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ORIGINAL RESEARCH

Determinants of Malaria Morbidity Among School-Aged Children Living in East Hararghe Zone, Oromia, Ethiopia: A Community-Based Case–Control Study

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Background: Understanding the determinants of malaria morbidity offers helpful insights toward the changing malaria situation, which might lead to the adjustment of malaria program activities. Even though the determinants of malaria morbidity remain unknown, school-aged children were the highest malaria morbidity contributors in the East Hararghe Zone. Therefore, this study aimed to assess the determinants of malaria morbidity among school-aged children in the study area from February 1 to May 31, 2020.

Methods: A case-control study was conducted among school-aged children living in ten randomly selected low, moderate, and high malaria transmission *kebeles*. Cases were confirmed as positive for malaria, while controls were confirmed as negative for malaria among randomly selected school-aged children. Rapid diagnostic testing (RDT) and blood film (BF) malaria testing methods were used. Multivariable logistic regression was used to identify association between malaria and its determinants.

Results: The determinants of malaria infection were having no formal education (adjusted odds ratio (AOR)=4.91, 95% CI: 1.20–20.17), low family wealth index (AOR=2.50, 95% CI: 1.22–5.12), being from rural residence (AOR=2.34, 95% CI: 1.87–4.12), living near to stagnant water (AOR=2.01, 95% CI: 1.14–3.54), having a maximum of three family members (AOR=0.37, 95% CI: 0.18–0.78), using indoor residual spraying (IRS) (AOR=0.15, 95% CI: 0.08–0.29) and long-lasting insecticide-treated net (LLITN) over the last night (AOR=0.19, 95% CI: 0.10–0.35), and living in the house surrounded by cultivated land(AOR=0.24, 95%CI: 0.10-0.60) compared with their counterparts.

Conclusion: This study revealed that residence, family size, education, wealth index, stagnant water existence, and using LLITN and IRS had significant association with malaria morbidity. Thus, all concerned bodies, including the community should strengthen working on stagnant water elimination around their house to cut the breeding site of the malaria vector mosquito. Moreover, the findings have an important implication for improving interventions targeting the economic status and literacy of the society that may help in the reduction of the risk of malaria in the school-aged children.

Keywords: determinants, malaria, school-aged children, Ethiopia

Introduction

Malaria is one of the most devastating infectious diseases costing many lives each year in the world. In most of the malaria-endemic countries, the infection is one of the public health problems, causing 445,000 global deaths of which 91% occurred in sub-Saharan Africa in 2016. Each year, over 90% of malaria cases are reported in Africa, reflecting a disproportionately higher disease burden on the continent compared to the rest of the world.[1–3] Especially, the malaria burden among school-aged children (5–14 years) is more prevalent than in other pediatric age groups.[4]

Africa has made great progress toward reducing transmission through the use of vector control tools such as bed nets and indoor residual spraying (IRS).[5–8] However, a recent study showed that malaria infection is still the most prevalent

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cause of death in Africa. The study also revealed that *P. faclciparum* cospecialize with Anopheles gambiae mostly spreading in the continent.[2] In 2020, Africa contributed 95% of malaria cases and 96% of malaria deaths occurring around the globe. These deaths were majorly recorded among children of the continent.[9]

Although Ethiopia has brought changes in malaria diagnosis, treatment, vector-borne disease control, and health services coverage, there is still a gap in malaria burden reducing interventions.[10] Studies showed that in Ethiopia, malaria cases increased from 621,345 to three million and deaths related to malaria raised from 1561 to 4782 from 2015 to 2016, over one year.[11,12] Regarding the dominant malaria transmitting species in Ethiopia, between June 2016 and July 2017, of the total confirmed malaria cases, 70% were caused by *P. falciparum*, while 30% of them were by *P. vivax*.[13] The species dominance and the number of malaria morbidities vary due to different factors such as previous weather conditions or intervention measures.[14]

Studies exposed that factors associated with malaria infection included geographical locations, season, age, socio-economic status, environmental factors, changing malaria situation, and sex.[15–17] Particularly, school-aged children lead to an increase in the incidence of clinical attacks of malaria, including severe attacks, even though it substantially declined in the disease burden.[11] Several studies presented that the malaria morbidity peak age was school-aged children.[18–21] Among these school-aged children, malaria status was determined by the level of transmission, level of acquired immunity, intervention programs, level of transmission, and age.[13,16,22] In spite of the fact that school-aged children are the main source of malarial transmission between human and mosquito, Cohee et al reported that the impact of malaria infection among school-aged children of sub-Saharan Africa is still not appreciated very well.[23] Similarly, the determinants of malaria infection are not explored well among school-aged children in Ethiopia. Therefore, this study aimed to assess the determinants of malaria morbidity among school-aged children in East Hararghe Zone, Oromia, Ethiopia.

Methods and Materials

Study Setting, Design, and Period

A community-based case–control study was conducted in East Hararghe Zone, Oromia, Eastern Ethiopia between February 1 and May 31, 2020. East Hararghe Zone administrative center is located in Harar, 525 km away from Addis Ababa due east. The zone is one of the twenty administrative zones in the Oromia Regional State, bordered by West Hararghe due West and Somali Regional State due east. The area of the zone is 24,247.66 sq. km. East Hararghe Zone consists of twenty administrative districts and four administrative towns, which further comprise a total of about 548 *kebeles* (sub-districts). It is the most populated zone in Oromia regional state with an estimated total population of 3.7 million.[24] According to the current malaria stratification in the East Hararghe Zone, about 282 (52%) *kebeles* were endemic malaria areas by the level of malarial endemicity, while the rest 20%, 30%, and 50% were categorized in high, moderate, and low, respectively[25] (Figure 1).

Study Population and Eligibility

All households which had school-aged children were included in the study. An active case detection (ACD) was done through weekly household visits to identify and register malaria and non-malaria cases. Children who were confirmed to be positive for the malaria test were categorized as a case group for malaria morbidity, while the children who tested negative for malaria were categorized as a control group. For the households that had more than one school-aged child one of them was selected randomly. The selected children were included in the study regardless of malaria symptom manifestation. A household that had no school-aged children was excluded. In addition, malaria positive case that had no neighboring school-aged malaria negative child was excluded from the cases group. Each strata of low, moderate, and high endemic malaria transmission had relatively similar transmission across rural and urban *kebeles*. Moreover, children who were treated for malaria two weeks before the data collection period were excluded from the study.

Sample Size Determination and Sampling Procedure

A total of 504 samples (168 cases and 336 controls) were determined using OpenEpi Version 3, open-source calculator SSCC (Sample Size Case Control).[26] The sample size determination was done using the two population proportions with assumptions such as a power of 80%, proportion of malaria (p=56%) among school-aged children who did not use LLITN

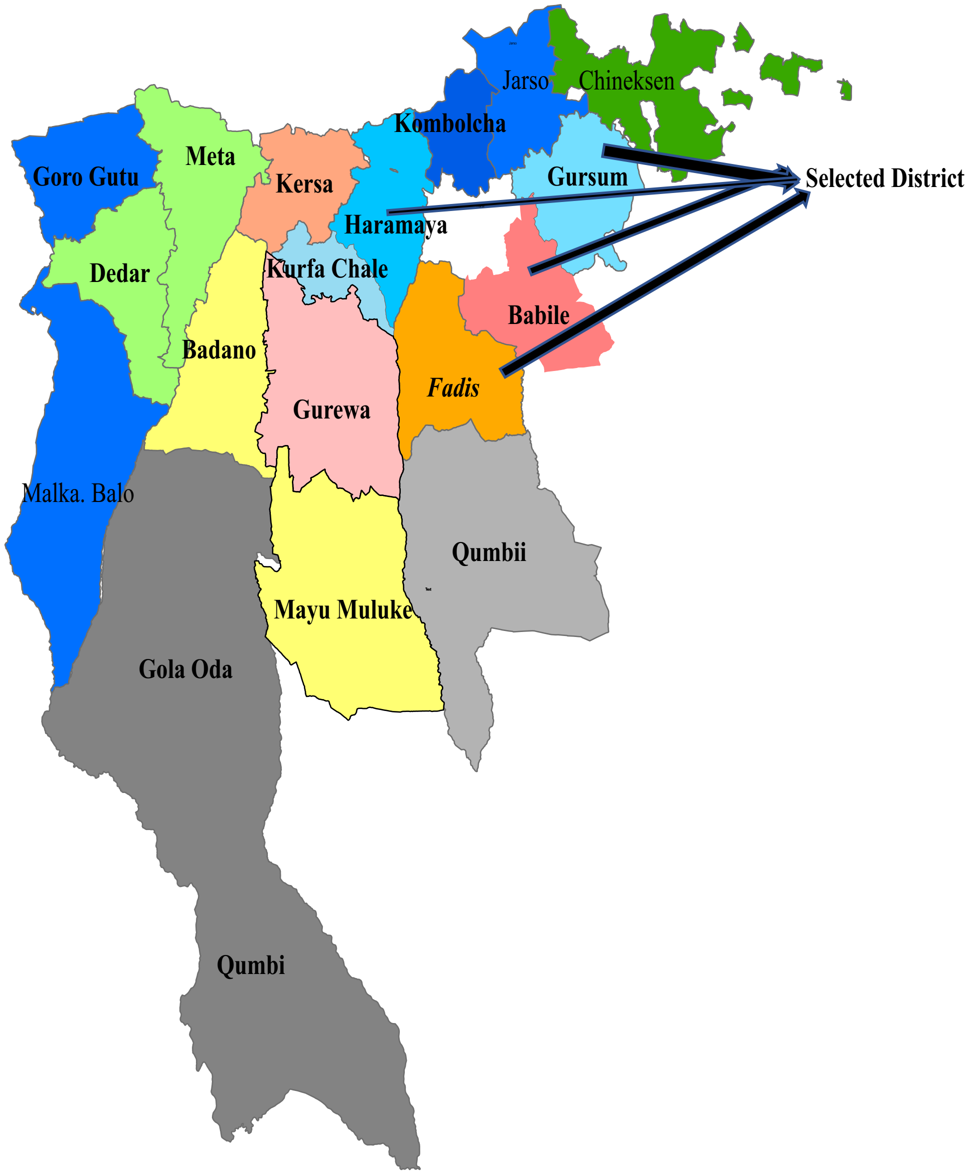

Figure 1 Map of East Hararghe Zone, Oromia Regional State, Eastern Ethiopia, 2020

Notes: Chineksen, Jarso, Kombolcha, Gursum, Kersa, Meta, Dedar, Haramaya, Kurfa Chale, Babile, Badano, Gurewa, Fadis, Malka Balo, Mayu Muluke, Qumbii, Gola Oda, Qumbi.

in the previous night,[27] 5% of level of significance, anticipated odds ratio (OR=1.75) among cases, and a case to control ratio=1:2. Cases and controls were automatically selected based on the RDT/microscopy results. The sample size was determined using the following formula[26] :

$n_1 = \left(Z\alpha_{/2} \pm Z_{1-\beta}\right) pq(r \pm 1)$, where,

$r(p_1 - p_2)^2$

$n_2 = rn_1$, n_1=number of cases, n_2=number of controls, $Z\alpha_{/2}$=standard normal deviate for two-tailed test based on alpha level (relates to the confidence interval level), Z_β=standard normal deviate for two-tailed test based on beta level (relates to the power level), r=ratio of controls to cases, p_1=proportion of cases with exposure and $q_1=1-p_1$, p_2=proportion of controls with exposure and $q_2=1-p_2$, $\bar{p}=p_1 \pm rp_{2\,/\,r+1}$, and $\bar{q}=1-\bar{p}$.

Kebeles were randomly selected using a stratified sampling technique based on considering Epidemiological Strata such as the National Malaria Strategic Plan (NMSP) of malaria status low, moderate, or high transmission. According to

Ethiopian Federal Ministry of Health (FMOH) malaria stratification,[16] East Hararghe Zone has 282 (52%) malaria-endemic *kebeles* which were high endemic 56 (20%), moderate endemic *kebeles* 85 (30%), and low endemic *kebeles* 141 (50%).[25] Therefore, ten *kebeles* were selected proportionally based on the level of malaria endemicity using a simple random sampling (SRS) technique. Then, strata were created for all selected *kebeles* based on their category of level of malaria endemicity. Finally, 168 cases and 336 controls were identified from each strata after examining the children for malaria. The only difference of the case and control was the malarial status, while other characteristics were assumed to be similar for both groups. To ensure the assumption of their similarity, we randomly selected the control from the neighbor of the case that detected positive for malaria. In addition, the same technique, equipments (microscopy and RDT), and examiners were strictly used to get the malaria result.

Procedures for Laboratory Examinations

Rapid Diagnostic Testing of Malaria in Human Blood

The CareStart™ malaria HRP2 test kit (Access Bio Inc., NJ, USA) is used for the rapid qualitative detection of Malaria Histidine-rich Protein 2 (HRP2) in human blood as an aid in the diagnosis of malaria infection. Using this kit, 5 µL of whole blood is introduced into the sample with the aid of a pipette after finger pricking. Two drops of assay buffer are added to the well. The result was read within 20 min.[28]

Malaria Blood Films for Microscopy

Thick blood films were prepared on a glass slide using 10 µL of blood, evenly spread to cover an area of 15×15 mm^2 of the slide. The smear was stained with 10% Giemsa for 10 minutes and then examine under oil immersion with a light microscope (magnification ×100). The slides were double-read by a trained laboratory technician. Asexual parasite densities were estimated by counting the number of parasites per 200 white blood cells (WBCs) in the thick film. Parasite counts were converted to parasites per microliter (µL) using relative WBC of 8000 leukocytes per µL of blood. Similarly, gametocyte rate and density were determined by counting against 500 leukocytes and converted to parasites per microliter as for asexual parasites.[28] A sample was considered negative if no parasite was counted after 200 high power fields have been read. In the case of discrepancy occurrence in the findings in a slide between the two initial technicians (positive or negative or a 50% or more difference in parasite density), a third, more senior laboratory technician reading was deemed necessary and then adopted. All of the positive blood films including a 10% random sample of negative blood slides were examined for quality control.

Data Collection Tools and Methods

Data were collected by nineteen trained laboratory technicians and supervised by experienced public health professional (one) and microbiologists (two). The training was provided for two days for data collectors and supervisors on the objectives and laboratory techniques used for testing malaria. All data collectors were familiar with the study area and spoke the local language (Afaan Oromo). The questionnaire was a modified version of the Malaria Indicator Survey (MIS) questionnaire that was used by Ethiopia FMOH in 2015.[29] The questionnaire had an observation part for screening malaria suspects and blood tests for the determination of malaria infection using microscopy/RDTs. Parents/guardians' children were asked a simple set of structured questions on socioeconomic variables, environment-related characteristics, malaria prevention methods such as using insecticide-treated bednets and indoor residual spraying in the interior wall of their home. The tool was translated into a local language (Afaan Oromo) and pretested before the actual data collection period.

Data Processing and Analysis

Once the accuracy, completeness, and consistency of the data were manually checked, the data were entered into Epidata version 3.1 and exported to SPSS version 22 for analysis. A binary logistic regression model was used to assess the association between the determinants and malaria morbidity among school-aged children. Variables that had a *p*-value <0.25 in bivariable logistic regression were transformed to the final model. The association between explanatory variables and malaria morbidity was determined by a multivariable logistic regression model with an adjusted odds ratio. Finally, the significance level of the association between the independent variables and malaria morbidity was declared at a *p*-value of

<0.05 at 95% of confidence intervals. The Hosmer–Lemeshow (*P*>0.05) test was used to check the goodness-of-fit of the logistic regression model assumptions.

Ethical Consideration

Ethical clearance was obtained from the Haramaya University College of Health and Medical Sciences Institutional Health Research Ethics Review Committee (IHRERC) after reviewing the study protocol. The letter of permission was obtained from the college and sent to the East Hararghe Zonal health office. The zonal health office further sent a letter of cooperation down to the district health office and then to *kebeles* in the selected districts. This study was conducted in agreement with the Declaration of Helsinki. Data collection was started after getting ethical approval from the institutional ethics committee. The purpose of the study was briefly explained to the study participants. A written informed consent was obtained from parents of all selected children. Blood samples were collected by trained health workers/laboratory technicians who had experience in the blood sample collection and examination. A sterilized blood lancet was used to avoid infection. Individuals who tested positive for malaria were treated according to the Ethiopia standard treatment guideline.[30] The data that were collected from the participants were kept confidential. Voluntary participation was guaranteed and participants were free to opt out.

Results

A total of 168 cases and 336 controls participated in the study. One-third, 56 (33.3%) of the cases and nearly a quarter, 77 (22.9%) of the controls were children aged between 10–14 years. The median age and interquartile range (IQR) of cases and controls were 11 years with IQR of 8 (7–15) and 12 years with IQR 12 (8–16), respectively. The majority, 141 (83.9%) of cases and 244 (72.6%) of controls were rural residents. Around two-thirds, 113 (67.3%) of the cases and more than one-third, 141 (42.0%) of the controls lived in a family whose household head had no formal education. A quarter, 42 (25%) of cases and 18 (5.4%) of controls were living in a household with an overcrowded family (Table 1).

Environmental Characteristics and Malaria Prevention Measures Used

Nearly half, 76 (45.2%) of cases and more than a quarter, 90 (26.8%) of the controls lived near the stagnant water. The majority, 143 (85.1%) of cases and more than two-thirds, 214 (67.1%) of controls observed with liquid waste in or around their living compound. One hundred and twenty-two (72.6%) of cases and 147 (43.8%) of controls had no IRS sprayed for their dwelling homes during the last six months before the survey. Few 11 (6.6%) cases and only four (1.2%) controls had a previous history of treatment for malaria. All 168 (100%) cases and almost all 334 (99.8%) controls either lived in a malaria area or had a travel history to malarious areas in the last two weeks (Table 2).

Determinants of Malaria Morbidity

In multivariable logistic regression, determinants of malaria infection including residence area, family educational status, family size, family wealth index, nearness of stagnant water around the living house, LLITN utilization, living around cultivated land, and spraying IRS chemicals in-dwelling home had a statistically significant association with malaria morbidity at *p*-value of less than 0.05.

This study showed that children who lived in a rural area had 2.34 times higher odds of malaria than those who lived in an urban area (AOR=2.34, 95% CI: 1.87–4.12). Odds of having malaria were 4.91 times more likely higher among children whose family had no formal education compared to those whose family had a higher educational level (AOR=4.91, 95% CI: 1.20–20.17). Moreover, this study revealed that children born from a family with a lower household wealth index had malaria 2.50 times more likely than those who were born from a rich family (AOR=2.50, 95% CI: 1.22–5.12). Children who lived around stagnant water had malaria 2.01 times more likely than those who lived beyond 2 km away from stagnant water (AOR=2.01, 95% CI: 1.14–3.54). Children whose home was surrounded by cultivated land had malaria 76% less likely than those whose home was surrounded by shrub type of land (AOR=0.24, 95% CI: 0.10–0.60). Children whose family had less family size had odds of malaria 63% less likely than the family who had larger family size (AOR=0.37, 95% CI: 0.18–0.78). Children whose households used the LLITN in last night had reduced malaria morbidity by 81% compared to their counterparts (AOR=0.19, 95% CI: 0.10–0.35). Moreover, children

Table 1 Socio-Demographic Characteristics of Study Participants, East Hararghe Zone, Oromia, Ethiopia, 2020

Variables (n=504)	Category	Malaria Status	
		Cases (%)	Controls (%)
Sex	Male	66 (39.3)	148 (44)
	Female	102 (60.7)	188 (56)
Age	5–9 years	56 (33.3)	77 (23)
	10–14 years	65 (38.7)	122 (36)
	15–18 years	47 (28)	137 (41)
Place of residence	Urban	27 (16)	92 (27.4)
	Rural	141 (84)	244 (72.6)
Altitude above sea level	<1500 meters	60 (35.7)	118 (35.1)
	1500–1750 meters	59 (35.1)	123 (36.6)
	≥1750 meters	49 (26.3)	95 (28.3)
Educational status of the household head	No formal education	113 (67.3)	141 (42)
	Primary	42 (25)	106 (31.5)
	Secondary	9 (5.4)	49 (14.5)
	Higher	4 (2.4)	40 (12)
Family occupational status	Farmers	149 (88.6)	251(74.7)
	Merchant	10 (6)	46 (13.7)
	Gov. worker	9 (5.4)	39 (11.6)
Family size category based on LLITN distribution	1 to 2	0 (0)	27 (8)
	3 to 4	20 (12)	135 (40.2)
	5 to 6	106 (63)	156 (46.4)
	≥7	42 (25)	18 (5.4)
Household wealth index	Low	98 (58.3)	175 (52.1)
	Medium	48 (28.6)	90 (26.8)
	High	22 (13.1)	71 (21.1)

who lived in insecticide chemical sprayed interior wall of the home had malaria 85% less likely compared with their counterparts (AOR=0.15, 95% CI: 0.08–0.29) (Table 3).

Discussion

In Ethiopia, malaria fighting programs have been maximized through LLITN and IRS provisions, improving healthcare services, and improving malaria diagnosis and treatment. However, at country level, the interventions are primarily targeted to areas with greater than 2500 meter elevation. Thus, malaria is still one of the health problems that is affecting many lives.[10] The school-aged children are the highest malaria morbidity contributors.[21] The data from the study zonal health department (2019) also revealed that malaria morbidity declined substantially but continued to be increased among school-aged children.[25] However, little is known about the individual and household risk factors. The current study identified that

Table 2 Environmental Charactersitics and Malaria Prevention Measures Used Among Study Participants in East Hararghe Zone, Oromia, Ethiopia, 2020

Variable	Category	Cases	Controls	%
Access to information (through radio/TV)	Yes No	264 71	123 43	76.8 22.8
Number of rooms	One Two and above	76 260	34 134	21.8 78.2
Main materials of rooms made of	Cement Sand	90 246	37 131	22.8 77.2
Presence of opening on wall/window	Yes No	149 187	127 41	54.8 45.2
Main source of drinking water for the household members	Hand pump Spring	260 76	119 49	75.2 24.8
Availability of toilet per house hold	Yes No	279 56	133 35	81.7 18.3
Liquid waste available within or outside of compound	Yes No	214 105	143 25	73.3 26.7
Stagnant water around the house	Yes No	90 246	76 92	32.9 67.1
IRS used in the interior wall of home in the last six months	Yes No	189 147	46 122	46.6 53.4
Painted/covered the sprayed interior wall	Yes No	17 177	11 39	11.5 88.5
LLITN used last night	Yes No	274 62	100 68	74.2 25.8

residence, family educational status, family economic status, size of family members, using LLITN, using IRS, and living around stagnant water were associated with malaria morbidity among school-aged children.

Based on the results of this study, it was found that rural resident children had greater odds of malaria morbidity when compared to urban resident children. This finding was similar to other studies conducted in Ethiopia[27] and Malawi.[31] Reasons could be due to rural residents could have low socioeconomic status, made their house from thatched roofing, use agriculture as their main source of family income, and have no access the health services easily.[32] Residence place of the child could also contribute to the individual's way of life, housing condition, and vectors breeding site; rural resident children could move about freely and may go outside more often and therefore may be more susceptible to mosquito bites, thereby getting malaria infection.

The children whose families had low wealth index had a higher odds of malaria morbidity than those whose families had higher wealth index level. This study finding was in line with studies from Tanzania[33] and South Africa,[34] Madhya Pradesh India,[35] Republic of Tanzania,[36] and Myanmar.[37] The parents who have a lower wealth index could not afford to protect the child from getting malaria morbidity. One possible reason could be that household economic status plays an important role in the management of illnesses, for the household with low wealth index could suffer from transportation, treatment costs, and diagnosis costs.[38,39]

This study revealed that numbers of household members had a significant association with the odds of having malaria. Families who had many household members had increased odds of malaria morbidity compared to those who had less household members. This study showed a similar result to the studies done in India,[35,40] Ethiopia,[41] and Vietnam.[42] The possible reason could be that family size plays an important role in the household socioeconomic status due to lower health

Table 3 Determinants of Malaria Morbidity in School-Aged Children in East Hararghe Zone, Oromia, Ethiopia, 2020

Variables		Malaria Status		COR (95% CI)	AOR (95% CI)
		Cases (%)	Controls (%)		
Place of residence	Urban	27 (16)	92 (27.4)	0.51(0.32–0.82) *	1
	Rural	141 (84)	244 (72.6)	1.00	2.34 (1.87–4.12) **
Land cover type	Cultivated	125 (74.4)	232 (69)	1.05 (0.63–1.59)	0.24 (0.10–0.60) **
	Bare	7 (4.2)	37 (11)	0.35 (0.14–0.87) *	0.92(0.23–3.70)
	Shrub	36 (24.4)	67 (20)	1.00	1.00
Age group in years	5–9	56 (33.3)	77 (23)	2.12 (1.32–3.42) *	1.87 (0.98–3.59)
	10–14	65 (38.7)	122 (36)	1.55 (0.99–2.43) *	6.34 (0.85–11.06)
	15–18	47 (28)	137 (41)	1.00	1.00
Family size	1 to 3	0 (0)	27 (8)	0.000	0.37 (0.18–0.78) **
	4 to 5	20 (12)	135 (40.2)	0.06 (0.03–0.13) *	0.04 (0.02–1.12)
	6 to 7	106 (63)	156 (46.4)	0.30 (0.16–0.53) *	0.76 (0.18–1.92)
	≥ 8	42 (25)	18 (5.4)	1.00	1.00
Educational status of the House hold Head	No formal education	113 (67.3)	141 (42)	8.01(2.78–23.07) *	4.91(1.20–20.17) **
	Primary	42 (25)	106 (31.5)	3.96(1.34–11.76) *	4.44 (0.88–18.28)
	Secondary	9 (5.4)	49 (14.5)	1.84 (0.53–6.41) *	4.68 (0.78–27.92)
	Higher	4 (2.4)	40 (12)	1.00	1.00
Family Occupation	Farmers	149 (88.6)	251 (74.7)	2.57 (1.21–5.46) *	0.87 (0.17–4.36)
	Merchant	10 (6)	46 (13.7)	0.94 (0.35–2.55) *	0.61 (0.12–2.97)
	Gov. worker	9 (5.4)	39 (11.6)	1.00	1.00
Household wealth index	Low	98 (58.3)	175 (52.1)	1.81 (1.06–3.10) *	2.50 (1.22–5.12) **
	Medium	48 (28.6)	90 (26.8)	1.72 (0.95–3.11) *	6.11(0.97.–16.38)
	High	22 (13.1)	71 (21.1)	1.00	1.00
Proximity to Stagnant water	Yes	76 (45.2)	90 (26.8)	2.26 (1.53–3.33) *	2.01 (1.14–3.54) **
	No	92 (54.8)	246 (73.2)	1.00	1.00
IRS used in the home	Yes	46 (27.4)	189 (56.3)	0.29 (0.20–0.44) *	0.15 (0.08–0.29) **
	No	122 (72.6)	147 (43.7)	1.00	1.00
LLITN use in last night	Yes	100 (59.5)	274 (81.5)	0.33 (0.22–0.50) *	0.19 (0.10–0.35) **
	No	68 (40.5)	62 (18.5)	1.00	1.00
Visiting clinics within 48 hrs of illness	Yes	91 (54.2)	274 (81.5)	0.27 (0.13–0.40) *	0.28 (0.15–1.81)
	No	77 (45.8)	6 2(18.5)	1.00	1.00

Notes: *Associated in bivariate analysis, **Associated in multivariable analysis.

services access distribution among the members. In addition, this can be due to the higher probability of easy familial malaria transmission among larger family members in the household because of nearness of infected and susceptible humans if there is an infected person in the family.[43]

Furthermore, children whose family had no formal education had a higher odds of malaria morbidity compared to children whose family had formal education. This result agreed with the results from Ethiopia,[27] Mali,[44] and India.[35] It is the fact that uneducated people can not read and understand the messages written as teaching aids such as leaflets, brochures, and banners that focus on the prevention and control methods of malaria. A study reported that the health needs of school-aged children have been largely ignored.[45] In addition, if uneducated people get sick from malaria, they could delay in seeking treatment that results in the further transmission of malaria from infected individuals to healthy people.

Children whose family used LLITN had odds of contracting malaria less likely compared to children whose family did not use LLITN. The result was in agreement with studies conducted in different parts of Ethiopia.[27,46–48] In fact, using LLITN is one of the major malarial disease transmission prevention. The children whom their house wall was sprayed with chemicals (IRS) during the past six months were less likely to have malaria morbidity than those whom their house wall was not sprayed. This aligned with the studies conducted in south Ethiopia[49] and Equatorial Guinea.[50] However, this finding was contrary to the finding from Tanzania[51] that showed that using IRS did not reduce the risk of malaria infection. This can be due to the resistance of mosquito species to the sprayed chemicals despite that the family trust the protective effect of the chemical.[52]

The current study revealed that the proximity of water body within less than 2 km to home increased odds of malaria morbidity than children with their home located beyond 2 km from the water body. This study was similar with the findings from southwest Ethiopia,[15] Uganda,[53] and Cameroon.[54] It is the fact that the open water sources such as rivers, swamps, and stagnant water may ultimately become the ideal mosquito breeding habitats. Thus, the mosquito can easily move within 2 km radius of areas from their breeding sites that enable the mosquito to bite any person within this areas.

This study result showed that the shrub land cover type around home increased odds of malaria morbidity than the home surrounded by bare land. This study was in line with the studies conducted in Ethiopia[27] and Kenya.[55] This might be due to the fact that the shrub areas may favour the breeding of mosquitos. The reproduction of the vector is one of the malaria transmission cycle.

Strengths and Limitations of the Study

This study could generate a highly needed information as a malaria among school-aged children is not well-characterized in the previous studies particularly in Ethiopia. In addition, the malaria testing validity was mantained by reexamining all positive and 10% of randomly selected negative tested samples using microscopy examination as the quality check of the RDT test.The limitation was the inclusion of only one season (February to May), when the high malaria morbidity is expected.

Conclusions and Recommendations

This study revealed that being a rural resident, having a larger family size, lower economic status, and living in the home proximal to the stagnant water were found to be determinants of malaria morbidity among school-aged children in the East Hararghe Zone. The evidence of this study shows that interventions such as using LLITN and IRS in the home focused on malaria illness of school-aged children may potentially benefit to prevent malaria. In addition, all concerned bodies including the community should work on the elimination of stagnant water surrounding the living house to cut the breeding sites of mosquitoes. Moreover, the findings have an important implication for improving interventions such as economic growth and literacy of the society that may help in reducing the risk of malaria morbidity in school-aged children.

Abbreviations

AOR, adjusted odds ratio; CI, confidence interval; COR, crude odds ratio; CSA, Central Statistics Agency; IRS, insecticide residual spray; LLITN, long lasting insecticide treated net; RDT, rapid diagnostic test; NMSP, National Malaria Strategic Plan.

Data Sharing Statement

All the data used in this study can be available from MA upon request.

Acknowledgments

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors declare that they have no conflicts of interest.

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