Original Article

A Five-Year Trend of Malaria Parasitemia with Coverage and Use of the Major Control Interventions in Itang District, Gambella Region, Western Ethiopia (2017–2021)

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Abstract

Background: One of the main global public health issues that affect several facets of the population is malaria. Ethiopia primarily uses Indoor Residual Spraying (IRS) and Long-lasting Insecticidal Nets (LLINs) as lifesaving frontline malaria vector prevention and control interventions. This study intends to assess the trend of malaria prevalence and coverage and utilization of IRS and LLINs in Itang district, western Ethiopia.

Methods: A retrospective analysis was conducted on malaria cases reported by Health Centers from 2017 to 2021. Data were gathered between July 02, 2021, and October 30, 2021, using a community-based cross-sectional household survey to evaluate the coverage and utilization of IRS and LLINs. The chi-square test was used to compare the trend of malaria prevalence among sex and age groups. Statistical significance was considered at $P < 0.05$.

Results: Among 4,500 patients with suspected cases of malaria, 40% of the cases had microscopically confirmed malaria. *Plasmodium falciparum* was more prevalent than *P. vivax* in the district. Only 368 (38.25%) people slept under the net yesterday night out of the 962 people who utilized it overall during the study period. 127 (63.5%) households reported no insecticide spraying in the past 12 months, while 73 (36.5%) reported their houses were sprayed.

Conclusion: The number of malaria cases reached its peak in 2019 and hit its lowest point in 2021. Results show that IRS and LLINs coverage and utilization were poor and warrant community awareness and support by all concerned bodies.

Keywords: Malaria; Prevalence; Indoor Residual Spraying; Long-lasting Insecticidal Nets; *Anopheles* mosquito

Introduction

Malaria is one of the most significant global public health issues, which affects many different demographic groups, most frequently women and children. In 2021, there were 247 million malaria cases, up from 245 million in 2020, according to the World Malaria Report (1). In 2021, 619,000 malaria fatalities were anticipated, down from 625,000 in 2020. 93% of malaria cases and 94% of malaria-related fatalities worldwide occur in the WHO African Region (2), which bears a disproportionately large share of the burden of the disease globally. The majority of malaria cases are found in the three WHO regions: Africa, Southeast Asia, and the Eastern Mediterranean. Every year, malaria continues to be the leading cause of illness and mortality in the WHO African region (2).

Global malaria mortality decreased steadily between 2000 and 2019, from 736,000 in 2000 to 409,000 in 2019, according to WHO research. Malaria mortality in children under the age of five as a whole decreased from 84 % in 2000 to 67% in 2019. The Global Technical Strategy (GTS) baseline estimates over 453,000 deaths worldwide in 2015. The malaria fatality rate, or the number of deaths per 100,000 at-risk individuals, decreased from about 25 in 2000 to 12 in 2015 and 10 in 2019, with the rate of decline slowing in the latter years (1). Malaria deaths decreased by 44%, from 680,000 in 2000 to 386,000 in 2019, and the malaria fatality rate decreased by 67% during the same period in the WHO African Region. Deaths per 100,000 people at risk decreased from 121 to 40 (1).

Malaria is transmitted via the bite of the disease-carrying female *Anopheles* mosquitoes. *Anopheles* is a genus of mosquitoes first described by JW Meigen in 1818, which belongs to the family Culicidae and order Diptera. *Plasmodium* is a genus of parasites belonging to the family Plasmodiidae and order Haemosporidia. In 1897, William H Welch created the name *Plasmodium falciparum*, and *P. vivax* was investigated by Grassi and Feletti in 1890. Symptoms of infections can range from being absent or extremely light to being serious diseases that can cause problems including cerebral malaria, organ failure, pulmonary edema, and even death (3).

In Ethiopia, more than forty species of *Anopheles* mosquitoes have been identified and documented so far (4, 5). Of these *Anopheles* mosquito species, *Anopheles gambiae* s.l. (*An. gambiae* s.l.) has been cytogenetically identified as *An. arabiensis* which are the primary malaria vector widely distributed in the country (6–11), with *An. pharoensis* the second most frequent vector species in the country and *An. funestus* and *An. nili* asother secondary vectors which were, in the past, important malaria vectors in limited areas in Ethiopia; however, they are now extremely scarce and very localized in their distribution (12-18). *Anopheles nili* is the least common and most localized species, and it is found in the southwestern, western, and northwestern parts of Ethiopia (12, 13). Recently, *An. stephensi* has been documented in the country (19, 20). Previous investigations suggested that the species responsible for malaria transmission in Gambella were *An. gambiae* s.l, *An. funestus* and *An. nili* (21, 22). Three anopheline species were documented in the Itang Special District area of southwestern Ethiopia, namely *An. gambiae* s.l., *An. coustani* and *An. pharoensis.* Of all *Anopheles* mosquitoes, *An. coustani* was the most prominent species followed by *An. pharoensis* and *An. gambiae* s.l. (23).

The minor rainy season (May–June) and the major rainy season (September–December), respectively, are when the two primary malaria transmission seasons are experienced in the region, including Ethiopia (24). In Ethiopia, insecticide-treated bed nets, indoor residual spraying, and the treatment of cases with artemisinin-based combination therapies have all shown encouraging results in the fight against malaria (25, 26).

The prevalence of malaria in various Ethiopian regions has changed throughout time. The prevalence, for example, may reach 32.7% in Southwest Ethiopia (27), 29.8% in Jimma town (28), 21.7% in Dembia District (29), 8.6 % in Southern Central Ethiopia (30), 6.9% in North Ethiopia (31), and 5% in Bahir Dar city (32). Previous studies suggested that the characteristics that determine the prevalence of malaria in Ethiopia? are age and residence (33), lack of an insecticide-treated bed net (ITN), and lack of information (34).

Ending malaria epidemics by 2030 is a Sustainable Development Goals agenda and countries are targeting malaria elimination strategies. WHO urges countries to incorporate in their national strategic plan the provision, use, and timely replacement of LLINs to mitigate the problem of malaria (35). Ethiopia is targeting the elimination of malaria in the post-millennium development goals era, emphasizing evidence-based interventions. One of the interventions is scaling up and sustaining the utilization of LLINs (36).

LLINs protect people from being bitten by infected mosquitoes and are effective in reducing morbidity and mortality due to malaria. LLINs have a knock-down effect. They temporarily incapacitate and kill mosquitoes, have a repellent effect, and reduce contact between a person and mosquitoes by acting as a physical barrier (37, 38). Mosquito net use reduces about 50 percent of malaria illness among under-five children and pregnant women (38).

Malaria is heavily contributing to the economic burden in rural Ethiopia at the household and individual level due to high out-of-pocket payments and a person's day lost. Promotion of LLINs may play a role in mitigating the economic burden of the disease (39). The major vector control strategies being implemented in Ethiopia are indoor residual spray (IRS) in malaria-endemic places and increasing the availability and use of mosquito nets to prevent mosquito bites. Accordingly, about 72% of households living in malaria-endemic areas were protected by either long-lasting insecticide-treated nets (LLINs) or IRS according to the 2011 malaria indicator survey (36, 40, 41).

The first attempts at eradicating malaria were undertaken between 1955 and 1969, using a variety of strategies (42). This required a large organizational structure to undertake specific tasks needing full coverage, such as spraying of all houses, collection and microscopic examination of blood smears, and determination of all infections. Regardless of the epidemiological variations between malarious areas, the spraying operations were uniform and executed in all of them (43). Despite these efforts, it was quickly determined that eliminating malaria would not be possible in the allotted time, and the eradication campaign was changed into a control program (44). After so many years of spraying, *An. gambiae* strains resistant to Dichloro-diphenyl-trichloroethane (DDT) were reported as late as 1978 and is now known that resistance to DDT exists in several locations in Ethiopia (45, 46). Although *An. pharoensis* may be considered a vector of secondary importance, it will be extremely difficult to control as it is an exophilic species, resistant to DDT and strongly exophagus, and because it is not easy to apply simple larval control measures in the permanent and extensive breeding places of the species (10). DDT resistance of *An. gambiae* s.l. was reported in Itang District (46). *Anopheles arabiensis*, a member of the *An. gambiae* complex, has developed a high level of resistance against pyrethroid (deltamethrin and alpha-cypermethrin) in Itang District (23).

The Itang Special District Health Centre reports that malaria is one of the top ten primary causes of illness in the area. Itang is one of the malaria-prone districts in the Gambella region. There is no published research, even though malaria is the most common cause of visits and admissions to health facilities in the region. Therefore, the purpose of this study was to assess malaria prevalence over five years and evaluate the coverage of the main malaria control measures in the Itang district of western Ethiopia.

Materials and Methods

The study area and population

The study was carried out in Gambella Regional State's Itang Special District in southwestern Ethiopia (Fig. 1). The Itang Special District is located 822 kilometers southwest of Addis Abeba, the Ethiopian capital. The region is bordered by the Republic of South Sudan in the west, the Southern Nations, Nationalities, and Peoples Region in the south and east, and the Oromia Regional State in the north and east. The region's principal ethnic groups are Anywa, Nuer, Mezengir, Opwo, and Komo.

There are 159,679 men and 147,237 women living in the area, according to the 2007 housing and population census of Ethiopia (Itang District Health Office, 2015). Some 25% of the people who live in the area consider themselves to be urban. Riverside agriculture is prevalent in the area during recessions. Particularly, Anywa and Opwo commonly cultivate maize and sorghum, whilst cattle are the main source of revenue for the Nuer community. Out of the 14 districts in the area, Itang Special District was specifically chosen for the current study since the majority of its population is indigenous and lives in the most remote part of the territory compared to other districts.

There are 23 kebeles (small administrative units) in the district altogether. The three largest indigenous ethnic groups of the district are Nuer (61%), Anywa (30%), and Opwo (8.5%), and they all reside in stratified communities according to their ethnicity. With three Health Centers, the district's projected healthcare coverage is 60.3%; however, only one of these facilities has been offering malaria treatment. Additionally, only 5 of the 8 health stations in remote areas have been offering medical services. Among the top five infectious diseases in the district are Tuberculosis (TB) and malaria.

Study design and period

The retrospective malaria trend analysis and assessment of malaria intervention coverage and use were conducted using the facility and community-based cross-sectional study approaches respectively. Data were gathered from March 2, 2021, to October 30, 2021, by reviewing all malaria cases reported to Health Centers over the previous 5 years (July 2017 to October 2021). However, the community-based cross-sectional household survey was conducted using a pre-tested semi-structured questionnaire to assess the malaria prevention and control intervention coverage and utilization. Data was gathered from July 2, 2021, to October 30, 2021, primarily during the major transmission season when the local communities are aware of and sensitive to malaria.

Study population

Data on malaria-confirmed and unconfirmed cases from four Health Centers namely Eliya, Puldeng, Bazil, and Itang Health Centres were gathered for the retrospective cross-sectional study. However, for the coverage and use of IRS and LLINs data were gathered from representative households in four preselected kebeles in the district.

Inclusion and Exclusion Criteria

All patients who have been suspected of having malaria and who have been clinically and laboratory-proven to have it were included. In addition, malarious kebeles (lowest administrative units) normally using IRS and LLINs were included. Exclusion criteria include kebeles where IRS and LLINs were not provided and individuals who were not suspected of having malaria but whose profile and clinical diagnosis were poorly documented.

Sample size determination and sampling techniques

All the available malaria case data for the retrospective study were gathered from the healthcare system, and these Health Centers were chosen using a purposive sampling technique because their malaria morbidity records were more complete than those of other study health facilities. However, the study only includes these four kebeles (Puldeng, Baziel, Eliya, and Itang) to create a representative sample.

For assessing coverage and use of IRS and LLINs, four kebeles were purposively selected based on malaria and IRS and LLINs information and accessibility for researchers.

To select a fairly representative sample of households, the sample size was distributed proportionally to each of the four malarious kebeles of the Itang district based on the number of households they have. Then households were randomly selected from a list provided by the district administration by systematic random sampling. The four studied kebeles consist of a total of 4500 households.

For the household survey for IRS and LLINs coverage and use, the sample size was determined using the single population proportion formula. $N= Z^2P(1-P)/d^2$ Where n is the sample size of households. P= proportion of households that slept under LLIN. No previous similar study was carried out in the area and to get the maximum sample size, P was taken as 50% (P= 0.5). The degree of accuracy required (sampling error) is 5%, that is, d=

0.05. Z= Standard score for 95% confidence level is 1.96. An additional 10% for non-response rates was taken. Substituting the above values, the calculated sample size for the study was 200 households.

The total number of HHs for the IRS and LLINs study from the four kebeles was 200 household heads. The households were selected using a systematic random sampling method. Systematic random sampling was calculated by using the formula K=N/n, where k is the sample interval, N is the total population, and n is the sample size. Therefore, the sample interval for household heads in this study could be K= N/n= 4500/200= 23.

In each kebele, 50 houses were selected from a random start and the head of household, or the spouse was interviewed. The heads of households or their spouses were preferred for interviews because they were knowledgeable about the health issues in their communities. When there was nobody to interview at the time of the visit, a neighboring house was included to evaluate the LLINs and IRS coverage.

Source of data

The source data for the retrospective study was the Health Centers, where patients were treated clinically and using a rapid detection test and microscopy and recorded on the registration book, by month, year, and sex from 2017–2021. Malaria services are provided in all health facilities (health posts and Health Centers) in the area.

Data collection tools

Threats to the validity and reliability of data were minimized through the training of all research assistants and data collectors. The questionnaires were checked at the end of each day for omissions and inconsistencies. The questionnaires were pre-tested to ensure clarity and logical sequence. The questionnaires were both closed-ended and open-ended to collect data from the selected households, and it was organized to collect socio-demographic data which includes sex and age, household net usage and coverage, net usage last night, and coverage of indoor residual spraying. Furthermore, the questionnaires were translated into the commonly used language (Amharic) and back to English. Key informants were interviewed to gather information about coverage and use of IRS and LLINs

Data collection methodology

From the patient's registration book in four Health Centers namely Puldeng, Baziel, Eliya, and Itang Health Centres information about laboratory results and sociodemographic characteristics of the cases was gathered. By using a standardized questionnaire, coverage, and net usage data were also obtained from randomly selected households. A household was defined as a group of people who share a common residence and partake in common meals.

Study variables

Dependent variables

The number of confirmed malaria cases or unconfirmed malaria cases that were reported from 2017–2021. Coverage and use of IRS and LLINs.

Independent variables

Demographic elements (age and gender): Age was categorized in years and sex is a binary variable and was categorized as Male and Female. Seasonality was categorized as wet and dry.

Data quality control

Depending on how recently the data was collected, it required daily monitoring for completeness, inconsistencies, inaccuracy, and validity. Before data entry, the data were categorized and coded, ordered, and processed. A few confirmed malaria cases were divided into months for each year to describe the seasonal pattern of malaria. Inconsistencies were fixed and double data entry was performed.

Data analysis

To prepare the data for analysis, they were all verified for accuracy and cleared of any discrepancies. The SPSS statistics version was used to evaluate the data once they were entered into Excel and analyzed using SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp. Descriptive statistics were used to show the trends of malaria prevalence in terms of seasons, years, gender, age, Health Center, and species of malaria parasite; the chi-square test was used to compare the trend of malaria prevalence in sex and age groups; statistical significance was considered at P< 0.05. The retrospective malaria data and coverage and use of IRS and LLINs were summarized using tables.

Results

The prevalence of malaria cases

In the Itang area from 2017 to 2021, blood films from 4,500 patients suspected of having malaria were prepared and evaluated. 1,800 (40.00%) of these were malaria cases with microscopic confirmation (Table 1). In 2021 and 2019, respectively, malaria cases were reported at their lowest (n= 324) and highest (n= 401). The years 2019 and 2017 had the largest (n= 939) and lowest (n= 869) proportions of patients with malaria suspicion, respectively.

The prevalence of malaria parasites

The following malaria parasites were found in the study area: *P. falciparum*, *P. vivax*, and mixed infections. In comparison to past years, 2019 saw the most cases of *P. falciparum*, *P. vivax*, and mixed infections, followed by 2018. *Plasmodium falciparum* infections were more prevalent than *P. vivax* infections in the Itang District (Fig. 2).

Malaria prevalence in the Itang District by sex

The prevalence and number of confirmed malaria cases by sex for the previous 5 years are shown in Table 2. Males were composed of 748 (41.6%) and females were 1,052 (58.4%) of the malaria prevalence. There was a statistically significant difference in malaria prevalence between the sexes (χ^2= 8.56, df= 2, P< 0.05).

Malaria prevalence by age group in the Itang district

Malaria infections were noted across all age groups (Table 3). Age groups and malaria burden had a statistically significant relationship (χ^2= 3.084, df= 6, P< 0.05). The age range from 15 to 30 had the highest prevalence of infection, at 33.9%, followed by the age range from 30 and up, at 30.1%, and the age range from 5 to 14 years, at 21.0%. The age group under five years old experienced a low infection rate.

Malaria prevalence as reported by Itang District health facilities

The data gathered for this study from four health clinics in the district revealed variances in malaria prevalence. Itang Health Center had the highest prevalence, with 532 (29.56%) instances, followed by Eliya Health Center with 439 (24.39%), Puldeng Health Center with 427 (23.72%), and Baziel Health Center with 402 (22.33%) cases (Fig. 3).

Malaria prevalence by season of transmission

In Ethiopia, the three seasons' malaria prevalence was examined. The primary wet season, which runs from June to September, saw the most recorded instances of malaria, and the dry season, which runs from October to January, saw the middle between the highest and lowest. The primary wet season had higher levels of *P. vivax*, *P. falciparum*, and mixed infections than the dry season (Fig. 4).

Coverage and Use of IRS and LLINs

A total of 200 respondents were successfully interviewed for this study, yielding a response rate of 100.0% for major control intervention coverage and utilization.

Coverage of Indoor Residual Spraying (IRS)

Indoor residual house spray coverage is presented in Table 4. Nearly thirty-seven percent of the households reported that their homes were sprayed with insecticide in the last 12 months, while 63.5%, stated they were not sprayed in the last 12 months. Forty percent of respondents perceived the benefit of the IRS is to reduce mosquito bites.

With a respondent rate of 42.46%, Itang had the most households that were sprayed (Table 5), whereas Eliya had a respondent rate of 24.66%. Baziel and Puldeng had the fewest residences that had been sprayed.

Coverage and Use of Long-lasting Insecticidal Nets (LLINs)

The findings of this survey showed that 179 (89.5%) houses had nets, while just 21 (10.5%) did not have a net at the time of the study. 80 (44.7%) families had three or more nets, 57 (31.84%) households had two nets, and just 42 (23.46%) households had just one net. Long-lasting Insecticidal Nets were used by 162 (90.5%) of the households, while only 17 (9.5%) utilized any other kind of net. The majority of responders who resided in the home had more than 4 children number with 97 responses (48.5%), those with 4 in their homes with 66 respondents (33.0%), those with 3 people in their homes with 31 respondents (15.5%), and those with 2 people in their homes with 6 respondents (3%). The percentage of respondents who believed their nets were in fair condition was highest among 78 (43.57%) (Table 6). As shown in the table, 123 (68.72%) homes are currently using their nets, while just 56 (31.28%) households are not. Only 47 (38.21%) of the 123 houses that indicated they were currently utilizing their nets used them last night, while 76 (61.79%) of those households did not. From the 47 households who slept in their nets last night, only 25 (53.20%) households reported that there were two family members present; 11 (23.40%) households reported that only three people were present; 8 (17.02%) households reported that four peoples are slept in their nets last night and above four peoples are slept in their nets last night in 3 (6.38%) households.

Coverage of Long-lasting Insecticidal Nets by Kebeles

With a respondent rate of 65 (36.31%) in this study, Puldeng was the kebele with the highest percentage of households that own a net, followed by Itang with a respondent rate of 42 (23.46%). For the households that own a net, Eliya had a 42 (20.67%) response rate and Baziel had a 35 (18.99%). The only kebele with response rates of 52.94% and 34.57% respectively was Puldeng, whose households own more nets and LLINs (Table 7). Net ownership and the Itang district community were statistically significantly correlated (χ^2= 16.75, df= 3, P< 0.05).

Net use last night

Only 368 people slept under the net last night, out of the 962 users who are actively using it. In this study, those aged 15 to 49 make up the majority of those who used a net last night, with a respondent rate of 188 (51.09%), the majority of those who slept under LLINs last night, with a respondent rate of 51.35%, and the majority of those who slept under any net last night, with a respondent rate of 48.57% (Table 8). With a response rate of 123 (33.42%), Puldeng is the sole kebele with the highest number of persons who slept under a net last night, according to the results in Table 6 above. The kebele Puldeng had respondent rates of 48.57% and 31.83%, respectively, and had the highest proportion of residents who slept beneath any net and LLINs last night.

Table 1. Data on the annual distribution of malaria cases in the Itang District, Ethiopia, 2017–2021

Year	Total number of blood film examined	Total number of cases (%)
2017	868	343 (39.52%)
2018	923	374 (40.41%)
2019	939	401 (42.71%)
2020	893	358 (40.09%)
2021	877	324 (36.94%)
Total	4500	1800 (40.00%)

Table 2. The previous five years of malaria prevalence by sex in the Itang District, Ethiopia, 2017–2021

Sex	Variable	Malaria Case			Total	Chi-square (x^2)	P-value
		P. falciparum	*P. vivax*	Mixed			
Male	Count	406	301	41	748		
	% within malaria case	42.2%	41.6%	35.3%	41.6%	8.555	0.000
Female	Count	555	422	75	1052		
	% within malaria case	57.8%	58.4%	64.7%	58.4%		
Total	Count	961	723	116	1800		
	% within malaria case	100.0%	100.0%	100.0%	100.0%		

Table 3. Age-specific *Plasmodium* spp. prevalence in the Itang District, Ethiopia, 2017–2021

Variable			Malaria Case			Total	Chi-square (x^2)	P-value
			P. falcipa-rum	*P. vivax*	Mixed			
Age for Category	**<5**	Count	146	114	10	270	3.084	0.000
		% within malaria case	15.2%	15.8%	8.6%	15.0%		
	5–14	Count	209	149	20	378		
		% within malaria case	21.7%	20.6%	17.2%	21.0%		
	15–30	Count	322	250	39	611		
		% within malaria case	33.5%	34.6%	33.6%	33.9%		
	>30	Count	284	210	47	541		
		% within malaria case	29.6%	29.0%	40.5%	30.1%		
Total		Count	961	723	116	1800		
		% within malaria case	100.0%	100.0%	100.0%	100.0%		

Table 4. Coverage of IRS in Itang District, Ethiopia, 2021

Characteristics	Categories	Frequency (N)	Percentage (%)
Was your house sprayed with insecticide last 12 months	Yes	73	36.5
	No	127	63.5
If yes, when was last sprayed	In the last 12 months	34	46.58
	In last 6 months	39	53.42
Perceived benefits of using the IRS	Reduce mosquito bites	29	39.73
	Reduce cockroaches	16	21.91
	Prevent malaria	21	28.77
	No benefit	7	9.59

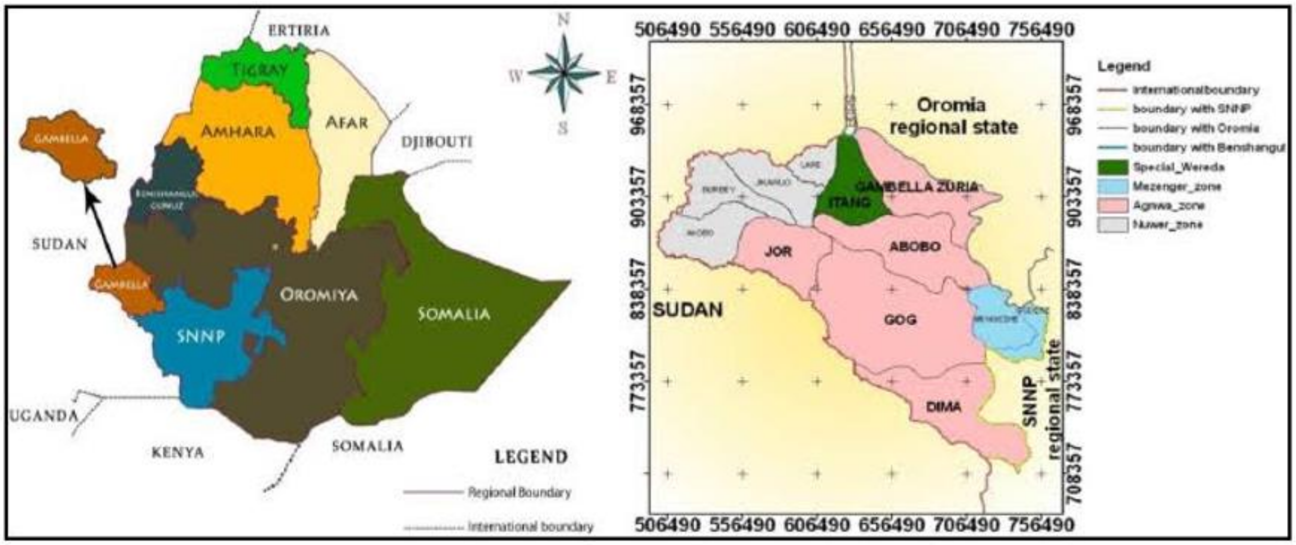

Fig. 1. Map of the study area

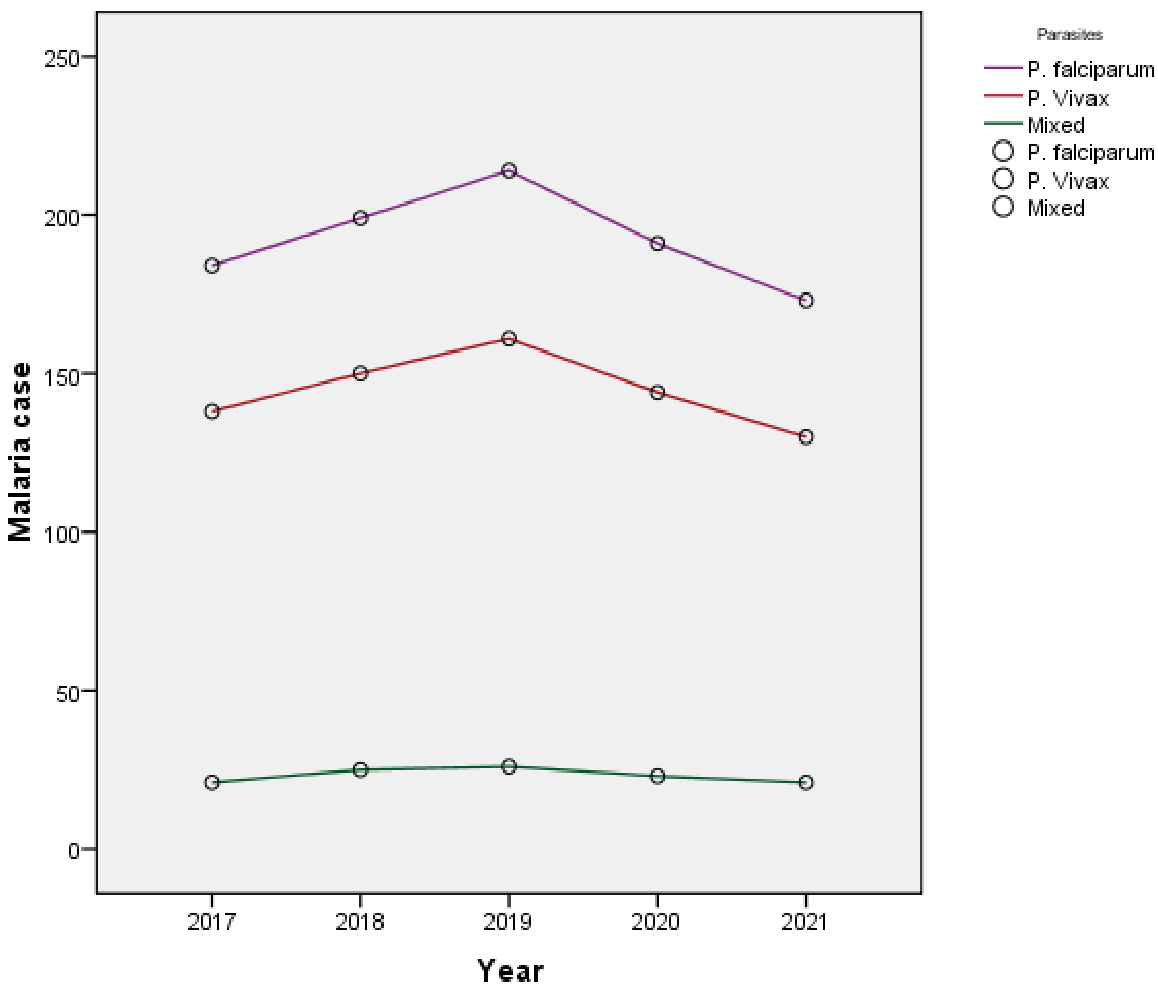

Fig. 2. Trends of malaria parasite species from 2017 to 2021, Itang District, Ethiopia

Table 5. IRS coverage by Kebeles in Itang District in 2021

Characteristics	Households sprayed at least once				Total		Chi-square	P-value
	With the last 12 months		0–6 months					
	n	%	n	%	N	%		
							7.654	0.00
Baziel	7	17.94	5	14.70	12	16.44		
Eliya	10	25.64	8	24.52	18	24.66		
Itang	19	48.72	12	35.29	31	42.46		
Puldeng	3	7.69	9	26.47	12	16.44		
N	39	100.0	34	100.00	73	100.00		

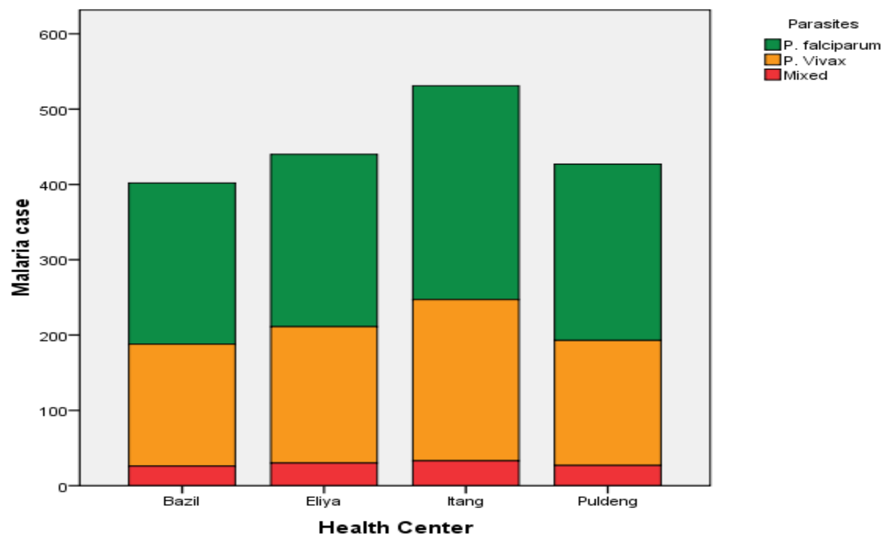

Fig. 3. Malaria prevalence and parasitological data in four health facilities in the western Ethiopian area of Itang, 2017–2021

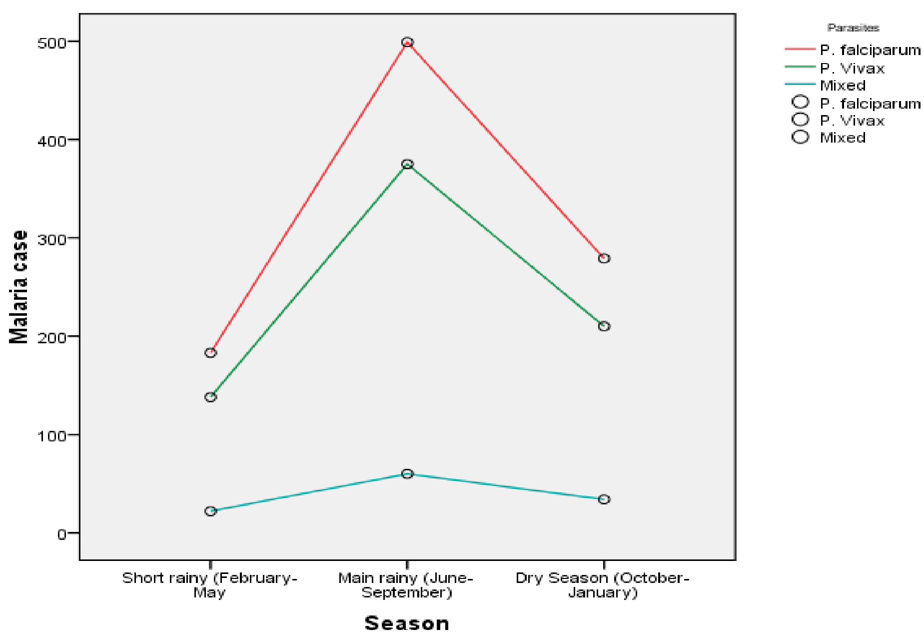

Fig. 4. Seasonal *Plasmodium* species distribution in the Itang District of Ethiopia from 2017 to 2021

Table 6. Household Long-lasting Insecticidal Nets coverage and utilization, Itang District of Ethiopia, 2017–2021

Characteristics	Categories	Frequency (N)	Percentage (%)
Is there an LLIN in this house?	Yes	179	89.50
	No	21	10.50
Number of LLINs in your house	1	42	23.46
	2	57	31.84
	≥ 3	80	44.70
Net ownership	Any net	17	9.50
	LLINs	162	90.50
Household number	2	6	3.00
	3	31	15.50
	4	66	33.00
	Above 4	97	48.50
Type of net	Untreated net	5	2.80
	Locally Treated Net (LTN)	12	6.70
	LLINs	162	90.50
Condition net	Good (no holes)	53	29.61
	Fair (no holes that fit a torch battery)	78	43.57
	Poor (1–4 holes that fit a torch battery)	31	17.32
	Unsafe (> 5 Holes that fit a torch battery)	6	3.35
	Unused (still in package)	11	6.15
LLIN use			
Are the net is currently used	Yes	123	68.72
	No	56	31.28
Net use the previous night	Yes	47	38.21
	No	76	61.79
How many of your family members slept under LLIN last night?	2	25	53.20
	3	11	23.40
	4	8	17.02
	Above 4	3	6.38
Reasons for not using the available LLINs	Nets do not prevent malaria	6	10.71
	Afraid of its toxicity	17	30.36
	Other	33	58.93
Reasons for unavailability of LLINs	Not available	3	14.29
	Lost/stolen	2	9.52
	Used for other purposes	10	47.62
	Old; then thrown away	6	28.57

Table 7. Long-lasting Insecticidal Nets coverage by kebeles in Itang District, Ethiopia, 2017–2021

Characteristics	Net ownership				Total		Chi-square	P-value
	Any net		LLINs					
	n	%	N	%	N	%		
							16.75	0.00
Baziel	3	17.65	32	19.75	35	18.99		
Eliya	5	29.41	32	19.75	37	20.67		
Itang	0	0.00	42	25.93	42	23.46		
Puldeng	9	52.94	56	34.57	65	36.31		
N	17	100.0	162	100.00	179	100.00		

Table 8. Long-lasting Insecticidal Nets utilization by kebele, sex, and age categories, Itang District, Ethiopia, 2017–2021

Characteristics/Domain	Factors	Slept under the net last night				Total	
		Any net		LLINs			
		N	%	N	%	N	%
Age	< 5	2	5.71	20	6.00	22	5.98
	5–14 years	4	11.43	85	25.53	89	24.18
	15–49 years	17	48.57	171	51.35	188	51.09
	≥ 50 years	12	34.29	57	17.12	69	18.75
	N	35	100.00	333	100.00	368	100.00
Gender	Female	11	31.43	187	56.16	198	53.80
	Male	24	68.57	146	43.84	170	46.20
	N	35	100.00	333	100.00	368	100.00
	Baziel	11	31.43	80	24.02	91	24.73
	Eliya	7	20.00	91	27.33	98	26.63
	Itang	0	0.00	56	16.82	56	15.22
Kebele	Puldeng	17	48.57	106	31.83	123	33.42
	N	35	100.00	333	100.00	368	100.00

Discussion

According to the study, from 2017 to 2021, 40% of the blood films showed malaria cases. This result was comparable to a study from Kola Diba Health Center (39.6%) (47). However, studies conducted in Dembecha Health Center, Northwest Ethiopia (48), Kombolcha Health Center (7.5%) in North-central Ethiopia (49), Ataye (8.4%) in North Shoa (50), and Felegehiwot Referral Hospital (5.0%) in Bahir Dar (32) contrast with this assessment. These disparities may result from variations in malaria detection techniques and the capacity of laboratory personnel to locate and recognize malaria parasites. Furthermore, different regions may employ different strategies for the prevention and control of malaria. The prevalence of the disease may vary depending on factors such as demographics, economic activity, altitude fluctuation, research period, accessibility to health institutions, community awareness of vector management measures, LLINs, and IRS coverage and utilization. Moreover, the difference in the average annual prevalence of malaria within the study period might be due to the difference in climatic conditions. Greater attention toward malaria prevention and control measures by various responsible bodies, increased community awareness on the use of ITNs, insecticide spraying, best drainage systems for mosquito breeding sites and global climate change may all be contributing factors for the variation in malaria prevalence.

Plasmodium falciparum infections were more prevalent than *P. vivax* in Itang District. From the records of the Ijaji, Bako, and Sayo Health Centers (2008–2012), Geshere et al. (27) reported that the rates were 66.38%, 17.13%, and 49.43%, respectively. The results of this did not agree with those of Abate et al. (51), who reported that *P. vivax* was the main species and accounted for 76.2% of positive samples in a retrospective study in Mojo town. This can be a result of variations in the study period, sample size, study area, and other elements.

This study's findings on malaria prevalence are complementary to those from a study conducted in 2003 at the Assendabo Health Center (52) in which the causes of malaria were identified and treated. The prevalence of *P. falciparum* is 32 (51.6%), and there were 12 mixed infections (7.8%), indicating that *P. falciparum* predominated in this study as well.

The greater prevalence of *P. falciparum* finding in this study is agreed with the national data and other related research conducted in Ethiopia (53, 54–56). However, this outcome disagrees with a prior report from Jimma Town that stated *P. vivax* was more common (8).

According to Woyessa et al. (57), *P. vivax* predominates in Butajira and the adjacent areas since 86.5% of the patients tested positive for *P. vivax*, 12.4% for *P. falciparum*, and 1.1% had mixed infections.

These inconsistencies could be brought about by variations in malaria detection techniques and the capacity of laboratory employees to locate and recognize malaria parasites (58). Operations for preventing and controlling malaria may also differ from one place to another. The prevalence of the disease may differ depending on factors such as demographics, economic activity, altitude difference, research period, health institution accessibility, community awareness of vector control, and LLINs and IRS coverage.

In addition to human activity, weather extremes, and natural catastrophes have influenced the development of vector-borne infectious diseases (59, 60), pointing to the role of climate change in these occurrences. Rapid transmission of diseases that were not previously common, like malaria, has also been caused by environmental changes like the introduction of a new insect into a region or population (59).

Plasmodium falciparum is common in tropical and subtropical regions of Central and South America, Africa, and Asia. According to (61), the five species all belong to the same genus and each one has a distinctive look under the microscope and somewhat diverse patterns of symptoms. It causes the most severe infections and is to blame for almost 90% of the deaths brought on by malaria in Sub-Saharan Africa. According to this study, compared to past years, 2019 saw the highest number of instances of *P. falciparum*, *P. vivax*, and mixed infections, with 2018 coming in second. *Plasmodium falciparum* infections are more prevalent than *P. vivax* infections in the Itang District, while mixed infections are less prevalent overall.

In our analysis, females outnumbered males in both the number and prevalence of confirmed malaria cases over the previous five years. There was a statistically significant gender difference in malaria prevalence. As a result, there is a connection between gender and malaria cases. This investigation found that all age groups had malaria infection. The burden of malaria was statistically significantly correlated with age groups. With a prevalence of 33.9%, the age group of 15 to 30 years had the greatest infection rate, which was followed by the age group of 30 years and above with a prevalence of 30.1%. The age group of children under five years old experienced a low infection. They claim that there is no appreciable variation in prevalence by age group, area, or globally, which is at odds with (49). Additionally, there is no predictable trend for the prevalence of malaria according to age.

This study found that the primary wet season, which runs from June to September, saw the highest number of malaria cases reported, while the dry season, which runs from October to January, saw the lowest number. The primary wet season saw higher levels of *P. vivax*, *P. falciparum*, and mixed infections and lower levels during the dry season. The months of September through November saw the highest rates of malaria cases (27.1%), while December, January, and February during the dry season saw the lowest rates of infection (22.5%). The seasonality seen in the current study is like that seen in investigations conducted in other regions of Ethiopia (62, 63). In most areas of Ethiopia, the main malaria transmission season typically runs from September to December, following the wettest month of June through September. Another ten-year study conducted in Jimma Town revealed changes in the species composition of *Plasmodium* because of environmental variables, in addition to variations in the number of malaria cases (28).

In this study, 63.5% of the households reported that their homes had not had insecticide spraying in the previous 12 months, whereas 36.5% reported having received one. This is lower than the 95.3% found by (67) in Tanzania in a survey performed after a round of IRS. Regarding the reported advantages of using IRS, 39.73% of families said that it decreased mosquito bites, 28.7% claimed that it prevented malaria, 21.91% claimed that it decreased cockroaches, and only 9.59% claimed that there was no advantage. Arguments against utilizing the IRS 48.03% of respondents claimed it is inconvenient, followed by 28.35% who said it stinks, 13.39% who said it irritates the skin, 7.08% who said it poisons domestic animals, and only 3.15% who said it stains walls. Similar to Munga et al. (68), when asked why they thought spraying was important, 82% (n= 274) of respondents indicated it helped to reduce mosquito bites inside of homes, 9% (n= 29) claimed it helped to reduce the number of cockroaches, and 0.6% (n= 2) said it had no value at all. Only 9% (n= 29) of respondents connected IRS to reducing malaria transmission. Those who did not readily embrace using the IRS did so for a variety of reasons. Thirty percent (n= 7) of the respondents disapproved of IRS as a viable malaria prevention strategy due to skin irritation, and foul odor, 35% (n= 8), and 21% (n= 5) domestic animal toxicity. Others (13%) refused to accept the IRS because it damages walls or takes too long to process.

According to the findings of this study, Itang had the most sprayed households per every four kebeles. Itang was the kebele where most households had been sprayed over the past year and the past six months. As a result, there were differences between kebeles and sprayed houses.

Contrary to this study, in Western Ethiopia's Gilgele Gibe Field Research Centre, Derbew et al. (64) found no statistically significant correlation between the head of household's educational attainment and the use of LLITNs. The results demonstrate that among vulnerable populations, education influences the use of mosquito nets. Additionally, it demonstrates how a higher level of education prevents behavior and attitude changes by obstructing social and economic development, which ultimately results in pregnant women and children under five in Ethiopia not using mosquito nets.

Sena et al. (65) found that compared to households with three or fewer members, those with larger families were less likely to use LLINs/ITNs. The aforementioned research showed that pregnant women and children under five in Ethiopia utilize mosquito nets in large part due to household size. Large families may not have enough mosquito nets for the family or may not have enough space in their dwelling for the nets to be hung. These factors can all have an impact on how often mosquito nets are used.

Like the current study, it was linked to a 6.6% rise in respondents' usage of LLINs in Cameroon following an 8-month implementation. Additionally, it revealed a 12% rise in the respondents' under-five children's net usage the previous night (66). According to study (25) findings, the most effective way to lower malaria incidence and the density of the target vector population was to use indoor house spraying and LLINs for malaria control. However, Ethiopia was unable to stop the spread of malaria because of a lack of enthusiasm for the usage of LLINs and indoor house spraying techniques.

The significant increase in insecticide resistance in malaria vector populations globally especially in Africa is due to the large-scale and extensive application of insecticides in the form of IRS and LLINs for vector control (69). Different levels of insecticide resistance of *An. arabiensis* has been reported from various regions of the country against a range of insecticides of different classes, such as organochlorines (DDT), pyrethroids (permethrin, deltamethrin, lambda-cyhalothrin), and carbamates (bendiocarb), organophosphates (malathion) (70–74). The use of two or more insecticides having different modes of action alternatively within a given period could delay the development of insecticide resistance at a significant level. The removal of its selection pressure would help to restore the susceptibility of the vector population that was resistant to the insecticide under consideration (75).

Implications of the study

The findings of this study imply that the District Health Offices, health care systems, and other Stakeholders seeking to better understand the prevalence of malaria among households in Itang district in Gambella and perhaps other regions of Ethiopia. The coverage and usage of LLINs and IRS suggest that current efforts and strategies are inadequate. The findings of this study also suggest that developing proper intervention programs is needed against malaria.

Limitations of the study

The study was based on cross-sectional primary data, so some respondents were unwilling to spare their time to give the necessary data. Second, the data analyzed for this study are cross-sectional; therefore, no definitive statements regarding the causal relations between malaria parasitemia and the outcome variables can be made. Besides, the responses of the sample households may not be free from personal bias. Despite the challenges, the survey has worked hard and took safety measures to minimize these limitations and realize the objective of the study.

Conclusion

The current work, conducted in Itang District from 2017 to 2021 found the overall prevalence of malaria confirmed 40.0% cases. *Plasmodium falciparum* infections were more common than *P. vivax* infections and their mixed forms in the district. According to our analysis of the number and prevalence of malaria cases that have been confirmed by sex over the past five years, females had more instances than males. According to our study, prevalence peaked between the ages of 15 and 30 years, followed by over 30 years and between 5 and 14 years. The age group of children under five years old experienced low infection. The results of this study also demonstrate that there was variance in the distribution of nets in the local kebeles. The age group that used the net the most yesterday night was 15–49 years old. Our study results also show that a large number of households have not had their homes treated with IRS in the past year, and only a small number of people lived in such homes. These results call for an urgent need to implement control measures including the coverage and use of ILLNs and IRS at the community level, targeting risk factors, community awareness, and management of this condition by health professionals.

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Ethical consideration

The study was approved by the Wollega University Research Ethical Review Committee (Ref. No. W/U/795/2021), and informed consent was obtained from each subject before inclusion in the study. The respondent's right to decline to answer any of the questions or to take part in the discussion was honored. Confidentiality of all information obtained from respondents was assured by safely and securely storing the questionnaires.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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