Epidemiology and Health System Journal
doi:10.34172/ehsj.26304 2025 Spring;12(2):58-65 http://ehsj.skums.ac.ir

Original Article

Prevalence of Malaria and Associated Risk Factors Among Children Under 15 Years of Age Living Near the Gilgel Gibe Hydroelectric Dam in Southwestern Ethiopia

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Received: November 17, 2024
Revised: June 9, 2025
Accepted: June 10, 2025
ePublished: December 2, 2025

Abstract

Background and aims: Malaria is endemic in Jimma Zone, southwestern Ethiopia. The Gilgel Gibe hydroelectric dam (GGHD) in the area might exacerbate the transmission of malaria. This study assessed the prevalence of malaria and associated factors among children under 15 years of age living along the dam.

Methods: A community-based cross-sectional study was conducted in six kebeles along the GGHD from May 2021 to December 2022. Data on households' (HHs) sociodemographic characteristics and exposure to mosquito bites and prevention strategies were collected from 320 HHs. After obtaining child assent and parental consent, a blood sample was collected from 1,374 febrile children from 825 HHs (including 320 HHs) and diagnosed with malaria infection using microscopy.

Results: About 92% (n = 294) reported mosquito bites, and 74.1% (218) experienced bites during night time. Further, 69.7% (205) had mosquito nets, and 60.2% (177) slept under the net the previous night. Respondents who reported frequent mosquito bites had twice risk of malaria infection (adjusted odds ratio [AOR] = 2.0, 95% confidence interval [CI]: 2.22–3.23, *P* = 0.02). In addition, the prevalence of malaria was 4.3% (12) and two times higher among children who did not sleep under a mosquito net the previous night (AOR = 2.05, 95% CI: 1.47–6.86, *P* = 0.04).

Conclusion: The overall malaria prevalence was higher in October than in May or December. The prevalence of malaria was higher among children under 15 years of age living in HHs found with in ≤ 3 km of GGHD than in those > 3 km from GGHD. The prevalence of malaria was associated with the absence of HH mosquito net availability and residents' lack of using mosquito nets the previous night.

Keywords: Malaria, Prevalence, Children, Ethiopia

Introduction

Malaria remains a significant public health problem caused by the bite of infected *Anopheles* mosquitoes.[1,2] Once the sporozoites are inoculated into the human host, they migrate to the liver, where they mature and release merozoites into the blood circulation.[3] The disease is characterized by high temperature (≥ 37.5°C) or fever in malaria patients.[2] Currently, four species of *Plasmodium* can cause human diseases, including *Plasmodium falciparum*, *Plasmodium vivax*, *Plasmodium ovalue*, and *Plasmodium malariae*.[2] *Anopheles arabiensis* continues to play a leading role in malaria transmission in Ethiopia.[4] In addition, other *Anopheles* species, such as Anopheles coustani, Anopheles phronesis, *Anopheles nili*, and *Anopheles funestus*, play a minor role in malaria transmission in Ethiopia.[5]

Globally, malaria infected about 249 million people and claimed the lives of 608,000 in 2022.[6] The burden has been increasing in Africa, where 94% of the cases and 96% of the deaths occur.[7] Ethiopia contributed to a 23% increase in the number of cases between 2021 and 2022. The country experiences an increasing number of cases and deaths each year.[8,9] The pattern of malaria transmission varies from area to area depending on the local climate, rainfall, and altitude conditions.[10] It is mainly transmitted from September to November, followed by April to June. Factors such as sociodemography, access to indoor residual insecticide sprays and insecticide-treated nets, and prompt case treatment determine the risk of malaria infection.[11,12] Environmental modifications, most notably water development schemes, create suitable conditions for the breeding of malaria-transmitting *Anopheles* species and increase the transmission of the disease.[13] The Gilgel Gibe hydroelectric dam (GGHD) in southwestern Ethiopia is among several dams in the country constructed for hydroelectric power generation. Such dams have previously been associated with a high burden of malaria. This is partly because dams create favorable breeding habitats and atmospheric moisture that increase vector populations and survival.[14,15]

Jimma Zone is one of the malaria-prone areas in the southwestern part of the country. The zone comprises 22 districts and 444 kebeles (villages), of which 6, 64, 55, and 19 kebeles are considered high, moderate, low, and very low malaria transmission risk, according to the Ministry of Health's classification.[16] Sokoru is one of the districts in Jima Zone where 830 malaria cases were reported in 2022, of which 426 and 403 were *P. falciparum*-infected and *P. vivax*-infected cases, and 1 was a mixed case. In the Omo-Nada district, 462 cases were reported, comprising 314 *P. falciparum*, 141 *P. vivax*, and 7 mixed cases. There were 216 (194 *P. falciparum*, 21 *P. vivax*, and 1 mixed) and 211 (115 *P. falciparum* and 96 *P. vivax*) cases in the Kersa and Nadhi-Gibe districts, respectively.[16]

The highest rate of morbidity and mortality among children belongs to malaria cases.[3] The risk of infection among children is influenced by several factors, including the density of vectors, the distribution and biting behavior of vectors, the local *Plasmodium* species, the availability of infected human hosts, the level of exposure to infected mosquitoes, immunologic status, genetic factors, and environmental factors.[17, 18] Although malaria transmission is expected to be high along the GGHD, its impact on the local children remains less understood. Therefore, this study aims to investigate malaria's prevalence and associated factors among children living in households (HHs) around the GGHD.

Materials and Methods

Study Design and Setting

A community-based cross-sectional study was conducted in six kebeles of Burka-Asendabo, Wirtu-Yedi, Dimitu, Jimma-ber, Hareer, and Gibe along the GGHD (Figure 1). The kebeles are considered to be highly malarious. The Burka-Asendabo and Wirtu-Yedi kebeles are located in the Omo-Nada district. In addition, Dimitu and Jimma-Beri kebeles are situated in the Nadhi-Gibe and Sekoru districts, respectively. Furthermore, Hareer and Gibe kebeles are located in the Kersa district (Figure 1). The GGHD is found in Jimma Zone,Oromia region, Southwestern Ethiopia, at 260 km away from Addis Ababa.[19] The GGHD reservoir encompasses approximately 50 km^2 and is situated at an average altitude of 1671 meters above sea level,[14] with geographic coordinates of 7.83° latitude and 37.32° longitude. The region is characterized by a humid climate, with an average annual rainfall of 1,550 mm and an average temperature of 19°C.[19]

Study Design and Period

The study was conducted during May 3–30, 2021, October 1–30, 2021, and December 4–29, 2022, corresponding to the minor malaria transmission season, the major malaria transmission season, and the dry seasons in Ethiopia, respectively.[11] The HHs were categorized into two groups. One group included those located within ≤ 3 km from the GGHD, and the other group constituted those located at > 3 km from the GGHD, assuming a maximum flight range of mosquitoes of approximately 3.0 km.[20,21] The six kebeles comprised a population of 860,730 (49.5%, n = 426,061 males [50.5%] and 434,669 females [50.5%]). Children under 15 contributed to 47% (404,543) of the population, of whom 200,248 were males and 204,295 were females.[16]

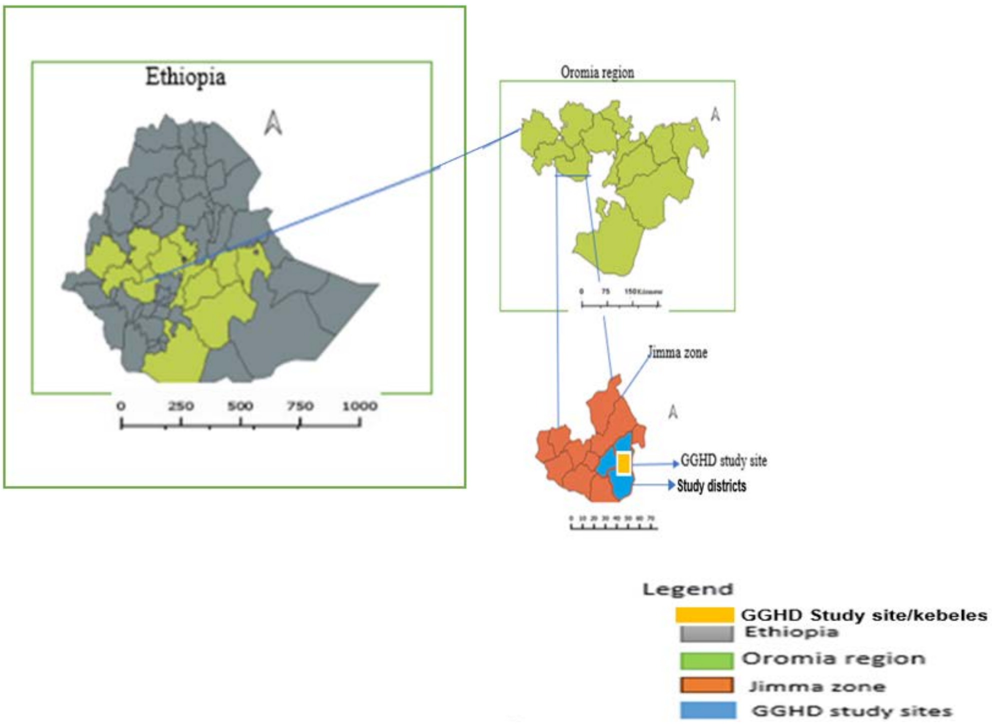

Figure 1. Map of the Study Kebeles and the Gilgel Gibe Hydroelectric Dam in Southwestern Ethiopia. *Note* The figure was generated using QGIS software

Study Population

Children aged under 15 who lived in the six kebeles were the study population, and our study sample included children aged under 15.

Sample Size

The sample size was calculated using a double population-proportion formula, considering a 95% confidence interval (CI) and a 5% margin of error (d).[22, 23] The previous malaria prevalence of 5.5% (P1) among children living in HHs within 3 km of GGHD and the 2.2% prevalence (P2) among children living in HHs at > 3 km of GGHD were used in this study.[15] Overall, 313 children were expected to be included from villages within 3 km, and 313 children were expected to be included from >3 km radius of GGHD (n = 626 children). A total of 1,374 children under 15 years of age who had signs and symptoms of malaria were included from 825 HHs, of whom 689 were from HHs located at ≤ 3 km from GGHD and 685 were from HHs located at > 3 of GGHD. In May 2021, 548 children were included from 320 HHs; in October 2021 and December 2022, 626 and 200 children;due to resource limitation, were included from 385 and 120 HHs, respectively.The sample size of children was increased to 1,374 (548 in May 2021, 626 in October 2022, and 200 children in December 2022) because our study focused on community settings, where the prevalence of malaria was assumed to be low as compared to the report of malaria prevalence from clinical settings.

Socio-Demographic Data Collection

The sociodemographic characteristics of 320 HH representatives were collected using a structured questionnaire. At each selected HH, housewives, their spouses, or any adult members consented to participate in the study, and the children's assent was sought. The required data were collected using standardized, pretested, and structured interview questionnaires. The questionnaire was prepared in English and translated into the local language, Afan Oromo, which was used to collect information on HH characteristics, risk factors of malaria infection, and malaria prevention and control practices. Place of residence, distance of HHs,child caregivers, educational status, employment status, and number of HHs were the sociodemographic variables. On the other hand, exposure status to mosquito bites, residents' involvement in out door activities, history of travel outside of the GGHD, net ownership, use of nets the previous night, and spraying with residual insecticide were malaria prevention practices. Child anthropometric data were also collected using body measurement data (anthropometry). Both the height and weight of the children were measured using a calibrated and standardized stadiometer and weighing scale, respectively.[24]

Sampling Procedure

Six kebeles were selected purposely from the four districts based on their previous malaria report last year. We used the pre-existing kebele structures of got as a cluster to choose the study HHs (one Got covers 25 HHs). Using cluster sampling, 33 clusters (825 HHs) were selected from the existing 308 clusters. The 17 clusters were within ≤ 3 km of GGHD, and 16 clusters were within > 3 km of GGHD). All HHs from 33 clusters were included in the analysis (Figure 2).

The housewife, her spouse, or any adult member of the HH was asked about the presence of a febrile child/children in the house. The fever (temperature of > 37.5°C) of each child's axillary (underarm) was checked with a thermometer. Febrile children whose parents or guardians signed a written consent and assented children were included in the study. However, children who received antimalarial treatment within 42 days before the date of the data collection period were excluded from the

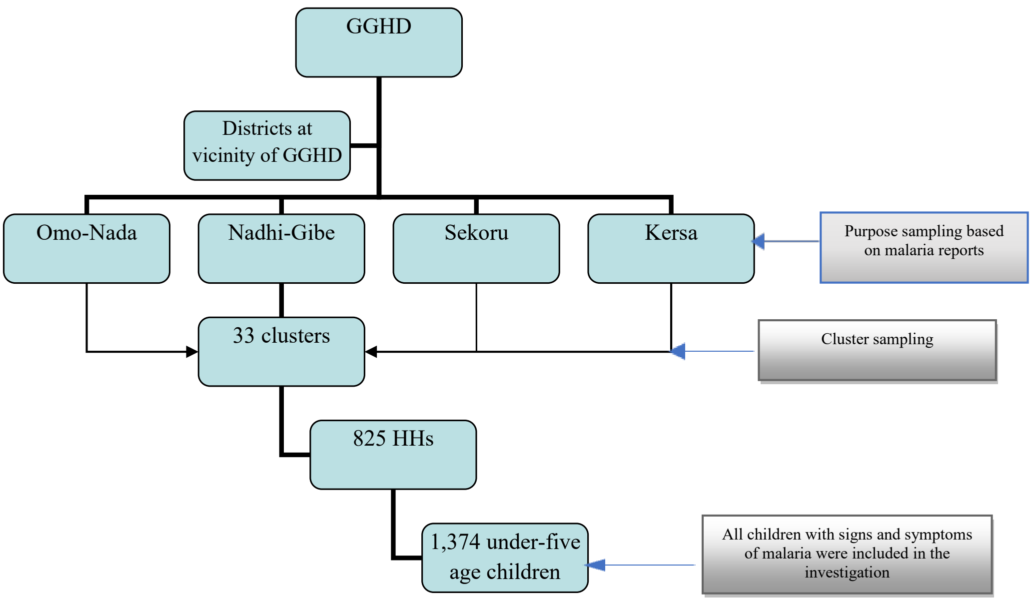

Figure 2. Sampling Framework of the Study Sites and HHs. *Note*. HH: Household

investigation.[25]

Malaria Diagnosis

A capillary blood sample was collected from children under 15 using sterile blood lancets after obtaining their parents' signed written consent and assent. A senior medical laboratory technician collected the blood samples following a standard guideline.[26] Each child's signs, symptoms, and fever (temperature of > 37.5°C) were checked during blood sampling. A malaria case had a fever and an axillary temperature of > 37.5°C and was microscopically positive for *Plasmodium* species.[27]

Thin and thick blood films were prepared, air-dried, labelled, placed in slide boxes, and transported to the nearest laboratory. In the laboratory, thin blood films were fixed with methanol, and both thick and thin films were stained with 10% Giemsa for 10 minutes and diagnosed for *Plasmodium* species under an oil immersion microscope. About 100 fields of thick blood film were observed before a slide was reported negative for *Plasmodium* species.[26,28,29]

Data Quality Assurance

Data collectors were trained on the questionnaire's content and how to undertake the data collection using the questionnaire. Furthermore, experienced laboratory technicians performed blood sample collection, blood smearing on microscope slides, staining smears with Giemsa stains, and screening the stains for *Plasmodium* species under an oil immersion microscope. The Giemsa stains were checked for quality before staining using a known positive *Plasmodium* species.

Data Analysis

The obtained data were analyzed using SPSS, version 26 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to determine frequencies and percentages of study variables. Both bivariate and multivariable logistic models were run. The crude odds ratio (OR) with a 95% CI was utilized for the bivariate model. The adjusted odds ratio (AOR) with a 95% CI was employed for the multivariate model. Multiple logistic regressions with a 95% CI were performed among variables that showed an association in the bivariate model ($P \leq 0.05$) with the outcome of interest to identify factors that determine malaria infection among children and to control the effect of confounders, for variables which have $P > 0.05$ in the bivariate model, that were not statistically significant separately were analyzed with other variables, whether they contributed significantly to the model or not.[30] The OR with a 95% CI was used to compare the strength of association between predictor variables and target outcomes among children living in HHs at ≤ 3 km and away of > 3 km from GGHD.

Results

Sociodemographic Characteristics

Three hundred twenty HH heads were interviewed in May 2021, during the minor malaria transmission season. Nearly 12.5% (n = 40) and 17% (n = 54) of HHs were selected from the Burka Asendabo and Wirtu-Yedi kebeles of the Omo-Nada district. In addition, 35% (n = 112), 16% (n = 54), and 9.5% (n = 30) HHs were chosen from Dimitu kebele of the Nadhi-Gibe district, Deneba kebele of the Sekoru district, and Hareer and Gibe kebeles of the Kersa district, respectively (Table 1). Of the total, 50.5% (162) lived within 3 km of the GGHD, and 49.5% (158) lived ≥ 3 km from the GGHD. Approximately 93% (297) of the respondents were mothers, and 5% (16) were male heads of HHs. Among the mothers, 37% (118) had no formal education, and 35% (112) and 28% (90) attended primary education and secondary education or above, respectively.

Residents' Exposure to Mosquito Bites and Prevention Strategies

About 92% (294) of the HH respondents perceived exposure to mosquito bites (Table 2). Nearly 74.1% (n = 218) and 25.9% (n = 76) reported having bites during nighttime and the day, respectively. Over 19.4% (n = 57), 72.8% (n = 214), and 7.8% (n = 22) of HH respondents indicated that they permanently, sometimes, and rarely experienced mosquito bites, respectively. Furthermore, 67% (n = 197) were involved in out door activities, and 59.6% (n = 176) had a travel history outside the GGHD before the study period. About 38.1% (n = 112) of the respondents had an HH member with symptoms of malaria within the previous six-month period. Close

Table 1. Sociodemographic Characteristics of Inhabitants Along the GGHD, Southwest Ethiopia, 2021-2022 (n = 548 respondents)

Variables	Response	Number (%)
Kebeles/place of residence	Burqa Asendabo	40 (12.5)
	Wirtu yedi	54 (17.0)
	Dimitu	112 (35.0)
	Deneba	54 (16.5)
	Hareer	30 (9.5)
	Gibe	30 (9.5)
Distance of HHs from GGHD	≤3 km	162 (50.5)
	>3 km	158 (49.5)
Child caretakers	Mother	297 (92.8)
	Father	16 (5)
	Others	7 (2.2)
Educational status of child care takers (n = 320)	No formal education	118 (37)
	Primary (1-8)	112 (35)
	Secondary and above	90 (28)
Employment status	Housewife	71(22.3)
	Farmer	112 (35)
	Government employee	55 (17.1)
	Merchant	82 (25.6)
Number of HHs included in the blood sampling survey (n = 825)	May 2021	320 (38.7)
	October 2021	385 (46.7)
	December 2022	120 (14.6)

Note. GGHD: Gilgel Gibe hydroelectric dam; HH: Household.

Table 2. A Resident of HH Exposure to Mosquito Bites and Prevention Strategies for Mosquito Bites Along GGHD, Southwest Ethiopia, 2021-2022 (n = 548 Respondents)

Variables	Response	Number (%)
The risk of mosquito bites (n = 320)	Yes	294 (92)
	No	26 (8)
Duration of most mosquito bites (n = 294)	Night	218 (74.1)
	Throughout the day	76 (25.9)
Frequency of mosquito bites at your residence (n = 294)	Always	57 (19.4)
	Sometimes	214 (72.8)
	Rarely	23 (7.8)
Participation in late out door activities (n = 294)	Yes	197 (67)
	No	97 (33)
Visits made to other areas outside GGHD (n = 294)	Yes	176 (59.8)
	No	118 (40.2)
Symptoms of malaria among children under 15 years within six months (n = 294)	Yes	112 (38.1)
	No	182 (61.9)
Availability of mosquito net (n = 294)	Yes	205 (69.7)
	No	89 (30.3)
HHs use of mosquito nets of the previous night (n = 294)	Yes	177 (60.2)
	No	117 (39.8)
HHs sprayed interior walls within six months	Yes	32 (11)
	No	262 (89)
Duration of last spray of interior walls within one year (n = 294)	Within < 6 months	32 (11)
	6-12 months	115 (39)
	> 12 months	147 (50)

Note. HH: Household; GGHD: Gilgel Gibe hydroelectric dam.

to 70% (n = 205) of the respondents reported mosquito net ownership, and 60.2% (n = 177) used their nets last night. Approximately 89% (n = 262) of the respondents' houses were not sprayed with residual insecticide within the previous six-month period, 39% (n = 115) had their houses sprayed within the last one-year period, and 50% (n = 147) had their houses sprayed before the prior year.

Prevalence of Malaria Among Children

Among the 1,374 under 15-year-old children, 50.1% (n = 689) and 49.9% (n = 685) were from HHs located within ≤ 3 km of the GGHD and at > 3 km from the GGHD, respectively (Table 3). The overall prevalence of malaria was 3.78% (n = 52). The overall prevalence of *P. falciparum* was 2.25% (n = 31), and *P. vivax* was 1.52% (n = 21) during the study period. The prevalence of malaria was 4.64% (n = 32) among children living within ≤ 3 km from GGHD and 2.9% (n = 20) among those living at > 3 km distance from GGHD. The prevalence of malaria was 3.28% (n = 18) in May 2021, 4.79% (n = 30) in October 2021, and 2% (n = 4) in December 2022. In addition, the prevalence of malaria in the study district was 8% (n = 22) in the Sekoru district and 5.4% (n = 18) in the Omo-Nada district. The proportion of *P. falciparum* and *P. vivax* among the positives was 59.6% (n = 31) and 40.4% (n = 21).

Table 3. Prevalence of Malaria Among Children Under 15 Years of Age Along GGHD Southwest Ethiopia 2021-2022 (N = 1374 Children)

Variable	Number (%)
Number of children under 15 years included in the study (**N = 1374**)	
≤ 3 km	689 (50.1)
> 3 km	685 (49.9)
Overall prevalence of malaria at GGHD (N = 1374)	52 (3.78)
Prevalence of *P. falciparum*	31 (2.25)
Prevalence *of P. vivax*	21 (1.52)
Prevalence of malaria among children under ≤ 15 years of age	
≤ 3 km (n = 689)	32 (4.64)
> 3 km (n = 685)	20 (2.9)
Prevalence of malaria by season	
May 3–30, 2021 (n = 548)	18 (3.28)
≤ 3 km (277)	10 (3.6)
P. falciparum	7 (2.5)
P. vivax	3 (1.08)
> 3km (n = 271)	8 (2.95)
P. falciparum	4 (1.47)
P. vivax	4 (1.47)
October 1–30, 2021 (n = 626)	30 (4.79)
≤ 3 km (n = 312)	18 (5.76)
P. falciparum	12 (3.8)
P. vivax	6 (1.92)
> 3 km (n = 314)	12 (3.8)
P. falciparum	8 (2.5)
P. vivax	4 (1.3)
December 4-29, 2022	4 (2)
≤ 3 km (n = 100)	2 (2)
P. falciparum	-
P. vivax	2 (2)
> 3 km (n = 100)	2 (2)
P. falciparum	-
P. vivax	2 (2)
Prevalence of malaria by district	
Sekoru (n = 274)	22 (8.0)
Omo-Nada (n = 331)	18 (5.4)
Tiro-Afeta (n = 481)	8 (1.7)
Kersa (n = 290)	4 (1.37)
Species of malaria parasite	
P. falciparum among total positives (n = 52)	31 (59.6)
P. vivax among total positives	21 (40.4)

Note. GGHD: Gilgel Gibe hydroelectric dam; *P. falciparum*: *Plasmodium falciparum*; *P. vivax*: *Plasmodium vivax*.

Factors Associated With Malaria Infection

A child with frequent mosquito bites was 2.1 times more at risk of malaria infection than one with a rare bite [AOR = 2.14, 95% CI: 2.22–3.23, *P* = 0.02]. A child who lived in an HH not sprayed with insecticide was at higher risk of malaria infection [AOR = 1.79, 95% CI: 0.23–4.64, *P* = 0.9] compared to the child who lived in sprayed HHs within 12 months before data collection. In addition, malaria prevalence was 2 times higher among children who did not sleep under a mosquito net the previous night [AOR = 2.05, 95% CI: 2.14–6.86, *P* = 0.04] than children who slept (Table 4).

Discussion

The overall prevalence of malaria among children living in six kebeles along GGHD was 3.78%. It was slightly higher among children living within ≤ 3 km of the dam (4.64%)

Table 4. Factors Associated With Malaria Prevalence Along GGHD in Southwest Ethiopia, 2021-2022

Explanatory Variables		Malaria Infection Status		Bivariate Model			Multiple logistic regression model		
		Positive n (%)	Negative n (%)	COR	95% CI	*P* value	AOR	95% CI	*P* value
Distance of HHs from GGHD	≤3 km (n=277)	10 (3.6)	267 (96.4)	1.23	0.478-3.168	0.6	1.24	0.43-2.86	0.9
	>3 km (n=271)	8 (2.9)	263 (97.1)	1.00			1.00		
Visits made outside GGHD (n=320)	Yes	13 (4.5)	221 (69)	0.95	0.329-2.757	0.9	2.88	0.23-2.89	0.8
	No	5 (1.56)	81 (25.3)	1.00			1.00		
Frequency of mosquito bites (n=294)	Always	8 (2.7)	55 (18.7)	2.42	0.149-1.571	0.03	2.0	2.0-3.23	0.02
	Sometimes	6 (2)	202 (68.7)	1.54		0.6			
	Rarely	4 (1.3)	19 (6.4)	1.00			1.00		
HHs sprayed their interior walls within 12 months (n=294)	Yes	8 (2.7)	139 (47.3)	1.00		-	1.00		
	No	10 (3.4)	137 (46.5)	1.49	0.302-2.057	0.6	1.79	0.23-4.64	0.9
Sleeping under a mosquito net last night before the survey day (n=294)	Yes	6 (2)	171 (58.2)	1.00		1.00	1.00		
	No	12 (4.1)	105 (35.7)	1.53	0.111-0.842	0.03	2.0	2.14-6.86	0.04

Note. HH: Household; GGHD: Gilgel Gibe hydroelectric dam; AOR: Adjusted odds ratio; CI: Confidence interval; COR: Crude odds ratio.

and higher in October, followed by May and December. *P. falciparum* accounted for 59.6% of the total positives, while *P. vivax* accounted for 40.4%. There was a relatively higher prevalence of malaria among children living in houses not sprayed with residual insecticides (4.1%) than among those living in sprayed households.

The prevalence of malaria among children living in six kebeles along the GGHD, southwestern Ethiopia, was 3.78%, which was slightly higher among children living within ≤ 3 km of the dam (4.64%) than those living > 3 km (2.9%) from the dam. This finding is in line with the results of a previous study conducted in 2009, which reported a higher risk of malaria in children living closer to the dam than those living farther away.[13] The findings of a study performed by Kibret in 2010 at the Koka and Ziway areas also showed increased malaria infections and monthly malaria incidences within 3 km of the reservoirs compared with the control sites.[21] Similarly, a study conducted around the Akosombo dam in Ghana demonstrated a 20% increase in malaria incidence within a 3 km radius of the reservoir.[31], indicating that proximity to water bodies can contribute to an increased risk of malaria infection. However, the role of other factors also needs to be taken into consideration.

Malaria infection had the highest rate in October, followed by May and December. The proportion of *P. falciparum* among the positives was 59.6% (31%), and that of *P. vivax* was 40.4% (21%). A health facility-based study performed by Jemal et al also revealed a species composition not far from this study, in which the percentages of *P. falciparum* and *P. vivax* were 52.1% and 44.2%, respectively, in the Asendabo, Jimma zone, Southwest Ethiopia.[32] The species composition was also similar to the national species composition of *P. falciparum* and *P. vivax* [10] because microscopic examination was used to examine malaria species composition at the national level. However, the species composition for *P. vivax* was higher than the findings of the study by Sena et al, which were reported within 2–3 km of GGHD.[33] These contradictory results might be attributable to the difference in the study population (under 5 years of age), study methodology, and the study period (2003-2011) in the study of Sena et al.

HH ownership of mosquito nets and previous night net use were 69.9% (n = 205) and 60.2% (n = 177), respectively, which is higher than the 2015 malaria indicator survey results, in which 45% of HH members used mosquito nets.[11] This difference in the study period is an improvement in HH net utilization. The results related to access to nets conform to the findings of a study by Birhanu et al, in which 70.9% of the study HHs had at least one long-lasting insecticidal net (LLIN) at the time of the survey.[34] This similarity is because we adapted the national malaria indicator survey to measure HHs' net access and use for this study. At the same time, only 38% had slept under the LLIN the previous night. According to a community-based longitudinal study conducted by Solomon et al, only 8% of the HHs owned at least one LLIN after 110 weeks of follow-up, and the average LLIN use was 36% and 4.6% during the first year and second year of follow-up, respectively.[35]

The prevalence of malaria among children living in HHs not sprayed with residual insecticides (4.1%) was relatively higher than the prevalence among those who lived in sprayed households . Zhou et al observed that the use of indoor residual spraying (IRS) was associated with lower rates of malaria infection, and significantly higher effectiveness was observed in IRS coverage ≥ 80% than in IRS coverage < 80%.[36] Amesa et al found that a lack of ITN was associated with malaria outbreaks in Nono Benja Woreda, Jimma Zone, Ethiopia.[37] This finding contradicts that of Ethiopia's 2015 malaria indicator survey report, in which 29% of all HHs in malaria areas used IRS within the last 12 months preceding the survey.[11] The difference in study years and design could contribute to different study results.

According to a study by Hilton in 2024, the impact evaluation of IRS and synergist piperonyl butoxide nets in Ethiopia resulted in an overall reduction of malaria cases in both arms of the interventions.[38] Loha et al concluded that LLINs and IRS, in combination or alone, may not eliminate malaria in areas with low malaria incidence. To further reduce malaria transmission in such settings, complementary interventions that can reduce the residual malaria transmission should be explored in addition to LLINs and IRS.[39] This suggests that, for low malaria-endemic settings, such as GGHD, complementary interventions need to be enhanced, and behavioural interventions also require due attention to improve the use of LLIN among HHs around GGHD.

Strengths and Limitations of the Study

The study was conducted near GGHD, which could be a hotspot for malaria transmission.The results can guide policymakers' actions.Nonetheless, other irrigation sites and hydroelectric dam areas were not covered due to budget limitations.

Conclusion

The overall prevalence of malaria was higher in October than in May or December. The prevalence of malaria was higher among children under 15 years of age living in HHs found within ≤ 3 km of GGHD than at > 3 km from GGHD. Moreover, the prevalence of malaria was associated with the unavailability of HH mosquito nets. The prevalence of malaria was associated with the frequency of mosquito bites, absence of HHs mosquito net and not using a mosquito net, and not spraying.

Acknowledgments

This article was derived from a research project approved by the Addis Ababa University School of Graduate Studies at Akililu Lemma Institute of Pathobiology (approval No. ALIP. IRB/69/2014/21). The researchers gratefully thank the housewives, heads of HHs, and children who participated in this study.

Authors' Contribution

Conceptualization: Desalegn Ararso Garoma, Sisay Dugassa Lemma, Abebe Animut Ayele.
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Competing Interests

The authors declare that there is no conflict of interests.

Ethical Approval

Ethical considerations in this study included obtaining permission from the Ethics Committee, the Institutional Review Board of Aklilu Lemma Institute of Pathobiology, Addis Ababa University (No. ALIP IRB/69/2014/21), and the Oromia Regional Health Bureau (BEFO HTBFH/176/16210).

Funding

This work was supported by Addis Ababa University School of Graduate Studies.

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