10)], and lack of awareness on malaria prevention [AOR = 8.28 (CI 2.31–29.73)] were significantly associated with Malaria outbreak.
Conclusion: A number of factors, including lack of ITNS, lack of malaria health education, stagnant water, and IRS (indoor residual spray), were significantly linked with the occurrence of malaria outbreaks. The woreda health office should therefore provide ITNS to the community, use indoor residual spray, and disseminate health information regarding efficient and long-lasting malaria preventive and control techniques.
Keywords: malaria, outbreak, Nono Benja

Introduction

Nowadays, malaria is one of the most widespread infections worldwide, particularly in developing countries. Globally, there were an estimated 219 million cases of malaria infection and 435,000 deaths in 2017.[1] According to World Health Organization Africa, the home continent has reported 200 million cases of malaria in 2017, accounting for 92% of all cases.[1] Ethiopia is among the sub-Saharan African countries where malaria is endemic. Given that it is consistently ranked among the top three causes of illness and death in Ethiopia, malaria presents a serious public health risk.[2,3]

With relative rates of about 60% and 40%, respectively, *Plasmodium falciparum* and *Plasmodium vivax* are the two most common parasite species that cause malaria in Ethiopia[2] and.[1] The location and season have an impact on this ratio. *Plasmodium falciparum* is the most common parasite species during malaria epidemics; it causes almost all malaria fatalities as well as severe and complicated symptoms.

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Malaria is transmitted to humans through the bite of a female Anopheles mosquito. Once within the human body, the parasites immediately proliferate in the liver and eventually the blood.[4,5] After being infected an individual shows symptoms like fever, chills, sweats, headaches, muscle aches, nausea, and vomiting. Similarly, the physical manifestations, such as tiredness, perspiration, and a raised body temperature, are frequently vague. On the other hand, the clinical signs of disorientation, coma, convulsions, severe anemia, and respiratory difficulties might also present.[6]

In Ethiopia, where the disease is thought to be endemic over three-quarters of its territory, more than 60 million people, or 60% of the total population, are at risk of contracting malaria. Records from previous years indicate that 4–5 million cases and 40,000–50,000 deaths annually were caused by malaria,[1] which accounted for 30% of all DALYs lost and significantly hampered social and economic development. About 75% of the country is malarial, and 68% of the population lives in places where malaria is a concern, according to data from the Ethiopian Federal Ministry of Health.[7] Malaria is a serious issue in Ethiopia, where it has long been the leading cause of disease and mortality.[7]

In Ethiopia malaria has a latency period that can vary from several weeks before the rainy season begins to more than a month after it ends. The disease is dependent on both altitude and precipitation levels. In Ethiopia's highland or highland fringe (marginal) regions, malaria epidemics are relatively common, mostly occurring at elevations of 1000–2000 meters above sea level.[7] Malaria often spreads in Ethiopia in response to the bimodal rainfall pattern, which normally occurs in June/July–September and March–April.[2]

There have been malaria outbreaks in the Amhara, SNNPR, and Oromia regions despite the difficulties facing the national malaria control program. By doubling the weekly cases criterion from the previous year for health posts having a five-year data set, or by using the weekly threshold for health posts with at least one year of data, the outbreak is detected early.[8] Despite the long history of IRS in Ethiopia, there is a dearth of knowledge, attitudes, and IRS-related behaviors in the country. The community's reaction to IRS differs; in certain areas, plastering house walls following pesticide application is rather typical.[2]

Improved health care, more precise malaria diagnosis, and expanded use of insecticide-treated nets (ITNs) and indoor residual spraying (IRS) are all signs of rising malaria interventions. Nevertheless, ITN and IRS coverage nationally reached 92.5% in 2016 and 64% in ITN coverage, respectively, only in epidemic-prone areas over 2500 meters in elevation. P. falciparum malaria rates remained virtually unchanged between 2000 and 2016, indicating that additional efforts are needed to curb the disease's spread (3). According to a Pawe District research, the majority (67%) confirmed that mosquitoes carry the disease, and a sizable portion (79.8%) knew that mosquitoes bite at night. Major malaria prevention methods were indicated by 89.7% of individuals to be sleeping under a bed net and 34% to avoid collected water sources.[9]

It contributed 0.78% of the total DALY in Ethiopia and 1% of the global DALY due to malaria in 2016, with an estimated 2,927,266 new cases and 4782 deaths, with a crude death rate of 4.7/100,000 and an age-standardized death rate (ASDR) of 4.9/100,000 in the population. Approximately 332,100 life years (YLL) were lost, and 35,200 years were lived with disability (YLD) due to malaria. Males had a slightly higher mortality and DALY related to malaria in 2016, and under-5 children were heavily affected.[1]

Rates of illness and mortality increased dramatically (ie, three to five times) during epidemics in Ethiopia.[10] Since 2005, Ethiopia has been stepping up one of the largest and most ambitious malaria control programs in Africa to support the country's Health Sector Development Plan (HSDP) and national child survival plan.[10] In 2016, the death rate from malaria in Ethiopia accounted for 0.7% (4782/700,100) of all deaths and 2.8% (4782/168,700) of deaths from infectious and parasitic diseases. Similarly, 1.2% (4782/408,125) of Africa's malaria-related mortality and 1.07% (4782/446,446) of the world's malaria mortality have been attributed to Ethiopian malaria mortality. Over the course of the years 2000 to 2016, the proportion of malaria-related deaths reported in Ethiopia, Africa, and worldwide is decreasing. Public health issues still exist, nonetheless, particularly when epidemics occur.[1]

Presence of intermittent river, stagnant water, irrigation, lack of knowledge on transmission, prevention and control mechanisms of malaria, not using Insecticide Treated Bed Net, absence of environmental control, not wearing protective clothing, having waste collection material at home, staying outdoor overnight, increasing parasite resistance to malaria drugs, vector resistance to insecticides, low coverage of malaria prevention services, and general poverty were among variables associated with malaria morbidity and mortality.[4–8]

In general outbreak investigation and response is one of the components of public health emergency response activities. Rapid outbreak investigation and response limit the number of cases and geographical spread, shorten the duration of the outbreak, and reduce fatalities. Therefore, this study aims to describe the magnitude and identify risk factors associated with malaria outbreak in Nono Benja woreda and undertake appropriate public health control measures.

Materials and Methods

Study Design

Descriptive cross sectional study followed by unmatched case-control study design was used to identify determinants of the malaria outbreak in the woreda.

Study Setting

The investigation was carried out in the Jimma zone's Nono Benja woreda between the second week of September and the third week of November or until the case was resolved. Nono Benja is located 160 km from Jimma town and 314 km from Addis Ababa. One of the Jimma zone's 21 woredas, Nono Benja woreda is situated in the western portion of the zone. There are 2 urban and 21 rural kebele in Woreda. The boundaries of Woreda were shared by the southwest Shoa zone to the east, East Wollega to the west, the north-west Shoa zone to the north, and South Limmu Kossa Woreda to the south. The woreda is expected to have 84,320 people altogether in 2020, with males (43,554, or 50.23%) and females (41,966 or 49.77%) making up the population, according to the 2007 population census. Of all the children under one year old, there are 2715 (3.22%) and 12,648 (15%) who are six to 59 months old. Woreda has nineteen health posts and four health facilities. In Nono Benja woreda, an average of 21,080 people were served by one health center (national standard: one health center for 15,000–25,000 people). According to the Nono Benja woreda health office, the region is known to have two climate zones: Weynadega (78%) and Dega (22%).

This study was carried out in the year 2020 following a report of a malaria outbreak in Nono Benja woreda. The data concerning malaria outbreak was compared with the threshold (the second largest of the last five years of weekly reporting) in order to confirm the outbreak's existence. To ascertain whether the epidemic threshold had been crossed, the 2020 data was compared with the second-largest weekly number of cases during the 2016–2020 periods.

Population

Residents of Nono Benja, the area where malaria outbreaks happened, made up the study population. Infected kebeles that tested positive for malaria (RDT or microscopic test) or for patients who met the case definition and visited medical facilities were the target population of the study, whereas residents without malaria served as the controls.

Study unit- Case or controls those enrolled in the study, from which data was taken.

Case Enrollment and Control

Case-Those confirmed by laboratory either RDT or positive by microscopy.

Control- Those rest negative confirmed by laboratory either RDT or by microscopy.

Inclusion and Exclusion Criteria

Inclusion Criteria

Case: Any Nono Benja woreda resident who tested positive for malaria during the pandemic was considered a case.

Controls: A control was any resident of Nono Benja woreda during the outbreak periods but not affected by malaria and test negative for malaria.

Exclusion Criteria

Cases and controls: Critically ill patient who cannot communicate or respond for us during interview period were excluded.

Dependent variables: Malaria case status (Case or control)

Sample Size Determination

From the Kebeles outbreak, a total of 136 samples—68 cases and 68 controls—were included. The related factor with the largest sample size was chosen by applying significant associated factors from prior comparable research to calculate sample size. We have used Zα/2 of 1-B (power) = 80%, Zα/2 of 95% certainty = 1.96 to calculate the sample size by using the epi info 7.2.1 stat calc software (Table 1).

Sampling Procedure

A 1:1 unmatched case-control study with a sample size of 136 (68 cases and 68 controls) was used in this study. For each test positive case, the test negative controls were selected.

Data Collection Instruments and Procedures

Every day, based on the primary presenting symptoms as per the case definition and test results, a first-line list of the case was completed at all woreda facilities. This list included crucial fundamental information. A comprehensive literature review was conducted before developing a standardized questionnaire. The sociodemographic characteristics of cases and controls, potential risk factors for the disease, environmental factors, respondents' knowledge of malaria infection, patient characteristics (gender, age, and family size), symptoms, treatment, travel history, educational status of the patient and family, and distance from a health facility were all collected using an interviewer-administered questionnaire.

Management of Data Quality

A standardized questionnaire from related studies was used for this investigation, along with WHO instruments. The survey was written in English, translated into Afan Oromo, and then reviewed for consistency in language translation. Five percent of the sample underwent a pretest in order to preserve the data's quality. Before the last round of data collecting, questionnaires that were unclear or imprecise were modified. Two data collectors from the woreda health office, one worker from each health facility, and supervisors received orientation training on data collection methods for case control studies and how to fill out a line list. At the service location, a list with instructions on how to fill out information online was provided. Data collectors and supervisors verified the accuracy of the gathered information. The investigator also verified the consistency and completeness of the gathered data. After being imported into Epi version 3.1, the acquired data was exported to SPSS version 25.0 for additional analysis. To ensure the accuracy of the data entered, SPSS was used to check for outliers, missing values, and completeness of data.

Statistical Analysis

Microsoft Excel 2010 was used to perform a descriptive analysis on a line list. Following data collection, each questionnaire was visually inspected to ensure it was complete before being used for analysis. We coded each of the questionnaires. For additional analysis, the data was imported into Epi-data version 3.1 and exported to SPSS version 25.0. To characterize the study population in respect to pertinent variables, measures of central tendency, frequencies, and summary statistics were employed. Bivariate analysis was utilized to select candidate variables with a 25% p-value cutoff after descriptive statistics. To assess the significance of risk, bivariable and multivariable analyses were performed, and the odds ratio (OR) and associated 95% confidence interval (CI) were computed. To fit the final model, multivariable regression analysis was then employed. The variance inflation factor (VIF), which yields a minimum VIF of 1.2 and

Table 1 Sample Size Calculation for Investigating the Malaria Epidemic in Nono Benja Woreda, Jimma Zone, Ethiopia, 2020

Factors	(%) Exposure Among Cases	(%) Exposure Among Control	Ratio Control to Case	OR	n	n +10%	Reference
Artificial bodies of water close to the residence	73	21.29	2	10	38	42	(12)
Utilization of LLINs	50	16.67	2	4.61	87	96	(12)
Outdoor over night	74	14.2	2	3.7	122	**136**	(5)

a maximum VIF of 2.4—much below the acceptable cutoff value of VIF < 10—was used in this study to assess the multicollinearity issue. The Hosmer-Lemeshow goodness of fit (GOF) test was used to evaluate the model. Our model's Hosmer-Lemeshow GOF test has a p-value of 0.19, which is higher than 0.05 and indicates that the model fits the data well. In order to determine the contributing causes to the malaria outbreak, logistic regression was used. After estimating adjusted odds ratios (AORs) with 95% confidence intervals, the significance of the 5% p-value was assessed and reported appropriately. To present the findings, epicures, tables, graphs, and narration were employed.

Definition of Operations

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.

Putting on protective clothing: Individuals who, for the past three weeks, have worn long sleeves and pants to protect their hands and legs at night.

Good prevention knowledge: Individuals who performed well on prevention knowledge approaches questions but not above the mean are not good overall. It was deemed inadequate understanding of prevention to correctly answer two or less questions about prevention techniques; answering more than two questions about prevention methods was deemed good knowledge.

Transmission knowledge of those mosquitoes who transmitted those malaria bites, unless other than mosquitoes' bites, were considered to have no knowledge of transmission.

Presence of stagnant water – When stagnated water is found in their environment within a diameter of 2 km around their living home (up to 25 min away on foot).

Results

When comparing the current case count with the threshold—the second-largest five-year malaria data set in the woreda data—the epidemic was confirmed. In mid-September 2020, the Nono Benja woreda health office reported a possible malaria outbreak; consequently, a Jimma zonal health team was sent for confirmation and action. After the case was examined and compared to a comparable period in the previous five years, it was determined that an outbreak had started on September 10, 2020, and had continued until the 18th week, at which point it was contained to the normal state (the typical case level of area) by intervention (Figure 1).

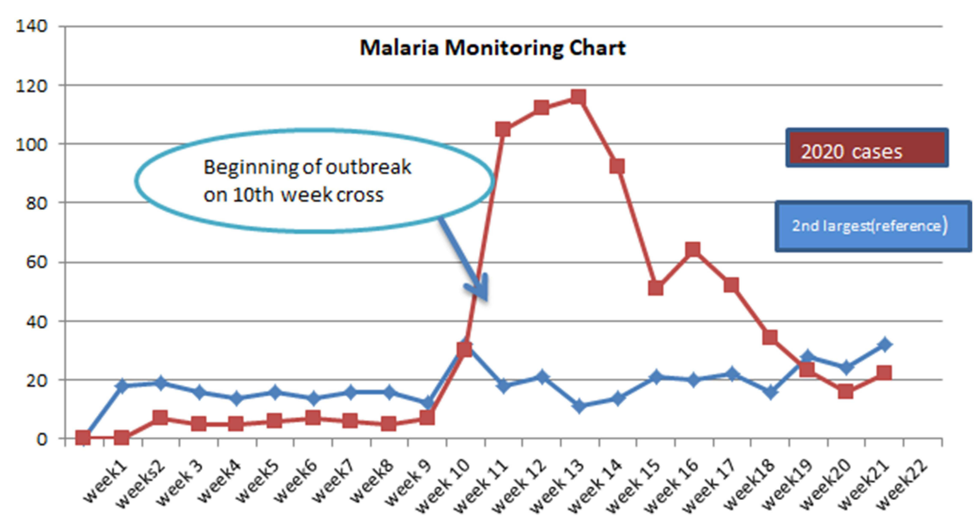

Figure 1 Malaria monitoring chart illustrating the time of the epidemic in the Jimma zone, Nono Benja woreda, Ethiopia in 2020.

Cases Described According to Time

The number of cases achieved the criteria in week 10 (105), peaked for four weeks (from the 10th to the 13th), and then started to decline somewhat in week 14 and beyond. From week 14 to week 18, the case decreased gradually, and starting in week 19, it fell below the typical woreda threshold (Figures 1 and 2).

Description of Cases and Death by Place

The case was detected in 15 (71%) kebeles in Nono Benja during the outbreak, but the proportion of cases varies across each kebele. Over all, the attack rate was 1%, but attack rates vary across kebeles, with the highest being 51.6 per 1000 population in Benja Rural to 1.1 per 1000 population in Dhokonu Kebele. Six hundred eighty-seven cases were detected during the time of the outbreak in woreda; the case occurred in 15 of the kebeles of woreda. Around one-third of the cases 199 (29%) were from Benja rural kebele, followed by 127 (18.5%) from Gurifat kebele, and around one-sixth of the cases 99 (14.4%) were from Ebicha kebele. In contrast, the lowest cases were detected in Dhokonu, Ilfata, and Roge, which accounted for less than 1% of the total cases (Table 2).

Description of Cases and Death by Person

Case distribution by age category indicates that around one-sixth of the cases (101, 14.7%) were under five years old, 197 (28.7%) occurred in 5–14 age groups, 232 (33.8%) occurred in 15–30 age groups, 114 (16.6%) occurred in 31–49 age groups, and only 43 (6.3%) of the cases were older than 49 years. The sex distribution shows that 55.3% of the cases were male and the rest, 44.7%, were female. During the outbreak period, no deaths occurred in any age or gender (Table 3).

Two species of *Plasmodium* were detected in this outbreak: 89.2% were due to *Plasmodium falciparum*, 10.5% were due to *Plasmodium vivax*, and less than 1% (0.3%) was due to mixed species (Figure 3).

Case-Control Analytical Epidemiology

This study comprised 68 cases of malaria positive and 68 controls that were tested negative for malaria but appeared to be in a good health. We evaluated the risk factors that lead to malaria infection and found the following.

In bivariate analysis, being male, age less than 15 year, lower educational level, Residence, Family Number, Marital status, and Religion were associated with outbreak of malaria among sociodemographic variables (Table 4).

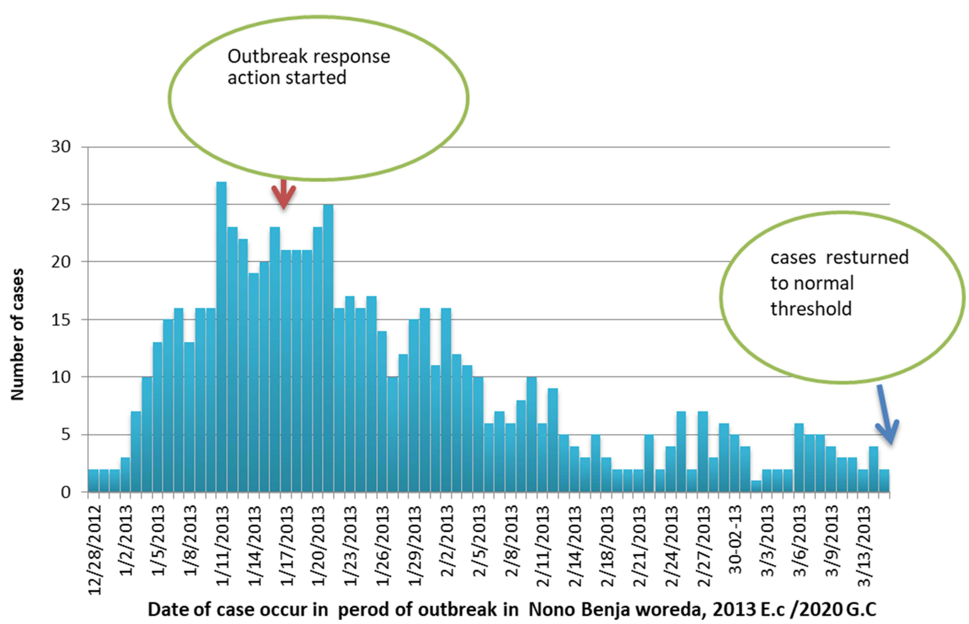

Figure 2 Epicurve of showing time of outbreak occurred in Nono Benja woreda, Jimma zone, Ethiopia in 2020.

Table 2 The Distribution of Malaria Cases by Kebele in Nono Benja Woreda, Jimma Zone, Ethiopia, 2020, Throughout the Outbreak Period

No	Kebele	Case		Death		CFR	Pop at Risk	Attack Rate per 1000
		No Cases	(%)	No Death	(%)			
1	Benja Rural	199	29.0	0	0	0	3860	51.6
2	Gurifat	127	18.5	0	0	0	5124	24.8
3	Ebicha	99	14.4	0	0	0	4051	24.4
4	Benja Town	62	9.0	0	0	0	5063	12.2
5	Alga	35	5.1	0	0	0	9386	3.7
6	Abiyu Gibe	34	4.9	0	0	0	2610	13.0
7	Chawo	27	3.9	0	0	0	5062	5.3
8	Amdo	25	3.6	0	0	0	5023	5.0
9	Wayu	22	3.2	0	0	0	3602	6.1
10	Abiyu Sombo	22	3.2	0	0	0	3602	6.1
11	Kolati	21	3.1	0	0	0	2227	9.4
12	Konchi	14	2.0	0	0	0	5837	2.4
13	Dhokonu	6	0.9	0	0	0	5245	1.1
14	Ilfata	6	0.9	0	0	0	4971	1.2
15	Roge	3	0.4	0	0	0	4661	0.6
	Total	687	100.0	0	0	0	70,324	10

Table 3 The Age and Sex Distribution of Malaria Cases in Nono Benja Woreda, Jimma Zone, Ethiopia, 2020, During the Outbreak

No		Category	Cases		Death		CFR
			Number of Case	(%)	Number of Death	(%)	
1	Age	<5yrs	101	14.7	0	0	0
		5–14yrs	197	28.7	0	0	0
		15–30yrs	232	33.8	0	0	0
		31–49yrs	114	16.6	0	0	0
		>49yrs	43	6.3	0	0	0
2	Sex	M	380	55.3	0	0	0
		F	307	44.7	0	0	0

Not having ITNS was associated with contracting with malaria, not sprayed in last one year, but staying or working outside of evening or overnight was not associated with malaria. Presence of stagnant water in living area, provision of health education in malaria, knowledge of malaria prevention and transmission were associated, wearing body covering or long sleeve cloth were associated with malaria. Presence of stagnant water is 3.36 times contracting compared contrast group (Table 5).

In multivariable analysis, not having ITNS was significantly associated with malaria outbreak; risk of having malaria was 3 times that not of having ITNS, [AOR 3.98, (CI = 1.24–12.72)].

Indoor Residual Spray (IRS) was also associated with malaria significantly, people who live in not sprayed house were almost 4 times attacked compared to those living in sprayed house in last one year from time of outbreak [AOR = 3.83 (CI 1.04–14.08)].

Presence of stagnant water in living area increases 4 times chance contracting malaria compared contrast group [AOR = 4.25), CI (1.37–13.10)].

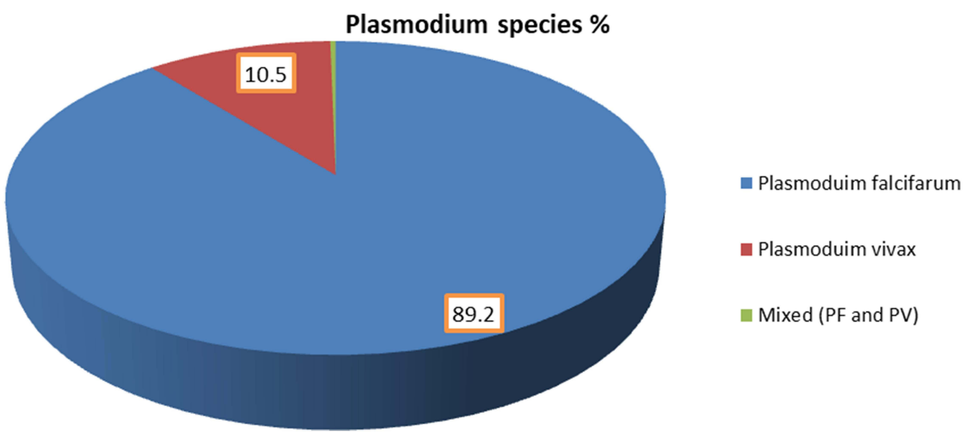

Figure 3 Pie chart illustrating the number of Plasmodium species in the Nono Benja woreda, Jimma Zone, Ethiopia, malaria outbreak, 2020.

Having poor knowledge of malaria prevention was associated with malaria outbreak, those who have poor knowledge has 5 times risk of malaria infection when compared with those who have good knowledge of prevention, [AOR = 8.28 (CI 1.31–29.73)] (Table 6).

Discussion

A malaria outbreak was looked into in southwest Ethiopia's Nono Benja Woreda. The overall attack rate was 10 cases per 1000 people. This was less than the attack rate of 12.1% in the northern Ethiopian district of Laelay Adyabo,[5] the

Table 4 Bivariate Studies of Socio Demographic Characteristics Linked to the Malaria Outbreak in the South-Western Ethiopian Region of Nono Benja Woreda Jimma Zone in 2020

No	Factors	Classification	Frequency	Case	Control	OR	CI 95% L	U	P. value
1	Sex	M	68	28	40	0.49	0.24	0 0.97	0.054
		F	68	40	28	Reference			
2	Age	<35	69	38	31	2.71	0.98	7.50	0.05
		25–34	35	18	17	2.73	0.86	8.62	0.86
		>34	32	12	20	Reference			Ref
3	Educational status	Less than grade four	76	22	54	2.76	0.61	12.48	0.18
		Grade four up to grade eight	30	6	24	0.33	0.06	2.01	0.23
		Grade nine up to grade twelve	14	2	12	0.27	0.046	0.04	0.02
		Grade 12 +	16	6	10	Reference			
4	Residence	Urban	35	14	21	Reference			
		Rural	101	54	47	1.72	0.78	3.76	0.17
5	Family Number	<=7	100	42	58	Reference			
		>7	36	26	10	3.59	1.56	8.23	0.00
6	Marital status	Not ever married	82	34	48	Reference			
		Ever married	54	34	20	0.34	0.10	1.25	0.07
7	Religion	Muslim	49	30	19	Reference			
		Orthodox	46	24	22	0.691	0.30	1.56	0.37
		Protestant	41	14	27	0.328	0.13	0.77	0.01
8	Occupation	Farmer	65	32	33	1.054	0.50	2.22	0.89
		Merchants	23	13	12	1.413	0.52	3.84	0.49
		Other than merchants and farmers	48	25	23	Reference			
9	Ethnicity	Oromo		59	58	Reference			
		Amhara		9	8	1.144	0.41	3.17	0.79
		Gurage		1	1	1.017	0.06	16.65	0.99

Table 5 Bivariate Analysis of Community Knowledge, Environmental Factors, and Malaria Prevention Efforts Linked to the 2020 Malaria Incidence in the Nono Benja Woreda Jimma Zone in Southwest Ethiopia

No	Variables	Category	Total Frequency	Case	Control	AOR	CI 95% L U		P. value
1	Owning ITNS	Yes	57	16	41	Reference			Ref
		No	79	52	27	3.98	1.25	12.72	0.02
2	IRS	Yes	39	7	32	Reference			Ref
		No	97	61	36	7.74	3.10	19.35	0.00
3	Staying /working outdoors in the evening or night	Yes	11	10		1.12	0.44	2.84	0.81
		No	57	58		Reference			Ref
4	Stagnant water	Yes	70	45	25	3.365	1.66	6.80	0.00
		No	66	23	43	Reference			Ref
5	Health education on malaria last 1 year	Yes	84	58	26	Reference			
		No	52	10	42	9.36	4.08	21.49	0.00
6	Prevention knowledge	Poor	51	41	10	9.98	4.17	23.84	0.00
		Good	85	27	58	Reference			Ref
7	Transmission knowledge	Yes	86	37	49	Reference			Ref
		No	50	31	19	2.16	1.05	4.40	0.03
		Ever married	54	34	20	0.41	0.20	0.84	0.01
8	Long sleeve and body covering cloth	Yes	63	25	30	2.179	1.09	4.33	0.02
		NO	73	38	43	Reference			Ref

Table 6 Multivariable Analysis of the Variables Linked to the 2020 Malaria Outbreak in the Nono Benja Woreda Jimma Zone, Southwest Ethiopia

No	Variables	Category	Total Frequency	Case	Control	AOR	CI 95%		P. value
							Lower	Upper	
1	Educational status	Less than grade four	76	22	54	2.76	0.60	12.48	0.23
		Grade four up to grade eight	30	6	24	0.33	0.05	2.01	
		Grade nine up to grade twelve	14	2	12	0.14	0.08	1.13	0.06
		Greater than 12	16	6	10	Reference			Ref
2	Owning ITNs	Yes	57	16	41	Reference			Ref
		No	79	52	27	*3.98*	*1.24*	*12.72*	*0.04**
3		Ever married	54	34	20	Reference	*0.10*	*1.12*	*0.07*
	Marital status	Not ever married	82	34	48				
4	Indoor Residual Spray IRS (chemical)	Yes	39	7	32	Reference			Ref
		No	97	61	36	*3.83*	*1.04*	*14.08*	*0.02**
5	Stagnant water	Yes	70	45	25	*4.25*	*1.37*	*13.10*	*0.01**
		No	66	23	43	Reference			Ref
6	Health education on malaria last 1 year	Yes	84	58	26	Reference			Ref
		No	52	10	42	3.10	0.96	10.02	0.06
7	Prevention knowledge	Poor	68	37	12	8.28	*2.31*	*29.73*	*0.00**
		Good	68	31	56	Reference			

Note: *Significant risk factors.

attack rate of an outbreak in the Tigray region's Abergelle district AR (33.1 per 1000 people),[11] the attack rate of 20 cases per 100 people in Sidama district,[12] and the attack rate of 8.9 cases per 1000 people in the Amhara region's Dera Mecha district.[13]

In this study, *Plasmodium vivax* (10.5%) and *Plasmodium falciparum* (89.6%) were the causes of nine out of ten cases. This finding is supported by this similar study from the Adyabo district (86%) and another similar study from Arba Zuria.[14] This outbreak had no case fatality rate, which is consistent with research conducted in northern Ethiopia.[11] This finding could indicate that early diagnosis and management of the outbreak were successful and less severe than the CFR in the Amhara region's Dera Mecha area.[13]

Compared to the control group, the likelihood of catching malaria is increased fourfold in the presence of stagnant water. This is comparable to a study conducted in the Tigray region, where one of the parameters linked to the malaria outbreak was the existence of mosquito breeding sites.[11] According to a study conducted in the Simada district, the malaria outbreak was associated with the availability of bodies of water where mosquitoes might reproduce.[12,14] Given that it was the post-rainy season and the surroundings were favorable for mosquito reproduction, it could be a sign of improper environmental management on the part of the locals, such as failing to remove standing water.

A malaria outbreak has been linked to low awareness of malaria prevention; those with low awareness are eight times more likely to contract malaria than those with high awareness. This result was consistent with the Laelay Adyabo district's conclusion that those who were aware of the malaria transmission method had a lower risk of contracting the disease compared to those who were not.[5,12] This suggests that when compared to a competent group, their lack of understanding impedes adoption or execution of preventative choices, which increases their impact.

Malaria outbreaks were significantly linked to a lack of ITNS; the risk of contracting the disease was four times higher in those cases. Similar research conducted in the Simada district demonstrates a link between malaria epidemics and the non-use of bed nets treated with insecticides.[12]

Since we have used malaria test RDT/microscopic test to identify the case of malaria, lack of strong diagnostic test could be the weakness of the study.

Conclusions

Malaria outbreak was confirmed in Nono Benja woreda. Benja Rural and Benja towns were the most affected kebeles of the woreda. Poor knowledge of malaria prevention, presence of stagnant water, not having bed net (ITNS) and no IRS (In door Residual Spray) in last one year before outbreak were significantly associated with the occurrence of malaria outbreak. As a result, the community should have had ITNS from the woreda health office, with a focus on high-risk locations and populations. To raise community awareness of risk prevention, health education on malaria prevention and control measures needs to be robust and long-lasting. Health professionals should conduct home visits with patients, hold community meetings, and offer health education regarding prevention and transmission. Communities should manage and safeguard their surroundings by removing standing water. Furthermore, twice a year, before the rainy season, routine interior residual spraying should be carried out. It is important to routinely manage or destroy possible mosquito breeding areas.

Abbreviations

AORs, Adjusted Odds Ratios; ASDR, Age-standardized death rate; CIs, Confidence Interval; HSDP, Health Sector Development Plan; ITNs, Insecticide-Treated Net; KM, Kilo Meter; LLIN, long-lasting insecticide-treated net; OR, Odds Ratio; PHEM, Public Health Emergency Management; SNNP, Southern Nation And Nationality People; SPSS, Statistical Package for the Social Sciences; WHO, World Health Organization.

Statement on Data Sharing

Data will be sent to the respective body upon request of the corresponding author.

Declaration of Ethics

The study was conducted according to the principle of the Declaration of Helsinki. The Jimma University Ethical Approval Committee has granted ethical approval by the letter written with reference number IHRPGD/201/20. Written and verbal consent from participants was obtained during the data collection process. Confidentiality was ensured by clarifying that no personal information would be disclosed, but rather that information would be displayed and shared as aggregated information generally.

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Author Contributions

Each author contributed significantly to the work reported, whether it was through ideation, study design, execution, data acquisition, analysis, and interpretation, or in all of these areas; they all helped draft, revise, or critically review the article; they approved the final version that was published; they all agreed on the journal to which the article was submitted; they all agreed to take responsibility for the work in its entirety.

Disclosure

The authors report no conflicts of interest in this work.

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